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Understanding landholder management of  
riparian zones in the Goulburn Broken  
Catchment.

Andrea Wilson, Amy Jansen, Allan Curtis & Alistar Robertson



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Wagga Wagga, NSW

Johnstone Centre, Wagga Wagga, NSW

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Bibliography.

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## **EXECUTIVE SUMMARY**

Riparian habitats support high levels of biodiversity and perform essential ecological functions. Management practices adopted by private landholders, such as the grazing of domestic livestock, can influence the condition of riparian habitats. In this project, we interviewed thirty-three landholders and undertook ecological condition assessments at forty-five sites to investigate the relationship between landholder management practices and riparian condition in the Goulburn Broken Catchment. To improve our understanding of landholder knowledge of riparian zones, we compared landholder and scientist assessments of ecological condition in riparian zones on private properties. We also collected information about potential impediments to the adoption of best management practices for riparian habitats.

The riparian zones sampled during this study were generally in poor condition. All sites had exotic plant species in the ground cover layer and where understorey was present it often included exotic species, such as blackberry. Broad relationships between ecological condition and domestic stock grazing were indicated, with riparian condition scores declining significantly with increased stocking rates. Discussions with landholders revealed that the time and cost associated with riparian rehabilitation were often an impediment to the adoption of recommended practices. However, a number of other impediments to adoption were also identified by landholders, such as the loss of fences during flooding, the continued maintenance required in rehabilitated areas and the perceived lack of necessity for changes to current riparian zone management.

Landholder and scientist assessments of ecological condition showed a significant positive correlation. Although this indicated good agreement between landholder and scientist assessments, a substantial proportion of landholders overestimated riparian condition within their riparian zones. Additionally, there is no evidence to support the hypothesised relationship between landholders riparian assessment scores and the adoption of recommended riparian management practices. It seems that understanding of riparian function is a more important factor contributing to adoption than the ability to accurately complete a descriptive assessment score. Therefore, we suggest that increased awareness of the functional importance of riparian habitat attributes may play an important role in encouraging the adoption of best practice riparian management.

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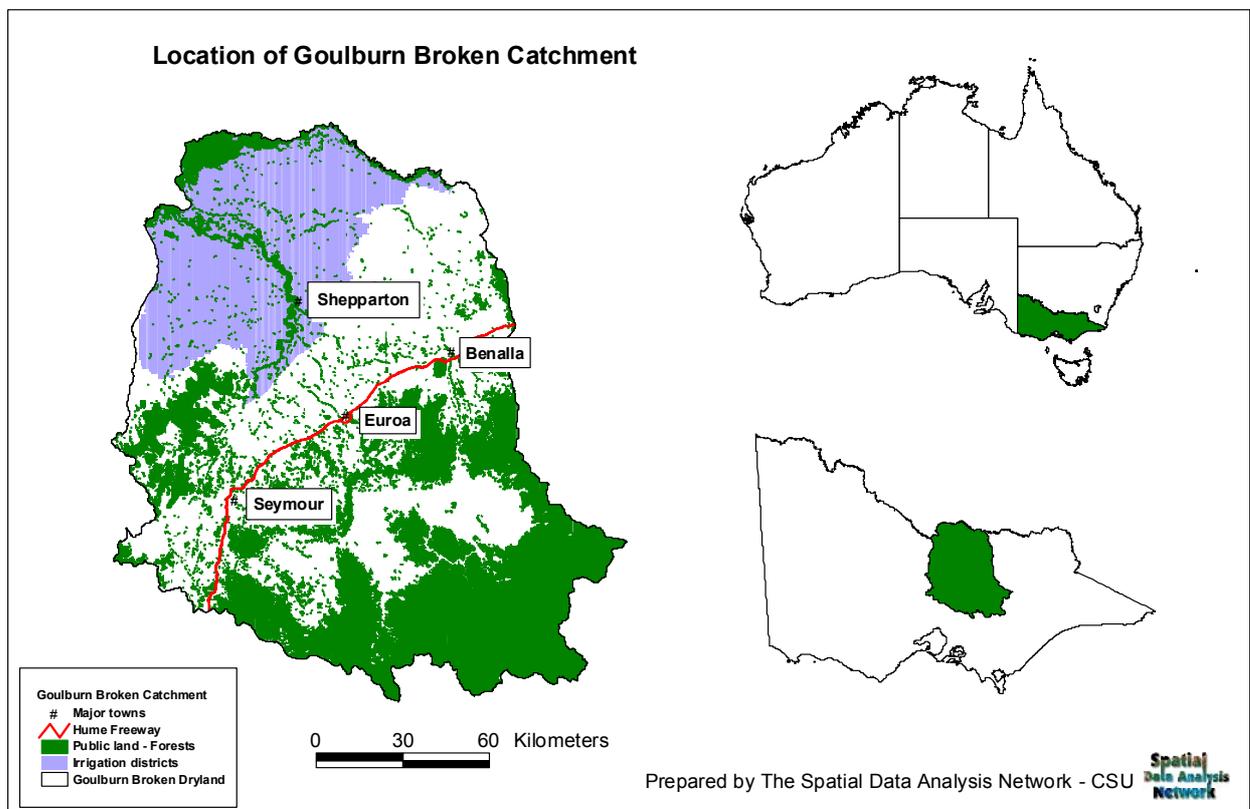
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# 1. INTRODUCTION

This report presents the findings of a field project undertaken in the Goulburn Broken Catchment (GBC) in October 2002 to assess the impacts of grazing on the condition of riparian zones. This work was supported by grants from the National Riparian Lands Program of the Goulburn Broken Catchment Management Authority (GBCMA) and Land & Water Australia.

The GBC is located in north east Victoria and includes the Goulburn and Broken River catchments (Figure 1). The GBC covers 2.3 million hectares (17% of Victoria), including 1.9 million hectares of non-irrigated land that is referred to as the Goulburn Broken Dryland. The GBC includes the major townships of Shepparton, Benalla, Euroa, Seymour, Mansfield and Broadford, and supports major primary and secondary industries, including food processing, forestry and tourism activities.

**Figure 1.** Location map of the Goulburn Broken Catchment.



In this project, we used thirty-three landholder interviews and forty-five rapid ecological condition assessments to gain information about management practices and riparian condition in the GBC. The research aims for this field project were:

1. To investigate the relationship between landholder management practices and riparian condition.
2. To compare landholder and scientist's assessments of the ecological condition of riparian zones on private properties.
3. To investigate the impediments to adoption of best management practices for grazing in riparian zones.

## **2. BACKGROUND**

### **2.1 Riparian zones**

Riparian zones perform essential ecological functions and are important regional sites supporting high levels of biodiversity (Naiman & Decamps 1997). Because they are at the boundary of terrestrial and aquatic systems, riparian zones are powerful indicators of catchment quality (Rapport *et al.* 1998). At the same time, human settlement has always been focused on rivers and human activity is often a major determinant of riparian structure and function (Dynesius & Nilsson 1994). Grazing by domestic livestock has been a major land use in riparian zones, and the grazing and trampling activity of domestic livestock can have a significant influence on riparian habitats (Trimble & Mendel 1995). In Australia, riparian and wetland habitats have often suffered more than dryland habitats from domestic grazing herds because stock concentrate around water sources (Robertson 1997). For instance, on the Murrumbidgee River in New South Wales, grazing management practices have been found to have a significant impact on riparian zone condition (Jansen & Robertson 2001a), riparian bird communities (Jansen & Robertson 2001b) and frog community structure (Jansen & Healey 2003).

A large proportion of riparian land in Australia is owned or managed by private landholders. While some factors controlling riparian condition operate at spatial and temporal scales beyond the influence of these land managers, management practices adopted at the paddock-scale by private landholders can influence the condition of riparian habitats (Jansen & Robertson 2001a).

## **2.2 Understanding riparian management in the Goulburn Broken Catchment**

In order to better understand landholders' knowledge of and attitudes towards riparian management in the GBC, a mail survey was conducted in 2001. A survey booklet was mailed to 300 property owners selected at random from lists supplied by the GBCMA, with a final response rate from landholders of over 60 percent (Curtis *et al.* 2001). Survey recipients were asked to provide an assessment of the condition of riparian zones on their properties

In their analysis of the 2001 mail survey data, Curtis *et al.* (2001) suggested that most respondents had a sound understanding of some of the less widely publicised functions or ecological processes. On the other hand, there were many managers of riparian zones who were either misinformed or reluctant to acknowledge the critical roles that clearing and stock grazing have had in contributing to riparian degradation. Differences in knowledge of riparian zone function and factors affecting riparian condition were linked with differences in the adoption of current recommended practices. This finding suggested there was considerable scope for community education to increase the adoption of recommended practices by increasing landholder knowledge of the important functions of riparian zones and of their generally degraded condition (Curtis *et al.* 2001).

Effecting behavioural change in private landholders is a complex task and experience suggests that no single instrument will address the underlying reasons for non-adoption of recommended practices for riparian management (Curtis *et al.* 2001). There has been a large investment of resources over the past ten years in awareness-raising and education programs, including those carried out by Landcare groups. Research suggests

that these activities do contribute to increased awareness and understanding and that these changes enhance landholder capacity to adopt current recommended practices (Vanclay 1992; Curtis & De Lacy 1996).

Although most respondents to the 2001 mail survey agreed that fencing and watering stock off-stream were aspects of improved riparian management, most had reservations about the efficacy of fencing, watering stock off-stream and intensively grazing riparian zones for short periods of time. Concerns about the efficacy of these current recommended practices appeared to be impacting on their adoption. Curtis *et al.* (2001) suggested that GBC managers and scientists needed to reassess approaches to fencing riparian zones, with community education activities using local demonstrations an important element of such work. They also suggested that those attempting to change land and water management practices should focus on awareness raising, improving knowledge and skills and on enhancing the acceptability of specific current recommended practices.

This project was undertaken to improve our understanding of landholder knowledge of riparian zones and the impacts of land management practices on riparian condition. In this study, we obtained data on riparian management practices through interviews with landholders and undertook riparian assessments using an ecological condition score developed by Jansen and Robertson (2001a). This facilitated the comparison of scientist's riparian assessments to those undertaken by landholders during the 2001 mail survey and provided data for analysis of the relationship between management practices and riparian condition in the GBC.

### **3. METHODOLOGY**

#### **3.1 Landholder interviews**

The 2001 mail survey by Curtis *et al.* (2001) identified 95 GBC landholders willing to participate in follow-up interviews and riparian assessments. In August 2002, reminder letters were sent to this group to re-acquaint them with the study and obtain their consent for farm visits. Fifty landholders returned signed consent forms to the authors and were telephoned to arrange interview times. After addressing difficulties with contact details and time availability, thirty-three farm visits were undertaken between 3<sup>rd</sup> October and 25<sup>th</sup> October 2002. The majority of these farm visits were undertaken in the upper and mid catchment, owing to a relatively poor response from landholders in the lower catchment.

The final interview questions and format were developed after consultation with the Upper Goulburn Waterway Working Group (UGWWG) and GBCMA staff on draft versions (see Appendix 1). Interview questions investigated the attitudes of landholders and their riparian zone management practices, including:

- Farm size, time owned, predominant land-use, stocking rates.
- Length of river frontage, flooding frequency and extent.
- Location map of the area that landholders used for their ecological condition assessment in the 2001 mail survey. This enabled us to conduct our comparative assessment of riparian condition at the same location.
- For grazed riparian zones – stocking rate, watering points, periods of grazing vs rest.
- For fenced riparian zones – area fenced, revegetation initiatives, pest management, reasons for fencing.
- Attitudes to riparian improvement – management practices recently adopted, impediments to adoption, cost effectiveness.

Although cattle were the dominant livestock in the riparian zones studied, landholders in the GBC also run both sheep and horses. Information on stocking rates provided by landholders was standardised to dry sheep (wethers) equivalents (dse) per hectare per annum, using conversion factors for different types of stock (Appendix 2). Stocking rate within floodplain paddocks may not be the best estimate of the impact of livestock

on riparian zones because stock often concentrate their activities at land-water interfaces (Robertson 1997). Therefore, cowpat density was also used as an index of cattle activity at each site (Jansen & Robertson 2001a). To do this, cowpats were counted along four, evenly spaced transects perpendicular to the river. Transects were measured to a composite distance of 100 m and cowpats counted within 1 m of the line on each transect, covering a total area of 200m<sup>2</sup>.

### **3.2 Ecological condition and rapid appraisal**

Owing to the spatial scales of human impacts on the landscape and the need for assessment of ecological change, there is an expanding field of research focused on rapid appraisal techniques to measure ecosystem condition or integrity (Fairweather 1999; Boulton 1999). Here, condition refers to the degree to which human-altered ecosystems diverge from local semi-natural ecosystems in their ability to support a community of organisms and perform ecological functions (Karr 1999).

Recently, Jansen and Robertson (2001a) developed and tested an index for the rapid appraisal of the ecological condition of riparian sites on the Murrumbidgee River (Table 1) using a sub-set of the indicators proposed by Ladson *et al.* (1999). The index was made up of six sub-indices, each with a number of indicator variables. In this study, we used an abbreviated version of the Jansen and Robertson (2001a) index as shown in Appendix 3. The five sub-indices included in the rapid assessment were: (1) Habitat continuity and extent (HABITAT), (2) Vegetation cover and structural complexity (COVER), (3) Standing and fallen debris (DEBRIS), (4) Dominance of natives *vs* exotics (NATIVES), and (5) Indicative species (SPECIES).

This approach enabled us to investigate relationships between land use and riparian condition at 38 sites on private property. Of the 38 riparian sites surveyed, 13 were grazed, 21 ungrazed and 4 were sites subject to occasional periods of short grazing (crash grazed for 10% or less of the year). Thirty-three of these 38 sites were identified by landholders as those assessed for the 2001 mail survey. An extra 5 sites were included in the data set to provide comparative examples of different land management practices.

**Table 1.** Functions of the riparian zone at different levels of organisation, the components of the riparian ecosystem which perform those functions, and the indicators of the function used in this study to determine condition.

Functions	Components	Indicators
<i>Physical:</i>		
Reduction of erosion of banks	Roots	Tree cover
Sediment trapping	Roots	Tree cover
Controlling stream microclimate/ discharge/ water temperatures	Riparian forest	Tree cover
Filtering of nutrients	Vegetation, leaf litter	Ground cover vegetation Leaf litter cover
<i>Community:</i>		
Provision of organic matter to aquatic food chains	Vegetation	Vegetation cover Leaf litter cover
Retention of plant propagules	Terrestrial CWD <sup>1</sup> , leaf litter	Terrestrial CWD <sup>1</sup> Leaf litter cover
Maintenance of plant diversity	Regeneration of dominant species, presence of important species, dominance of natives vs exotics	Amount of regeneration Damage to regeneration Presence of reeds Dominance of native vs exotic vegetation
Provision of habitat for fauna	Terrestrial CWD <sup>1</sup> , leaf litter, standing dead trees/hollows, riparian forest, habitat complexity	Terrestrial CWD <sup>1</sup> Leaf litter cover Standing dead trees Vegetation cover Number of vegetation layers
<i>Landscape:</i>		
Provision of biological connections in the landscape	Riparian forest (cover, width, connectedness)	Vegetation cover Width of riparian forest Longitudinal continuity of riparian forest
Provision of refuge in droughts	Riparian forest	Tree cover

<sup>1</sup>CWD = Coarse Woody Debris

Seven 'Public Land' sites were also included in the survey as a comparison to private landholdings. Indices of ecological condition need to be benchmarked against relatively undisturbed sites in order to provide a measure of variation from natural situations (Boulton 1999). Local landholders and GBCMA staff were consulted to identify Public Land sites within the catchment that were considered to be relatively undisturbed by grazing activities and possessed significant areas of native remnant vegetation. Public Land sites used for comparison during this study included Gooram Falls Reserve (Seven Creeks), Mt Samaria State Forest (unnamed creek) and Glenn Creek (State Forest) and were chosen based on the following criteria:

- Public lands managed to exclude domestic livestock,
- Located close to landholder sample sites (eg. mid and upper catchment),
- Representative of conditions at landholder sites (eg. same dominant vegetation community),
- Possessed significant tracts of remnant vegetation.

All surveys were conducted by a single, trained observer. Each sample site was a 200 metre section of the riparian zone along one side of a river or creek. At each site, vegetation along the riverbank was assessed to determine the length and number of any discontinuities (gaps of at least 20 m) in canopy cover. Four transects (30 m x 5 m; perpendicular to the direction of river flow) were evenly spaced along the river or creek bank. The following parameters were scored according to Appendix 3 within each of these transects:

- River width and width of the riparian vegetation (on the side of the river being assessed),
- Vegetation cover within three layers (ground cover - grasses, herbs, reeds and sedges to 1 m tall; understorey - herbs, reeds, shrubs and saplings 1-5 m tall; canopy - trees >5 m tall),
- Percentage of native species in each vegetation layer,
- The number of vegetation layers,
- Leaf litter cover on the ground and the percentage which was native species,
- The abundance of coarse woody debris (>10 cm in diameter) and the percentage which was native species,
- Presence of standing dead trees,

- Abundance of canopy species seedlings (<1 m tall),
- Grazing damage to canopy species seedlings,
- Reeds,
- Shrub regeneration.

The estimates for each indicator were averaged for each site, scored and weighted, then summed to give a total score for each site (see Appendix 3). Potential scores ranged from 0 (worst condition) to 50 (best condition). In order to summarise some of our results we grouped total condition scores for surveyed sites into five categories, as follows: very poor condition <25, poor condition  $\geq 25 < 30$ , average condition  $\geq 30 < 35$ , good condition  $\geq 35 < 40$ , and excellent condition  $\geq 40$ .

A comparison of landholder and scientist assessments of ecological condition of riparian zones was undertaken by analysing the relationship between the scores collected from landholders during the 2001 mail survey and those recorded during the scientist assessments in 2002. The ecological assessment questions answered by landholders in the 2001 mail survey are listed in Appendix 4. The focus of this rapid assessment project specifically upon riparian vegetation resulted in the use of a simplified subset of the questions undertaken in the 2001 mail survey (see Appendix 4). Additionally, as landholders chose not to answer some of the survey or assessment questions, the number of comparisons (*n*) in each analysis varies.

## 4. RESULTS

### 4.1 Comparison of interviewed landholders to 2001 mail survey respondents

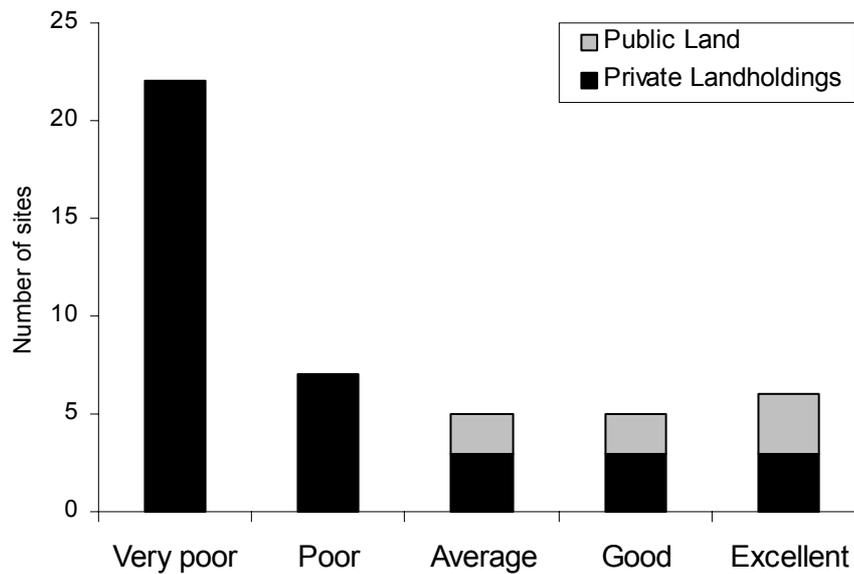
A comparison of our sub-sample group of landholders to those from the complete list of 2001 mail survey respondents showed that the mean age of respondents was very similar. The level of understanding of some of the less widely publicised functions or ecological processes in riparian zones was high amongst both groups of respondents (Table 2). However, the percentage of respondents identifying farming as their main occupation and the average property size was substantially different across the sample groups. The information in Table 2 also indicates that considerable disparity existed between the sample groups regarding confidence levels associated with fencing and the impacts of grazing stock in riparian zones. Therefore, it should be noted that some of the characteristics of this group of landholders may differ from those of the larger group questioned in the 2001 mail survey.

**Table 2.** Comparison of 2001 mail survey respondents and landholders included in this study.

	<b>2001 mail survey</b>	<b>This study</b>
Number in sample	93	33
Average property size	36ha	173ha
Percentage of respondents whose main occupation is farming	37%	53%
Average age of respondents	56	56
Knowledge of the ecological differences between willows and native vegetation in riparian zones	60%	73%
Knowledge of the ecological impacts of grazing domestic stock in riparian zones	46%	63%
Confidence in fencing of riparian zones as a means of controlling stock and revegetating riparian zones.	67%	88%

## 4.2 Riparian condition scores

Scores for riparian condition ranged from 5.7 to 44.7, and overall riparian zones were in poor condition (Figure 2). Although a number of Public Land sites scored within the Excellent category, no sites scored near the theoretical maximum (50) for the index. This was mainly due to the widespread occurrence of exotic species such as blackberry, the lack of coarse woody debris and low vegetation regeneration at many sites.



**Figure 2.** Frequency distribution of sites in condition categories ( $n=45$ ).

## 4.3 Land management practices in riparian zones

A summary of the frequency of adoption of recommended riparian management practices indicated that the majority of participants in this survey had adopted stock exclusion and/or fencing on their properties (Figure 3). However, very few landholders were implementing grazing techniques, such as crash grazing, in their riparian zones.

Of the sites at which grazing was undertaken ( $n=13$ ), the predominant land use was cattle grazing (cattle grazing 54%, sheep grazing 23%, horse grazing 15%), with an average property size of 180 ha. Only 23% of these landholders supplied off-river

watering points for stock and most (77%) grazed their riparian zones for 50% or more of the year. Mean stocking rate across grazed sites was 17 dse/ha/annum.



**Figure 3.** Percentage of the 33 landholders who had adopted recommended riparian improvement practices.

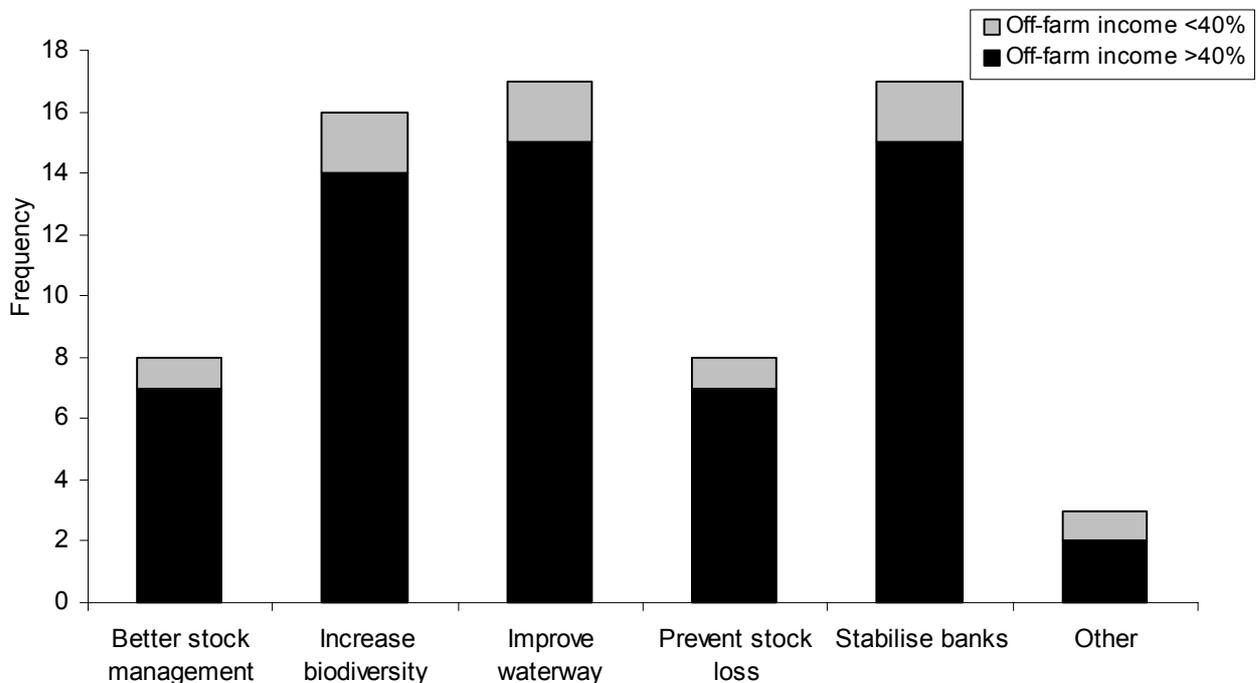
Discussions with landholders revealed that decisions regarding the adoption of new riparian land management practices were influenced by a variety of considerations. The time and cost associated with fencing and maintenance of riparian zones were often cited as impediments to adoption (Table 3). However, a number of other issues, such as the loss of fences during flooding and the potential of water troughs to run dry, were also raised by landholders.

**Table 3.** Impediments to the adoption of riparian management practices at grazed sites.

Management practice	Cost	Time	Flooding destroys fences	Want access to reliable water	Want access to feed	Practice is not necessary	Other
Fencing	23%	8%	23%	23%	15%	8%	-
Revegetating	23%	15%	-	-	23%	31%	8%
Crash grazing	-	-	-	-	62%	38%	-
Off-river water	31%	8%	-	61%	-	-	-

For ungrazed sites, mean property size was approximately 160 ha. The average size of riparian zones that had been fenced at these sites was around 865 m long and 100 m wide. The length of time elapsed since fencing of the riparian zone varied considerably across ungrazed sites (0 to 20 years), with an average of 4.8 years. Of the private landholdings which did not graze their riparian zones, 84% had undertaken tree planting activities and 80% had undertaken some type of pest management, with spot spraying being the most common method employed to control weeds.

A large proportion of landholders identified environmental rather than economic reasons for adopting these land management practices. For example, improving stock management was a less important reason for fencing than increasing biodiversity (Figure 4). There is an even distribution across both economic and environmental reasons amongst landholders who derive the bulk of their income from on-farm enterprises and those who do not (Figure 4). ‘Other’ reasons cited for undertaking fencing included salinity management and vegetation connectivity, as well as issues unrelated to riparian management, such as preventing young children from accessing creeks.



**Figure 4.** Frequency of reasons for adopting riparian management practices at fenced/ungrazed sites ( $n=25$ ). Bars represent the number of landholders that agreed with each of the nominated reasons.

Landholders that had undertaken riparian improvements on their properties, such as fencing, were also asked whether they believed such practices were cost effective. Results from these questions showed that many landholders believed management options aimed at improving riparian condition could produce economic gains. However, a large proportion of landholders saw these gains as long term (Table 4).

**Table 4.** Landholders’ beliefs about the long and short term cost effectiveness of riparian improvement practices ( $n=25$ ).

Are riparian improvement management practices cost effective:	YES	NOT SURE	NO
In the short term?	10	0	14
In the long term?	22	0	2

#### 4.4 Riparian condition scores and land management practices

Broad relationships between ecological condition and grazing of domestic stock were indicated, with riparian condition scores declining significantly as grazing intensity increased (Figures 5 & 6). Riparian condition scores also differed significantly between the three broad grazing categories, with grazed sites having significantly lower condition scores than ungrazed sites, and sites in the crash grazed category being intermediate (Figure 7).

There was no significant correlation between riparian condition scores and the number of years since fencing or exclusion of grazing stock (Figure 8). These results highlight the potential importance of historic events on riparian zone condition. The ecological condition score measured a variety of factors, some of which are the result of past practices, such as the clearing of floodplain forests and the removal of coarse woody debris. For example, a number of fenced sites scored poorly due to factors such as the removal of willows from the tree canopy or the collection of fallen trees for firewood.

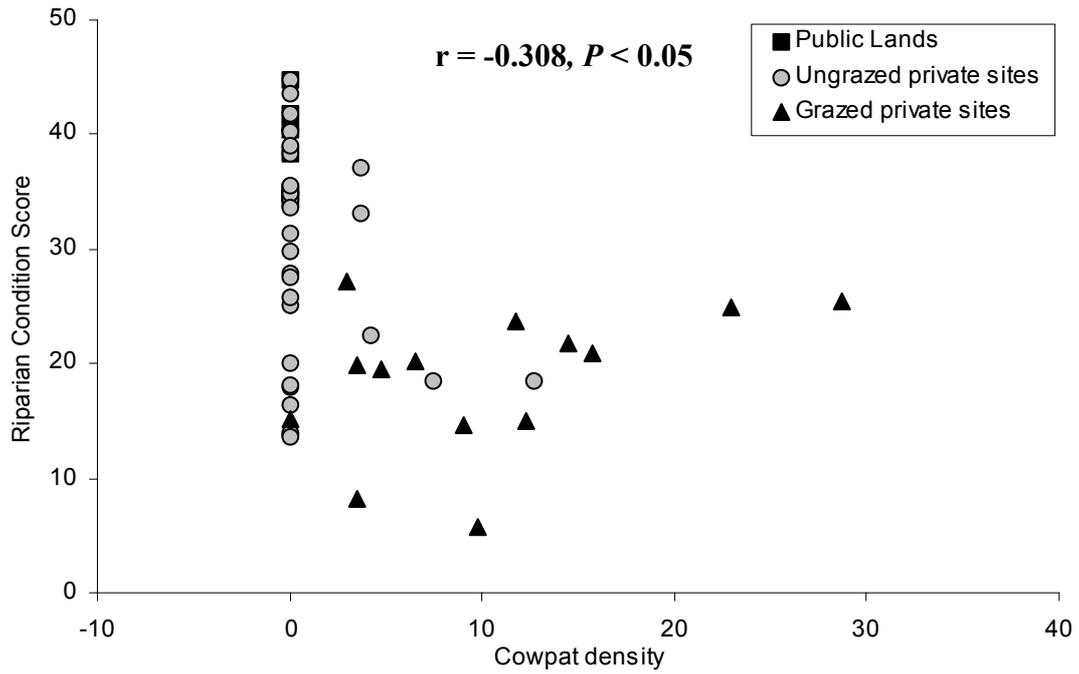


Figure 5. Riparian condition scores in relation to cowpat densities at each site ( $n=45$ ).

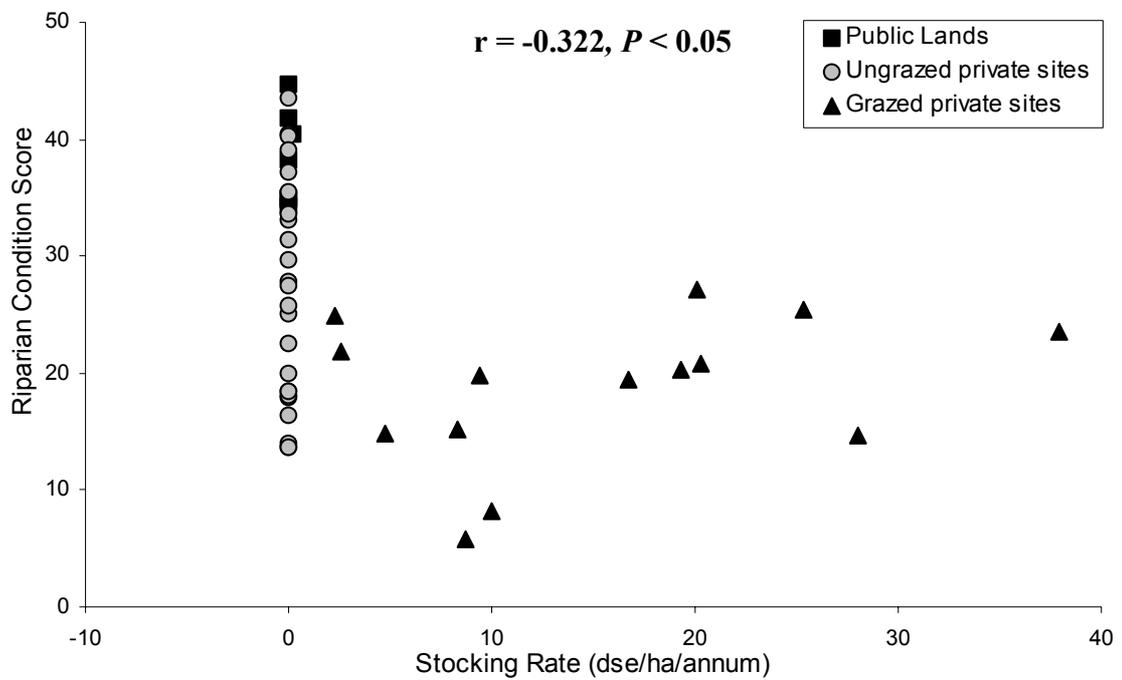
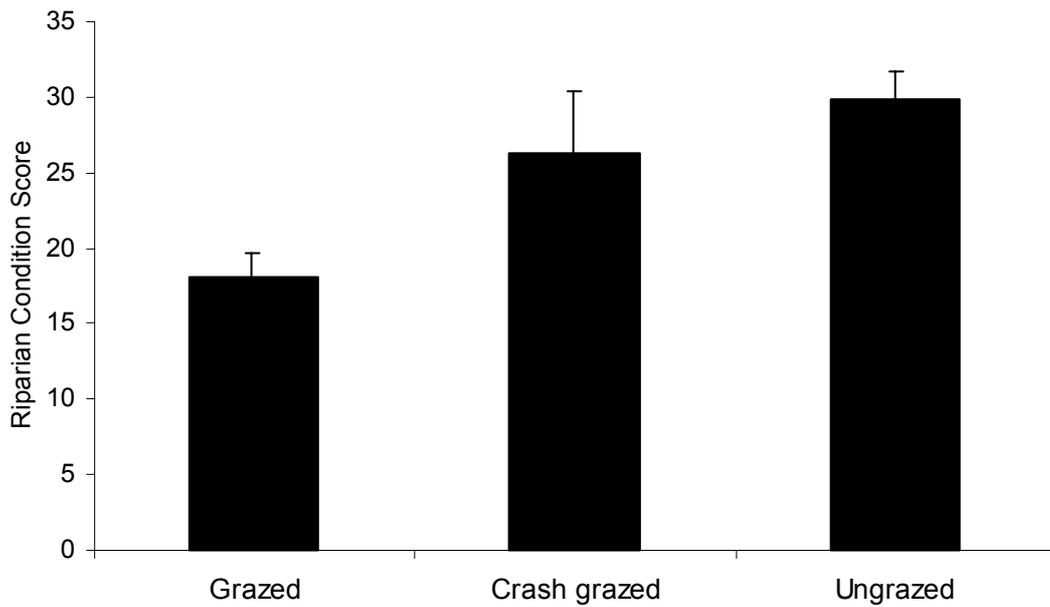
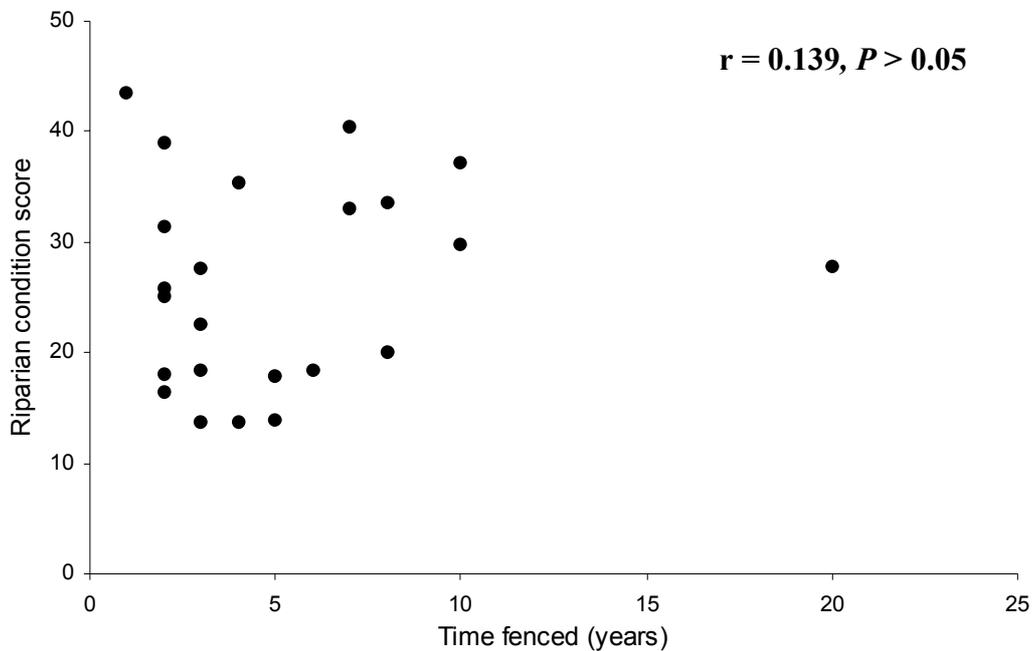


Figure 6. Riparian condition scores in relation to stocking rate at each site ( $n=45$ ).



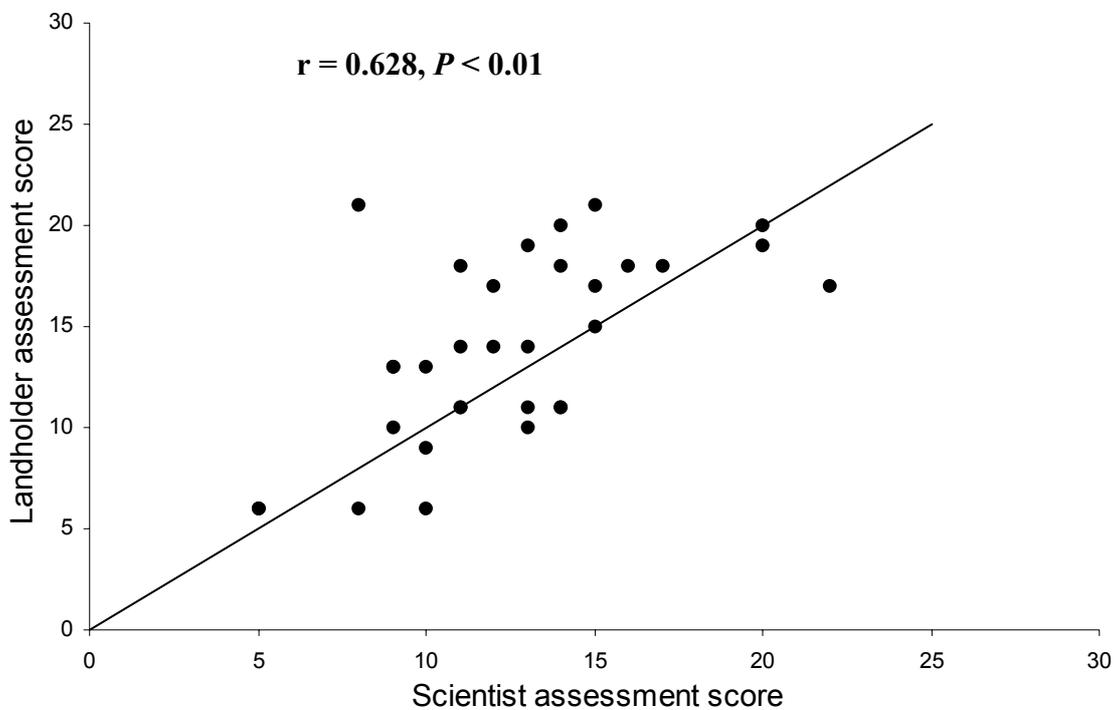
**Figure 7.** Mean riparian condition scores ( $\pm 1$  s.e.) for grazed ( $n=13$ ), ungrazed (Public Lands and private landholdings) ( $n=28$ ) and crash grazed ( $n=4$ ) sites. Only grazed and ungrazed scores are significantly different (ANOVA,  $P < 0.05$ ).



**Figure 8.** Riparian condition scores in relation to time fenced at ungrazed sites ( $n=23$ ).

#### 4.5 Landholder and scientist assessments of riparian condition

A significant, positive correlation was evident between landholder and scientist assessments of riparian condition (Figure 9). In particular, the determination of the proportions of native tree species within the canopy of riparian zones showed high levels of agreement (Table 5). However, 59% of landholders overestimated ecological condition within their riparian zones (Figure 9). The greatest disparity between scientist and landholder assessments was related to the estimation of native ground cover and tree canopy continuity within riparian zones (Table 5). Many landholders consider non-native grasses, such as phalaris, to be useful pasture species and do not view these species as weeds in riparian zones. This belief may have been the cause of overestimation of native ground cover by landholders. The lack of agreement between landholders and scientists assessment of canopy continuity is likely to be related to a lack of specificity in the self-assessment questions from the 2001 mail survey. The scientist assessments disregard tree canopy gaps below a specified cut-off point (eg. 20 metres), which landholders may have included in their assessment.



**Figure 9.** Comparison of landholder and scientist assessments of riparian condition ( $n=32$ ).

**Table 5.** Comparison of landholder and scientist scores for each component of the riparian condition assessment used in the 2001 mail survey ( $n=32$ ).

<b>Characteristic of the riparian zone surveyed</b>	<b>Number of landholders scores higher than scientist score</b>	<b>Number of scores equal</b>	<b>Number of landholders scores lower than scientist score</b>
Continuity of the tree canopy	3	7	22
Width of the tree canopy	10	16	6
Proportion of native species in the tree canopy	5	23	4
Proportion of native species in ground cover	21	7	4
Amount of leaf litter	17	14	1

## **5. DISCUSSION**

### **5.1 Ecological condition of riparian zones**

The riparian zones assessed during this study were generally in poor condition. Sixty-five per cent of sites scored in the poor or very poor category, owing to a lack of woody debris, few standing dead trees or leaf litter, fragmented overstorey tree cover and little regeneration. All sites had exotic plant species in the ground cover and where understorey was present it consisted mainly of exotic species. However, it should be noted that the GBC properties included in this research were drawn from a small subset of landholders that had indicated their willingness to participate. Therefore, the possibility should be considered that landholders volunteered for inclusion in the study due to their concerns about particularly degraded riparian zones.

While these sites functioned as livestock pasture, they were unlikely to provide the normal functioning of riparian zones (Naiman & Decamps 1997). This is because they lacked habitat for ground-dwelling and arboreal fauna, were likely to contribute less organic matter to aquatic food chains, and were unlikely to act as efficient sites for the interception of materials in overland flows. Certainly some vegetation, whether exotic or native, is considered better than none in preventing erosion, filtering nutrients and providing habitat for fauna. However, it is not known whether exotic understorey species, such as blackberry, may fulfil some of the functions of native species. Exotic trees, such as willow, drop their leaves six months later than river red gums (Schulze & Walker 1997) thus shifting the timing of organic matter input to river channels. In addition, exotic trees may not provide the same kinds of habitat for fauna as do native tree species (Ladson *et al.* 1999). Moreover, many of the poor condition sites had little or no regeneration of the dominant canopy tree, river red gum. This suggests a poor prognosis for the future of the riparian zone in these areas. Once the existing trees die, there may be very little to take their place, resulting in further fragmentation and loss of habitat.

The Public Lands included in this study generally scored in the Good or Excellent condition categories, however even these sites did not obtain a maximum score of 50. They generally had an intact overstorey tree canopy, a well developed understorey of wattle, significant coarse woody debris and litter cover, and undamaged seedlings of

the overstorey trees. However, they often had significant growth of exotic blackberry in the understorey and very low proportions of native grasses in the ground cover.

## **5.2 Influence of grazing on riparian condition**

Cowpat density and stocking rates were negatively correlated with ecological condition scores, suggesting that livestock have a significant influence on riparian condition. However, these correlations were relatively weak and highlight the potential importance of other historic events on riparian zone condition. For example, cowpat density provides only a ‘snapshot’ view reflecting current grazing pressure. The ecological condition score measured a variety of factors, some of which are the result of historical events, such as the clearing of floodplain forests and the removal of coarse woody debris. Riparian condition is thus not solely a direct result of current grazing practices, but generally responds rapidly to the exclusion of stock or rotations aimed at decreasing the impact of stock (Elmore 1992; Fleischner 1994; Robertson & Rowling 2000).

In the GBC most riparian lands are privately owned, and much of the responsibility for restoration of riparian zones rests with farmers and their management of livestock. Fortunately, some of the factors that may have a significant influence on the condition scores for riparian zones, such as stocking rates, are readily amenable to management by farmers. Other studies (eg. Jansen & Robertson 2001a) have found, and data collected in this study also suggest, that crash grazing may lead to improved riparian condition. The provision of alternative watering points in riparian paddocks would also reduce the impacts of grazing and trampling on riparian zones. This is likely to be most important during the drier summer and autumn months, when livestock have the most impact on floodplain habitats (Robertson 1997). A few farmers have already recognised the benefits to both their stock and the river banks of providing off-river water, and have done so. However, riparian condition will not approach that of undisturbed sites for some time, purely in response to alterations in livestock management. For instance, Public Land sites from which stock have been excluded, still have problems with exotic plants. Therefore, farm management at the paddock-scale aimed at improving the condition of riparian zones will also require a focus on weed removal. Many farmers already have a program of noxious weed control but this should be extended to all farms as well as to Crown Land and State Forests.

### **5.3 Landholder adoption of current recommended practices**

During this study, maintenance activities, such as weed control, were often discussed by landholders as an important but frequently ignored consideration when fencing off riparian zones on their properties. For several landholders that had already undertaken fencing or revegetation, the continued maintenance associated with these initiatives was cited as an unforeseen and discouraging aspect. In a number of cases, landholders expressed reluctance to undertake further recommended practices or encourage others to do so because of the difficulties associated with maintaining rehabilitated areas. These feelings were particularly heightened at the time of data collection, given the current drought conditions. We recommend that greater consideration be given to the maintenance of established rehabilitation areas in riparian zones to preserve the goodwill and enthusiasm of participating landholders.

Other impediments to adoption of recommended practices for riparian improvements included time, cost and the loss of resources, such as permanent water or good quality grazing area. However, these difficulties associated with improved riparian management are readily amenable to funding solutions. Indeed, a number of landholders indicated that access to funding would facilitate the adoption of current recommended practices. However, it should be noted that other impediments, such as flood damage to fences or lack of necessity for improved management, require alternative solutions. Acknowledgment of the difficulties associated with repeated flood damage to fences is essential in reformulating strategies for best management practices in riparian zones of the GBC. Additionally, the belief of some landholders that improved riparian management is not necessary may need to be addressed more widely using community education programmes.

### **5.4 Landholder and scientist assessments**

A large proportion of landholders overestimated the ecological condition of riparian zones on their properties. The greatest disparity between scientist and landholder assessments was related to the estimation of native ground cover and tree canopy continuity within riparian zones. Non-native grasses, such as phalaris, are often viewed by landholders as useful pasture species, therefore they are not considered to be weeds in riparian zones. Despite these discrepancies, landholder and scientist assessments of

ecological condition at our study sites did show a significant positive correlation. Particularly in regard to tree canopy species, landholder and scientist scores showed a high degree of agreement suggesting that many landholders are capable of assessing some components of riparian condition. This may provide an important knowledge base upon which future education programs can be built and the adoption of recommended practices can be improved.

Using data collected from the 2001 mail survey, Curtis *et al.* (2001) found no statistical evidence to support the hypothesised relationship between landholders' riparian condition assessment scores and the adoption of current recommended practices. Although these authors suggested that the use of such a self-assessment process may not have revealed real differences in riparian condition, our results show that this is unlikely. Rather, we suggest that a lack of understanding of the functional importance of riparian zone attributes, such as native ground cover or coarse woody debris, may be an underlying contributor to low adoption amongst landholders. Observations by Curtis *et al.* (2001) highlight that a substantial minority of riparian zone managers were either misinformed or reluctant to acknowledge the critical roles that clearing and grazing have had in contributing to riparian degradation. Indeed, Curtis *et al.* (2001) showed that current recommended practices, such as excluding stock from riparian zones, were significantly correlated with better functional knowledge about the impact of grazing on native vegetation and of the role of willows as a source of nutrients. These findings suggest that knowledge of riparian zone function may be a more important factor contributing to the adoption of current recommended practices than the ability to complete a purely descriptive assessment. Thus, promoting awareness of the functional importance of riparian zone attributes may play an important role in encouraging the adoption of current recommended practices.

## **5.5 Conclusions**

Findings from this study suggest the following conclusions:

1. Riparian zones in the GBC were generally in poor ecological condition, particularly in relation to the invasion of exotic plant species.
2. Broad relationships between ecological condition and grazing of domestic stock were indicated, with riparian condition scores declining significantly with both

cowpat density and stocking rate. This suggests a significant contribution of domestic livestock grazing to the degradation of riparian zones in the GBC.

3. Although some landholders will be encouraged by funding support to take up recommended management practices for riparian zone improvement, a large proportion remain unconvinced. Increased confidence in the effectiveness of these recommended practices and awareness of the need for their implementation is required.
4. Scientist and landholder assessments of riparian condition were significantly correlated. However, a large proportion of landholders substantially overestimated the ecological condition of riparian zones on their properties.
5. Increased understanding of the importance of riparian zone attributes to ecological function may be necessary to improve adoption of current recommended practices.

## 6. REFERENCES

- Boulton, A. J. (1999) An overview of river health assessment: philosophies, practice, problems and prognosis. *Freshwater Biology*, **41**, 469-479.
- Curtis, A. and De Lacy, T. (1996) Landcare in Australia: does it make a difference. *Journal of Environmental Management* **46**, 119-137.
- Curtis, A., Robertson, A., and Tennant, W. (2001) *Understanding landholder willingness and capacity to improve the management of river frontages in the Goulburn Broken Catchment*. The Johnstone Centre, Charles Sturt University, Albury.
- Denney, G.D., Ridings, H.I. & Thornberry, K.J. (1990) An analysis of the variation in wool production between commercial properties from a survey of a wheat-sheep shire in New South Wales. *Australian Journal of Experimental Agriculture*, **30**, 329-336.
- Dynesius, M. & Nilsson, C. (1994) Fragmentation and flow regulation of river systems in the northern third of the world. *Science*, **266**, 753-762.
- Elmore, W. (1992) Riparian responses to grazing practices. *Watershed Management: Balancing Sustainability and Environmental Change* (ed. R. J. Naiman), pp.442-457, Springer, New York.
- Fairweather, P. G. (1999) State of environment indicators of 'river health': exploring the metaphor. *Freshwater Biology*, **41**, 211-220.
- Fleischner, T. L. (1994) Ecological costs of livestock grazing in western North America. *Biological Conservation*, **8**, 629-644.
- Jansen, A., and Healey, M. (2003) Frog communities and wetland condition: relationships with grazing by domestic livestock along an Australian floodplain river. *Biological Conservation* **109**, 207-219.
- Jansen, A., and Robertson, A. I. (2001a) Relationships between livestock management and the ecological condition of riparian habitats along an Australian floodplain river. *Journal of Applied Ecology* **38**, 63-75.
- Jansen, A., and Robertson, A. I. (2001b) Riparian bird communities in relation to land management practices in floodplain woodlands of south-eastern Australia. *Biological Conservation* **100**, 173-185.
- Karr, J. R. (1999) Defining and measuring river health. *Freshwater Biology*, **41**, 221-234.
- Ladson, A. R., White, L. J., Doolan, J. A., Finlayson, B. L., Hart, B. T., Lake, S. & Tilleard, J. W. (1999) Development and testing of an Index of Stream Condition for waterway management in Australia. *Freshwater Biology*, **41**, 453-468.

- Naiman, R. J. & Decamps, H. (1997) The ecology of interfaces: Riparian zones. *Annual Review of Ecology and Systematics*, **28**, 621-658.
- Rapport, D. J., Gaudet, C., Karr, J. R., Baron, J. S., Bohlen, C., Jackson, W., Jones, B., Naiman, R. J., Norton, B. & Pollock, M. M. (1998) Evaluating landscape health: integrating societal goals and biophysical process. *Journal of Environmental Management*, **53**, 1-15.
- Robertson, A. I. (1997) Land-water linkages in floodplain river systems: the influence of domestic stock. *Frontiers in Ecology: Building the Links* (eds N. Klomp & I. Lunt), pp. 207-218. Elsevier Scientific, Oxford.
- Robertson, A. I. & Rowling, R. W. (2000) Effects of livestock on riparian zone vegetation in an Australian dryland river. *Regulated Rivers: Research and Management*.
- Schulze, D. J. & Walker, K. F. (1997) Riparian eucalypts and willows and their significance for aquatic invertebrates in the River Murray. *Regulated Rivers: Research and Management*, **13**, 557-577.
- Trimble, S. W. & Mendel, A. C. (1995) The cow as a geomorphic agent - A critical review. *Geomorphology*, **13**, 233-253.
- Vanclay, F. (1992) The social context of farmers' adoption of environmentally-sound farming practices. In: *Agriculture, environment and society*, (eds G. Lawrence, F. Vanclay and B. Furze) pp. 94-121. Macmillan, Melbourne.

## Appendix 1 Landholder interview

### LANDHOLDER INTERVIEW

Background information to discuss with landholders:

- What the project is about
- What is a riparian area and why is it important
- All information remains completely confidential, names are not used in reports and you will be provided with a copy of the reports
- Questions will mainly be about: property size, stocking rates, streambank management

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Owner/Manager:

Interview Date:

Property Name:

Location:

Interviewees:

Ph. Number:

Mailing Address:

Creek Name:

#### General Questions

- How big is your property?  
\_\_\_\_\_ Hectares/acres
- How long have you owned/managed this property?  
\_\_\_\_\_ Months/years
- Is this a family property (passed down through generations)?  
YES/NO
- If YES, for how long has it been in the family?  
\_\_\_\_\_ Years
- What is/are the predominant land uses on your property?
  
- If this has changed in the last 5 years, what is the farm's history (if known)?
  
- How big is the area of grazing land on your property?
  
- What types of stock and how many of each do you have on your property?
  
- If this has changed in the last 5 years, what is the farm's history (if known)?
  
- What is the length of creeks or rivers on your land?  
(a) where you own both sides \_\_\_\_\_ m/km  
(b) where you own one side \_\_\_\_\_ m/km
- Does flooding ever affect the movement/rotation of stock by loss of paddock use?  
YES/NO

- If YES, how often does this *usually* occur and for what length of time (duration)?  
\_\_\_\_\_ How often  
\_\_\_\_\_ Length of time
- If flooding occurs, how far out of the creek channel do waters usually spread?  
\_\_\_\_\_ Metres

**Streambank areas and their management**

- Draw a mudmap of the creeks on the property that would be suitable for assessment in this study (assessed during mail survey or demonstrate different management practices).

- Are these areas grazed by stock?

YES, grazed by stock:

- What is the size of the paddock?  
\_\_\_\_\_ hectares/acres
- What type of stock? Number of stock?
- What are the periods of grazing versus rest over the year?

- Are there watering points or do the stock use the creek/river for water?

NO, not grazed by stock/fenced to exclude stock:

- How large are these (length by width, one or both sides of creek)?
- Were these areas of remnant vegetation?  
Have they been planted with trees?  
Or with understorey/grasses?
- How long since this area was fenced?  
How long since this area was planted?
- What methods of weed management (if any) do you employ in these fenced areas?  
Mechanical (hand removal)   
Spot spraying   
Broad herbicide treatment   
Crash grazing   
No treatment   
Other (please specify)
- Which weeds or pest animals are of greatest concern?
- What was your primary reason for fencing off your river/creek frontage?  
Prevent stock loss   
Improve condition/health of waterway/water quality   
Prevent stock accessing neighbouring paddocks   
Prevent banks destabilizing   
Increase presence of flora and fauna species   
Better Stock Management   
Other (please specify)

### New Management Practices

- Have any of these land management practices been adopted on your farm recently to improve riparian zones? If not, are there any reasons why you might not adopt them?

Fencing remnant vegetation	<input type="checkbox"/>
Fencing rivers/creeks/drainage areas	<input type="checkbox"/>
Tree planting	<input type="checkbox"/>
Grazing techniques	<input type="checkbox"/>
Off-river watering points	<input type="checkbox"/>
Whole Farm or Natural Resource Plans	<input type="checkbox"/>
Other (please specify)	<input type="checkbox"/>

- Are there any initiatives or activities that have influenced you to consider taking up the above land management practices (eg. Landcare, demonstration farms, funding)?

- Do you think these new land management practices were cost effective:

(a) in the short term \_\_\_\_ YES/NO/NOT SURE

(b) in the long term \_\_\_\_ YES/NO/NOT SURE

## **Appendix 2 Conversion table for stocking rates**

Dry sheep equivalents (dse) for different types of stock under Australian conditions (after Denney, Ridings & Thornberry 1990).

<b>Stock</b>	<b>dse</b>
Rams	2
Wethers	1
Ewes	1.5
Weaner lambs	1.5
Bulls	14
Steers	9
Cows	8
Cows & calves	15
Weaner calves	6

### **Appendix 3 Methodology for rapid appraisal of riparian condition**

In this study, we used an abbreviated version of the Jansen and Robertson (2001) index of riparian condition. The five sub-indices included in our rapid assessment were:

- (1) Habitat continuity and extent (HABITAT),
- (2) Vegetation cover and structural complexity (COVER),
- (3) Standing and fallen debris (DEBRIS),
- (4) Dominance of natives *vs* exotics (NATIVES), and
- (5) Indicative species (SPECIES).

Each sample site was a 200 m section of the riparian zone on one side of the river or creek. A diagram was made of the vegetation along the bank recording the length and number of discontinuities in canopy cover. The bank was considered vegetated if the riparian vegetation was at least 5 m wide, and significant discontinuities were gaps of at least 20 m. At each site, four transects (30m x 5 m; perpendicular to the direction of flow) were evenly spaced lengthwise along the river or creek bank. The following parameters were measured within each of these transects:

- River width and width of the riparian vegetation (on the side of the river being assessed),
- The number of vegetation layers
- Vegetation cover within the three main layers (ground cover - grasses, herbs, reeds and sedges to 1 m tall, understorey - herbs, reeds, shrubs and saplings 1-5 m tall, and canopy - trees >5 m tall),
- Percentage of native species in each vegetation layer,
- Leaf litter cover on the ground and the percentage which were native species,
- Presence of standing dead trees,
- The abundance of coarse woody debris (>10 cm in diameter) and the percentage which was native species,
- Abundance of canopy species seedlings (<1 m tall),
- Grazing damage to canopy species seedlings,
- Reeds,
- Shrub regeneration.

The estimates for each indicator were averaged for each site, scored and weighted, then summed to give a total score for each site. Potential scores ranged from 0 (worst condition) to 50 (best condition).

Sub-indices (and their weighting in the final score) and indicators of the Index of Riparian Condition, the range within which each was scored, the method of scoring for each indicator, and the number of measurements per site for each indicator (*n*).

Sub-index (weighting)	Indicator	Range	Method of scoring	<i>n</i>
HABITAT (10/50)	Width of riparian vegetation	0-4	Standardised by channel width (CW): 0 = < 0.25 * CW, 1 = 0.25-0.49 * CW, 2 = 0.5-1.49 * CW, 3 = 1.5-2.9 * CW, 4 = ≥ 3 * CW	4
	Longitudinal continuity of riparian vegetation	0-4	0 = < 40% vegetated bank, 1 = 40-64% vegetated bank, 2 = 65-79% vegetated bank, 3 = 80-94% vegetated bank, 4 = ≥ 95% vegetated bank, with one point taken off for each significant discontinuity	1
COVER (10/50)	Canopy cover	0-3	0 = absent, 1 = 1-30%, 2 = 31-60%, 3 = >60% cover	4
	Understorey cover	0-3	0 = absent, 1 = 1-30%, 2 = 31-60%, 3 = >60% cover	4
	Ground cover	0-3	0 = absent, 1 = 1-30%, 2 = 31-60%, 3 = >60% cover	4
	Number of layers	0-4	0 = no vegetation layers to 4 = ground cover, understorey, sub-canopy and canopy layers	4
DEBRIS (10/50)	Leaf litter	0-3	0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60% cover	4
	Standing dead trees	0-1	0 = absent, 1 = present	4
	Coarse woody debris	0-3	0 = none, 1 = small quantities, 2 = abundant but some removed, 3 = abundant/no signs of removal	4
NATIVES (10/50)	Canopy	0-3	0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60% cover	4
	Understorey	0-3	0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60% cover	4
	Ground cover	0-3	0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60% cover	4
	Leaf litter	0-3	0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60% cover	4
	Coarse woody debris	0-3	0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60% cover	4
SPECIES (10/50)	Canopy regeneration	0-2	0 = none, 1 = scattered, and 2 = abundant seedlings	4
	Damage to regeneration	0-2	0 = all damaged, 1 = some damaged, 2 = no damage	4
	Understorey regeneration	0-2	0 = none, 1 = scattered, and 2 = abundant seedlings	4
	Reeds	0-1	0 = absent, 1 = present	4

### Appendix 4 Self -assessment sheet included in 2001 mail survey

By summing scores (1 to 5) for each of the eight items, below, it was possible to calculate an index score for each landholder assessment of their riparian condition. Possible scores ranged from 8 to 40. However, for this project riparian habitats were the main focus of the ecological condition assessment. Therefore, the first three questions were omitted when comparisons between landholder and scientist assessments were undertaken, resulting in possible score ranges between 5 and 25.

<b>Assessing the condition of a section of your frontage</b>					
<b>Topics</b>	<b>Description of condition (circle your choice)</b>				
<b>Score</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>
<b>Is there evidence of bank erosion?</b>	Bank is stable	Limited erosion	Moderate erosion	Large areas of erosion	Most areas unstable
<b>Is the bed filling with sand?</b>	No sand build up	Limited sand build up	Moderate sand build up	Large areas of sand build up	Sand build up most areas
<b>Are there any snags in the river/creek channel?</b>	Plenty of snags from native trees	Many snags from native trees	Moderate snags	Hardly any snags	No visible snags
<b>Are there gaps in the tree canopy (sky blocked out along the bank)?</b>	No gaps in tree canopy cover along the bank	The odd gap in tree canopy	Full canopy cover along about half the bank	Few areas have full canopy	Few trees present along the bank
<b>How wide is the area where there are no gaps in the tree canopy?</b>	Full canopy at least 40m wide along all parts	Full canopy 40m wide most parts	About half has canopy cover 40m wide	Small areas full canopy 40m wide	No areas full canopy at least 40m wide
<b>What proportion of tree cover along the bank is native?</b>	All/almost all is native	More than half is native	About half is native	Over half is introduced	All/almost all is introduced
<b>What proportion of ground cover along the bank is weeds or introduced pasture?</b>	All/almost all ground cover is native	More than half is native	About half is native	Over half is introduced	All/almost all is introduced
<b>What proportion of ground along the bank is covered by leaves and sticks?</b>	All/almost all has leaves and sticks on the ground	More than half the area	About half the area	Less than half the area	Few areas have leaves and sticks on the ground