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**ESTABLISHING THE POTENTIAL FOR OFFSET  
TRADING IN THE LOWER FITZROY RIVER  
RESEARCH REPORTS**

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**Any comments will be gratefully received and should be directed to Associate Professor John Rolfe**

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## **Executive summary**

Central Queensland University, CSIRO, the Fitzroy Basin Association and the Central Queensland Regional Organisation of Councils were collaborating partners on a research project funded through the National MBI program. Funding for the project was \$120,000, and it ran from July 2003 to June 2005.

The objective of the project was to assess the potential for offset trading and other quantity-control mechanisms to address water quality issues in the Fitzroy basin. Assessing such potential typically requires an assessment of the supply and demand functions for mitigating actions. A major objective of the project was to explore the use of a stated preference valuation technique to make an assessment of the potential for quantity-control mechanisms to operate.

The case study for the project was the Fitzroy basin in central Queensland, which is the largest basin in the Great Barrier Reef catchment area. The large quantities of sediment and nutrient export are of concern and come predominantly from diffuse sources in the grazing industry. The focus of the research was on the potential supply of mitigation actions from this group. While the project focused on the specific circumstances of the case study area, the methodology applied and most of the key findings can be transferred to any region of Australia.

The potential supply of mitigation actions by landholders is very difficult to establish ex ante. However, such information may be crucial to the design of a quantity-based mechanism that requires supply of mitigation actions. In this study, the use of a stated preference technique called “choice modelling” and an experimental economics technique termed “experimental auctions” were applied to ascertain potential supply relationships.

The methodology involved a range of research tools. A desk-top analysis was conducted to review:

- the water quality issues in the Fitzroy,
- case studies of existing quantity-control mechanisms, and
- relevant decision criteria for the implementation of quantity-control mechanisms.

A stated preference valuation exercise (choice modelling technique) was designed and applied to provide information about the supply functions for mitigation and factors that might influence supply. Because choice modelling is delivered in a questionnaire format, additional information was gathered that would assist in the design and application of an MBI.

An experimental auction, a method developed in another MBI national pilot (ID 18), was applied in a workshop environment to provide further insights into supply functions for mitigation. Both the choice modelling and the experimental auctions were conducted with local landholders who were able to provide very specific information about

mechanism design and application as they would be likely participants if such a scheme were implemented.

There are a number of key results identified from the project. These are outlined as follows:

1. There are significant opportunities for reducing water quality impacts in the Fitzroy basin, and these lie principally with diffuse sources from agriculture. Sediment and nutrient export are major issues in the region and as rangeland grazing covers 87% of the basin area, it is the land use with the largest contribution to emissions. There are notable point source emitters, such as the abattoirs and sewerage treatment plants, but emissions from these sources are limited and face existing levels of government regulation and support. Any substantial measure to improve water quality in the basin will require agriculture to be involved. One key strategy that may be undertaken by agriculture in the catchment is to improve the condition of riparian strips. Changed management may enable these to act as buffer strips, so that more nutrients and sediment are intercepted before they enter major streams.

*Key finding 1: There are opportunities to provide mitigation actions in the Fitzroy basin.*

*Key finding 2: The mitigation action with the most potential is the provision of riparian buffer strips.*

2. A set of nine decision criteria have been developed on which to evaluate the viability of implementing a quantity-control mechanism. Applying these criteria to the situation in the Fitzroy indicated that cap-and-trade mechanisms are unlikely to be effective. While there are many non-point source emitters, there are relatively few point sources. The main emitters are spread across the extensive area of the basin, making the determination and implementation of a cap problematic. Scientific information that relates farm land management changes to specific environmental outcomes is limited, and both difficult and expensive to collect. There are insufficient numbers of point source emitters in the region and while there are many diffuse sources in agriculture, the imposition of a cap is politically and practically unrealistic. There is some potential for offsets to be used, but further work is needed to determine appropriate institutional arrangements and trading ratios. Bubble schemes over small groups of point emitters also have some potential, but require further investigation.

*Key finding 3: There are nine decision criteria that can be used to evaluate the introduction of quantity-control mechanisms.*

*Key finding 4: Cap-and-trade mechanisms are unlikely to be effective in the Fitzroy basin at the current time.*

*Key finding 5: There is some potential for offset trading in the basin.*

*Key finding 6: Bubble schemes for a small number of point sources may work in some areas.*

3. A trading market will only operate if there are clear gains to be made from trade, so that traders can at least meet their transaction costs. There must be variation in the costs of provision so that gains can be made when high cost suppliers trade with low cost suppliers. To establish the potential for trade, supply functions need to be estimated and the range in the costs of provision of different suppliers identified. Choice modelling and experimental auctions are both methods that can be used to estimate supply functions, and can be applied to reveal the influence of socio-economic characteristics and attitudinal factors.

*Key finding 7: Opportunities for trade can be estimated from supply functions.*

*Key finding 8: Choice modelling and experimental auctions can be used to assess supply functions, while accounting for landholder heterogeneity and a range of influencing factors.*

4. Choice modelling has generally been used to determine public preferences for environmental goods, but in this project the method was designed for a more specific purpose. A pilot survey highlighted some limitations in the method not previously encountered. The target population was restricted and hard to identify, and the complexity of information in the survey made it difficult for respondents to identify preferred supply options. A second survey that presented tradeoffs in a different format and was delivered in an interactive workshop, proved successful. Information was collected about the supply functions for the provision of buffer width and minimum levels of grass biomass in riparian areas of the Fitzroy.

*Key finding 9: Choice modelling has limitations where the respondents find complex choice sets difficult to comprehend and analyse.*

*Key finding 10: Choice modelling limitations can be overcome with careful design and delivery in a workshop environment.*

*Key finding 11: Choice modelling can provide details about supply functions for specific components of riparian management.*

5. Choice modelling is applied in a questionnaire format which means that apart from the “choice sets” section, further information about a range of issues within the policy context of the survey can be gathered. The surveys revealed important information that would assist in the design and implementation of an incentive mechanism. For example, attitudes to institutional and contractual arrangements may significantly influence the participation rates in a scheme and will need to be identified and avoided if a scheme is to have a chance of success. Survey responses highlighted the preference of landholders for relatively short term contracts (at least until such schemes become more familiar and better understood) rather than covenants. There was also a clear indication that participants would prefer to enter into contractual arrangements with their local NRM group, and given the current hostility to recent tree-clearing legislation, there was little

interest in dealing with the State Government. Other questions in the survey revealed significant variation in the capital costs of fencing and water points, associated with improved riparian management.

*Key finding 12: Information collected with surveys can provide details useful for mechanism design and application.*

*Key finding 13: Direct questions revealed substantial variation in capital costs associated with the supply of riparian mitigation actions.*

6. Experimental auction “games” were used to gather further information about supply functions. While the choice modelling exercise provided an overall value for buffer width and minimum grass biomass, the method does not reveal information about individual cost details which can be gathered in an experimental auction. Participants, were provided with dummy properties and asked to make bids (small prizes were awarded to provide a competitive incentive) based on their costs of meeting the prescribed riparian management standards. Large variations in both capital and variable costs were revealed.

*Key finding 14: Experimental auctions are appropriate for revealing finer level details about the opportunity costs facing landholders, while choice modelling provides a more general analysis of the tradeoffs. The roles of the two assessment techniques are complementary rather than competing.*

*Key finding 15: Experimental auctions reveal variation in both variable and capital costs.*

*Key finding 16: Experimental auctions reveal variation in the proportion of fixed costs as a percentage of total costs.*

7. The choice modelling survey and experimental auction were delivered in a complementary workshop format. This mixed method, interactive delivery format has great potential and improved the effectiveness of the task of both providing and gathering information. Integrating the different sections of a choice modelling survey with other tasks also worked well. The workshop participants obviously gave careful consideration to the information they provided (not necessarily the case in a field survey) and high quality data was collected.

8. The outcomes of the project provide information that can be applied in all regions in Australia. The proposed decision criteria to determine the suitability of quantity based mechanisms are generic and are not specific to the Fitzroy region. The use of choice modelling and experimental auctions to determine supply functions can also be applied in other situations.

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## **Introduction**

This report is the final report from a research project funded under the National Market Based Instruments program. The report includes a number of summary findings about the potential for quantity control MBIs to address water quality issues in the lower Fitzroy river basin. The research tools applied to design and develop an MBI are outlined and discussed. The findings from this project should be more widely applicable in other regions of Australia where the process of assessing the suitability of particular MBI mechanisms is important. The focus of this report is to outline a number of the issues that have been considered, and to give a summary of the key findings. Further details on the project are available in the earlier reports that have been produced.

## **Research Partners**

The research was carried out by four research partners:

- Central Queensland University,
- CSIRO,
- The Fitzroy Basin Association, and
- Central Queensland Regional Organisation of Councils.

## **Project funding and timelines**

Funding allocated by the National MBI program was \$120,000. The project ran from July 2003 to June 2005.

## **Project outputs**

The project results have been summarized in a series of reports, as follows:

Rolfe, J., Alam, K. and Windle, J. 2004 *Overview of the Fitzroy Basin and Opportunities for Offset Trading*, Establishing The Potential For Offset Trading In The Lower Fitzroy River Research Report No 1, Central Queensland University.

Rolfe, J., Alam, K. and Windle, J. 2004 *The Importance of Riparian Vegetation in Improving Water Quality*, Establishing The Potential For Offset Trading In The Lower Fitzroy River Research Report No 2, Central Queensland University.

Rolfe, J., Alam, K., Windle, J. and Whitten, S. 2004 *Designing the Choice Modelling Survey Instrument for Establishing Riparian Buffers in the Fitzroy Basin*, Establishing The Potential For Offset Trading In The Lower Fitzroy River Research Report No 3, Central Queensland University.

O’Dea, G. and Rolfe, J. 2005 *How Viable are Cap-and-Trade Mechanisms in Addressing Water Quality Issues in the Lower Fitzroy*, Establishing The Potential For Offset Trading In The Lower Fitzroy River Research Report No 4, Central Queensland University.

Windle, J., Rolfe, J., Whitten, S. and Alam, K. 2005 *Using Choice Modelling to Establish the Supply of Riparian Services*, Establishing The Potential For Offset Trading In The Lower Fitzroy River Research Report No 5, Central Queensland University.

A further report is still being prepared:

Rolfe, J., Windle, J., Whitten, S. and Reeson, A. 2005 *Evaluating the Combined Use of Choice Modelling and Experimental Workshops to Predict the Supply of Agricultural Mitigation Services*, Establishing The Potential For Offset Trading In The Lower Fitzroy River Research Report No 7, Central Queensland University.

In addition, the following conference papers prepared from the research material have been presented:

O’Dea, G. and Rolfe, J. 2005 “How viable are cap-and-trade mechanisms in addressing water quality issues in the Lower Fitzroy”, paper presented at the 49th Annual Conference of the Australian Agricultural and Resource Economics Society, 9th – 11th February 2005, Coffs Harbour, NSW.

Windle, J., Rolfe, J., Whitten, S. Alam, K. and Street, D. 2005 “Using choice modelling to establish the supply of riparian services and the potential for a water quality trading scheme in Central Queensland”, paper presented at the 49th Annual Conference of the Australian Agricultural and Resource Economics Society, 9th – 11th February 2005, Coffs Harbour, NSW.

Additional conference papers and journal articles will be published from the project results over time.

## **Background to the issue being considered**

The Fitzroy basin drains an area of approximately 142,645 km<sup>2</sup> (approximately 10 percent of Queensland's land area) into the Great Barrier Reef (GBR) lagoon and is the largest of the river basins in the GBR catchment. Because of its size and bio-physical conditions, there are high levels of sediment and nutrient export; the majority of which comes from diffuse sources. Concerns about the potential impact of reduced water quality on the health of the GBR and coastal areas (see, for instance, Furnas 2003; Productivity Commission 2003; Science Panel 2003; SQCA 2003) have led to the joint release of the *Reef Water Quality Protection Plan* by the Queensland and Australian Governments.

In terms of area, rangeland grazing is the principal land use and covers 87.5% of the basin area (Jones *et al.* 2000) and 94% of the area used for agriculture (Furnas 2003). As it occupies such a large area in the basin, it is the land use which has the most impact on water quality, and offers the most opportunity for providing mitigating actions. Other impacts on water quality come from point sources such as the mining industry, other agricultural uses, three abattoirs, a power station, and urban impacts such as storm-water run off, and sewerage treatment plants. While there are regulatory controls over the emissions from the point sources, emissions of sediment and nutrients from non-point sources tend to be exempt from any form of control because of measuring and monitoring difficulties and political sensitivities.

There are a range of market-like policy instruments that can be designed to improve environmental management (Sterner 2003). In the United States there has been some experimentation with the involvement of agriculture in water quality trading schemes. Breetz *et al.* (2005) notes how there have been nearly three dozen water quality trading systems over the past twenty years that have involved point source and non-point source emissions, and that twelve of these have included emissions from agriculture. A further 15 programs involving agricultural emissions have been proposed (Breetz *et al.* 2005), indicating the level of interest in applying market-like mechanisms to diffuse emission issues. While involvement by farmers in these trading systems is much lower than policy makers had expected (Randall 2004, Breetz *et al.* (2005), the development of these schemes identifies potential applications for similar mechanisms to applied in Australia.

There is potential for quantity-control water trading mechanisms to be used to improve water quality outcomes in the Fitzroy basin. Possible mechanisms include cap-and-trade, offsets and bubble schemes, and basically involve enterprises trading with each other to meet some externally-imposed cap. Governments can design and establish a market in water quality services by imposing constraints on the export of sediments and nutrients and providing a mechanism where producers trade those constraints between each other to find more efficient allocations that allow the constraints to be met. The small number of point source emitters, the size of contribution of the agricultural sector and the potentially low costs of mitigation from agriculture means that any trading mechanism should include landholders in the Fitzroy basin. As the nature of water quality issues in the Fitzroy are not very dissimilar to those in other catchments draining into the GBR, the design of a market trading mechanism may be more widely applicable.

A key issue for government is how to design a market trading mechanism in the absence of existing markets or information about how potential participants might trade water quality constraints between themselves. The types of information that is often required is detail about the following broad areas:

- (a) the appropriate cap to be placed on the relevant activity,
- (b) the variation in opportunity costs of meeting the cap requirements,
- (c) the type of market trading mechanism that can be implemented,
- (d) the number of potential participants in a market, and

(e) the transaction costs involved in operating the market.

Lack of information about how a prospective market might work is a major barrier to implementation of a trading mechanism. It is often necessary to describe or demonstrate to government planners, advisors and potential participants that significant variation in opportunity costs exist, and that participants will trade in the designated credits if a market is established. In some cases it is appropriate to model the potential operation of a trading market by identifying appropriate supply and demand functions. Market equilibrium is typically predicted to occur where demand and supply schedules intersect.

The estimation of separate supply and demand functions is particularly relevant in cases where trade between very different groups of credit holders is being designed. In cases where trade will only occur between similar types of suppliers, the estimation of a single supply function may be enough to allow predictions about market operations to be made. This is because a supply function can demonstrate potential variations in opportunity costs of the supply of mitigation services, and hence, allow predictions to be made about the likelihood of trade occurring. Identification of the variation in supply costs, both within and between enterprises, will allow some assessment to be made of the potential efficiency gains available from the use of market based instruments.

Supply information can also be used to make predictions about likely market behaviour in different scenarios. The information about potential supply is relevant to different market based options (e.g. competitive tenders, offsets and cap-and-trade), and can be applied more broadly in the selection of an appropriate market based instrument. This means the results of the project may be more generally applicable to other market based instruments in other catchments with water quality issues.

To address information gaps in the design stages of a market based instrument, two key types of information are required. The first is information about the types of market characteristics that are required before a successful trading market can be established. The second is predictions of potential supply and demand functions ahead of market establishment so that likely take-up rates and trading behaviour can be assessed in the design stages. The focus of this project is to demonstrate how information on both of these stages can be assessed.

## **Objectives of the project**

The project was designed to assess the potential to introduce quantity-control measures to improve water quality in the Fitzroy basin, a large catchment that drains into the Great Barrier Reef lagoon. The specific aims of the project were to:

- identify opportunities for a cap-and-trade mechanism to address water quality in Fitzroy basin,
- identify opportunities for other quantity-control measures, and
- develop the use of a stated preference technique to predict market operations.

## **Key research questions**

The key research question was to identify the potential opportunities for quantity-control MBI mechanism to be introduced in the Fitzroy basin to provide better water quality outcomes. In examining these opportunities, further research questions addressed related to the:

- identification of decision criteria on which to assess the potential of the MBI,
- assessment of local conditions in the Fitzroy relevant to these criteria,
- identification and assessment of supply functions for water quality mitigating actions,
- design and application of choice modelling to provide information to assist in mechanism design, and
- design and application of experimental auctions to gather information about mechanism design.

## **Methodology**

A range of research tools were utilised to address the different components in the project. A desk-top study was conducted to review water quality issues in the Fitzroy. This review (Rolfe *et al.* 2004a) included identification of types of emissions involved (mostly sediments and nutrients), the geographic sources (widespread across the basin), and the sectors that were contributing to emissions. The potential for each sector to reduce their emissions was also examined. In addition, the issue of mitigating activities was explored to determine if suitable actions could then be identified that could be applied in a trading scheme (Rolfe *et al.* 2004b).

The key aims of the project were conducted in two separate stages.

The first stage involved a desk-top study conducted to review and analyse the quantity-control mechanisms that could be applied to achieve water quality outcomes (O’Dea and Rolfe 2005). Three mechanisms were examined:

- Cap-and-trade programs,
- Offset programs, and
- Bubble schemes.

The review involved the identification of the necessary conditions that were required before each of these mechanisms could be introduced. The characteristics of the Fitzroy catchment were then tested against those baseline conditions to identify whether it was appropriate for some form of quantity-control mechanism to be introduced.

The second stage involved testing different analytical tools to ascertain potential supply (or demand) relationships. The use of two different tools, choice modeling and experimental auctions, were tested with landholder groups to identify the potential supply of water quality mitigation services.

Choice modelling is a stated preference valuation technique which has often been employed to estimate values for environmental tradeoffs (Bennett and Blamey 2001). The technique is adaptable for different purposes, and there is an emerging literature on the use of these conjoint-based mechanisms to analyse the potential supply of agricultural products or services (Lusk and Hudson 2004). In this project, the latter approach was followed, where choice modelling was employed to predict the tradeoffs that a landholder might consider when assessing the potential to supply mitigation actions (Rolfe *et al.* 2004c).

There were two main reasons why it was appropriate to use a stated preference approach. The first was that because mitigation actions were not currently supplied in a market setting, some mechanism or tool to predict supply *ex ante* was needed. Choice modelling has strengths due to its flexibility in presenting landholders with tailored alternatives (Lusk and Hudson 2004). A key alternative was to use farm production models and to then simulate the opportunity costs (in terms of lost production and capital costs) involved in supplying mitigation services. However, farm production models tend to ‘average’ costs across a number of participating enterprises, and are unlikely to incorporate the social issues and barriers to adoption that tend to accompany landholder involvement in water quality trading schemes (Breetz *et al.* 2005).

The second reason for nominating choice modelling is that this had more potential to identify differences in payment levels between individuals, due to variations in production systems, variations in individual characteristics or changes in the institutional setting. Allowing potential participants to ‘state’ the tradeoffs that they would consider had potential to be more accurate than a reliance on farm production models. As a choice modelling application allows landholders to ‘state’ their preferences directly, the resulting predictions of market share or values incorporate all factors relevant to landholder preferences, including production tradeoffs and social factors.

Two choice modelling exercises were conducted. After an initial pilot highlighted some difficulties (Windle *et al.* 2005), a second exercise was developed and delivered in a workshop environment. The aim of the choice modelling exercises was to collect information about:

- supply functions for mitigating actions, and different components or attributes of these actions,
- landholder characteristics and attitudes that might affect supply,
- the tradeoffs landholders make between these different components, and
- information to assist in the broad design of an MBI, e.g. attitudes to different institutional arrangements.

An experimental auction approach to the prediction of supply functions was also trialed in the workshops where the choice modelling surveys were collected. Experimental auctions involve a call for ‘dummy’ bids in a workshop setting for mitigation actions, similar to the operation of conservation tender schemes. The auctions are essentially a hybrid between an experimental economics approach and field trials, as they involve landholders engaged in limited number of hypothetical bidding rounds.

In this project, the experimental auctions were conducted with local landholders who were provided with dummy properties and were asked to indicate on a property map a riparian area that they were prepared to manage in a prescribed manner. They were also asked to enter a bid that reflected the cost to them of altering their management regime and providing the required conservation services. This process was aimed at collecting information that provided more specific insights into the design and operation of a particular MBI mechanism.

The workshops where a choice modelling valuation exercise was conducted in combination with an experimental auction, was a new methodological application, and the outcomes provided some useful insights into the benefits of such an approach.

Five main steps were followed in the process of information collection to allow the potential for offset trading to be evaluated:

1. Identify suitable industries / options for offsets,
2. Identify potential gains from trade,
3. Identify most efficient rules for offsets / standard of provision,
4. Identify other mechanism and contract design issues, and
5. Identify political economy issues.

## **Key results of the project**

### **1. The potential for mitigation actions in the Fitzroy**

For any type of trading scheme to take place there needs to be an identifiable good that can be traded, i.e. mitigation actions that will provide clear environmental outcomes. The definition of the good depends on the type of mechanism considered. Cap-and-trade schemes typically involve trade in permits for the release of the pollutant, i.e. permits for sediment or nutrient exports into a river system. Offset schemes tend to be more flexible, and may involve the purchase of mitigation actions which can account for negative impacts elsewhere. Mitigation activities tend to be simpler to identify and monitor than the movement of sediments and nutrients into a watercourse, and hence have major practical advantages. Constraints in measurement and monitoring, particularly for exports from diffuse sources, mean that it is often more practical to focus on the supply of mitigation actions than the supply of sediments and nutrients.

There are significant opportunities for reducing water quality impacts in the Fitzroy basin. There are a number of sectors that contribute to water quality impacts, including urban, transport, industrial, mining and agricultural sectors. Many point source emitters already face some level of regulation, while many diffuse source emitters do not. Opportunities to reduce emissions lie principally with diffuse sources from agriculture because of the extent of emissions from this sector (Rolfe *et al.* 2004a).

The overall impact of grazing and poor ground cover results in 63% of the sediment load in the Fitzroy River coming from hill slope erosion, 25% from gully erosion, and only 13% from stream bank erosion (NLWA 2003). This means that there are two main options for mitigating the impacts of the high levels of sediment and nutrient export:

- improving ground cover, and
- establishing riparian buffer strips.

Improving ground cover will be of benefit throughout the basin, particularly as hill slope erosion is the major contributor to sediment loads. However, establishing riparian buffer strips will intercept sediment transported from other areas and prevent it from reaching the river, as well as reducing the impact of stream bank erosion.

Riparian management has some advantages over ground cover as a focus for mitigating actions. Riparian areas:

- are clearly identifiable,
- can be readily monitored,
- have well recognized environmental impacts, and
- have recommended targets in GBR plans.

With ground cover, it is more difficult to set a standard that would define the mitigating actions as both the natural density of grass and the environmental benefit of improvements vary with grass types and broader regional ecosystem types. The specific environmental benefits (water quality improvements) of better ground cover in areas some distance from a river or creek are not well known. Monitoring ground cover in remote areas is also more difficult.

***Key finding 1: There are opportunities to provide mitigation actions in the Fitzroy basin.***

***Key finding 2: The mitigation action with the most potential is the provision of riparian buffer strips.***

## 2. Application of quantity based mechanism for water quality

MBIs can be categorised into two main groups; price based instruments and quantity based instruments. Price based instruments tend to be simpler to apply than quantity based instruments, but outcomes are often more uncertain. The outcomes of quantity based mechanisms are usually more certain (because a cap on emissions or other outcomes is fixed), but they tend to involve higher transaction costs. A major advantage of quantity based mechanisms is that they can be designed to suit the particular case study of interest. By contrast, price based mechanisms tend to be more uniformly applied, making it difficult to vary them between different case study situations. The focus in this project was on the potential application of quantity based mechanisms. A desk-top analysis was conducted to identify the key criteria that might identify the appropriateness of application in the Fitzroy.

### 2.1 Decision criteria for quantity control mechanisms

Key criteria for the introduction of emissions trading schemes in the United States can be used as a standard. These are reviewed and discussed in O'Dea and Rolfe (2005). The United States Environmental Protection Agency<sup>1</sup> list the existence of the following factors as requirements for an effective water quality trading program:

1. **There is an identifiable catchment.** This establishes the geographic scope of market.
2. **There are significant and sufficient point sources.** This is necessary to avoid thin markets and failure problems
3. **Total Maximum Load Allowances (TMLAs) have been established.** A cap needs to be set on a scientific basis.
4. **There are accurate and sufficient data.** This ensures that emissions can be measured to establish a basis for trading.
5. **The concentration-based discharge limitations must be met.** This avoids 'hotspots' developing in particular areas.
6. **There is a large difference in treatment costs across dischargers.** This ensures there is enough variation in opportunity costs to make trading attractive.
7. **The Total Discharge Permit (TDP) system must be accepted by the community and regulatory agency.** This ensures political economy support for trading system.
8. **An adequate institutional structure must be in place.** This ensures that the institutions needed for setting a cap and establishing a trading system exist.
9. **There must be adequate compliance incentives and enforcement mechanisms.** This ensures participants do not face perverse incentives to subvert the trading system.

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<sup>1</sup> See <http://www.epa.gov/owow/watershed/framwork.html> (accessed October 2004).

While the decision criteria are likely to apply to all quantity-control mechanisms to some extent, there will be some variation in their importance between the different mechanisms. For example, while the number of market participants (Criteria 3) is very important in the success of a cap-and-trade program, bubble programs can be run with a very small number of participants, while offset programs may be characterized by only a small number of sellers or buyers. Acceptance of the TDP system (Criteria 7) is particularly important for a cap-and-trade mechanism where it is often politically difficult to impose a cap, but may be a much smaller issue for other mechanisms.

## 2.2 Potential for quantity-control mechanisms in the Fitzroy

Three types of quantity control mechanisms were examined in this project; cap-and-trade, offsets and bubble schemes, and examples of how these might apply in the Fitzroy are outlined in Table 1.

**Table 1. Examples of quantity-control mechanisms for the Fitzroy basin**

<b>Mechanism</b>	<b>Emission type involved</b>	<b>Example</b>
<b>Cap-and-trade</b>	Between point sources only	Particular point source emitters such as sewerage treatment plants might trade credits with industrial emitters.
	Between diffuse sources only	A cap might be placed on landholder use of natural resources, permits allocated and trade allowed. Examples might include: <ul style="list-style-type: none"> <li>• % of riparian area that has to be fenced off</li> <li>• % of farm land to be covered by BMP</li> <li>• % of ground cover on farm</li> <li>• Kgs/ha of fertiliser use on farming areas</li> </ul>
	Between both point and diffuse sources	Diffuse sources (e.g. landholders) may be able to provide credits for inclusion in trading system involving point sources.
<b>Offsets</b>	Between point sources only	Particular point source emitters such as sewerage treatment plants might negotiate offsets from other individual emitters – may be particularly applicable in the case of new developments.
	Between diffuse sources only	Proponents of developments that have additional water quality impacts may be required to source offsets – e.g. an area of new farming land may have to offset with a grass filter strip.
	Between both point and diffuse sources	Particular point source emitters such as sewerage treatment plants might negotiate offsets from landholders who might provide grass filter strips/riparian buffers or other mitigation activities.
<b>Bubble scheme</b>	Between point sources only	A limited group of point source emitters might be covered in a bubble program and have to negotiate how they will jointly meet a target.

Three main factors appear to indicate the use of a cap-and-trade scheme in the Fitzroy may be currently unviable:

- There are not enough point sources for trade,
- There are measurement and monitoring difficulties, and
- There is likely to be limited political will to impose a cap.

The use of a cap-and-trade scheme for point sources is currently unviable because there are a limited number of existing point sources (and measurable emissions), and a reduction in point source emissions alone is not going to result in a significant water quality improvements. Furthermore, it is expected that the State Government will share the cost of sewerage treatment plant upgrades with Local Government Authorities under the Local Governing Bodies' Capital Works Subsidy Scheme. This means that another policy instrument is already being used to achieve improvements.

A cap-and-trade mechanism for diffuse sources only may also be unsuitable. While there are a large number of potential participants prepared to supply mitigation actions, any attempts to impose a cap and create demand would be at odds with current perceptions of property rights. There would be considerable resistance to the imposition of a cap. As well, measurement and monitoring difficulties would make the operation of a scheme difficult, and there may not be enough variation in opportunity costs to generate large trading gains.

A cap-and-trade mechanism that involved both point and diffuse sources has more promise because of the potentially large number of diffuse sources that might be willing to supply mitigation actions, and the potential variation in opportunity costs of mitigation actions between the different sectors. In the case of the Fitzroy though, the limited numbers of point source emitters also restricts the opportunities for this type of cap-and-trade mechanism to operate.

There are more opportunities for offset programs to be trialed. Opportunities for offsets between point source polluters are again limited by the small number of potential participants available. However, if there are major new industrial or intensive agriculture developments in the region, there may be more opportunity to use offsets as a way of reallocating available point source discharges.

Offsets between diffuse sources may also be unrealistic because of current institutional structures (perceptions of property rights), as well as monitoring and enforcement issues. However there may be some potential for offsets to be used in particular circumstances, particularly where new developments are occurring. For example the development of new farming areas that may increase sediment runoff could be offset with requirements to establish grass filters or riparian buffer strips. These might occur within a property (falling under a property planning process) or between properties (where offsets might need to be traded).

There is greater potential for offsets between point and diffuse sources to be designed. These would involve industry/urban sources purchasing offsets from agricultural and other diffuse sources. Point sources such as sewerage treatment plants might purchase

offsets and generate substantial savings in mitigation costs without incurring the transaction costs of a cap-and-trade mechanism. An example from the US indicates that it may be possible to introduce offset programs even in cases where only a small number of point source emitters exist (O’Dea and Rolfe 2005).

The main opportunity in offset trading would be to take advantage of the low costs of mitigation from agriculture, and including agriculture will have a more direct impact on water quality in the basin.

There may also be some opportunities to introduce bubble programs over point sources in the Fitzroy. Potential sources to include are Fitzroy Water’s sewerage treatment plants, the two key abattoirs in Rockhampton, and any new industrial developments at the Stanwell Power Station. Trading would allow point sources the freedom to determine where and how reductions are made while still meeting the cap requirement. The advantage of the bubble program is that it may allow cost effective reductions to be made between a very small group of participants without high transaction costs being incurred. However, the government’s policy of subsidizing upgrades of the sewerage treatment plants makes the implement of a bubble scheme unlikely in the short term.

A key issue in the Fitzroy that influences the potential for trading mechanisms is the small number of point source emitters, although emissions from a very limited number of point sources are significant. Agricultural practices are largely responsible for non-point source emissions and increasing sediment and nutrient loads in the Fitzroy. Any serious attempt to improve water quality will require that emissions from agriculture be addressed. However, emissions from agriculture tend to be highly variable, difficult to predict, and are often not closely related to changes in management practices.

***Key finding 3: There are nine decision criteria that can be used to evaluate the introduction of quantity-control mechanisms.***

***Key finding 4: Cap-and-trade mechanisms are unlikely to be effective in the Fitzroy basin at the current time.***

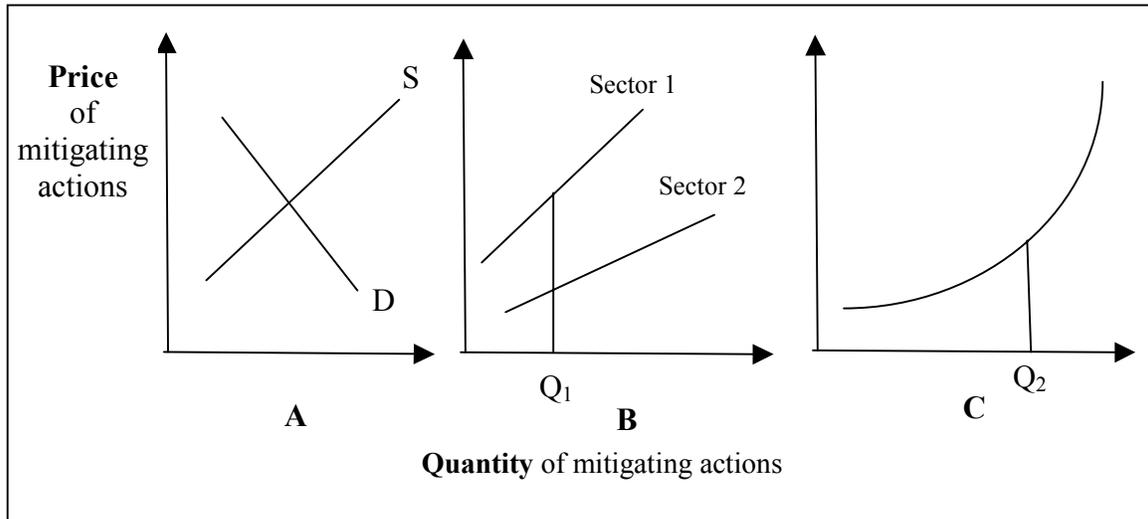
***Key finding 5: There is some potential for offset trading in the basin.***

***Key finding 6: Bubble schemes for a small number of point sources may work in some areas.***

### **3. Estimating supply functions for trade**

Opportunities for trade can be normally shown by the interaction of the demand and supply functions (Figure 1-A). However, when a cap on a particular activity is being imposed, some understanding of potential trading opportunities can come from an analysis of supply functions only. If there are a number of suppliers and there is sufficient variation in individual supply functions, i.e. there is variation in their costs of supplying the good, then there is potential for trade to occur.

**Figure 1. Supply functions for mitigating actions**



There are two potential trading scenarios to consider. Trade can occur between two sectors (Figure 1-B) or it can occur within the same sector (Figure 1-C). There is potential for inter sector trade if different sectors have different costs of supplying mitigating actions, and so there are potential gains to be made from trade. This is illustrated in Figure 1-B where the cost of supplying a quantity ( $Q_1$ ) of mitigation is much higher for Sector 1 than Sector 2.

In the Fitzroy, there are number of industries and land uses that have an adverse impact on water quality (outlined in Rolfe *et al.* 2004a), and each has quite different supply functions. The most notable difference is between the mining and grazing sectors. However, the political and regulatory context within which these sectors operate must be also considered as it influences their supply functions, i.e. their need to, and cost of, supplying mitigation.

Different industries have different restrictions and standards governing their emissions and hence their need to provide mitigating actions. Agriculture generally has no restrictions, although feedlots have a zero allowance. There are no formal restrictions on run off from urban areas, but the mining sector has a zero allowance. In addition, the government is prepared to assist some sectors to reduce their emissions, and hence reduce the costs of supplying mitigating actions. For example, the government is subsidising the upgrade of sewerage treatment facilities in Rockhampton.

There is potential for intra sector trade when there are variations in the costs of providing mitigating actions within a sector and so gains from trade can occur. This can be illustrated in Figure 1-C where the curve represents the costs of different suppliers. If a quantity ( $Q_2$ ) of mitigation is required, some suppliers are able to provide this at a lower cost than others. It would be in the interests of the high cost providers to trade with low cost providers.

### **3.1 Assessing potential supply useful for range of MBIs**

A key focus of the project was to assess the potential supply function of agricultural mitigation actions in terms of riparian buffer strips. This supply schedule will be relevant to a range of MBIs including the quantity based mechanisms of focus in this project, as well as other price based mechanisms such as competitive tenders or auctions for ecosystem services.

Having explored the potential of the various trading schemes in a desk-top study, a case study approach was applied to assess the supply of agricultural mitigation in terms of the provision of riparian buffer strips. The assessment process needed to account for the following factors that could affect the supply functions:

- A range of management actions, such as the size of a buffer strip, and the type and period of stock exclusion,
- Variations in biophysical attributes and ecological impacts such as stream order, soil type and existing vegetation cover,
- Variations in landholder characteristics, experience and attitudes, and
- Contract design options.

There are different ways that a supply schedule might be assessed. Farm production models could be applied to provide an estimate of the costs involved. However, such models would not be able to provide the range and complexity of information required. In particular, these models are limited in their ability to account for landholder heterogeneity, or sociological impacts such as attitudes to institutional factors. Choice modelling and experimental auctions are both methods can provide the level of detail required and the combination of the two methods in a workshop environment, proved particularly successful.

***Key finding 7: Opportunities for trade can be estimated for some situations from supply functions.***

***Key finding 8: Choice modelling and experimental auctions can be used to assess supply functions, while accounting for landholder heterogeneity and a range of influencing factors.***

#### **4. The design and application of choice modelling**

Choice modelling (CM), a stated preference valuation technique, is delivered in a questionnaire survey. This means that two types of information can be collected. First, information is collected in the “choice sets” where respondents state their preferences between different management options that are described with a standard set of attributes. Second, additional information is collected in specific questions that cover a range of issues, and if appropriate, correlated with the information provided in the choice sets.

In this project, the information collected in the choice sets was used to estimate the supply functions for key management actions (width of buffer strip and minimum ground cover levels) in the provision of riparian buffer strips. Other questions in the survey allowed a range of information to be collected that would assist in the design and application of an MBI mechanism. In terms of design, information was gathered which was needed to make initial choices about an MBI such as likely participation rates, the incentives payments required and the overall budget needed. In terms of mechanism application, information was collected that was needed to design a specific application such as the key factors that impact on participation and bid prices.

Two approaches to choice modelling were tested:

- A comprehensive CM survey delivered to landholders in the field, and
- A simplified general survey, delivered in workshops with landholders.

##### **4.1 Comprehensive CM survey**

This survey was developed to fulfil both mechanism design and application roles. It was designed to be delivered to graziers, in the field. Landholders were asked to complete a series of six choice sets. Baseline management conditions were fixed and these specified minimum ground cover, buffer width and conditions for stock exclusion. Each choice set was described in terms of four attributes: payment, river length, contract length, and contracting body. There were four options (a status quo and three other choices) in each choice set. At the end of each choice set, additional information was requested about necessary capital costs for the selected option. An example choice set is presented in Figure 2.

The pilot survey had a low response rate, indicating that this version of the survey proved too complex to operate. There were five main lessons to be learnt from the pilot, discussed in detail in Windle *et al.* (2005), which were considered in the development of a second amended CM questionnaire.

- The population for sampling was too limited,
- Some information being collected was too complex,
- The policy context and political environment deterred some respondents (new tree clearing legislation has had a negative reception from graziers),

- The experimental design used restricted choice selection, (the use of paired comparisons with qualitative attribute levels, in a three alternative combination had limitations), and
- The survey collection technique was not designed to maximize returns (respondents were provided with prepaid envelopes to return the completed surveys rather than collecting them directly from the respondent).

**Figure 2. Example choice set – comprehensive survey**

**Question 17a:** Carefully consider each of the following options. Suppose these were the ONLY ones available, which would you choose?

**Remember:** The main requirements for the condition of this river frontage area is that:  
 (a) should be a **minimum of 50 metres** from the top of the main bank  
 (b) should be **spelled for 40% of the year** (can be spelled at several different times to make up the 40%), and  
 (c) there should be a **minimum of 2000 kg/ha grass biomass** left by the end of the dry season (see photos for examples)

Payment received \$/km/year \$	% of your river frontage covered 	Length of agreement 	Who you deal with 	I would choose 
Option A \$0	Current	None	None	<input type="checkbox"/>
Option B \$300	10%	5 years	Local government	<input type="checkbox"/>
Option C \$300	20%	5 years	Community group	<input type="checkbox"/>
Option D \$750	10%	10 years	Local government	<input type="checkbox"/>

**If you chose an option other than option A, will you need to:**

**A. fence some part of your river frontage area? – Yes /No If Yes, how many kms? \_\_\_\_\_**

**B. put in extra watering points? – Yes / No If, yes, how many? \_\_\_\_\_**

Although there were some difficulties encountered in the application of the CM exercise, the tool itself is still useful and retains its advantages. The reasons it was selected remain relevant. In particular the methodology allows for the assessment of:

- the supply of riparian services,
- the cost of providing these services,

- how trade-offs may be made between both the level and cost of provision, and other attributes of provision, and
- how landholders' attitudes and socio-economic characteristics may influence the supply functions.

The difficulties encountered in the pilot could largely be overcome by redesigning and delivering the CM survey in an alternative format. Rather than landholders being asked to read and complete the survey at home, it was decided that an amended CM exercise could be completed with groups of landholders in a workshop format. This is referred to as the general CM survey

## 4.2 General CM survey

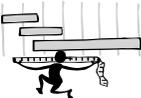
There were four main advantages associated with applying the CM exercise in a workshop format.

1. The information that frames the policy context of the CM scenario can be presented in an oral and visual format, which for many adults is an easier way of assimilating information than having to read it. Both Swanson *et al.* (2002) and Kontoleon *et al.* (2002), report the application of a Contingent Valuation Method survey in a group setting where background information is presented in both a visual and oral format.
2. Participants are able to ask questions and directly clarify any concerns.
3. A CM survey has three components. Some information is presented to respondents; other information is collected from them, and respondents are also required to complete the choice sets. In a working group environment these tasks can be separated and intermixed with other activities, making the process less onerous.
4. In a working group participants are likely to have more tolerance for tasks than they would for the completion of a questionnaire survey in the privacy of their home. It is therefore possible to ask each participant to complete a larger number of choice sets than would be possible in a questionnaire survey. This means that a sufficient number of choice sets can be completed with fewer respondents, in order to run a statistical model.

The general CM format, delivered in a workshop setting proved successful. The CM format was very simple. Many questions were asked in a separate questionnaire, and the choice selection was simplified. There was no distinction made between different river orders and participants were required to answer for a stream section on their property. The choice set (Figure 3) comprised of three attributes; price, buffer width and minimum grass biomass. Respondents were presented with three options, including the status quo, and there were nine sets to complete. Information about capital costs and contractual arrangements that had been collected in the choice set in the first survey, were collected in a separate exercise in the workshop.

**Figure 3. Example choice set – general survey**

**Question 4a:** Carefully consider each of the following options. Suppose these were the ONLY ones available, which would you choose?

Payment received \$/km/year  \$	Width of buffer strip  	Minimum grass biomass  	I would choose  
<b>Option A</b>			
<i>\$0</i>	<i>Current</i>	<i>Current</i>	<input type="checkbox"/>
<b>Option B</b>			
<b>\$100</b>	<b>10 metres</b>	<b>40%</b>	<input type="checkbox"/>
<b>Option C</b>			
<b>\$1000</b>	<b>100 metres</b>	<b>75%</b>	<input type="checkbox"/>

### 4.3 Choice modelling results

There was sufficient data from the general CM survey to produce a multinomial logit model (Table 2). Initial results indicate that:

- all three attributes are significant,
- the cost per kilometer of providing each metre of buffer width is \$3.70
- the cost per kilometer of providing each 1% of biomass is \$7.91

Results show that as the payment levels increased, respondents were more likely to select those options, but as conditions about buffer width or minimum biomass increased, respondents were less likely to select those options. The model also indicates that respondents with higher levels of education, and those with more extensive clearing on their property, were more likely to choose the status quo option and less likely to select a rebate option. Respondents who focused more on environmental outcomes than production outcomes, and those with dependent children, were more likely to select a rebate option.

However, the significant constant value indicates that factors other than those in the model are influencing the results.

The model provides information about landholder supply functions for certain riparian management services. The costs of supplying these services can then be compared with the demand for them, i.e. the gains or benefits associated with the management conditions

and the environmental services they provide. The most efficient outcome will occur when supply equals demand (Figure 1-A). For example, the optimal buffer width will be when the costs of providing buffer width (\$3.70/m/km) are equal to the benefits of having them.

**Table 2. Multinomial logit model for general CM survey**

	<b>Coefficient</b>	<b>Standard Error</b>	<b>Part worth</b>
Payment (\$/km/year)	0.0028***	0.0005	
Width of buffer	-0.0104**	0.0040	\$3.70 per metre
Minimum biomass level	-0.0226***	0.0084	\$7.91 per 1%
Constant	6.9554**	2.8184	
Age of respondent	-0.0068	0.0193	
Education level	-1.9621***	0.5333	
River order	0.2555	0.2353	
Extent of clearing	-1.7134***	0.4260	
Focus between production and environmental goals	1.3387*	0.7825	
Dependent children	3.0950***	0.9990	
<b>Model Statistics</b>			
No Choice Sets	144		
Log L	-96.19325		
Adjusted Rho-square	0.37008		

***Key finding 9: Choice modelling has limitations where the respondents find complex choice sets difficult to comprehend and analyse.***

***Key finding 10: Choice modelling limitations can be overcome with careful design and delivery in a workshop environment.***

***Key finding 11: Choice modelling can provide details about supply functions for specific components of riparian management.***

## **5. Results from questionnaire surveys**

Further information about respondents' characteristics, attitudes and supply functions was gathered from direct questions in the two surveys. Details were gathered about general socio-economic characteristics of respondents, attitudes to contractual arrangements, and further information about capital costs and overall supply functions for the sector.

## 5.1 Socio-economic characteristics

There were a number of respondent and property characteristics that may influence the provision of riparian services.

- 68% of participants had freehold ownership, indicating that attempts to implement land management changes through leasehold arrangements will be inadequate.
- 67% of participants thought their children would inherit the farm, indicating that they have an interest in the future economic and environmental viability of their enterprise.
- More than half (56%) have no off-farm income, so their farm viability is a primary concern. This is reinforced by high debt levels (65% in the first survey had some debt). Management changes will have to be cost effective.
- Less than half (43%) had dependent children, but CM results in Table 2 above, indicate that these respondents are more likely to select a rebate option.
- There was a large variation in property size (70 to 23,000 ha), with a median size of 4000 ha. This means there will be a range in the propensity of landholders to provide riparian services. Individual landholders may be able to make a large contribution.

## 5.2 Attitudes to contractual and institutional arrangements

Results indicate that there is support from graziers for an MBI to provide riparian management services. The majority of respondents (60%) in both questionnaires indicated that they were interested in incentive schemes where they would be paid by the government to provide environmental benefits. Most respondents (second survey) were even prepared to cost share with the government with 82% prepared to split the costs 25% landholder and 75% government, and 19% being prepared to split the cost 50/50 with the government.

However, initial results suggest that most respondents (second survey) would prefer to enter into an agreement with their local NRM group (56% ranked this as their first choice) rather than a government department. There was more support for Local Government (19% ranked this first and 44% ranked in either first or second), and less support for the Commonwealth Government (12% ranked it first, but nobody ranked it second). The most unpopular body was the State Government, as no landholder ranked it either first or second.

Contracts were a more acceptable arrangement than covenants, although there was a significant difference in responses in the two surveys. In the first survey many respondents were unsure, whereas in the second survey, there was a clear preference for contracts. Overall, in both surveys, 64% of respondents specifically indicated they preferred a contract rather than a covenant. In central Queensland, shorter term contracts are generally more appealing to landholders because they allow participants to trial a new mechanism and then withdraw at the end of the period if they find it unsuitable. Most

respondents (second survey) preferred the contract length to be less than five years (44%) or between five and ten years (44%). The other options were more than ten years or perpetual.

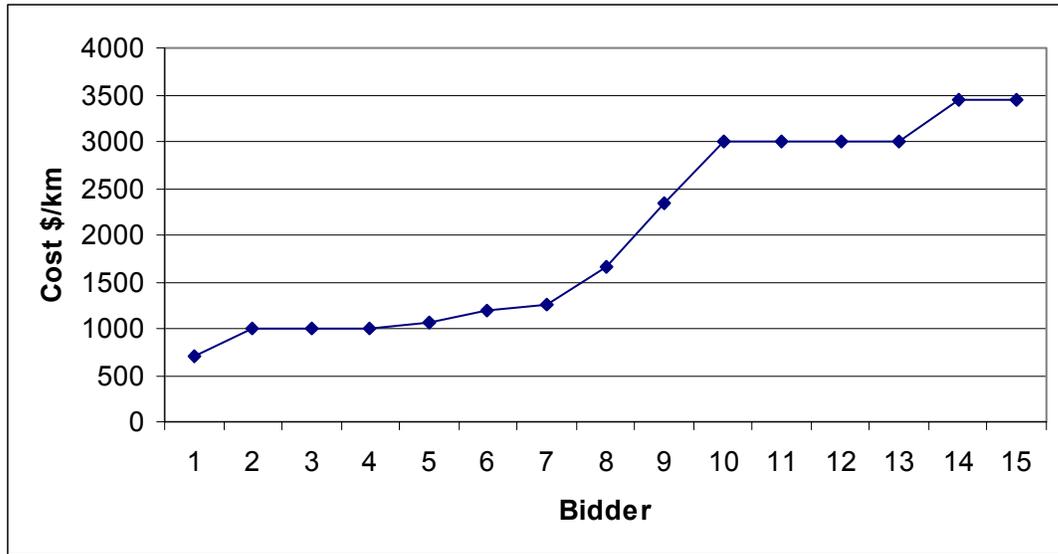
**5.3 Cost differentials.** Information from both questionnaires indicates that there is likely to be considerable variation in the costs of providing riparian services. Average stocking rates reported were 3.8 head per hectare but ranged from a minimum of two to a maximum of 7.6. As stocking densities will vary with vegetation type and management practices, respondents in both surveys were also asked about the percentage ground cover they retained in their riparian areas. Responses indicated that on average 76% of their total farm area had 40% ground cover at the end of the dry season in a normal year, but this ranged from a minimum of 10% to a maximum of 100%. In the last two (drought) years the average was lower at 57% of the total farm area, and the range greater (from zero to 100%).

In addition, there was some variation in the amount of clearing that had occurred in the riparian areas. In the second survey, respondents were asked about how much had been cleared within 100 metres of the stream bank. 25% had mostly cleared both sides of their stream and another 25% had some cleared. 31% had some cleared but had left a buffer strip along the bank, and 19% had cleared hardly any vegetation.

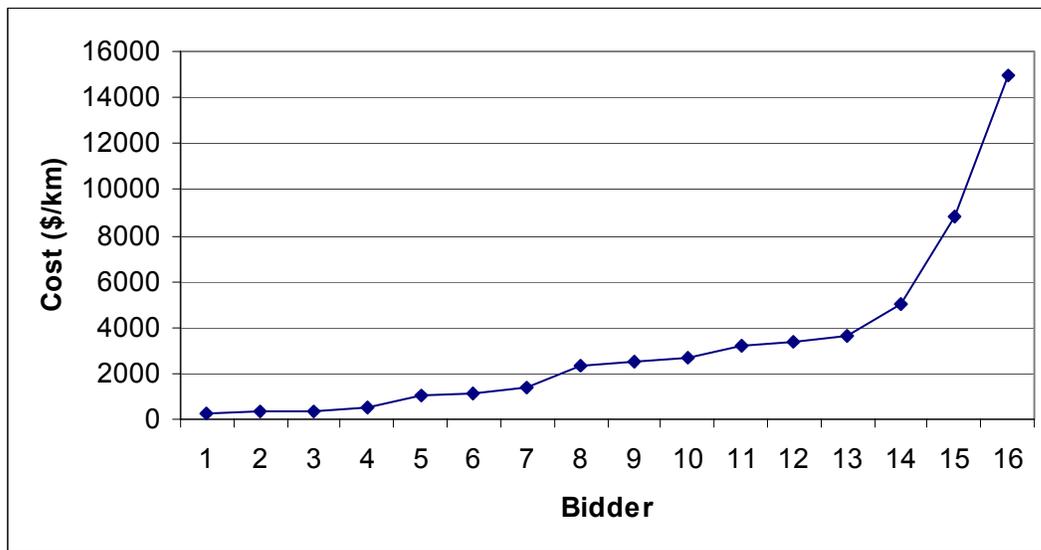
This range in stocking rates, variation in minimum ground cover levels and differences in the amount of vegetation clearing that has occurred, means that there would be considerable differences in the costs to landholders of meeting specific management conditions.

Information about capital costs was gathered from direct questions in the second survey. To ensure minimum grass cover levels are maintained in riparian areas, these areas need to be fenced so that stock can be excluded, and additional water points may need to be provided. These are the two main capital costs to be incurred. Initial results indicate a considerable cost range between landholders from \$700/km to \$3448/km for fencing (Figure 4) and from \$243/km to \$15,000/km for watering points (Figure 5).

**Figure 4. Fencing costs (\$/km)**



**Figure 5. Cost of watering points (\$/km)**



**Key finding 12:** *Information collected with surveys can provide details useful for mechanism design and application.*

**Key finding 13:** *Direct questions revealed substantial variation in capital costs associated with the supply of riparian mitigation actions.*

## 6. Results from experimental auctions

The experimental auction was designed to determine the variation in costs of providing riparian services which were revealed in the bid prices of respondents.

Workshop participants were given a dummy property. There were four different properties, each with the same attributes, but designed to appear different. An example is provided in Figure 6.

Each property map had:

- a large river and a smaller creek indicated on the map,
- an area of braided streams – typical in parts of the Fitzroy basin,
- three main vegetation types: alluvial, box-ironbark, and hill country – each separated into timbered and non-timbered areas,
- fenced paddocks,
- water points, and
- house and yards.

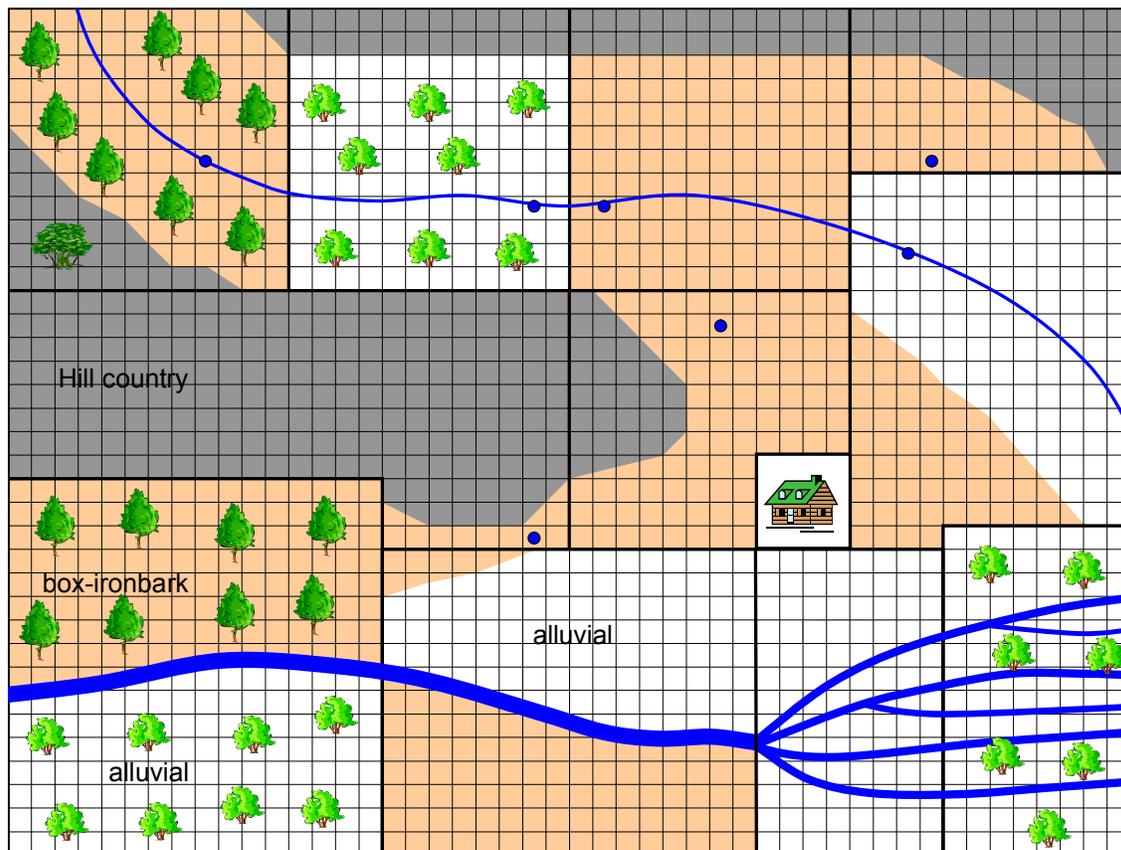
The following baseline management conditions were specified:

- Commitment to retain a minimum 40% grass cover at the end of the dry season (photo standards were provided).
- Fire was allowed but the area must be destocked until minimum biomass is reached.
- No additional exotic plant species can be introduced deliberately.

While minimum conditions were specified to ensure particular environmental outcomes, they still allowed landholders flexibility over their production outcomes, and cattle could still be grazed in designated areas. In addition, landholders were advised that any agreements would:

- be for a 5 year period with annual payments,
- be in the form of a contract, and
- include a monitoring process based on an annual visit, with two weeks notice.

**Figure 6. Example of a dummy property for the experimental auction**

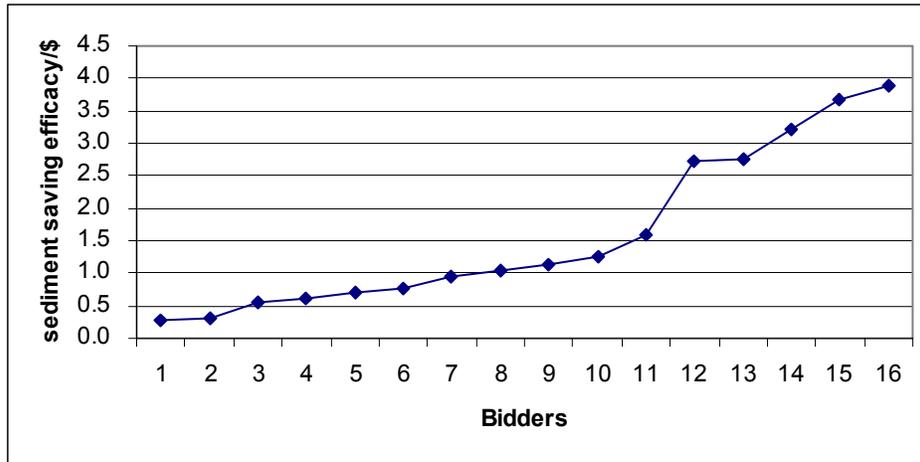


Participants were asked to mark on the maps the area of riparian buffer they were prepared to manage in this way and the bid amount (cost to them of the altered management regime). Small prizes were awarded for the most cost effective bids, to provide participants with an incentive to keep their bids as cost effective as possible.

A simple metric was developed based on the river type and whether the buffer area was timbered or non-timbered. The final score represented an efficacy value for the amount of sediment averted from entering the watercourse.

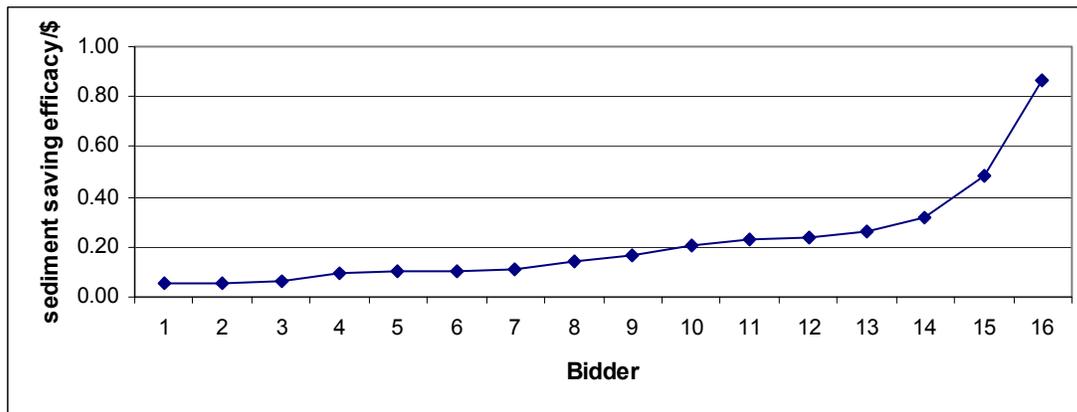
In the first round of bidding respondents were asked to focus on their opportunity costs and to assume any capital costs would be funded separately. The initial results indicate that there is a broad range of relative bid values which represent the variation in opportunity costs (Figure 7).

**Figure 7. Relative bid values - opportunity cost only**



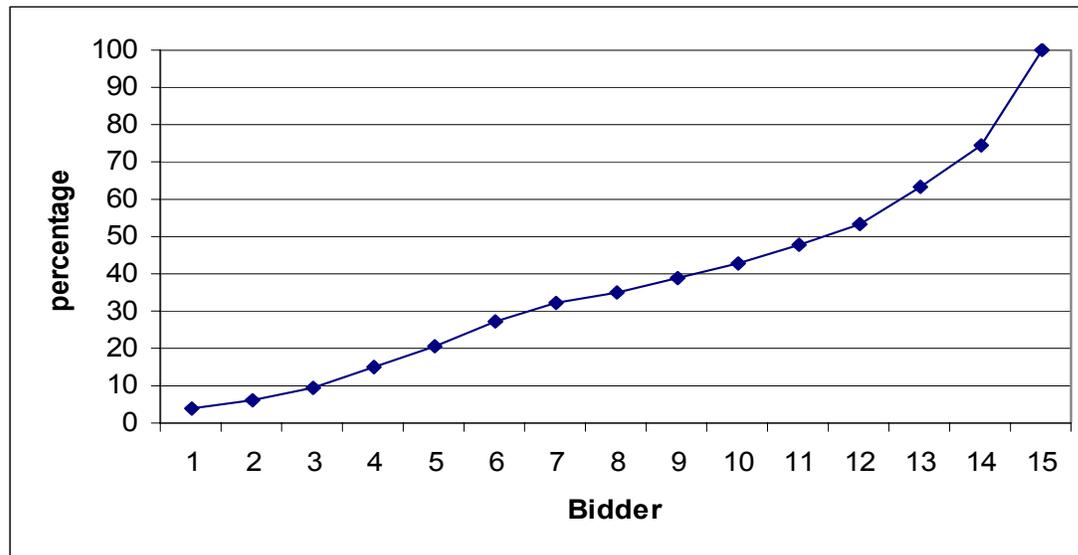
In the second round of bidding participants were asked to base their bids on both capital and variable costs, i.e. they asked for an initial payment (fixed costs) and an annual payment (variable costs). To calculate the relative bid values, the annual payment was discounted (at 7%) over the five year contract period. Again, the initial results indicate that there is a broad range of relative bid values which represent the variation in fixed and variable costs (Figure 8). The extent of the range indicates that it is much more efficient for some landholders to implement mitigation actions compared to others.

**Figure 8. Relative bid values - fixed + variable cost, for five years**



This range in values is not based solely on the variation in opportunity costs. There was a wide range in fixed costs (as indicated in Figures 4 and 5) and the proportion of fixed costs in the total cost estimate also varied (Figure 9). The contribution of fixed costs to total costs significantly reduced the amount of sediment that could be mitigated per dollar (Figure 8) compared to when only opportunity costs were considered (Figure 7).

**Figure 9. Fixed costs as a percentage of total costs**



The heterogeneity in landholders' cost of meeting certain management standards, or providing conservation services, is well known and it is the basis on which trade, particularly intra sector trade, can occur. It is also the basic requirement for competitive incentive schemes such as competitive tenders or auctions. The variation in fixed costs is less recognised. An established incentive scheme in the Fitzroy basin is the use of devolved grants to help landholders to cover fencing cost. Developed grants are a fixed price payment scheme and the results above suggest that more cost efficiencies could be gained by implementing discriminative price mechanisms, even for standard capital works such as fencing. The results in Figure 9 also suggest that a focus on fixed costs only (as with devolved grants) will limit the pool of applicants because of the high proportion of opportunity costs in total costs, incurred by some landholders.

***Key finding 14: Experimental auctions are appropriate for revealing finer level details about the opportunity costs facing landholders, while choice modelling provides a more general analysis of the tradeoffs. The roles of the two assessment techniques are complementary rather than competing.***

***Key finding 15: Experimental auctions reveal variation in both variable and capital costs.***

***Key finding 16: Experimental auctions reveal variation in the proportion of fixed costs as a percentage of total costs.***

## Summary findings

There are significant opportunities for reducing water quality impacts in the Fitzroy basin, and these lie principally with reducing the impacts from agricultural diffuse sources. The management of riparian buffer strips has potential as a mitigation action that can be applied in a trading scheme, and there is sufficient variation in the costs of providing these mitigation actions for there to be gains from trade.

A set of nine decision criteria have been developed on which to evaluate the viability of implementing a quantity-control mechanism. Applying these criteria to the situation in the Fitzroy indicated that cap-and-trade mechanisms are unlikely to be effective. While there are many non-point source emitters, there are relatively few point sources. The main emitters are spread across the extensive area of the basin, making the determination and implementation of a cap problematic. Such a process requires a large amount of scientific information which is not readily available. Scientific information that relates farm land management changes to specific environmental outcomes is limited, and remains both difficult and expensive to collect.

There also needs to be a sufficient number of traders to establish a viable market. There are insufficient numbers of point source emitters in the region and while there are many diffuse sources in agriculture, the imposition of a cap on this specific group is politically and practically unrealistic. There is some potential for offset trading as trades are easier to negotiate and not so many trades are required for a market to operate. However, further investigation would be required to determine appropriate institutional arrangements. Key issues relate to the adjustment of current regulations on point source emitters so that they can offset, and to determine the specification of trading ratios. Bubble schemes also have some potential, but also require further investigation.

In this case study the potential for trade has focused on assessing the supply functions for providing mitigating actions. The estimates of potential supply were made by applying a complementary combination of choice modelling and experimental auctions in a workshop environment. This mixed method, interactive delivery format has great potential and improved the effectiveness of the task of both providing and gathering information. Integrating the different sections of a choice modelling survey with other tasks also worked well. The workshop participants gave careful consideration to the information they provided (not necessarily the case in a field survey) and high quality data was collected.

One of the outcomes of the project was that there were limited opportunities to implement quantity based mechanisms in the region. However, details gathered about the supply function for riparian management, in particular the large variation in costs to landholders of providing mitigation, indicates that there is also potential to implement a price based mechanism such as a competitive tender, or auction.

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