Economic Evaluation of Riparian Land Management Options

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Executive Summary

This study looked at the benefits and costs of several riparian land management options. It explored a range of methods of economic evaluation and environmental evaluation and then applied some evaluation techniques to a case study in Wollondilly Shire, which is considering the effects of planning options to protect riparian land along the Nepean River and its tributaries.

The base case in the benefit cost analysis assumed that water quality would continue to decline and erosion along the riverbanks would continue unabated. Other scenarios consid red options such as varying widths of riparian land, erosion control, partial or no stock access, land resumption and provision of a specific habitat area.

Quantification of costs is generally more straightforward than quantification of benefits. Here benefits were equated to recreational expenditure using the travel cost method of benefit evaluation. The study assumed there was a direct relationship between riparian land management, water quality and recreational expenditure. Thus, different scenarios resulted in a change in recreational expenditure which was interpreted as changes in benefits. As riparian lands reduce nutrient runoff, benefits were also calculated as the avoided costs that would otherwise be incurred by a sewerage treatment plant in removing the equivalent amount of phosphorus. Improved water quality was measured using avoided health costs.

Existence benefits from improved habitats and preservation of archaeological and heritage sites were discussed but not valued in this case study.

Costs were calculated as the direct costs of implementing the riparian land options, such as fencing, revegetation and loss of income from agricultural land. The study calculated a benefit cost ratio as well as the net present value for seven scenarios. Neither of these indicators alone can decide whether a course of action should be followed, but both indicators should be considered in the decision making process.

The results of the Wollondilly case study indicated that several riparian land management options could be economically justified in terms of benefit cost ratios and net present values.

The evaluation methodology used in this case study can be applied to similar evaluations in other regions. Variations in benefits and costs will occur due to site characteristics and major purposes of the riparian land. While difficulties exist in determining and quantifying certain benefits and costs, identification and some quantification are necessary to establish the impact of proposed riparian land management policies.

Abstract

Riparian land management can reduce runoff, improve water quality and provide flora and fauna habitat. This applied study considered the methodology available to quantify benefits and costs of a range of riparian land management options.

A benefit cost analysis of riparian land management options was undertaken in Wollondilly Shire. The study assumed declining water quality, which influenced recreationists' behaviour. Costs assessed included erosion control, building a public swimming pool, fencing, revegetation costs, the costs of providing alternative drinking water for stock, and land acquisition. Benefits included recreation benefits, avoided costs of nutrient stripping and health benefits. The results indicated that from an economic point of view, a 20 metre riparian land width is justifiable within Wollondilly Shire.

A further study was undertaken to identify the factors influencing visitor numbers to Bents Basin, a recreation area in Wollondilly Shire. Regression analysis was used.

Keywords: riparian, benefit cost, recreation benefits,

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1 Background

The riparian land is "*the area made up of the bank and edge of river channels and other bodies of water...The riparian land forms a critical link between land and water environments. It shares characteristics with, and contributes to, both systems as well as holding unique characteristics of its own.....*". (New South Wales Water Resources Council 1993).

This area is instrumental in protecting water quality from nutrient runoff and bank erosion while healthy riparian vegetation maximises its effectiveness. Runoff, particularly urban runoff, causes high turbidity and high bacteriological levels in the water, mainly after heavy rain. High turbidity makes disinfection of water less effective. Rural land use contributes to water pollution through nutrients, chemical residues and salinity as well as soil erosion. Riparian strips can minimise agricultural runoff such as phosphorus and nitrogen (Riding and Carter 1992) and act as a buffer between the water courses and land use.

In many areas the riparian land is neglected and damaged. Poor management has resulted in loss of vegetation and bank destabilisation. Loss of riparian trees adversely affects the supply of organic matter to aquatic ecosystems (Riding and Carter 1992).

The aims of improving riparian land management are to;

- improve water quality for towns, riparian use, irrigation, recreation, fish habitat
- improve wildlife habitat. The riparian land provides shelter and habitat for fauna providing food and encouraging faunal diversity
- improve aesthetic qualities of the location
- reduce erosion
- preserve archaeological and heritage sites. Both Aboriginal and European habitation focussed on watercourses.

Developing a riparian buffer strip is one strategy in environmental protection. Its effectiveness is dependent on its width, condition and pollutants. Riparian vegetation acts as a filter against diffuse pollution.

The necessary width of buffer strips is influenced by their goal, soil type, slope, rainfall patterns and vegetation type. A review of the literature indicates that buffer strips 20-30 metres wide either side of the river are preferred for maintaining water quality (Riding and Carter 1992). Wider buffer strips are preferred for wildlife corridors (Benson and Howell 1993).

This study looked at the methodology for identifying and valuing benefits and costs of riparian land management options. It briefly outlines the concept of use and non use benefits and alternative ways of valuing these. The general direct costs of establishing riparian lands are also discussed.

Some evaluation methodologies were then applied to a benefit cost analysis of a case study, Wollondilly Shire. The economic analysis of various riparian land management scenarios highlighted the problems of lack of readily available data. The study explored the implications of assumptions used by a regression analysis of recreation demand.

The study developed and applied broad bioeconomic assumptions which can only benefit from further research and willingness by scientists to forecast future scenarios under varying conditions. These results from bioeconomic modelling based on minimal data must be treated with caution. However, as non use values were not calculated, benefits in the case study were underestimated.

2 Valuing benefits and costs

Benefits of improved water quality and rehabilitation of riparian land are many. Riparian lands help minimise river bank erosion with benefits to the land holder and downstream users. Riparian lands provide habitat for native birds and animals. Riparian lands act as a filter for runoff containing agricultural and domestic fertilisers, which can lessen the frequency of toxic algal blooms and associated health implications and also provide recreation benefits.

The implications are that in the long term society benefits from well vegetated and maintained riparian lands. However most of these benefits are difficult to value, partly due to the complex relationship between water quality, ecology, human behaviour and health risks and then problems in quantifying these relationships.

2.1 Use and non use benefits

Several techniques can be applied to establish use and non use values (Knapman and Stanley 1991, Wilks 1990). Use values refer to those values placed on physical use of the good, such as swimming in the river, picnicking along its banks, fishing or enjoying the view. Non use values are the psychological benefits obtained from environmental resources without direct use of the resource, such as existence values that are based on the knowledge that good water quality exists in the river or that the resource is well protected, even though it is not actually used by the respondent.

Use values can be estimated using the travel cost method, which calculates how much people are spending through travel to enjoy the resource. This method is particularly suited to estimating recreation values (Sinden 1990). The travel cost method involves surveying current users of a recreation area, for example establishing numbers of visits, frequency of use and distance travelled. A demand curve for the recreation area is calculated and can provide the total willingness to pay by consumers for enjoying the recreational resource. This method only calculates use values and therefore provides a minimum value of the resource.

The contingent valuation method can be applied to determine non use values such as existence values. It uses a survey approach to establish the respondents' willingness to pay or willingness to accept a monetary amount to fund hypothetical changes in the quality or quantity of a resource. This dollar amount represents a non use value of that commodity (Mitchell and Carson 1989).

The method has been widely applied, to value a range of environmental issues such as wetlands, preservation of habitats, and valuing instream flows. Australian contingent valuation studies have included establishing values for the Nadgee Reserve, Kakadu National Park, coral reef management and several wetlands (Hill 1993).

2.2 Property values

The property value or hedonic pricing method can be used to value a natural resource (Sinden 1992). Utilising house values, it is assumed that the price paid for the house or similar property will reflect the value of its environment (David 1968). For example a house with pleasing river views is valued higher than a similar house without river views. The differential in values reflects peoples' willingness to pay for that pleasing river view.

2.3 Alternative and replacement values

The alternative cost approach to values is based on the value of a particular resource being the cost of the next best alternative way of providing that service. Riparian lands help control water pollution from diffuse sources by filtering sediment and nutrients, reducing the export load to the river. An alternative method of preventing the same load of nutrients from entering the water is through increased treatment of effluent by sewerage treatment plants. Thus a benefit of improved riparian land management is the avoided costs of reducing phosphorous loads through sewerage treatment plants. The costs of losing access to the river for watering stock can be established by calculating the costs of alternative water supplies, such as pumps, stock water access ramps and bores.

The replacement cost approach is based on the replication of the resource. For example, the replacement cost of a natural wetland is the cost of creating an artificial wetland.

2.4 Opportunity costs

The opportunity costs associated with preserving a natural resource are the benefits that society would receive from the resources in alternative uses and which therefore are foregone. For example the opportunity cost of preserving riparian land is the income foregone from other uses such as agriculture or timber harvesting.

2.5 Health benefits

Benefits of improved environmental conditions, such as air pollution or water quality, can be established through avoided health impacts. The value of improved water quality can be measured as avoided health costs that would otherwise be incurred or as avoided loss of earnings resulting from decreased incidence of sickness or disease.

Health benefits are not restricted to human health and can apply to stock losses from poor water quality (Hassall & Assoc 1993).

2.6 Direct costs

In implementing specific riparian lands there are a number of direct costs incurred, such as fencing, revegetation, maintenance and erosion controls. Fencing costs include traditional or electric fences, site preparation and maintenance costs. Revegetation costs are affected by the terrain, soil, climate and purpose of the revegetation as well as existing vegetation. In some areas only facilitation of regeneration is required. Planting costs are influenced by seed availability, and density of planting as well as site preparation and maintenance. Many costs are site specific, such as revegetation costs and loss of agricultural production.

3 Case study- Wollondilly Shire

3.1 Introduction

Wollondilly Shire, situated south west of Sydney, is considering planning options to protect riparian lands along the Nepean River and its tributaries. This study assessed the range and extent of benefits and costs of riparian land management options.

Water quality studies (Water Board 1992) indicate that water quality deteriorates as the Nepean River travels downstream. Cumulative phosphorus and nitrogen levels increase with distance downstream as the influence of the catchment runoff increases, creating conditions at times that are conducive to algal blooms. Turbidity levels also increase gradually with the distance downstream and increase sharply during rainfall events. However conductivity levels are well below the upper limits for irrigation of salt sensitive crops.

Wollondilly Shire has a diverse range of land uses. It partly encompasses the Warragamba Dam catchment on its west side and the Nepean River catchment on the east side. Land use includes rural residential, intensive livestock (piggeries), intensive horticulture (market gardens), extensive livestock (grazing), extensive horticulture (orchards) and some natural vegetation.

Three different areas in Wollondilly Shire were studied to establish the costs and benefits of options in creating and protecting the riparian buffer land;

- The flood plain section of the river near Theresa Park, from the upstream edge of the Bents Basin recreational area (near Bringelly Creek) to the Mount Hunter Rivulet
- The Nepean gorge country near Douglas Park between Elladale and Allen's Creeks
- The Stonequarry Creek section through Picton.

3.2 Benefit cost study

A benefit cost study looks at the benefits and costs of implementing a range of plans. In this case a range of possible riparian management scenarios was considered, and valued to establish their economic viability.

The benefit cost study initially looked at the 'do nothing' or base case meaning that no further action was taken to improve or alter riparian lands. Thus erosion would continue to occur along some sections of the river, mostly in Theresa Park and Picton, and water quality would continue to decline. The study calculated a benefit cost ratio as well as the net present value for each scenario. The benefit cost ratio was calculated as the difference between each scenario and the base case. A ratio of greater than or equal to one indicated that the incremental benefits were at least equal to the incremental costs of that scenario. The net present value of each scenario was the present value of the benefits less the present value of the costs and showed the discounted value of that course of action.

The calculation of recreational benefits was based on the assumption that there was a direct relationship between the width of the riparian land and its effectiveness on river water quality (EPA 1994b). A relationship was assumed between water quality and recreational benefits as measured by costs incurred by visitors to three recreational areas, Douglas Park, Bents Basin and Blaxland Crossing. A further assumption was made that riparian land management in Wollondilly Shire directly affected water quality (and thus recreational activity) in these three recreational areas.

3.2.1 General assumptions

The economic analysis applied the following assumptions;

- a time frame for benefits and costs of 20 years
- annual population increase as per Department of Planning population forecasts for Wollondilly Shire
- discount rate of 7%
- sensitivity analysis, on discount rates (4%, 10%), on changes in gross margins, revegetation costs, sewerage treatment plant costs, recreational benefits and health costs

3.2.2 Valuing Benefits

Establishing values for benefits, particularly environmental benefits, can be costly and time consuming. Few market values are available; therefore methods such as travel cost and contingent valuation can be used. This section outlines the methodology used in the Wollondilly Shire study.

Use values; Recreation benefits

While the travel cost method can be applied in simple or sophisticated models, in this study a basic set of assumptions was used to estimate the value of changes in water quality and thus recreation values for recreational visitors to the Douglas Park, Bents Basin and Blaxland Crossing areas.

This application of the travel cost method assumed that all visitors drove to the recreational areas, as they are not situated close to public transport. The numbers of visitors per car were calculated and a value established by multiplying car visits by distance travelled, car travel costs and entrance fee paid (if applicable).

The study assumed that recreational use and benefits were directly proportional to population growth, that population would increase at forecast rates (Dept of Planning 1992) and that base benefit value would increase with projected population growth. However while benefit values would increase with population growth, it was also assumed that changes in water quality would influence demand for the recreational area. Deterioration in water quality would result in fewer visits being made (Walker and Greer 1992) while an improvement in water quality would result in more visits being made, either by current visitors, new visitors or both. Thus the value of the resource changed with a change in its quality.

The study assumed that in the 'do nothing' case water quality continued to decline, measured as a 10% decrease from the current position and therefore a 10% decline in recreational benefits. Various combinations of factors as represented by the scenarios were assumed to result in different effects on recreational benefits. For example a 50 metre wide riparian strip was assumed to result in a 10% increase in benefits from the current position, while a 20 metre wide riparian strip was assumed to result in a 5% increase.

The economic appraisal attempted to quantify use values only, which resulted in an underestimation of benefits as non use benefits were not included.

Nutrient stripping

This study looked at the cost of riparian buffer strips to reduce phosphorus export load compared to the same load being extracted through sewerage treatment plants.

Initially the potential phosphorus load was calculated for the estimated direct catchment areas to the Nepean River and Racecourse/Stonequarry Creeks within the three case studies of Theresa Park, Douglas Park and Picton. Diffuse phosphorous generation rates from land use in the Hawkesbury - Nepean Basin (EPA 1994b) were applied to land use in the catchment areas.

Effectiveness of the buffer strips depends on a number of conditions such as slope, vegetation and land use practices. The literature gives wide ranges of this effectiveness of buffer strips in reducing potential runoff (Fitzpatrick 1986, EPA 1994a, Outhet, personal communication). The study assumed that different widths of heavily vegetated riparian lands reduced potential phosphorus runoff by varying amounts; 10 metres by 75%, 20 metres by 90% and 50 metres and over by 100%. It was assumed that a buffer strip reached its full effectiveness rate after five years whereby it was fully established.

These reductions in phosphorus runoff could be offset by costs incurred in stripping phosphorus by a sewerage treatment plant. The marginal rate applied was that of reducing phosphorus from 1 to 0.3 mg per litre in a 5 Ml per day plant. This size plant was used as its capacity was similar to the mean flow of the projected treatment plants at Picton and Menangle (EPA 1994a).

Benefits of establishing a riparian buffer strip were calculated as the avoided sewerage treatment plant costs of extracting phosphorus

Health benefits

Health in the Wollondilly Shire could be adversely affected by swimming in polluted water or coming in contact with toxic blue-green algal blooms. Moreover the health of people downstream is also influenced by the quality of water flowing from Wollondilly Shire. This is particularly significant given the recreational areas of not only Douglas Park but the immediate large areas of Bents Basin and Blaxland Crossing and further downstream, the recreational areas at Penrith, Sackville and Wiseman's Ferry.

Declining water quality was anticipated to result in future toxic blue-green algae blooms in Wollondilly Shire. Blooms form under several favourable environmental conditions such as high nutrient levels, especially phosphorus, and low nitrogen to phosphorus ratios. Blue-green algal blooms are increasing in frequency in the Nepean River system and can have detrimental human, animal and aquatic health impacts. Riparian land management that reduces soil erosion and water turbidity will help reduce the incidence of toxic algal blooms.

For humans, ingesting toxic algae can have short run health problems (acute) or long term (chronic) effects such as liver damage. Even skin contact with algae through swimming can cause skin problems and allergic reactions (Hassall & Assoc. 1993). The health impacts can be valued by costing medical costs and lost production, measured through lost earnings. On this basis Hassall & Assoc. calculated total cost per chronic case from algal hepatotoxins at $414,000. With an incidence rate of about 2.5 per million at risk population (defined by Hassall & Assoc. as the population of the major urban centres of NSW) the total costs of ill health could increase significantly over the 20 years of the benefit cost study. In this study the cost of acute illness was calculated as an average of costs from illness due to endotoxins and hepatotoxins based on their average incidence rate.

As the study assumed that the 'do nothing' scenario would result in deteriorating water quality, it also assumed that at least these current rates of incurred health costs would continue. Avoided chronic and acute health costs were included in the benefit cost figures in scenarios 4, 5 and 6 as the most likely impact on reduced incidences of toxic blooms would be from riparian land rehabilitation of at least 20 metres width. The at risk population was the numbers of visitors to the three recreational areas under study

Animal health costs were not included in this study as there were generally not significant sheep and cattle numbers along the river in the case studies. However, data from the Darling River indicates a death rate of 0.4% for sheep and cattle critically exposed to acute algal toxins (Hassall & Assoc. 1993). Deteriorating water quality in Wollondilly Shire will increase the risk of stock losses.

3.2.3 Benefits not valued

Habitat values

Developing riparian lands can improve habitat for native fauna. The quantification of this benefit can be troublesome. As water quality improves, the anticipated improvement in habitat and native animal numbers can be partly measured through increases in recreation visits to the recreation areas in Wollondilly Shire.

Otherwise the contingent valuation method can be applied where respondents are asked their willingness to pay to preserve for example, a particular species or native habitat. In the USA this technique has been applied to a wide range of species, such as the whooping crane, eagle and various fish (Hill 1993). In Australia the method has been applied particularly to valuing habitat preservation, as in Kakadu National Park, Fraser Island (Wilks 1990) and Victorian wetlands studies (Hill 1993), and natural bushland near Brisbane (Windle and Cramb 1993).

In Wollondilly Shire there are a number of rare and vulnerable species of fauna such as the Koala, Turquoise Parrot, several bats and the Glossy Black Cockatoo (Ardill 1994). Benson and Howell (1993) outline a comprehensive list of significant flora species in the Shire. Remnant riparian forests containing rare and vulnerable plant communities are also in the study area (Benson and Howell 1993).

Given time and cost constraints habitat values were not quantified in this study, thus benefits of any action that resulted in improvement in habitats were underestimated.

Timber harvesting

If appropriate trees are planted in riparian lands there is the potential for future harvesting of the native forests. However this would defeat the purpose of developing natural habitat and was not considered a viable option for this region. As well, there are considerable time lags before logging could begin, and restrictions on logging activities along prescribed watercourses. It would be unfortunate if a source of income was considered when in reality there would be unsurmountable restrictions on the activity. While vegetation is already established in the Douglas Park area, it was not considered particularly suitable for logging and therefore no benefits accrued from timber harvesting.

3.2.4 Valuing Costs

Erosion control

Some areas of riverbank are prone to erosion, particularly along the alluvial flats. Without erosion control measures undertaken, estimates were that half the length of the Theresa Park riverbank would erode at the rate of one metre in width per year, while the annual erosion rate in the Picton area was estimated at approximately half a metre for one tenth of the length through the Picton area (Outhet personal communication). Costs were based on using rocks for erosion control.

Swimming pool

For this study the building of a community swimming pool was proposed in five years' time when water quality was assumed to have deteriorated to the point where swimming was no longer feasible in the Nepean River recreational areas of Douglas Park, Bents Basin and Blaxland Crossing. This was based on the assumption that the additional recreational swimming pool was a perfect substitute for swimming in the river at these sites.

Fencing

Fencing of riparian land prevents livestock from grazing along the river banks and their access to water from the river. This reduces bank destabilisation and soil compaction, resulting in less bank erosion. Some areas could be suitable for restricted grazing and restricted access to water, such as using a ramp to the water's edge. Electric fencing costs were used.

Revegetation

Revegetation and regeneration costs are very site specific, depending on climate, soil, topography, hydrology and purpose. The three case studies provided three different scenarios for revegetation in terms of planting, weeding, regeneration and maintenance requirements. These were reflected in costs. The assumption was made that the revegetation program was aimed at rehabilitating the area rather than just arresting current decline.

Costs used in the study were based on local practice (Wollondilly council), an average of a number of quotes obtained and the literature (Benson and Howell 1993, Dept Water Resources Vic 1992).

Stock access to the river and riparian land

Stock access to riparian land creates several problems for both the vegetation and river bank erosion. Access to the river for drinking water can be a major source of bank erosion. In some areas total restriction on stock access to the riparian land was proposed. In other areas restricted access would be a viable alternative.

Alternative watering options were:

- to provide alternative water supply by pumping water to stock away from river banks
- to sink bores, or spearpoints or
- to provide hardstands or ramps for watering access at river.

Gross margins

The value of foregone land productivity due to the establishment of a riparian strip was established using gross margins. Wollondilly Shire land use maps were used to determine the type and extent of activity on land adjacent to the Nepean River and Stonequarry Creek in the three case studies. Then gross margins were calculated based on information obtained from the Department of Agriculture. Gross margin is the difference between gross income of the activity and variable costs incurred. Therefore it excludes fixed costs and return to non paid labour but was considered an appropriate measure where only a portion of the enterprise's productivity was affected by the proposed riparian land management option.

Land acquisition

One method of ensuring the rehabilitation of riparian land in an urban situation would be to acquire land along the river. In Picton most land along the case study section is either used for grazing or housing.

The study made several assumptions regarding urban land acquisition. Where a 10 metre wide riparian strip included land acquisition it was assumed that council reached an agreement with a developer in the new residential area to purchase a number of blocks according to the width of the proposed riparian land. Where a broader riparian strip necessitated further urban land acquisition, the council was assumed to resume blocks of land along the Stonequarry Creek at a rate dictated by the width of the riparian land.

For a proposed 20 metre riparian land 15 house blocks were assumed to be acquired while 64 would be acquired if a 50 metre riparian land scenario with land acquisition had been considered.

Alternative habitat

Finally the study looked at the costs of providing alternative flora and fauna habitats. Here the riparian land could be narrower than otherwise, such as 10 or 20 metres rather than 50 metres. To compensate for the narrower riparian land a large area of land could be purchas·d and developed as wildlife habitat. This was a very general scenario as the concept is site and species specific. However it was assumed that one lot of land of 200 hectares was purchased. It was assumed that the land did not require planting, merely the allowance of regeneration. It was further assumed there were costs in fencing this specific habitat land with electric fencing and ongoing fence and land maintenance costs.

3.3 Base case and scenarios

This section looks at specific scenarios, their benefit cost ratios and net present values. The range in scenarios and the costs and benefits appraised hopefully addressed the broad range of issues associated with riparian lands. The topic is complex because of the multi purposes served by riparian lands. Therefore the range of riparian land management options covered by the following scenarios is meant to be indicative rather than all inclusive

Base Case; Do nothing

Under the base case or 'do nothing' scenario riparian land use would continue as now; no further action would be implemented to protect, or rehabilitate the riparian land. The water quality would continue to deteriorate both within the Shire and noticeably downstream as fertilisers and nutrients from agricultural land and residential land use continued to pollute the waters. Erosion of river banks would continue, partly as livestock accessed their river drinking water and instability of banks continued due to agricultural use and lack of vegetation.

This erosion and continued decline of water quality due to urban and agricultural runoff were assumed to result in a decline in recreational benefits (from Douglas Park gorge, Bents Basin and Blaxland Crossing) of 10% from the current position.

To summarise the base case;
Base case
- deteriorating water quality calculated as a decline in recreation benefits by 10% from current situation
- loss of income from erosion of riverbanks
- phosphorus removal by sewerage treatment plant
- health costs incurred due to deteriorating water quality

Scenarios

Scenario 1; Swimming pool
Scenario 1 addressed the issues of water quality and recreational use
costs
- community swimming pool built in year 5
- loss of income from erosion of riverbanks
- phosphorus removal by sewerage treatment plant

benefits
- avoided loss of recreational benefits from base case to current situation
- avoided health costs

Scenario 2; erosion control
Scenario 2 addressed the issue of erosion control in riparian land
costs

- cost of erosion control works
- phosphorus removal by sewerage treatment plant
- health costs incurred due to deteriorating water quality

benefits

- avoided loss of recreational benefits of 5% from base case
- avoided loss of income from erosion of riverbanks

Scenario 3; *10 metre riparian land, no stock access, no land acquisition*
Scenario 3 addressed the riparian land issues of revegetation, stock access and ensuing water quality.
costs

- revegetation and planting
- electric fencing
- loss in income from 10 metre wide riparian land
- pump costs for supplying river water to stock
- health costs incurred due to deteriorating water quality
- some phosphorus removal costs by sewerage treatment plant

benefits

- avoided loss of income from erosion of riverbanks
- avoided loss of recreational benefits of 5% from base case
- some avoided cost of phosphorus removal

Scenario 4; 20 metres riparian land, no stock access
This scenario addressed similar issues as scenario 3, with a stronger positive effect assumed on water quality and nutrient removal due to the wider riparian land, reflected by increased recreation and health benefits.
costs

- revegetation and planting
- electric fencing
- loss in income from 20 metre wide riparian land
- land acquisition in Picton
- pump costs for supplying river water to stock
- some phosphorus removal costs by sewerage treatment plant

benefits

- avoided loss of income from erosion of riverbanks
- increase of 5% in recreational benefits from current situation
- some avoided cost of phosphorus removal
- avoided health costs

Scenario 5; 20 metres plus partial stock access.
Scenario 5 addressed similar issues as the previous scenario except in the treatment of stock access to the river.
costs

- revegetation and planting
- electric fencing
- partial loss in grazing income from 20 metre wide riparian land
- land acquisition in Picton
- ramp costs for stock access to river water

- some phosphorus removal costs by sewerage treatment plant

benefits

- avoided loss of income from erosion of riverbanks
- increase of 5% in recreational benefits from current situation
- some avoided cost of phosphorus removal
- avoided health costs

Scenario 6; 50 metres riparian land, except for 10 metres in Picton, no stock access.
Scenario 6 addressed the issues of providing flora and fauna habitat along with the practical consideration of established urban development near the river banks in Picton.
costs

- revegetation and planting
- electric fencing
- loss in income from 50 metre wide riparian land
- land acquisition in Picton and in the new residential development
- pump costs for supplying river water to stock
- some phosphorus removal costs by sewerage treatment plant

benefits

- avoided loss of income from erosion of riverbanks
- increase of 10% in recreational benefits from current situation
- some avoided cost of phosphorus removal
- avoided health costs

Scenario 7; 10 metre riparian land, no stock access, habitat purchase.
Scenario 7 addressed the issue of providing flora and fauna habitat while minimising the impact of rehabilitating riparian land to riparian landholders.
costs

- revegetation and planting
- electric fencing
- loss in income from 10 metre wide riparian land
- land acquisition in Picton
- pump costs for supplying river water to stock
- health costs incurred due to deteriorating water quality
- some phosphorus removal costs by sewerage treatment plant
- acquisition, fencing and regeneration of 200 hectares

benefits

- avoided loss of income from erosion of riverbanks
- avoided loss of recreational benefits from base case to current situation
- some avoided cost of phosphorus removal

3.4 Results

The results of the benefit cost analysis are summarised in Table 1, which shows the benefit cost ratios and net present values for each scenario. Scenarios 1, 4, 5 and 6 produced positive benefit cost ratios at a 7% discount rate. The greatest positive net present value of $7.5 million was given by scenario 1.

Table 1

Riparian land management scenarios
Benefit cost ratios and net present values
Discount rate 7%

	scenario	benefit cost ratio	net present value $
1	swimming pool	3.6	7,508,901
2	erosion control	0.1	(9,160,521)
3	10 metres, no stock access, no land acquisition	0.2	(8,233,476)
4	20 metres, no stock access	2.0	6,791,108
5	20 metres, partial stock access	2.1	6,866,187
6	50 metres, 10 metres in Picton	1.3	3,771,700
7	10 metres, no stock access, habitat purchase	0.2	(17,017,202)

These results must be considered in perspective given the assumptions on water quality and recreationists' behaviour. Note that non use and habitat values (as possibly obtained by the contingent valuation method) were not included. It would be reasonable to expect these benefits would move the benefit cost ratios upwards, particularly for scenario 7.

The benefit cost ratio and net present value for scenario 1 were the highest. However this scenario did not address the underlying problems of declining water quality, bank erosion, reduced wildlife habitat and loss of archaeological and heritage sites.

Scenario 2 only addressed the erosion problem in riparian lands and excluded the costs of fencing, revegetation and loss of income. Scenario 3 was assumed to have little impact on benefits from improved water quality. Scenarios 4, 5 and 6 reflected benefits from improved water quality on recreational use and the health benefits of improved water quality.

In contrast scenario 7 appeared to have a low benefit cost ratio but did not include the non use benefits that would presumably have occurred through improvement in habitat for endangered species. As for scenario 3, it was assumed that 10 metre riparian width did not have sufficient positive impact on water quality to influence health costs. This could have been a conservative approach with benefits understated.

3.5 Sensitivity Analysis

Sensitivity analysis indicated the effect of a change in a significant variable on the results. Table 2 shows the effects of altering discount rates to 4% and 10 % on the benefit cost ratios. Appendix 1 indicates the effects of increases and decreases in gross margins, recreation benefits, changes in revegetation establishment costs, sewerage treatment plant costs and health costs. Scenarios 4, 5 and 6 maintained their positive net present values throughout these variations.

Table 2

Riparian land management scenarios
Benefit cost ratios
Discount rates 4%, 7% and 10%

	scenario	benefit cost ratio 4%	7%	10%
1	swimming pool	3.7	3.6	3.5
2	erosion control	0.1	0.1	0.1
3	10 metres, no stock access, no land acquisition	0.3	0.2	0.2
4	20 metres, no stock access	2.3	2.0	1.8
5	20 metres, partial stock access	2.4	2.1	1.8
6	50 metres, 10 metres in Picton	1.5	1.3	1.2
7	10 metres, no stock access, habitat purchase	0.2	0.2	0.2

With respect to changes in discount rates, scenarios 4, 5 and 6 appeared sensitive. Changes of +50% and - 50% in gross margins had little impact on benefit cost ratios while similar changes in revegetation costs had a small impact on final benefit cost ratios. This scale of change in sewerage treatment plant costs had a significant impact on the benefit cost ratios of scenario 1 only. The ratios were sensitive to similar changes in recreation benefits as shown in Table 3.

Table 3

Change in recreation benefits
Benefit cost ratios at 7% discount rate

	scenario	benefit cost ratio 7%	50% increase	50% decrease
1	swimming pool	3.6	4.1	3.2
2	erosion control	0.1	0.2	0.1
3	10 metres, no stock access, no land acquisition	0.2	0.3	0.2
4	20 metres, no stock access	2.0	2.4	1.7
5	20 metres, partial stock access	2.1	2.4	1.8
6	50 metres, 10 metres in Picton	1.3	1.6	1.1
7	10 metres, no stock access, habitat purchase	0.2	0.3	0.1

3.6 Summary

This benefit cost analysis of riparian land management options in Wollondilly Shire indicated that scenarios 1, 4, 5, and 6 had benefits consistently outweighing the costs. If non use values for improved habitats were to be obtained using the contingent valuation methodology, the expectation would be of stronger benefit cost ratios, particularly for scenario 7.

However there must be caution in interpreting the results given both the sensitivities of the analysis to recreation benefits and health costs, and the broad assumptions underlying this calculation of benefits. The study was useful in identifying and quantifying the impacts of riparian land options. It also highlighted the difficulties in quantifying some benefits without extensive technical data.

To summarise, implementation of the riparian land management options considered in scenarios 4 to 7 (given the anticipated habitat existence benefits) in this study would benefit the immediate community and the broader community as Wollondilly becomes a leader in recognising the benefits of rehabilitating riparian lands

3.7 Regression Analysis

Water quality of oceans, beaches and rivers is of major concern to the general public (EPA 1994c, Hill 1994, Imber et al 1991, David 1971). The riparian land management options study assumed that people responded to a perceived change in water quality, so that a decline in water quality was reflected in a change in the number of visitors to the recreation areas.

However, there are other factors influencing the visitor numbers to the area; entry fees to the site, weather conditions, seasonality (summer or winter), distance to the recreational area and income level of visitors. The major factors influencing visitor numbers to Bents Basin recreational area were studied.

Data

The study was based on data from secondary sources. Number of visitors to the Bents Basin State Recreation Area and entry fees were obtained from the Bents Basin office. This information was available for the period from December 1986 to June 1994. Number of rainy days in the region was obtained from the Bureau of Meteorology. Information regarding perceived water quality was obtained from local press articles. Average weekly earnings and petrol prices were obtained from the ABS publications.

Method

A regression model was developed to examine the factors influencing the number of visitors to the recreation site. The factors considered in the model were; water quality in the Hawkesbury-Nepean river, number of rainy days in the region, average weekly earnings, entry fees to the recreation area, petrol prices, seasonality (summer or winter), and school holidays.

It was hypothesised that visitor numbers to Bents Basin State Recreational Area depend on the above factors as follows;

$$VN = \alpha - RD - WQ + AWE + EF - PP + S + SH$$

Where VN = Number of Visitors
RD = Rainy Days
WQ = Water Quality
AWE = Average Weekly Earnings
EF = Entry Fees to Bents Basin
PP = Petrol Prices
S = Seasonality
SH = School Holidays

SAS computer package was used to analyse the regression model.

Visitor numbers were regressed against the number of rainy days, water quality in the river, average weekly earnings, entry fees to the recreational site, seasonality (summer or winter), and school holidays. All the dollar values (average weekly earnings, entry fees and petrol prices) were expressed in real terms (1994 values).

Visitor numbers (VN) - monthly visitor numbers to Bents Basin during the period December 1986 to June 1994 were used as the dependent variable.

Number of rainy days (RD) - this variable considered the number of rainy days in a particular month during the period from December 1986 to June 1994. This was assumed to negatively influence the number of visitors.

Water quality (WQ) - Water quality was regarded as a factor in determining the visitor numbers. Number of visitors, especially those who visit for recreational activities like swimming and fishing is likely to depend on the water quality in a recreational site. Deterioration in water quality is assumed to reduce the number of visitors.

Since a suitable indicator of water quality was not readily available, a surrogate indicator was used in the model. It was assumed that the local paper articles which showed the deterioration of water quality would influence readers or visitors adversely and the visitor numbers would drop accordingly. Hence, a dummy variable for water quality (WQ) was included in the model: WQ was set equal to one (WQ=1) if there was an article highlighting the deterioration of water quality in a particular month, otherwise equal to zero. The variable WQ was expected to have a negative influence on the dependent variable (VN).

Average weekly earnings (AWE) - Average weekly earnings for New South Wales published quarterly by the ABS were used for this variable. These figures are issued only for February, May, August, and November months so for the other months this variable was included as a missing value. By including AWE in the model, it was assumed that the higher the gross income levels the greater the number of people visiting Bents Basin. Hence, AWE was expected to positively influence the visitor numbers.

Entry fees (EF) - Entry fees to the Bents Basin recreational site were also included in the model as a variable. It was assumed that higher entry fees would lower the number of visitors to the recreational site, reflecting the negative influence of entry fees on the visitor numbers.

Petrol prices (PP) - In order to examine the cost of travel on the visitor numbers, petrol prices were included in the model. Higher petrol prices w :re expected to negatively influence the number of visitors.

Seasonality (S) - Seasonality, considered to have two major seasons, summer and winter, was regarded as an influential factor in determining the number of people visiting a recreational site. Hence, a dummy variable (S) was included in the model to represent the seasonality. S was set equal to one (S=1), if it was a summer month, otherwise equal to zero. Variable S was assumed to be a positive influence on visitor numbers.

School Holidays (SH) - Generally, it was considered that more visitors go to recreational sites during school holiday periods than other periods. In order to examine the effect of school holidays, a dummy variable (SH) was included in the model: SH was set equal to one (SH=1) for a school holiday month, otherwise equal to zero. Variable SH was assumed to be positively related to visitor numbers.

Results

The results of the analysis showed that the variable school holidays (SH) is a linear combination of other variables. Hence, a sub set (without variable SH) of the original model which is of full rank was chosen automatically for further analysis by the SAS program.

The estimated regression line is as follows;

$$\underset{(3659.5)}{VN = 1637.77} - \underset{(24.1)}{73.78RD} - \underset{(200.9)}{9.98WQ} + \underset{(6.3)}{0.89AWE} - \underset{(46.6)}{127.46EF} - \underset{(15.6)}{8.23PP} + \underset{(177.0)}{826.79S}$$

* The figures in parentheses are standard errors.
DW - 1.60

The model has an R-squared value of 0.67, meaning that about 67 percent of the variation in the visitor numbers is explained by the variables included in the model. The computed F value of 6.01 is significant at 0.001. Therefore the joint hypothesis (the true partial slope coefficients are zero) can be rejected, i.e. the number of visitors does depend on the variables included in the model. Further, the estimated regression model has hypothesised a relationship between visitor numbers and other variables included in the model. However, only three variables; rainy days, entry fees and seasonality were highly significant at a 1% significance level (Table 4).

Table 4.

Variable	Parameter Estimate	Standard Error
Intercept	1637.77	3659.55
RD	-73.78	24.09
AWE	0.89	6.28
EF	-127.46	46.59
PP	-8.23	15.58
S	826.79	177.02
WQ	-9.98	200.88

The stepwise regression analysis also revealed that of the independent variables, only RD, EF, and S contributed significantly to an explanation of the dependent variable, visitor numbers. The R-squared was 0.66 and the estimated F value of 13.67 is significant at 0.0001 level. The resulting function is;

$$VN = 1534 - 71RD - 129EF + 807S$$
$$(253.4)\quad(21.1)\quad(43.0)\quad(137.6)$$

* The figures given in parentheses are standard errors.

Discussion

The resulting R-squared values were disappointing. Independent variables may not truly represent the characteristics of the sample of visitors used in the dependent variable. Average weekly earnings data were of NSW population averages and not of the visitors considered in the model. The results would have been more realistic if information on the income levels of visitors was available.

Petrol prices were used as a variable to represent travel cost to the recreational site. For local residents the cost of travelling may not be a major factor in visiting Bents Basin so that petrol prices were not reflecting the true travel cost of the visitors in a particular month. As with average weekly earnings, using the actual travel cost of visitors in the analysis would produce more accurate results especially for the R-squared.

Most visitors to Bents Basin lived in the Penrith City Council area, followed by the Liverpool and Fairfield local government areas. Hence, local newspaper articles on water quality in the Hawkesbury-Nepean River were used to represent the visitors' perception of the water quality in the recreational area. Even though swimming was the major activity of visitors to Bents Basin, not all visitors to the area would be concerned about water quality depending on the purpose of their visit. Those visiting the area for swimming or fishing presumably would be more concerned about the water quality than those who visited for other activities like picnicking and barbecuing.

Possibly there is only a tenuous link between perceived water quality in the Hawkesbury -Nepean River and Bents Basin. In fact, Bents Basin has not had water quality problems over the period 1990-1994 (Kerr personal comm., EPA 1994d) and although the earlier period of the study was not so heavily sampled, no water quality problems are known. Walker and Greer (1992) certainly indicated that visitors to the Hawkesbury-Nepean River altered their recreation behaviour in the presence of non toxic blue-green algae in the river and negative publicity. Their study showed that negative media attention had far reaching effects in terms of time and distance on visitor numbers to the river.

4 Conclusion

Applying a range of possible scenarios of riparian land management to the case study of Wollondilly Shire indicated not only the magnitude of costs and benefits but also the difficulties in quantifying them. The rehabilitation of riparian lands can be expensive to those incurring the costs of revegetation, fencing and loss of agricultural income. However, considerable community benefits can be reaped from enhanced wildlife habitats and reduced health costs due to the consequent improved water quality. The study showed that positive net present values can be expected even without quantification of non use values.

The methodology used in the Wollondilly case study can be applied to similar evaluations in other regions. Variations in benefits and costs will occur due to site characteristics and major purposes of the riparian land, and with data availability. While difficulties exist in determining and quantifying certain benefits and costs, identification and some quantification are necessary to establish the impact of proposed riparian land management policies.

This information provides the basis for policy development and implementation. The study clearly supports the concept of riparian land management while demonstrating the wide range of options involved and the complexity of valuation. The methodology is transportable and can be readily applied to other case studies.

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Appendix 1 Wollondilly Riparian Land Case Study

Sensitivity Analysis

Table A indicates that changes in gross margins had little impact on overall ratios for the combined three areas within the case study. However, in some local areas changes in gross margins may have significant impacts.

Table A

Change in gross margins
benefit cost ratios at 7% discount rate

	scenario	benefit cost ratio 7%	50% increase	50% decrease
1	swimming pool	3.6	3.6	3.6
2	erosion control	0.1	0.1	0.1
3	10 metres, no stock access, no land acquisition	0.2	0.2	0.2
4	20 metres, no stock access	2.0	1.9	2.2
5	20 metres, partial stock access	2.1	2.0	2.2
6	50 metres, 10 metres in Picton	1.3	1.2	1.5
7	10 metres, no stock access, habitat purchase	0.2	0.2	0.2

Table B indicates that changes in revegetation establishment costs had a small impact on benefit cost ratios.

Table B

Change in revegetation establishment costs
benefit cost ratios at 7% discount rate

	scenario	benefit cost ratio 7%	50% increase	50% decrease
1	swimming pool	3.6	3.6	3.6
2	erosion control	0.1	0.1	0.1
3	10 metres, no stock access, no land acquisition	0.2	0.2	0.3
4	20 metres, no stock access	2.0	1.9	2.2
5	20 metres, partial stock access	2.1	1.9	2.3
6	50 metres, 10 metres in Picton	1.3	1.2	1.5
7	10 metres, no stock access, habitat purchase	0.2	0.2	0.2

Table C indicates that a 50 % change in sewerage treatment plant costs had a significant impact on the benefit cost ratios of scenarios 1, but little impact on the rest of the scenarios.

Table C

Change in sewerage treatment plant costs
benefit cost ratios at 7% discount rate

	scenario	benefit cost ratio 7%	50% increase	50% decrease
1	swimming pool	3.6	2.6	5.9
2	erosion control	0.1	0.1	0.1
3	10 metres, no stock access, no land acquisition	0.2	0.3	0.2
4	20 metres, no stock access	2.0	2.1	2.1
5	20 metres, partial stock access	2.1	2.1	2.1
6	50 metres, 10 metres in Picton	1.3	1.4	1.3
7	10 metres, no stock access, habitat purchase	0.2	0.2	0.2

Table D indicates that the benefit cost ratios were sensitive to changes in recreation benefits, which were treated in the study as a benefit of improved water quality.

Table D

Change in recreation benefits
benefit cost ratios at 7% discount rate

	scenario	benefit cost ratio 7%	50% increase	50% decrease
1	swimming pool	3.6	4.1	3.2
2	erosion control	0.1	0.2	0.1
3	10 metres, no stock access, no land acquisition	0.2	0.3	0.2
4	20 metres, no stock access	2.0	2.4	1.7
5	20 metres, partial stock access	2.1	2.4	1.8
6	50 metres, 10 metres in Picton	1.3	1.6	1.1
7	10 metres, no stock access, habitat purchase	0.2	0.3	0.1

Table E indicates that the benefit cost ratios are sensitive to the calculated level of health benefits, which were included as an avoided cost in scenarios 1, 4, 5 and 6.

Table E

Change in health benefits
benefit cost ratios at 7% discount rate

	scenario	benefit cost ratio 7%	50% increase	50% decrease
1	swimming pool	3.6	5.0	2.3
2	erosion control	0.1	0.1	0.2
3	10 metres, no stock access, no land acquisition	0.2	0.2	0.4
4	20 metres, no stock access	2.0	2.7	1.5
5	20 metres, partial stock access	2.1	2.7	1.5
6	50 metres, 10 metres in Picton	1.3	1.7	1.0
7	10 metres, no stock access, habitat purchase	0.2	0.2	0.2