# CATCHMENT BENEFITS OF REMNANT NATIVE VEGETATION CONSERVATION

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Land & Water Resources
Research & Development Corporation

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SEVENTH REPORT OF THE PROJECT
*Economics of remnant native vegetation conservation on private property*

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**Reports of the project *Economics of remnant native vegetation conservation on private property***

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Report 4
Walpole, S., Lockwood, M., Miles, C.A. (1998) *Influence of remnant native vegetation on property sale price*. Johnstone Centre Report No. 106. Johnstone Centre, Albury.

Report 5
Miles, C.A., Lockwood, M., Walpole, S., Buckley, E. (1998) *Assessment of the on-farm economic values of remnant native vegetation*. Johnstone Centre Report No. 107. Johnstone Centre, Albury.

Report 6
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As at September 1999, copies of Reports 3, 6, and 7 were available from Michael Lockwood, PO Box 789 Albury, 2640, Phone (02) 6051 9884. Reports 1, 2, 4 and 5 are out of print. Reports 4 and 5 are available by email - contact mlockwood@csu.edu.au

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## Abstract

Based on information available from neighbouring projects, and studies undertaken for the whole Murray-Darling catchment, the following catchment-level costs incurred by individuals, non-agricultural businesses and public utilities due to rising water tables and decreased water quality were calculated for the Northeast Victoria and the Murray catchment in NSW:

- costs of remnant vegetation clearance to local government;
- costs of remnant vegetation clearance to non-farm businesses;
- costs of remnant vegetation clearance to urban households; and
- cost of carbon dioxide release following clearing.

Based on a 7% discount rate and a 40 year time period, the possible benefits of retaining RNV in the NSW study area that might otherwise be cleared were \$4.31 million for local government, \$0.08 million for non-farm business, \$0.15 million for private households, and \$3.27 million for the broader community in terms of carbon sequestration. The possible benefits of retaining RNV in the Victorian study area were \$0.21 million for local government, \$0.32 million for non-farm business, \$0.05 million for private households, and \$6.84 million for the broader community in terms of carbon sequestration.

## 1. Introduction

The widespread clearance of native vegetation has been identified as one of the major environmental issues facing Australia, significantly impacting on agriculture in both physical and economic terms. Impacts of clearing include dryland salinity, weed invasion, soil erosion, soil structural decline and the loss of species (Nadolny *et al.* 1991, ABS 1992). In addition, the non-agricultural community has also incurred significant costs due to land clearing, with numerous inland urban communities being affected by decreased water quality and damage to public and private infrastructure through rising water tables.

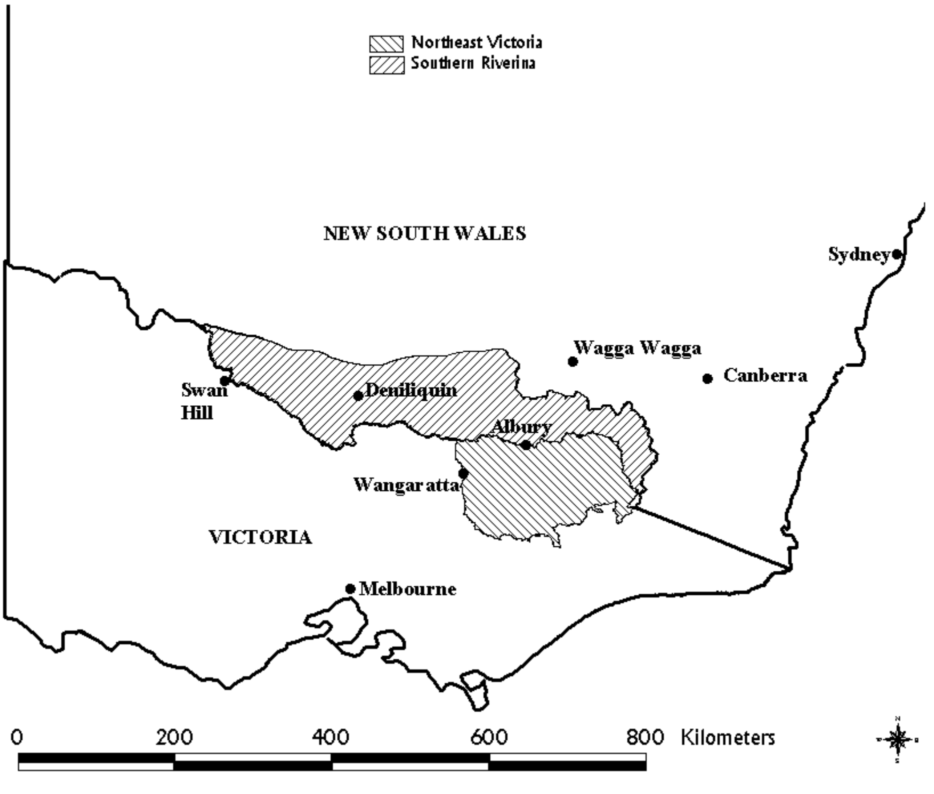
Remnant native vegetation (RNV) is the term used in this study to describe those patches of bushland which remain on private property following the widespread clearance of native vegetation. While there are numerous benefits of conserving RNV, there are also significant costs involved with the management of these areas. Data on these costs and benefits has been scarce - a deficiency that is impeding development of rational policies which are both acceptable to landholders and adequately address community demands for the public good benefits afforded by RNV. It has been a major purpose of the project *The economics of remnant native vegetation conservation on private property* to fill this data gap for two study areas: Northeast Victoria and the Murray Catchment Management Area in southern NSW (Figure 1). Previous reports have assessed community willingness to pay for RNV conservation (Lockwood & Carberry 1998), impacts of RNV on property values (Walpole *et al.* 1998) and on-farm costs and benefits (Miles *et al.* 1998). This report focuses primarily on the off-site effects of RNV clearing - that is, those which occur or are experienced away from the site of the action causing degradation. The goal of this study is to assess the market benefits of conserving RNV at the catchment level so that this information can be considered in policy development.

Dryland salinity and soil erosion are the two main degradation types that may be exacerbated by continuing RNV decline, and may have an impact on downstream rural and urban populations. This report reviews the theoretical basis of determining the off-site impacts of RNV decline, and examines previous attempts to estimate off-site values. The results of catchment benefits for the two study areas are then presented, followed by a comparison of these values with other costs and benefits of RNV conservation.

### 1.1 Study areas and RNV conservation scenario

RNV in the two study areas was identified using remote sensing in conjunction with field surveys. The Victorian study area covers 1,880,056 ha, including 113,313 ha of RNV; 1,205,498 ha of forested public land; 8,000 ha of private pine plantations; and 553,245 ha of predominantly cleared private land. It contains three catchment basins, the Upper Murray, Kiewa and the Ovens. The NSW study area covers 3,643,686 hectares, including 203,429 ha of RNV; 381,076 ha of forested public land; 15,896 of private pine plantations; and 3,043,285 ha of predominantly cleared private land. Topography in the study areas varies from alpine high plains, steep mountain ranges in the south and east, to intermediate hilly areas which drop to flat or gently undulating plains to the west.

**Figure 1 Study areas**



The assessment of on-site benefits was based on improving the conservation status of RNV in the two study areas as described in Table 1. An identical scenario is also being used to assess community and on-farm values.

**Table 1. RNV conservation scenario**

| *Scenario* | *Consequences* |
|---|---|
| Current situation maintained | • RNV on some properties is extensively grazed and/or used for timber products[1]<br>• RNV on some properties is not fenced[1]<br>• Some landholders have intentions to clear over the next 10 years (7,174 ha in Victoria and 3,425 ha in NSW)<br>• Biodiversity decline will continue on some properties |
| Improved RNV conservation scenario | • Fence largest RNV block on each property where this is currently unfenced<br>• Prohibit all RNV clearing<br>• Allow grazing consistent with biodiversity conservation[2]<br>• Allow collection of firewood and posts consistent with biodiversity conservation[3]<br>• Rate of biodiversity decline will be reduced |

[1] See Miles *et al.* (1998a) for details.

[2] Based on limiting grazing to a maximum of 10 weeks per year. Details of grazing regimes consistent with achieving biodiversity outcomes need to be determined according for the particular requirements of each vegetation type. At present such detail is unavailable.

[3] Limit firewood and post extraction to a maximum of 0.5 tonne/ha/year. Miles *et al.* (1998a) also assessed the on-farm costs of excluding timber extraction altogether.

## 1.2 Externalities and the public good values of RNV

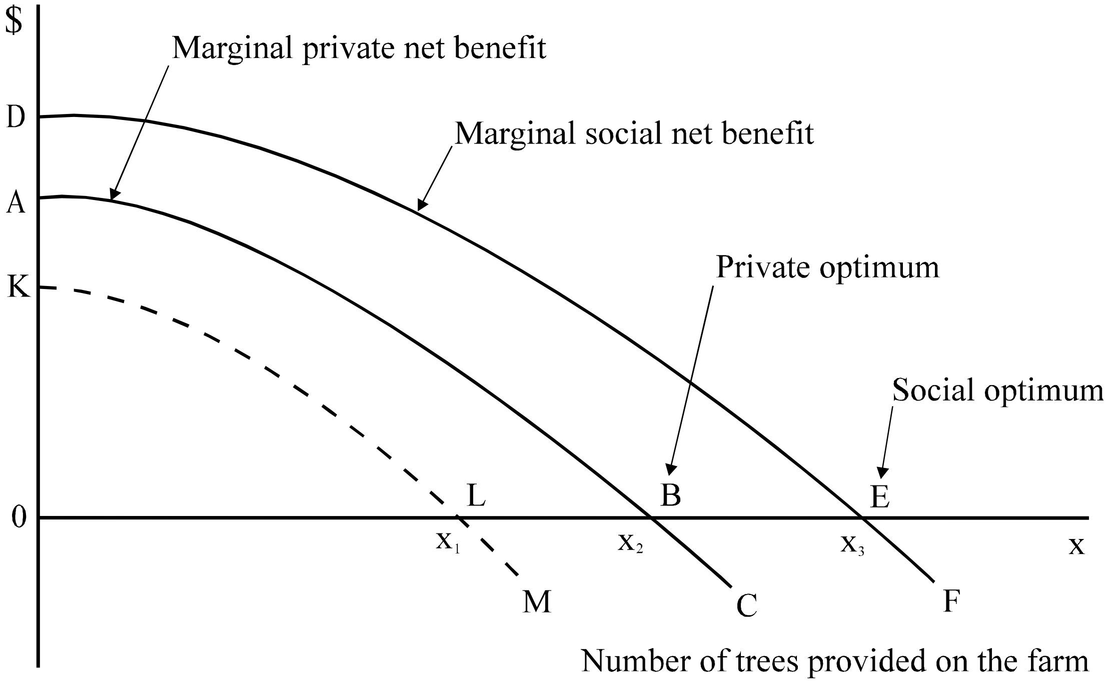
A market externality is said to arise when a market transaction effects on the quality or quantity of goods and services not directly involved in that transaction. Externalities can be either positive or negative. An example of a positive externality is the benefit that upstream forest owners provide to downstream farmers in the form of a steady water supply made possible by a forested watershed. Logging of forests on the other hand has negative 'spillovers' on downstream activities such as farming, irrigation, transport and industry, in the form of flooding, sedimentation, and irregular water supply (Panayotou 1992).

Externalities can relate to costs imposed on others as a result of particular land use practices. In relation to RNV, an example of a negative externality is where a landholder clears an area of bush in order to increase his/her area of land for production. The costs from this action such as loss of biodiversity, rising of water tables and lowered water quality downstream, are borne by downstream landholders and society as a whole. There is no incentive for the upstream landholder to consider these costs as they do not have a negative impact on their profitability. Private returns therefore diverge from social returns. Those landholder who do take external costs into account are at a disadvantage to competitors who do not.

Unlike a pure public good, such as air quality, RNV is actually a mixed good, having elements of both private and public goods. An area of RNV may be owned and managed by an individual for private gain, but the public also receive the benefits of management, or the costs of mismanagement. Private goods related to RNV may include things like household firewood, timber, or production benefits from shade or shelter for stock. Public goods associated with RNV may include landscape aesthetics, wildlife habitat or improved water quality.

Since areas of RNV incorporate characteristics of public goods, markets will not necessarily provide a sufficient supply of that good. Ultimately the private owner of the remnant will determine the level of supply. When external costs are not included in the value that landholders place on a resource, it is likely that economically inefficient land practices will occur. Decisions made by individual landholders, based on free market principles, will result in an under-supply of public goods such as RNV. The combined demand for private and public values for conserving RNV is essentially much greater than the private demand for conserving RNV. Figure 2 illustrates a hypothetical situation, with curve ABC representing the marginal private net benefit of tree provision on a property, and curve DEF representing the marginal social net benefit. Here private net benefits are maximised when $x_2$ trees are on the property, while society would prefer to see $x_3$ trees retained. However, some landholders may fail to realise the actual extent of private benefits from trees on their farms, illustrated by the curve KLM, and thus may only maintain $x_1$ trees on the property. Tisdell (1984) suggested that the private optimal amount of tree retention ($x_2$) could be achieved if improved information and community support were provided. To ensure a socially optimal supply of trees $x_3$, some additional government intervention is required. This may take the form for example, of regulations that require a certain level of tree retention, or the provision of publicly funded incentives to conserve RNV on private land.

**Figure 2. Possible divergence between the private and social optimum in tree provision on farms** (Tisdell 1984)



## 1.3 Examples of off-site value estimates

Australian studies undertaken to estimate the off-site or catchment level impacts of land degradation are summarised in Table 2. The majority of these studies do not attempt to directly attribute levels of tree clearing to the subsequent degradation damage. However, it is widely accepted that the fundamental cause of dryland salinity is the removal of deep-rooted perennial vegetation and replacement with shallow-rooted crops and annual pastures (CIE 1998). It is not possible to make this direct link between tree clearance and soil erosion, as subsequent agricultural practices such as cultivation and overgrazing following clearing, will also contribute to this type of degradation.

One of the original attempts to place an economic value directly on the cost of tree clearing in Australia was undertaken by Greig & Devonshire (1981). Their estimates were based on the assumption that the retention of tree cover would prevent increases in costs to downstream households who would otherwise be forced to use more saline water. Their analysis involved estimating a hydrological function for water salinity based on tree cover, geology and rainfall data from 56 Victorian catchments. Based on the coefficients determined for this function, the increase in salinity that would follow a one percent reduction in tree cover for the Loddon catchment was calculated to be 6.2 mg/l. The additional costs to domestic households from this increase were then calculated on the basis of the decreased service life, increased operation costs, maintenance and repairs of water-using appliances, and use of soaps and cleaners. This cost was estimated to be 13.3 cents/household/year for each mg/l increase in dissolved salt, or $1,829/year for all households in the catchment. This estimate does not include the cost to industrial, agricultural and recreational water users, as these were not considered to be significant.

We do not have the biophysical information required to replicate the method developed by Greig and Devonshire (1981) for the two study areas. We are, however, able to apply the Oliver *et al.* (1996), Lubulwa (1997) and Whish-Wilson & Shafron (1997) estimates to our Northeast Victoria and Murray catchment study areas (Sections 2.1 to 2.3).

## 1.4 Extent of salinity in the study areas

In the Murray catchment area, salinity has been reported in most parts of the catchment. According to Toohey & Associates (1996), the Murray catchment is affected by dryland salinity in the Mullengandra, Deadmans, Majors and Bowna Creeks and surrounding Hume Weir. Further west in the irrigated parts of the catchment, the watertable is within 2 metres of the surface for 46,300 ha of land, and at the current rate of groundwater level rise this area is predicted to increase to 331,400 ha by 2020 (Toohey & Associates 1996). Oliver *et al.* (1996) conducted surveys of local government authorities in which each council was asked to estimate the area of their shire affected by salinity. The results for those NSW local government areas in the Murray catchment are given in Table 3.

## Table 2. Summary of estimated off-site costs of land degradation associated with tree clearing

| *Type of impact* | *Location* | *Cause of cost* | *Year of estimate* | *Annual cost* | *Reference* |
|---|---|---|---|---|---|
| Soil erosion | Eppalock catchment, Victoria | Maintenance costs for roads, bridges and water supply | 1974/75 | $15, 000 - 30,000 | Dunn & Gray (1978) |
| Stream salinity | Loddon catchment, Victoria | Damage to household equipment | 1980 | $4.40/ha | Greig & Devonshire (1981) |
| Salinity | Victoria | Downstream water quality effects | 1990 | $7.3m | Dumsday & Oram (1990) |
| Salinity | Northern and Western Victoria | Damage to household equipment | 1984 | $2.9m | Salinity Committee (1984) |
| Salinity | South Australia | Damage to household equipment | 1984 | $7.2m | Peck *et al.* (1983) |
| Salinity | Bendigo, Ballarat and Horsham area, Victoria | Damage to roads | 1983 | $1.1m | Salinity Committee (1984) |
| Soil erosion | Public utilities in NSW | Damage to bridges and roads, restoration of coastal sand drift | 1983 | $10.7m | Barter (1986) |
| Salinity/ soil erosion | Coorong & District, South Australia | Public infrastructure maintenance | 1997 | $0.4m | CDLAPSC (1997) |
| Soil erosion | Queensland | Damages to urban water supplies, drainage maintenance, silt removal, dredging | 1988 | $31.3m | Russell *et al.* (1990) |
| Salinity | Murray Darling Basin | Repairs and maintenance of infrastructure | 1993 | $8.2m | Oliver *et al.* (1996) |
| Salinity | Loddon and Campaspe catchments, Victoria | Damage to household equipment | 1995 | $0.67/ h'hold | Lubulwa (1997) |
| Salinity | Loddon and Campaspe catchments, Victoria | Damage to non-farm business equipment | 1995 | $26/ business | Whish-Wilson & Shafron (1997) |
| Salinity | Loddon and Campaspe catchments, Victoria | Cost of reduced agricultural production attributable to salinity | 1995 | $19.6m | Whish-Wilson & Shafron (1997) |

**Table 3. Areas affected by salinity for NSW local government areas** (Oliver *et al.* 1996)

| *Local Government Area* | *Area affected by salinity (%)* |
|---|---|
| Albury | <5 |
| Berrigan | >20 |
| Conargo | >20 |
| Corowa | no data |
| Culcairn | 15-20 |
| Holbrook | <5 |
| Hume | 15-20 |
| Lockhart | 5-10 |
| Murray | <5 |
| Tumbarumba | no data |
| Urana | no data |
| Wakool | >20 |
| Windouran | <5 |

In Northeast Victoria, the presence of salinity has been recorded in the Indigo, Springhurst, Everton, Murmungee, Bobinawarrah, Tarrawingee, Londrigan, Oxley, Lower Ovens, Boorhaman, and Rutherglen areas, as well as in the urban areas of Wangaratta and Wodonga (North East Regional Catchment and Land Protection Board 1997). The estimated salt-affected area for Northeast Victoria was 250 ha in 1988 (Government of Victoria 1991), but had increased to 2,500 ha by 1996 (Lumsdon & Reid 1996). According to Croome (1998), saline discharge areas in Northeast Victoria are increasing at around 6 percent per annum, and are predicted to affect 12,000 hectares within 30 years if there is no intervention. Steeply rising groundwater levels (20-100 cm/year) in the riverine plain terraces in the Ovens basin have been reported by Lumsdon & Reid (1996), who predicted that there will be a similar trend in groundwater rises in other parts of the catchment where extensive clearing has occurred. The extensive clearing of native vegetation was given as the primary cause of the increased groundwater accessions. However, in the Oliver *et al.* (1996) survey, the nine Victorian councils who responded (out of the 11 pre-1996 local government areas), all stated that they had either no problems with salinity or rising water tables, or were unaware of any problems.

## 1.5 Water quality in the study areas

Two indicators of water quality that relate to RNV conservation are turbidity and salt loads, that latter being measured by electro-conductivity (EC). The Victorian Office of the Commissioner for the Environment Guidelines classify median salinities of less than 100 EC units as being ‘excellent’ for a plains river (NECMA/OBWQWG 1998). The Northeast Victorian catchment consists of the Upper Murray, Ovens and Kiewa Basins, from which the Mitta Mitta, Kiewa, and Ovens Rivers flow into the Murray River. The three river basins contribute 38 percent of the total water to the Murray-Darling system (NERCLPB 1997). The Upper Murray, Kiewa, Ovens and their tributaries are fed by groundwater inflows in the upper catchments. The rivers and streams in the upper and footslope parts of the catchment are generally clear, but become turbid in the floodplain areas (Government of Victoria 1995). Riparian RNV is particularly important for minimising the introduction of sediment into waterways. Water quality observations conducted in 1993 (Croome 1998) indicated baseline EC values of 40 to 50 μS/cm in the upper reaches of the Ovens River, increasing to 100 μS/cm in the middle and lower reaches of the river under reduced discharge conditions.

The NSW Murray catchment consists of the Murray River and its tributary (the Billabong Creek, which contributes flows via the Edward and Wakool Rivers) to a point where it is joined by the Darling River, near Wentworth. The catchment area above Hume Dam contributes 25 percent per annum of the total inflow to the Murray, while the Billabong Creek contributes around 2 percent of the total water entering the Murray (Toohey & Associates 1996). Water EC measurements show a gradual increase in salinity from the upper catchment (Murray River at Jingellic median EC of 42 μS/cm) to the lower end of the catchment (Murray River downstream of Wakool Junction median EC 280 μS/cm) (Department of Land and Water Conservation 1995). Turbidity in the Murray River also increases from the upper to the lower end of the Murray catchment (Toohey & Associates 1996). This increase in turbidity can be attributed in part to the more turbid inflow from the Ovens River in Northeast Victoria.

The rate by which salinity levels are increasing is unknown. However, rapid rises in salinity are likely in some areas, particularly in the southwest of the Murray catchment. A salinity audit has recently been undertaken by the Murray-Darling Basin Commission, which will provide information on the rates of watertable rise by geologic unit for areas within the Murray-Darling Basin in NSW and the percentage of land likely to be salt-affected in the future for areas within the Murray-Darling Basin in Victoria. Unfortunately this information was unavailable at the time of writing this report.

## 2. Costs of remnant vegetation clearance at the catchment level

The catchment-level costs incurred by individuals, non-agricultural businesses and public utilities due to rising water tables and decreased water quality are relatively easy to identify and therefore tangible costs associated with this damage are readily determined (Eberbach 1998). Based on information available from neighbouring projects, and studies undertaken for the whole Murray-Darling catchment, the following costs were calculated for the Northeast Victorian and Murray catchments:

- costs of remnant vegetation clearance to local government;
- costs of remnant vegetation clearance to non-farm businesses;
- costs of remnant vegetation clearance to urban households; and
- cost of carbon dioxide release following clearing.

The analysis of on-farm economic values associated with RNV (Miles *et al.* 1998) included estimates of the benefits RNV contributes to controlling land degradation within each property. Over a 40 year period, at a discount rate of 7%, these benefits were estimated to be \$66.5 million for the Murray catchment and \$34.1 million for Northeast Victoria. It is not possible to extend this contribution to neighbouring properties with any degree of confidence. We have therefore left this value component out of our analysis, recognising that in doing so, some underestimation of net benefits will result.

## 2.1 Costs of remnant vegetation clearance to local government

As noted above, in 1994-95, the Australian Bureau of Agricultural and Resource Economics surveyed local government councils within the Murray-Darling basin to determine the impacts of salinity and rising water tables on infrastructure (Oliver *et al.,* 1996). Eight of the fifteen councils in the Murray catchment indicated that they had made repairs and maintenance expenditure due to salinity/rising water tables totaling $862,200. A summary of this expenditure is given in Table 4.

**Table 4. Local government annual repairs and maintenance expenditure due to salinity/rising water tables for the Murray catchment**

| *Feature* | *Expenditure ($)* |
|---|---:|
| Roads and bridges | 855,100 |
| Sewerage pipes and disposal systems | 3,700 |
| Other | 3,400 |
| **TOTAL** | **862,200** |

All Northeast Victorian councils indicated that they had no repairs and maintenance expenditure related to salinity and rising water tables. However, based on the information on salinity levels (Section 1.3), it is reasonable to assume that some costs are currently being incurred, but have not been attributed by councils to salinity. According to Oliver *et al.* (1996) annual average expenditure due to salinity and rising water tables was $149,000 for Victorian councils and $114,000 for NSW councils across the Murray-Darling basin. For the purposes of this analysis, it was assumed that an annual expenditure of $50,000 is being incurred by councils in the Victorian study area.

## 2.2 Costs of remnant vegetation clearance to non-farm businesses

Businesses located in areas affected by salinity and high water tables will incur costs related to damaged capital infrastructure and amenities. A study undertaken for the Loddon and Campaspe catchments (Whish-Wilson & Shafron 1997) found that the average annual cost for non-farm businesses affected by salinity and high water tables was $26. There are 3,994 non-farm businesses in the NSW study area, and 3,069 in the Victorian study area. These businesses include accommodation, construction, manufacturing/mining, services, and retail/wholesale. Our calculations of the costs due to salinity assume that the non-farm businesses in the upper parts of the catchment (east of Albury-Wodonga and south of Wangaratta) are not affected by salinity. This reduces the total number of non-farm businesses affected by salinity to 3,859 in the NSW study area, and 2,478 in the Victorian study area. Therefore, the total annual costs are $100,334 and $64,428, respectively. A summary of this expenditure is given in Table 5.

**Table 5. Business repairs and maintenance expenditure due to salinity/rising water tables for the NSW and Victorian study areas**

| | *Murray catchment* | *Northeast Victoria* |
|---|---|---|
| Total number of businesses | 3,994 | 3,069 |
| Number affected by salinity and high water tables | 3,859 | 2,478 |
| Annual cost per business ($) | 26 | 26 |
| **Total annual cost ($)** | **100,334** | **64,428** |

## 2.3 Costs of remnant vegetation clearance to urban households

The Australian Mineral Development Laboratories (AMDEL) assessed the cost to urban households of either repairing, maintaining or replacing items damaged by saline town water (Lubulwa 1997). The AMDEL study included the impact of salinity on pipework and water fittings, hot water heaters, domestic appliances, water softeners, detergents and soaps, clothing, motor vehicles, garden produce, pot plants and evaporative air conditioners. The 1995/96 salinity cost estimate was 0.67 ($/household/year/EC unit). These results can be used to estimate the costs to households from increases in EC units. The number of households in urban centres or localities in Northeast Victoria and the Murray catchment are given in Tables 6 and 7.

Our calculations of the cost to urban households due to salinity assume that the households in the upper parts of the catchments are not affected by salinity. Based on survey results for the Loddon and Campaspe catchments (Lubulwa 1997), it is also reasonable to assume that ten percent of all households have a rainwater tank, thus negating any salinity damage effects. This reduces the total number of households affected by salinity in the Northeast Victoria to 15,675, and in the Murray catchment to 23,357. The households in Swan Hill, Echuca, Moama and Barham were not included in the analysis, as it was not possible to separate the effects from the Goulburn/Broken and Loddon/Campaspe catchments. If it is assumed that at the current rate of clearing in the catchments, the annual increase in EC units is 1 µS/cm per year (1 EC unit), then the annual costs to all Northeast Victorian and Murray catchment households are $10,502 and $15,649 respectively.

The assumption of 1 µS/cm per year is likely to be very conservative, but there is no historical information available to give estimates of rates of change over time. To test the influence of this assumption, we also calculated the benefit estimates assuming a rate of 5 and 20 µS/cm per year. The annual costs to all Northeast Victorian and Murray catchment households are $52,511 and $78,246 respectively for an increase of 5 µS/cm per year and $210,045 and $312,984 respectively for an increase of 20 µS/cm per year. These values based on higher rates of salinity increase are used in Section 2.5 to test their effect on the final benefit estimates.

**Table 6. Number of households in Northeast Victoria** (CLIB96 1997)

| *Urban centre/locality* | *Number of households* |
|---|---|
| Barnawartha | 148 |
| Beechworth | 977 |
| Bellbridge | 111 |
| Bright | 639 |
| Chiltern | 407 |
| Corryong | 479 |
| Moyhu | 81 |
| Mt Beauty | 655 |
| Myrtleford | 1,047 |
| Porepunkah | 178 |
| Rutherglen | 706 |
| Tallangatta | 364 |
| Tangambalanga | 131 |
| Tawonga | 99 |
| Wahgunyah | 247 |
| Wangaratta | 6,067 |
| Wodonga | 9,290 |
| Yackandandah | 229 |
| **TOTAL** | 21,855 |

**Table 7. Number of households in the Murray catchment** (CLIB96 1997)

| *Urban centre/locality* | *Number of households* |
|---|---|
| Albury | 15,694 |
| Berrigan | 390 |
| Corowa | 2,050 |
| Culcairn | 418 |
| Deniliquin | 3,064 |
| Finley | 801 |
| Holbrook | 503 |
| Howlong | 613 |
| Jerilderie | 355 |
| Jindera | 259 |
| Khancoban | 148 |
| Lockhart | 342 |
| Mathoura | 263 |
| Moulamein | 185 |
| Mulwala | 594 |
| Tocumwal | 595 |
| Tumbarumba | 595 |
| Urana | 144 |
| Wakool | 84 |
| Walla Walla | 193 |
| **TOTAL** | 26,695 |

## 2.4 Carbon sequestration

Human activities such as the burning of fossil fuels and land clearing are increasing the levels of greenhouse gases such as carbon dioxide in the earth's atmosphere. Elevated levels of these gases is likely to cause global climate change. Forests act as 'sinks' that absorb carbon dioxide, thereby building up a store of carbon in trees, other plants and soil. When land is cleared, a large proportion of the stored carbon is rapidly converted back into carbon dioxide. Land clearing contributed about 13% of Australia's greenhouse gas emissions in 1996 (AGO 1998).

Preserving and increasing the area of forest can enable Australia to reduce emissions and meet international commitments under the Kyoto Protocol. As a signatory to the Protocol, Australia intends, in conjunction with other industrialised nations, to adopt binding national emission targets. Australia's annual emission allocation for the five year Kyoto commitment period, scheduled to begin in 2008, is equivalent to 108 per cent of 1990 emission levels, subject to adjustment for sinks and international transfers (AGO 1999).

The mechanisms necessary to implement the protocol are still being developed. One possibility being considered is to incorporate carbon sinks, such as forest plantations, into an emissions trading system by allocating credits for the amount of carbon sequestered (stored in plants). Plantation operators could sell these credits in an emissions trading system. Prevention of clearing RNV could also be considered as a carbon credit. The value of such carbon credits cannot be determined with certainty. Estimates place the value of permits at between \$10 and \$50 per tonne of carbon dioxide, with a mid-range of \$30 per tonne meaning that the value of Australia's emissions allocation under the Kyoto Protocol is about \$12 billion per year (AGO 1999).

Preventing clearing of RNV in the two study areas can make a small contribution to reducing greenhouse gas emissions. Carbon sequestration has been highlighted by the Centre for International Economics (CIE 1998) as the most important off-site use value of remnant vegetation. For the purposes of this study, it is useful to include an estimate of these benefits, although these values are clearly not restricted to the study areas.

An indicative value can be put on the carbon sequestration benefits of preventing RNV clearing by equating them with the estimated value of the equivalent carbon credits. For the purposes of this report, we have adopted the most conservative of the estimates reported in AGO (1999) of \$10 per tonne of carbon dioxide. After clearing, carbon is released from a site for a 20 year period, which results in around 180 tonnes of carbon dioxide being released from each cleared hectare of land (CIE 1998). Given a value of \$10/tonne carbon dioxide, the benefit of not clearing is \$1,800 per hectare. As noted in Table 1, landholders intend to clear 7,174 ha in the Northeast Victoria, and 3,425 ha in the Murray catchment over the next 10 years. Assuming that landholders will clear the entire area they indicated in the first year, the annual carbon sequestration benefit of not clearing would be \$645,660 per year and \$308,250 per year for the next 20 years for the Victorian and NSW study areas respectively.

## 2.5 Calculation of present values

The catchment benefits of conserving RNV were calculated as the difference between the costs incurred from the current management scenario and those likely to be incurred under the proposed conservation scenario (Table 1). These benefit estimates take into account to the relative contribution of RNV to water table levels and water quality compared with vegetation on public land, perennial pasture and tree planting on private land. The calculations drew on the work of the Murray-Darling Basin Commission (1996), that attributed the benefits of vegetation impact on the water table and water quality in proportion to the area of remnant vegetation occurring in the catchment. Of the tree cover in Northeast Victoria and Murray catchment, 8.5% and 33.9% respectively is RNV, with the balance being forested public land, hardwood and softwood plantations. For the purposes of this study, these values were used to indicate the proportional contribution RNV makes to the water table and water quality levels in the two study areas.

Based on the costs described in Sections 2.1 to 2.4, the present values of the catchment benefits (PVBs) due to retaining remnant vegetation are as indicated in Table 8. In order to facilitate comparisons with the value components estimated in Miles *et al.* (1998), the calculations have been undertaken for a 40 year time period. Values have been discounted at three rates - 4%, 7% and 10%. Given the relatively large contribution made by carbon sequestration, Table 8 also gives PVB estimates that exclude this value component. In addition, PVBs at a 7% discount rate were calculated for the alternative estimates of household expenses based on higher the EC values discussed in Section 2.3. These are presented in Table 9.

## 3. Conclusion

The catchment benefits associated with the preventing RNV clearing in the two study areas were equated with the consequential avoidance of salinity related costs that would be experienced by households, businesses and local governments. On this basis, RNV conservation yields a net benefit, over 40 years and at a discount rate of 7%, of about $4.5 million in the Murray catchment and almost $1 million in Northeast Victoria. Under the same conditions, the carbon sequestration benefits were estimated to be about $3.3 million for the Murray catchment and $6.8 million for Northeast Victoria. In comparison, from the surveys reported in Miles *et al.* (1998), the on-farm contribution RNV made to agricultural productivity in terms of mitigating land degradation was $66.5 million for the Murray catchment and $34.1 million for Northeast Victoria.

The potential savings to local government, households and non-farm businesses from ceasing RNV clearing are larger for the NSW study area, where the RNV makes up a larger proportion of total tree cover compared with Northeast Victoria. The costs currently being incurred by local government in the Murray catchment are high in comparison with non-farm businesses and households. It is not possible to draw a comparison between the Victorian and NSW local government costs until some reliable values can be obtained from the councils in Northeast Victoria.

## Table 8. Catchment PVBs over a 40 year scenario

| | **Northeast Victoria** ($ million)[1] | | | **Murray catchment** ($ million)[1] | | |
|---|---|---|---|---|---|---|
| | *Current situation* | *Proposed scenario* | *Net change* | *Current situation* | *Proposed scenario* | *Net change* |
| *4% discount rate* | | | | | | |
| **Cost** | | | | | | |
| Local government | -1.29 | -0.93 | 0.36 | -24.20 | -16.96 | 7.23 |
| Non-farm business | -1.81 | -1.27 | 0.54 | -2.17 | -1.98 | 0.19 |
| Households | -0.29 | -0.21 | 0.09 | -0.35 | -0.23 | 0.12 |
| Carbon | -8.77 | 0 | 8.77 | -4.19 | 0 | 4.19 |
| PVB | | | 9.76 | | | 11.73 |
| PVB (without carbon) | | | 0.99 | | | 7.54 |
| *7% discount rate* | | | | | | |
| **Cost** | | | | | | |
| Local government | -0.83 | -0.62 | 0.21 | -15.82 | -11.51 | 4.31 |
| Non-farm business | -1.18 | -0.86 | 0.32 | -1.49 | -1.34 | 0.15 |
| Households | -0.19 | -0.14 | 0.05 | -0.24 | -0.16 | 0.08 |
| Carbon | -6.84 | 0 | 6.84 | -3.27 | 0 | 3.27 |
| PVB | | | 7.43 | | | 7.80 |
| PVB (without carbon) | | | 0.59 | | | 4.53 |
| *10% discount rate* | | | | | | |
| **Cost** | | | | | | |
| Local government | -0.58 | -0.44 | 0.13 | -11.26 | -8.49 | 2.78 |
| Non-farm business | -0.84 | -0.63 | 0.21 | -1.11 | -0.99 | 0.12 |
| Households | -0.14 | -0.10 | 0.03 | -0.18 | -0.12 | 0.05 |
| Carbon | -5.50 | 0 | 5.50 | -2.62 | 0 | 2.62 |
| PVB | | | 5.87 | | | 5.58 |
| PVB (without carbon) | | | 0.36 | | | 2.95 |

[1] rounded to nearest $10,000

## Table 9. Effect of various rates of salinity increase on PVB using a 7% discount rate

| *Assumed rate of salinity increase* | *Northeast Victoria PVB ($ million)[1]* | *Murray catchment PVB ($ million)[1]* |
|---|---|---|
| 1 μS/cm per year | 7.43 | 7.80 |
| 5 μS/cm per year | 7.64 | 8.11 |
| 20 μS/cm per year | 8.42 | 9.28 |

[1] rounded to nearest $10,000

It is reassuring that the magnitude of the results presented here are comparable with those of the other studies reviewed in Table 2. It must be recognised, however, that our benefit estimates involve numerous assumptions and considerable uncertainty. The following points indicate some aspects of particular concern.

1. The approach used by Whish-Wilson & Shafron (1997) in the Loddon and Campaspe catchments provides a good model for how to estimate the total costs of salinity and high water tables on agricultural productivity. Their approach requires detailed data on the areas affected by salinity, which, at the time of writing, were unavailable for Northeast Victoria and the Murray catchment. Furthermore, there are no models that enable predictions to be made of the impact clearing particular areas of RNV might have on salinity levels. We have therefore been unable to include the marginal benefits that preventing clearing makes to the agricultural productivity of downstream properties. As noted above, local on-farm productivity benefits were estimated from the surveys reported in Miles *et al.* (1998). To produce more reliable and inclusive results, detailed biophysical catchment models are required that enable estimates to be made of the effect each hectare of RNV has on water tables. The strata described in Miles *et al.* (1998a) would provide a suitable scale for an analysis. The two study areas were stratified according to broad vegetation type (BVT), landform, climate and land use. The combination of all four land characteristics resulted in a total of 79 strata that contained RNV for the Murray catchment and 55 strata for Northeast Victoria. For each stratum, a model could be developed that indicated the contribution a hectare of native vegetation makes to mitigating downstream salinity. These effects could then be translated into impacts on agricultural productivity. Such an analysis is beyond the scope of the work reported here.

2. As noted in Section 2.3, we have assumed that salinity will rise by 1 μS/cm per year over the next 40 years. The actual rate of change may be much greater than this. However, as shown in Table 9, the PVB estimates are not highly sensitive to the rate of salinity rise.

3. The clearing rates that are the basis of our estimates come from a landholder survey done in 1997. Since that time, approval has been given for a large softwood processing mill to be established at Tumut. This new mill has been guaranteed that at least 30,000 ha of new pine plantations will be established. It is likely that some of these will be located in the Murray catchment, leading to additional pressures to clear RNV.

4. We have assumed a direct proportional link between area of forest cover, including RNV, and the salinity related costs faced by households, businesses and local government. This is clearly a simplistic assumption, and the relationships involved are almost certainly far more complex than we have been able to accommodate in our analysis. Again, a detailed catchment model is required to enable more reliable estimates to be made.

5. We have assumed that the claim by Victorian councils that they currently incur no salinity related costs reflects a lack of recognition on their part of the impact salinity has on infrastructure maintenance and replacement costs. Accordingly, our analysis included consideration of the role RNV conservation plays in avoiding such costs. However, the validity of including this (small) benefit component is unknown.

6. A market in carbon permits is unlikely to reflect the full economic value of reducing greenhouse gases. Estimates based on market price of these permits may therefore under-state the full economic benefit of avoiding greenhouse gas emissions. And of course the benefits calculated here for carbon sequestration are purely speculative, as a system of carbon credits does not currently exist in Australia.

Most of the assumptions we have made will tend to result in underestimation of RNV catchment benefits. These benefit estimates will be integrated with other costs and benefits in the forthcoming eighth report of *The economics of remnant native vegetation conservation on private property* project. To foreshadow the results of this report, the benefits reported here are small in comparison with community willingness to pay for RNV conservation, and the net costs RNV conservation imposes on landholders. Furthermore, the benefit cost analysis indicates that under most circumstances the net benefits of conserving RNV are greater than the costs. Underestimation of the catchment benefits will not affect this conclusion.

## 4. References

Australian Bureau of Statistics (1992) *Australia's environment: issues and facts*. AGPS, Canberra.

Australian Greenhouse Office (1998) *Greenhouse sinks and sustainable land management*. Commonwealth of Australia, Canberra.

Australian Greenhouse Office (1999) *National emissions trading: issuing the permits*. Discussion paper no. 2. Commonwealth of Australia, Canberra.

Barter, S.A. (1986) *An economic analysis of soil erosion damage to public utilities*. Report No. 9 of the project estimation of unpriced and social benefits of soil conservation. University of New England, Armidale.

Centre for International Economics (1998) *Measures and methodologies to determine the effectiveness of vegetation management programs: literature review*. Centre for International Economics and CSIRO, Canberra.

CLIB96 (database) (1997) *1996 Census of population and housing: release 1*. Australian Bureau of Statistics, Canberra.

Coorong & Districts Local Action Plan Steering Committee (1997) *Coorong & Districts local action plan: protecting agriculture and natural resources* (draft). Coorong & Districts Local Action Plan Steering Committee, Coomandook.

Croome, R. (1998) Dryland salinity: impacts on Ovens River. *Natural Resource Management* 1(1): 8-11.

Dumsday, R.G., Oram, D.A. (1990) Economics of dryland salinity control in the Murray River Basin, northern Victoria (Australia), in Dixon, J.A., James, D.E., Sherman, P.B. (eds) *Dryland management: economic case studies*. Earthscan, London.

Dunn, T., Gray, I. (1978) *Economic evaluation of Eppalock catchment soil conservation project, Victoria*. AGPS, Canberra.

Eberbach, P.L. (1998) Salt-affected soils: their cause, management and cost, in Pratley, J., Robertson, A. (eds) *Agriculture and the environmental imperative*. CSIRO, Melbourne.

Government of Victoria (1991) *State of the environment report: agriculture and Victoria's environment*. Office of the Commissioner for the Environment. Government of Victoria, Melbourne.

Government of Victoria (1995) *Preliminary nutrient guidelines for Victorian inland streams*. Publication 478, Environment Protection Authority. Government of Victoria, Melbourne.

Greig, P.J., Devonshire, P.G. (1981) Tree removals and saline seepage in Victorian catchments: some hydrologic and economic results. *Australian Journal of Agricultural Economics* 25(2): 134-148.

Lockwood, M., Carberry, D. (1998) *Stated preference surveys of remnant native vegetation conservation*. Johnstone Centre Report No. 104. Johnstone Centre, Albury.

Lubulwa, M. (1997*) Loddon and Campaspe catchments: costs of salinity to urban households*. Report to the Murray Darling Basin Commission. ABARE, Canberra.

Lumsdon, D., Reid, M. (1996) *Groundwater trends and salinity risk in the North-east Region*. Centre for Land Protection Research, Technical Report No. 33. Department of Natural Resources and Environment, Melbourne.

Miles, C.A., Lockwood, M. Walpole, S., Buckley, E. (1998) *Assessment of the on-farm economic values of remnant native vegetation*. Johnstone Centre Report No. 107. Johnstone Centre, Albury.

Murray-Darling Basin Commission (1996) *Cost-sharing for on-ground works*. MDBC, Canberra.

Nadolny, C., Burrows, W.H., Pickard, J., Hannam, I. (1991) Tree clearing in Australia. *Search* 22(2): 43-52.

North East Catchment Management Authority and Ovens Basin Water Quality Working Group (1998) *Draft Ovens basin water quality statement*. Department of Natural Resources and Environment, Wangaratta.

North East Regional Catchment and Land Protection Board (1997) *North east regional catchment strategy*. North East Regional Catchment and Land Protection Board, Wodonga.

Oliver, M., Wilson, S., Gomboso, J., Muller, T. (1996) *Costs of salinity to government agencies and public utilities in the Murray-Darling basin*. ABARE Research Report No. 96.2. ABARE, Canberra.

Panayotou, T. (1992) The economics of environmental degradation: problems, causes and responses, in Markandya, A., Richardson, A. (eds) *The earthscan reader in environmental economics*. Earthscan, London.

Peck, A.M.J., Thomas, J.F., Williamson, D.R. (1983) Salinity issues: effects of man on salinity in Australia. *Water 2000* Report No. 8. AGPS, Canberra.

Russell, I.W., Izac, N.A-M., Cramb, R.A. (1990) *Towards an evaluation of the off-site costs of erosion in Queensland*. University of Queensland, Brisbane.

Salinity Committee (1984) *Salt of the earth: final report on the causes, effects and control of land and river salinity in Victoria*. Government of Victoria, Melbourne.

Tisdell, C.A. (1984) *Costs and benefits of tree conservation, maintenance, regeneration and planting: evaluation of case studies*. Research Report No. 104. University of Newcastle, Newcastle.

Toohey & Associates (1996) *NSW Murray catchment resource profile: social, financial, economic and environment*. Prepared for the NSW Murray Catchment Management Committee. Toohey & Associates, Albury

Walpole, S., Lockwood, M., Miles, C.A. (1998) *Influence of remnant native vegetation on property sale price*. Johnstone Centre Report No. 106. Johnstone Centre, Albury.

Whish-Wilson, P., Shafron, W. (1997) *Loddon and Campaspe catchments: costs of salinity and high water tables to farms and other businesses*. ABARE Report to the Murray Darling Basin Commission. ABARE, Canberra.