Influence of remnant native vegetation on rural land values: a hedonic pricing application

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Abstract

Much of Australia's native vegetation has been cleared or altered as a result of agricultural development. The native vegetation that remains on private land is highly fragmented and continues to be degraded and modified due to various land use and environmental pressures. One of the major concerns of landholders in retaining and managing remnant native vegetation (RNV) in the agricultural landscape is the lack of information and understanding about the potential benefits and costs associated with conservation of these areas. The contribution of RNV to changes in rural property values needs to be examined when considering future policy and management strategies to encourage private landholders to retain and conserve RNV within the agricultural landscape.

The northeast Victorian catchment and the Murray catchment of NSW were chosen to examine the effect of RNV on rural property values using hedonic price analysis. The hedonic price approach explores the relationship that exists between the price of a good and the bundle of characteristics (or attributes) which the good possesses, to explain variations in the prices of the differentiated goods under consideration. Land sales records for the past ten years were obtained for properties greater than two hectares within the catchment areas, and those containing areas of RNV were identified. The purchasers of these properties were interviewed to determine the characteristics that influenced their purchase decision. Using this information, multivariate regression models have been estimated to quantify the contribution to property values of different attributes including the presence and nature of RNV. Based on the results of this hedonic analysis, the property market does not appear to be a good measure of the economic value of RNV.

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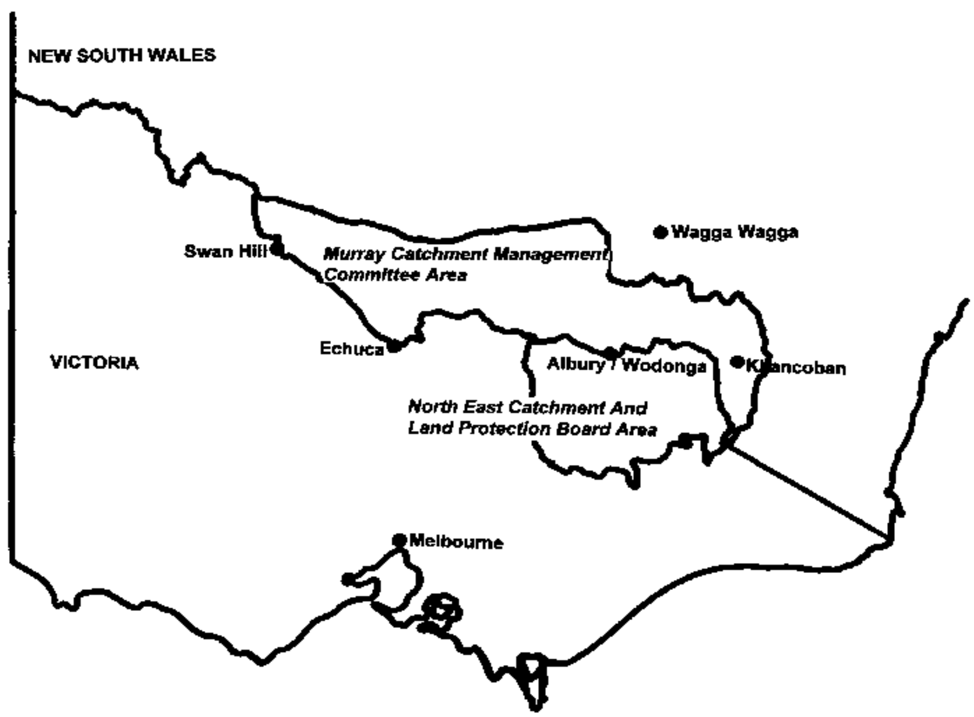
1. Introduction

Much of Australia's native vegetation has been cleared or altered as a result of agricultural development. The native vegetation that remains on private land is generally highly fragmented and continues to be degraded and modified due to various land use and environmental pressures. Remnant native vegetation (RNV) on private property has a range of values that are potentially relevant for an economic analysis of management options. One of the major concerns of landholders in retaining and managing remnant native vegetation in the agricultural landscape is the lack of information and understanding about the potential benefits and costs associated with conservation of these areas. The contribution of RNV to changes in rural property values needs to be examined when considering future policy and management strategies to encourage private landholders to retain and conserve RNV within the agricultural landscape.

It may be possible to determine the market value of RNV through market transactions of properties containing RNV. Hedonic pricing provides a means of determining the contribution of RNV to observed changes in land prices. This report details the results of the work on the influence of RNV on property sale price for two study areas - northeast Victoria and the Murray catchment of New South Wales (NSW) (Figure 1). Details of the study areas are given in Lockwood *et al.* (1997a, 1997b).

Figure 1. Study areas



2. Hedonic pricing and its applications to environmental valuation

This section examines the theory of hedonic pricing, and reviews issues related to functional form of the model and assumptions related to the nature of the market being examined. A number of applications of hedonic pricing are reviewed, specifically related to measuring values associated with vegetation, as well as other relevant applications. The hedonic model that is applied in this study is then formulated on the basis of this information.

From an economic perspective, the ability to value goods and services and obtain measures of welfare change where price or output levels change is often difficult for environmental 'goods'. In the transaction of land, it is often possible for individuals to choose their level of consumption of environmental goods through their choice of location, or selection of market goods. Remnant native vegetation can be regarded as an environmental good, and thus it may be possible to determine the market value of RNV through transactions of properties containing RNV. This suggests that in a decision to purchase a property, there may be an implicit market for the presence or amount that RNV contributes to the observed prices and consumption of market goods.

Hedonic pricing provides a means of determining the contribution of RNV to observed changes in land prices. The theoretical basis for this approach can be found in Rosen (1974), Freeman (1979) and Palmquist (1991). Hedonic pricing explores the relationships that may exist between the price of a good and the bundle of characteristics (or attributes) which the good possesses, to explain variations in the prices of the differentiated goods under consideration. The procedure involves the estimation of a hedonic price function of the form:

(1) $P_i = f(Z_i)$

where P is the price of the good, and Z_i is a (j x 1) vector of the j characteristics of the ith good. Upon estimation of this function, the partial derivative of price with respect to the jth characteristic

(2) $MP_j = \delta P_i/\delta Z_j$

yields the implicit marginal price (MP) of the jth characteristic, which can be used to construct an inverse demand function for the environmental 'good'. That is, the partial derivative may be interpreted as the additional amount that the marginal buyer would be willing to pay to obtain one more unit of the jth characteristic, all other things held constant. This calculation is based on the separability assumption that the consumer values the environmental characteristic independently of all other commodities consumed. Garrod & Willis (1992a) noted that when the focus is on individual implicit prices rather than the overall price of the good, specification of the hedonic model becomes more critical. Issues relating to functional form and omitted variable bias will be now be examined.

Functional form

Economic theory provides little direction as to the choice of correct functional form for the hedonic price equation. Therefore, specification of the functional form has been the source of much attention in the literature (Linneman 1980; Halvorsen & Pollakowski 1981; Milton *et al.* 1984; Cropper *et al.* 1988; Streeting 1990; Coelli *et al.* 1991; Palmquist 1991; Halstead *et al.* 1997). Given the potential variability in the estimation of coefficients using different functional forms, the issue requires careful examination.

The use of a linear hedonic function for valuing environmental goods appears to be particularly unrealistic, given it implies that the marginal implicit prices of attributes are constant, and thus independent of the quantity of an attribute the good possesses (Rosen 1974). This implies that the marginal willingness to pay (WTP) for increases in the quantity of an environmental good are the same regardless of the existing state of the environment (Streeting 1990). In the case of RNV, a more realistic scenario might be one where the WTP for RNV may increase (but in decreasing margins) up to a point where the proportion of trees may begin to have an overall negative impact upon agricultural productivity. This sort of relationship is inconsistent with a linear approximation. The use of a non-linear hedonic price function, which generates varying marginal prices, would seem more appropriate.

While it is relatively easy to dismiss the linear specification as being inappropriate, it is more difficult to make a choice between non-linear forms. On the basis of evidence provided by Cropper *et al.* (1988), Williams (1989) and Halstead *et al.* (1997), consideration of linear, log-linear, and log-log transformations seems appropriate. Once estimated, a modified J-test (MacKinnon 1983) and Ramsey Reset test (Ramsey 1969) can be used to guide model selection.

An important factor in the choice of functional form is the possibility of variable misspecification or omission in the data set. Misspecification may result in the estimated coefficients being biased and inconsistent, or inefficient (Streeting 1990). Butler (1982) suggested that in the case of a model where the main interest lies in an environmental explanatory variable (not necessarily considered a key variable in the estimation), a more complete specification of variables may be important. Hedonic theory is able to provide guidance about the types of variables that should be included in the model. However, there may be limiting factors that do not allow the collection of a complete data set for model estimation, leading to the omission of important variables.

Other estimation issues that must be considered include multicollinearity and heteroskedasticity. High correlation coefficients between explanatory variables may create difficulty in separating the different effects of these variables. An arbitrary cut-off value of 0.4 for correlation coefficients has been used by King & Sinden (1988) and Coelli *et al.* (1991) to test for multicollinearity. One solution if multicollinearity is identified is to omit the offending variable(s) from the model. However, this approach may lead to unnecessary misspecification bias. Coelli *et al.* (1991) argued that if there are strong *a priori* reasons to include a variable in the model, and providing its t-ratio is reasonable despite multicollinearity, the best approach is to retain the correlated variables. The use of data of a spatial nature may lead to heteroskedasticity in the estimated models. Heteroskedasticity refers to the situation where the variances of the error term of an estimated model are not constant, thus resulting in estimated coefficients that are inefficient (Griffiths *et al.* 1993). Griffiths *et al.* (1993) discussed the forms of heteroskedasticity, which can be tested for using the SHAZAM statistical package (White 1993).

The market

With its derivation from consumer theory, hedonic pricing relies on the assumption of market equilibrium, which is required to interpret the implicit prices of environmental characteristics of a household's marginal WTP (Harris 1981). However, equilibrium cannot realistically be assumed at a point in time given constraints on information, institutions and immobility of individuals. According to Freeman (1979) these constraints may introduce random rather than systematic errors into WTP estimates. Harris (1981) noted that hedonic price estimates will only reflect households' marginal WTP for a particular environmental attribute if the measured level of the attribute corresponds to that perceived by the consuming household. In the case of RNV, the presence or proportion of this attribute is likely to be immediately apparent to the household when making a purchase decision. If two or more submarkets exist within an area, a separate demand function must be estimated for each submarket.

Applications of hedonic pricing to vegetation

A hedonic pricing study related to RNV is being undertaken in South Australia (Marano 1998), which is attempting to establish statewide and regional models of market values for rural properties that include remnant vegetation. Part of the research is attempting to determine the impact that heritage agreements (protective covenants) have had on market values since the inception of the South Australian *Native Vegetation Act* in 1984. Preliminary results from this work suggest that RNV does not have a significant effect on property prices.

The only other Australian research of this nature was undertaken by Reynolds (1978), who attempted to relate measures of naturalness and scenic quality of vegetation with rural property values in northern NSW. Rather than using actual sale observations, an unimproved capital value estimate was used as a proxy measure. Tree cover (basal area of tree cover), plant and animal diversity and numbers were estimated, as well as ratings for aesthetics and naturalness. Based on 23 sites, it was found that increases in vegetation cover were associated with decreases in land value.

There are several overseas studies that have used hedonic pricing to examine the influence of vegetation on residential property sale values. These studies generally focused on the amenity value of vegetation. For example, Garrod & Willis (1992b, 1992c) used hedonic pricing to examine the influence of the amenity value of woodlands in Great Britain on housing values. The model relied on the broad assumption that there was a single, continuous market for rural housing in Great Britain at the time of the study. Following Graves *et al.* (1988), explanatory variables were divided into three categories; focus, free and doubtful variables. Focus variables were those of special interest to the study, being the proportion of forested area covered by three different tree categories. Free variables were those variables known to affect the property value but were of no special interest, and the remaining doubtful variables were those that may or may not affect the dependent variable. Using a linear Box-Cox estimation, it was found that there was a positive relationship between housing prices and the proportion of broadleaved woodlands, but a negative relationship associated with the proportion of mature conifer woodlands.

Using the same approach, but applying the model at a regional level, Garrod & Willis (1992c) estimated a log-linear model that included woodland and other countryside characteristics as focus variables, as well as partitioning the woodland variable according to the amount of cover. This was done to investigate whether house values were affected by adjacent woodland only when it exceeded a critical density level. It was found that in the proximity of at least 20% woodland cover average house values were raised by 7.1%. In conclusion, Garrod & Willis (1992c) noted that the study was constrained by the fact that the environmental data was neighbourhood-specific rather than house-specific, and would be enhanced by more detailed locality information.

More recently, Powe *et al.* (1997) were able to address this constraint by using a GIS to obtain measurements of residential access to woodlands specific to each household in the study. House sales in the vicinity of a forested area in the Southhampton and New Forest region of Great Britain were regressed in a linear Box-Cox model against distance and locational woodland variables, as well as various amenity/disamenity, structural and socio-economic attributes. There appeared to be a large amenity benefit associated with proximity to woodland.

Geoghegan *et al*. (1997) incorporated spatial landscape indices in a hedonic model to explain residential values in a region around Washington DC, USA. Spatial indices of diversity and fragmentation were measured from a GIS to represent patterns of land use (including forests) in the landscape surrounding the parcel sold. Using these measurements, as well as ‘normal’ explanatory variables of structural, neighbourhood and location characteristics in a log-log estimation, it was found that the nature and pattern of land use surrounding a parcel had an influence on price. Another result of interest was that the effect on price varied if the parcel was in a highly developed, suburban or rural area.

In contrast to the studies described above, which assessed the amenity value of large forests and woodlands in the vicinity of residential properties, Anderson & Cordell (1988) and Morales (1980) examined the influence of trees occurring within the boundaries of urban residential properties. Both of these US studies recorded increases in property values due to the presence of trees. In Finland, Tyrväinen (1997) examined the amenity value of urban forests (areas of forest vegetation preserved during urban development as opposed to created parks). The results indicated that the presence of these forests had a positive influence on apartment prices.

An application by Clifton & Spurlock (1983) examined the influence of various factors on rural land prices in southeastern United States, including a vegetation measurement (percent of tract in forest). It was hypothesised that properties with relatively more forest than cropland would have lower prices. Linear hedonic models were estimated for 8 different land markets, and the percentage of forest was a significant negative variable in each model.

Other hedonic pricing applications

Most hedonic price applications measuring the influence of environmental goods on property values have concentrated on urban properties. However, there are a number of studies that have focused on rural land values.

King & Sinden (1988) investigated the relationships between land condition and farm values for the Manilla Shire in NSW to explore whether the benefits of land improvement exceeded the costs. They concluded that land condition was clearly recognised by the market, with better-conserved land selling for higher prices. This result indicated that land condition influences price in ways additional to expectations of immediate yields or output. These influences reflect expectations of longer-term yields, a desire to obtain and maintain a fully productive soil resource by purchasing better land, and a desire to avoid the unpriced costs of improving land in poor condition (King & Sinden 1988).

Other applications of the hedonic-price approach to studying the effects of soil quality and erosion on land values have met with mixed results. Miranowski & Hammes (1984) analysed land values in Iowa based on the hedonic-price approach. They found that prices for land reflected differences in soil characteristics, but were less confident in determining whether the market was discounting the value of farm land enough to account for loss of productive capacity due to land degradation (Miranowski & Hammes 1984). Gardner & Barrows (1985) and Barrows & Gardner (1987) investigated the relationship between investment in soil-conservation practices and land price in southwestern Wisconsin. They argued that soil productivity is an important determinant of farm-land prices; however, their study concluded that investment in soil conservation was only capitalised into land values in the presence of severe, readily visible erosion problems. Ervin & Mill (1985) cited the lack of availability and high cost of information relating erosion to yield impacts and associated production costs to explain why land prices may not fully incorporate erosion effects. Palmquist & Danielson (1989) used the hedonic technique to value drainage and reductions in the erosion potential of the land, and found that land values were significantly affected by both potential erosivity and drainage requirements.

Hedonic price model

The study areas chosen for this project are very large. The Murray catchment is 40,000 square kilometres, while the northeast catchment is 19,750 square kilometres. In developing a hedonic model that attempts to capture the influence that RNV may be having on rural land values, it is important to consider a range of political, climatic, geographical, biophysical and land use factors. The main categories that may be involved in the determination of rural land prices for the northeast Victorian and NSW Murray catchment study areas are:

- external forces - government influences that are likely to affect the use and profitability of the farm;

- land characteristics - those factors that influence productivity, consumption and location; and
- vegetation characteristics - the nature of the RNV that exists on the property and the surrounding area.

Symbolically, the structural form of the model can be stated as:

(3) $P_i = f(LEG_i, LAND_i, VEG_i)$,

where for property i, P is sale price, LEG indicates whether the land purchase was made before or after clearing legislation was introduced, LAND is a vector of production, consumption and location characteristics, and VEG is a vector of RNV characteristics.

3. Data

The Northeast Catchment Management Region covers an area of 1,880,000 hectares, 40% of which is privately owned. There are 115,945 hectares of RNV on private land in the catchment. The main broadacre agricultural land uses are beef, dairy, sheep for wool and meat, and cereal and hay cropping. A number of more intensive industries such as hardwood and softwood forestry, hops, tobacco, grapes, and orchards are also present in the catchment. The Murray Catchment Management Region covers an area of 3,643,700 hectares, 90% of which is privately owned. There are 203,856 hectares of RNV on private land in the catchment. Agricultural land use across the catchment varies greatly, with a gradation from east to west of beef and forestry, dryland sheep and cereal cropping, irrigated cropping, through to semi-arid rangelands grazing of beef and sheep.

Data for the hedonic study comes from three main sources; land sales records, direct responses from surveyed landholders, and biophysical information from the GIS database for the study areas.

Land Sales Records

All real estate transactions are registered with the Valuer General's Offices in NSW and Victoria. An area of 2 hectares was chosen for the minimum size of a holding to be included in the analysis. This helped to ensure that data were not collected from urban properties.

Sales information for 2480 properties in the northeast Victoria study area were obtained. This covered all private transactions of land greater than 2 hectares from 1987 - 1997. The variables provided with these sales records were; seller name, owner name, owner address, property location, total area, parish, municipality, lodged plan number, title number, sale date, municipality name, sale price, sale terms, improvements, construction classifications, and land use classifications.

The equivalent information for the Murray catchment in NSW proved to be more difficult and costly to obtain. This finally led to a decision to approach each local government authority within the catchment for land sales data once it was established which survey participants had made a land purchase within the last 10 years.

With the provision of sale contract dates, it was possible to determine whether the land purchases had been made before or after land clearance regulations were introduced. In Victoria, the *Planning and Environment Act 1987* was amended in November 1989, introducing statewide controls over the clearing of native vegetation, and requiring landholders to obtain a permit before clearing. In August 1995, the NSW State Environment Planning Policy No. 46 - Protection and Management of Native Vegetation was introduced to prevent inappropriate native vegetation clearance in NSW. With this information, it will be possible to determine whether there were any significant differences in land purchase values before and after these respective clearance controls were introduced.

Survey data

It was necessary to conduct surveys with landholders who had purchased land containing RNV in order to obtain detailed information regarding the property, the nature of the purchase, and factors that influenced their decision. The landholder survey also collected data for other purposes, as reported in Miles *et al*. (1998). Selection of an appropriate survey technique, development of the survey instrument, selection of interviewees, and conduct of the interviews are described in detail by Miles (1998), so will not be repeated here. The survey was divided into three sections, Parts A, B and C. Questions in Part A related to general background information about the respondent's property and remnants. Questions in Part B related to the on-farm costs and benefits of RNV management, incentives for RNV management, and information about the respondents and their household. Detailed descriptions of these questions are given in Miles (1998).

Part C of the survey contained questions relating to the purchase of property containing RNV. Questions 30 - 48 gained information about the sale, the seller, perceived condition and productivity of the land at the time of purchase, the presence of a house and/or other buildings on the property, as well as its proximity to other currently owned properties, and the gross income from the purchased property. Question 49 listed 27 different factors that may have added, detracted, or had no influence on the purchase price. Respondents were asked to rate on a scale from minus 5 (detracted most from the value), 0 (didn't affect the value) to plus 5 (added most to the value) the influence of each factor.

GIS data

Resource inventory data collected as part of the broader study and stored in GIS form (Lockwood *et al*. 1997a, 1997b), provided information on broad vegetation type classifications, landform and climate for the two study areas. GIS coverage of all land parcels within the Victorian study area made it possible to link the property sales records with land parcels that contained RNV. Unfortunately, land parcel data in GIS form for the NSW study area proved to be too difficult and costly to obtain, so this information was obtained from each individual shire in the study area in hard copy form.

Additional information

Miles *et al.* (1998) determined the cost of alternative management regimes for RNV. Current costs associated with the management of RNV included fencing, weed and pest control, as well as various other activities specific to individual properties. An informed purchaser is likely to be aware of these costs at the time of purchase, and thus may use this information as a guide to their purchase decision. The costs of implementing alternative management scenarios that included fencing out all remnants, excluding or limiting grazing, and firewood and timber extraction were also calculated for each property.

From the sources of information outlined above, and on the basis of the categories outlined in Equation (3), the following variables were defined.

External

LEG = whether the land purchase was made before or after clearing legislation was introduced (1=yes, 0=no)

As explained above, a significant negative coefficient for LEG would indicate that the imposition of clearance regulations has had a negative impact upon the value of land containing RNV.

Land

(i) Production characteristics

AREA = Area of land purchased (ha)
CLEAR = Area of cleared land (ha)
PROD = Productivity rating (1=unproductive, 2=productive, 3=highly productive)
BUILD = Additional buildings and sheds (1=yes, 0=no)
ADD = Purchase of land in addition to land already owned (1=yes, 0=no)
EROS = Erosion rating rating (1=low, 2=moderate, 3=high)
SAL = Salinity rating (1=low, 2=moderate, 3=high)
ACID = Acidity rating (1=low, 2=moderate, 3=high)
INC = Gross income from purchased property ($ 1996/97)
COST1 = Cost of current RNV management ($/year)
LAND1 = Present floodplain (1=yes, 0=no)
LAND2 = Plain above flood level (1=yes, 0=no)
LAND3 = Gentle to moderate hill (1=yes, 0=no)
LAND4 = Steep mountain and hill (1=yes, 0=no)
CLIM1 = 300-400mm rainfall (1=yes, 0=no)
CLIM2 = 400-500mm rainfall (1=yes, 0=no)
CLIM3 = 500-600mm rainfall (1=yes, 0=no)
CLIM4 = 600-700mm rainfall(1=yes, 0=no)
CLIM5 = >700mm rainfall, temperate (1=yes, 0=no)
CLIM6 = >700mm rainfall, montane (1=yes, 0=no)
GEO1 = Coarsely or finely textured unconsolidated deposits (1=yes, 0=no)
GEO2 = Finely textured unconsolidated deposits (1=yes, 0=no)
GEO3 = Granites and gneisses (1=yes, 0=no)

GEO4 = Sedimentary rocks (1=yes, 0=no)
GEO5 = Volcanic rocks (1=yes, 0=no)
GEO6 = Granites and gneisses, sedimentary rock (1=yes, 0=no)
RANK1 = Potential agricultural income (-5=detracted most, 0=didn't affect, 5=added most)
RANK2 = Condition and placement of fences (-5=detracted most, 0=didn't affect, 5=added most)
RANK3 = Condition of dams etc (-5=detracted most, 0=didn't affect, 5=added most)
RANK4 = River frontage (-5=detracted most, 0=didn't affect, 5=added most)
RANK5 = Water availability (-5=detracted most, 0=didn't affect, 5=added most)
RANK6 = Appearance of paddocks (-5=detracted most, 0=didn't affect, 5=added most)
RANK7 = Appearance of landscape (-5=detracted most, 0=didn't affect, 5=added most)
RANK8 = Presence of adjoining public land (-5=detracted most, 0=didn't affect, 5=added most)
RANK9 = Existence of weeds and pests (-5=detracted most, 0=didn't affect, 5=added most)
RANK10 = Fire risk (-5=detracted most, 0=didn't affect, 5=added most)
RANK11 = Presence of conservation covenant (-5=detracted most, 0=didn't affect, 5=added most)
RANK12 = Potential to clear more land (-5=detracted most, 0=didn't affect, 5=added most)
RANK13 = Potential capital gain (-5=detracted most, 0=didn't affect, 5=added most)
RANK14 = Shire rates (-5=detracted most, 0=didn't affect, 5=added most)

These variables represent indicators of current levels of productivity of the property, as well as the range of factors that may affect productivity in the future. It would be expected that the price per unit area would increase as the property size decreased, reflecting the demand for smaller properties by 'hobby' farmers, as well as the use of smaller areas of land for more intensive and productive land uses. Production is represented as a total output value, as well as a productivity rating given by the purchaser. The presence of buildings may affect the productive capacity of the property, and an additional purchase will also help to increase output. Ratings for soil erosion, salinity and soil acidity were also subjective ratings provided by the purchasers based on information available to them at the time of purchase. The LAND, CLIM and GEO variables were based on the particular landform that a property fell within. The GEO variables were not available for the NSW study area. Details of these landforms are given in Miles *et al.* (1998). The RANK variables represent the respondent's ranking of various factors that may have affected their purchase decision.

(ii) Consumption characteristics

HOUSE = Presence of a house (1=yes, 0=no)
RANK15 = Condition and nature of farm buildings (-5=detracted most, 0=didn't affect, 5=added most)

RANK16	=	Condition and nature of house (-5=detracted most, 0=didn’t affect, 5=added most)
RANK17	=	Access to power and telephone (-5=detracted most, 0=didn’t affect, 5=added most)
RANK18	=	A place to bring up a family (-5=detracted most, 0=didn’t affect, 5=added most)
RANK19	=	Nearness to family/relatives (-5=detracted most, 0=didn’t affect, 5=added most)
RANK20	=	Good building site (-5=detracted most, 0=didn’t affect, 5=added most)
RANK21	=	Good view (-5=detracted most, 0=didn’t affect, 5=added most)

Given that the purchased property may not only be a source of income, but also a place of residence, the consumption characteristics listed above are important factors to include in a hedonic model. The RANK17 variable was viewed in terms of future capacity to build a house, rather than enhancing the productive capacity of the property in terms of power for water pumps or sheds.

(iii) Location characteristics

DIST	=	Distance of land from sealed road (km)
RANK22	=	Distance to nearest town (-5=detracted most, 0=didn’t affect, 5=added most)
RANK23	=	Access to property already owned (-5=detracted most, 0=didn’t affect, 5=added most)

There are a number of major cities and towns that service the northeast Victorian catchment and Murray catchment of NSW. Wodonga and Wangaratta in Victoria, and Albury, Corowa and Deniliquin in NSW are major regional trade centers, while the smaller towns of Myrtleford, Bright, Mount Beauty, Beechworth, Yackandandah, Tallangatta, and Corryong in Victoria, and Barham, Mathoura, Tocumwal, Finley, Conargo, Jerilderie, Berrigan, Urana, Mulwala, Howlong, Lockhart, Culcairn, Holbrook, and Tumbarumba in NSW provide important facilities such as schools, churches, hospitals, social and sporting clubs.

Vegetation

RNVHA	=	Total area of RNV (ha)
PATCH	=	Number of patches of RNV (no.)
QUAL	=	Quality of RNV (1=degraded, 2=modified, 3=intact)
PRRNV	=	Proportion of RNV on purchased property (%)
PROP10	=	RNV > 10% of property area (1=yes, 0=no)
PROP20	=	RNV > 20% of property area (1=yes, 0=no)
PROP30	=	RNV > 30% of property area (1=yes, 0=no)
PROP40	=	RNV > 40% of property area (1=yes, 0=no)
PROP50	=	RNV > 50% of property area (1=yes, 0=no)
PROP60	=	RNV > 60% of property area (1=yes, 0=no)
PROP70	=	RNV > 70% of property area (1=yes, 0=no)
PROP80	=	RNV > 80% of property area (1=yes, 0=no)
PROP90	=	RNV > 90% of property area (1=yes, 0=no)
BVT1	=	Inland slopes woodland(1=yes, 0=no)
BVT2	=	Dry foothill forest (1=yes, 0=no)

BVT3	=	Moist foothill forest (1=yes, 0=no)
BVT5	=	Valley grassy woodland (1=yes, 0=no)
BVT6	=	Riverine grassy woodland (1=yes, 0=no)
BVT7	=	Mallee (1=yes, 0=no)
BVT8	=	Plains grassy woodland (1=yes, 0=no)
RANK24	=	Presence of remnant native vegetation (-5=detracted most, 0=didn't affect, 5=added most)
RANK25	=	Condition of remnant native vegetation (-5=detracted most, 0=didn't affect, 5=added most)
RANK26	=	Presence of remnant native vegetation on adjoining properties (-5=detracted most, 0=didn't affect, 5=added most)
RANK27	=	Presence of adjoining pine forest (-5=detracted most, 0=didn't affect, 5=added most)

The vegetation measurements are a reflection of the property owners perception of vegetation on their property and the surrounding area, as well as measurements taken from the landforms. In addition to the PRRNV variable, the PROP variables were calculated to determine whether property values were affected by the presence of RNV when it exceeded a critical proportion of the total property. As noted in Miles (1998) and Miles *et al.* (1998), the quality ratings estimated by the landholders are similar to the assessments made during the resource inventory phase of the project (Lockwood *et al.* 1997a, 1997b).

4. Results

4.1 General observations

Victoria

Of the 2,480 land sales transactions provided by the Victorian Office of the Valuer General, 364 purchased properties were identified that contained RNV. Despite the provision of purchaser details, many were not listed in the Telstra White Pages, several numbers had been disconnected or were never answered despite attempts to call at various times during the day and evening, and some people initially contacted indicated that they either had no RNV or only scattered or planted trees. Of the 130 landholders contacted who had RNV, twenty-one respondents declined to participate in the survey at the time of the initial phone call, and nine refused for a variety of reasons once they had been sent the initial information sheets (see Miles 1998), giving a final response rate of 77%. Of the 100 respondents who participated in the survey, 80 indicated that they had made a purchase of land containing RNV in the past 10 years. This sample therefore represents 22% of all properties purchased in the past 10 years containing RNV.

The general observations made from the Victorian surveys are summarised in Table 1. The average area purchased was 115 hectares, and the average price paid was $178,499, or $2,732/ha. The average area of RNV on the purchased properties was 35 hectares, or 33% of the total property. Forty-six percent of respondents were making an additional purchase of land, and 45% of the properties contained a house at the time of purchase. The average age of the purchasers was 46, and their average length of education was 12 years. The average household gross income was $68,417,

Table 1
Summary of general observations for Victorian and NSW surveys

Measurement	Victoria	New South Wales
Number of respondents	80	44
Average area purchased (ha)	115	656
Average price paid ($)	178,499	498,275
Average price per hectare ($/ha)	2,732	980
Average area of RNV (ha)	35	142
Proportion of RNV (%)	33	21
Additional purchase (%)	46	80
House on purchased property (%)	45	58
Average age of purchaser (years)	46	45
Average length of Education (years)	12	13
Average household gross income ($)	68,417	112,359
On-farm income (%)	40	74
Landcare member (%)	53	56

with 40% of this being derived from on-farm income. Seventeen percent of the respondents had no on-farm income, while 20% derived their total income from on-farm production. Fifty-three percent of the respondents were members of Landcare.

Of the factors listed in Q49 of the survey (in order of importance), water availability, appearance of the landscape, good view, potential income, a place to bring up a family and the presence of RNV added most to the value of the land at the time of purchase, while weeds and pests, fire risk and adjacent pine forest detracted most from the value of the property. It is interesting to note that aesthetic factors such as the appearance of the landscape and a good view were rated more highly than the perceived productive capacity of the property. The top rating of water availability is supported by a recent survey of 58 properties advertised in *The Land* and the *Stock and Land*. In the descriptions provided for these properties, factors such as access to power and telephone, water availability, the presence or area of trees, a view, school access, topography, soil type and fencing were highlighted. Water availability was the factor referred to most often (72% of advertisements), followed by the presence of a house (66%). The presence of trees was highlighted in 21% of advertisements.

The influence of the clearance regulations on property values deserves examination. Thirty-four percent of Victorian properties were purchased prior to November 1989, the remainder after the introduction of the legislation. There was no significant difference in the sale price per hectare before or after the introduction of the legislation (Wilcoxon rank sum test z = -1.10, n = 52,28, p = 0.27). The introduction of the clearance legislation had no significant influence on the purchaser's future intentions to clear (Pearson's $\chi^2 = 0.05$, df = 1, p = 0.82). This suggests that the legislation may have had no influence on prices because it is perceived to be a regulation that is not strictly upheld, thus future 'improvements' to the purchased property may still include the option to clear. Alternatively, the legislation may have no influence on the purchase price because the purchaser may have no intentions to clear in the future.

New South Wales

Due to the lack of information on sales records within the NSW study area, survey participants could not be selected in a purposive manner as they had been in Victoria. Of the 255 landholders contacted, seventy respondents declined to participate in the survey at the time of the initial phone call, and fifty-nine refused once they had been sent the initial information sheets. The reasons given were similar to those of the Victorian respondents, however it was felt that anxiety and suspicion regarding the more recent land clearance legislation in NSW was in large part to blame for the disappointing response rate (49%). Of the 122 participants surveyed on a random basis in the Murray catchment, 44 indicated that they had made a purchase of land containing RNV in the last ten years. It is not possible to estimate what proportion of total properties sold with RNV this figure represents.

The general observations made from the NSW surveys are summarised in Table 1. The average area purchased was 637 ha, and the average price paid was $521,560 or $987/ha. The average area of RNV on purchased properties was 145 ha, which is 19% of the total area purchased. Eighty-two percent of respondents were making an additional purchase of land, and 57% contained a house at the time of purchase. The average age of the purchasers was 44, and their average length of education was 13 years. Average household gross income was $113,318, with 76% of this being derived from on-farm income. Five percent of the respondents had no on-farm income, while 30% indicated that their sole source of income was from on-farm production. Fifty-seven percent of the respondents were members of a Landcare group.

Of the factors listed in Q49 of the survey (in order of importance), potential agricultural income, water availability, access to property already owned, appearance of the landscape and potential capital gain were the most important factors affecting the value of the land, while weeds and pests, fire risk and shire rates detracted most from the value. In comparison to the Victorian results, factors affecting production appear to have a higher priority than the aesthetic values in influencing property values.

4.2 Hedonic models

Victoria

The rural land market in the northeast Victorian catchment appears to be suitable for the application of the hedonic technique, as it is characterised by a differentiated product (rural land) being sold in a competitive market. The flow of information in this market appears to be very good, with many real estate agents advertising within the region, as well as more widely. There are no large buyers or sellers in the market who could individually influence this market for rural land, and there are no barriers to entry apart from insufficient finance. Therefore, the assumption of pure competition can be made for this market.

Following the discussion of functional forms in Section 3, ordinary least squares estimates of the linear, log-linear, and log-log functional forms were undertaken based on Equation (3), and these are presented in Table 2.

Table 2
Hedonic price functions for the three alternative functional forms for all Victorian surveys[a]

Independent variables	Linear depvar = PRICE	Log-linear depvar = log (PRICE)	Log-Log depvar=log (PRICE)
AREA	484.43	0.20E-02	0.22
	(6.43)	(4.36)	(3.65)
HOUSE	130390.00	0.77	0.79
	(6.88)	(6.65)	(6.47)
RANK2	12262.00	0.07	0.27
	(2.97)	(2.81)	(2.60)
GEO4	70014.00	0.23	0.26
	(3.16)	(1.73)	(1.81)
BVT2	36343.00	0.29	0.29
	(1.86)	(2.42)	(2.31)
PROP50	-48543.00	-0.41	-0.41
	(2.19)	(3.00)	(2.91)
intercept	-29321.00	10.72	9.93
R square	0.66	0.61	0.58
R square-adj	0.63	0.58	0.55
RESET(2)	7.07	0.01	3.28
RESET(3)	6.81	0.34	1.73
RESET(4)	5.44	0.56	1.52
N	80	80	80

[a]T-ratios are in parentheses.

Adjusted sale price[1] (PRICE) was the dependent variable for the linear model while the natural log of (PRICE) was the dependent variable for the log-linear and log-log

[1] The PRICE variable is expressed in 1997 dollars, having been adjusted by an index of rural land values supplied by the Victorian Office of the Valuer General. Total price is used as the dependent variable as opposed to per hectare property price, as the majority of rural properties advertised for sale in publications such as *The Land*, *Stock and Land* and *The Weekly Times* express values as total

models. In the log-log model, the natural log of AREA and RANK2 were taken, while the dichotomous variables remained untransposed. A large number of the estimated coefficients had t-ratios that were not significant at the ten percent level, thus were omitted from the final models.

The correlation coefficients of the independent variables revealed no significant multicollinearity between any of the variables. Given the spatial nature of the data, the existence of heteroskedasticity in the models also needed to be tested. The SHAZAM package (White 1993) provides a number of tests for various forms of heteroskedasticity. All tests for the log-log and log-linear models were insignificant, while six of the calculated statistics indicated significant heteroskedasticity in the linear model. Therefore, a heteroskedastic consistent covariance matrix (White 1980) was employed in further analysis to correct the estimates for an unknown form of heteroskedasticity.

The choice between the linear, log-linear, or log-log models is guided by the modified J-test and Ramsey Reset test. The F-values of the Ramsey Reset test for the log-linear and log-log functional forms are all insignificant at the 5% level, but are all significant for the linear model, indicating misspecification in the linear model. Following Coelli *et al.* (1991), a modified J-test[2] was carried out. The t-ratios relevant to this test are
presented in Table 3, and it can be concluded that the log-linear model is preferred over the linear and log-log model, while no difference could be discerned between the linear model and the log-log model. On the basis of this test and the Ramsey Reset test, it is concluded that the log-linear model is superior overall.

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amounts. This choice is also supported by testing for heteroskedasticity in the estimated models, where it was found that no significant heteroskedasticity exists in the preferred model.

[2] The J-test is a test of non-nested hypotheses. Its calculation for the case of two models involves two steps. Firstly each model is estimated and its predictions stored. Then each prediction is included as a regressor in the competing model . The J-test needs to be modified when the dependent variables are not the same by suitably transforming the predictions of one model before including them as a regressor in the other. Three conclusions can be drawn from a J-test: (i) if the t-ratios of the included predictions are either both significant or both insignificant neither model is preferred to the other; (ii) if predicitions of model 1 in model 2 is significant and the converse insignificant, then model 1 is preferred; and (iii) if predictions of model 2 in model 1 are significant and the converse insignificant, then model 2 is preferred.

New South Wales

The Murray catchment rural land market appears to be suitable for the application of the hedonic technique for the same reasons given in the Victorian results section (p. 15). However, it is important to note that the Murray catchment is much larger than the northeast Victorian catchment, with considerably more environmental variation in terms of climate and landform, and would probably not be viewed as a homogenous unit by potential land purchasers. In addition, only 44 NSW survey respondents indicated that they had made a land purchase in the past 10 years, which may not be a large enough sample size to adequately explain variation in market values. Ordinary least squares estimates failed to reveal any statistically significant relationships that included RNV, with low t-values and R^2 values recorded. Therefore, no models will be presented for the NSW study area.

Table 3
T-ratios for the J-Test for functional form (Table 2 models)

	Model into which predictions are included		
Model from which predictions were derived	linear	log-linear	log-log
linear	****	-0.71	3.13
log-linear	2.05	****	3.07
log-log	2.52	0.54	****

Combined NSW and Victorian data

Due to differences in the NSW and Victorian study areas described in Lockwood *et al.* (1997a, 1997b), it did not seem reasonable to attempt to model all the combined data. Rather than one land market prevailing, it is more likely that separate sub-markets exist across the study areas. Four NSW shires in the eastern end of the Murray catchment, Tumbarumba, Holbrook, Culcairn and Hume closely resembled the land use, climatic and biophysical characteristics present in the northeast Victorian catchment. In addition, the property market is these shires is likely to have a similar structure to that in northeast Victoria. Therefore it was decided to estimate models based on these combined data comprising all the Victorian and part of the NSW data.

Ordinary least squares estimates of the linear, log-linear and log-log functional forms were undertaken based on Equation (3), and are presented in Table 4. Adjusted sale price (PRICE) was the dependent variable for the log-linear and log-log models. In the log-log model, the natural log of AREA and RANK2 were taken, while the dichotomous variables remained untransposed. A large number of the estimated coefficients had t-ratios that were not significant at the ten percent level, thus were omitted from the final models. The correlation coefficients of the independent variables revealed no significant multicollinearity between any of the variables. Tests indicated that no significant heteroskedasticity existed in the log-linear and log-log models, while all of the calculated statistics indicated significant heteroskedasticity in the linear model. Once again, a heteroskedastic consistent covariance matrix was employed in further analysis to correct the estimates for an unknown form of heteroskedasticity. The F values of the Ramsey Reset test for the log-log functional form are all insignificant at the 5% level, and are all significant for the log-linear and linear model, indicating misspecification in the log-linear and linear models. The t-ratios of the modified J-test are presented in Table 5, and it can be concluded that the linear model is preferred over the log-log model, while the log-linear model is preferred over the log-log model. No difference could be discerned between the linear and log-linear models. On the basis the Ramsey Reset test and the heteroskedasticity tests, the log-log model is preferred, while on the basis of the modified J-test either

Table 4
Hedonic price functions for the three alternative functional forms for combined Victorian and New South Wales Surveys[a]

Independent variables	Linear depvar = PRICE	Log-linear depvar = log (PRICE)	Log-Log depvar=log (PRICE)
AREA	476.40	0.16E-02	0.36
	(8.94)	(6.24)	(6.49)
HOUSE	96695.00	0.57	0.56
	(3.67)	(4.43)	(4.43)
ADD	24825.00	0.28	0.20
	(0.96)	(2.20)	(1.62)
RANK2	13870.00	0.07	0.15
	(2.75)	(2.68)	(1.48)
PROP50	-44098.00	-0.38	-0.34
	(1.44)	(2.55)	(2.29)
intercept	10134.00	10.98	9.78
R square	0.58	0.52	0.53
R square-adj	0.56	0.50	0.50
RESET(2)	8.30	17.33	1.53
RESET(3)	5.84	9.08	1.99
RESET(4)	4.10	6.01	0.90
N	96	96	96

[a]T-ratios are in parentheses.

Table 5
T-ratios for the J-Test for functional form (Table 4 models)

	Model into which predictions are included		
Model from which predictions were derived	linear	log-linear	log-log
linear	****	4.47	2.88
log-linear	-2.83	****	2.72
log-log	1.43	1.32	****

the linear or log-linear model is preferred. It was concluded earlier in this report that the use of a non-linear functional form was more appropriate for this type of analysis, while the presence of heteroskedasticity will lead to estimated coefficients that are inefficient. Therefore, the log-log model will be used for further interpretation.

4.3 Interpretation of the preferred models

In the preferred log-linear model in Table 2, all coefficients have the expected sign. The regression estimate fits the data reasonably well, with 61% of variation in the dependent variable being explained. The remaining variation can most likely be explained by the omission of important variables, as well as the use of proxy variables and random errors. The size of the property (AREA) and the presence of a house (HOUSE) have a strong positive influence on property value. The presence of sedimentary parent material on the property (GEO4), and fences with good condition and placement (RANK2), also have a positive influence on property value. The presence of dry foothill forest (BVT2) has a positive influence on property value, while the existence of RNV at a proportion greater than 50% (PROP50) has a negative influence.

The coefficients of a log-linear equation represent the average percentage change in value for a unit change in a characteristic (marginal price), therefore a literal interpretation of this coefficient suggests that the presence of dry foothill forest would raise the value of the average property by 29%, or $51,764. However, this result cannot be interpreted in terms of the amount of RNV on the property, only its presence or absence. The BVT2 (Dry Foothills forest) variable was examined further to see if it was acting as a proxy for any other measurements not included in the model. Correlation coefficients between BVT2 and all other variables used in preliminary modelling attempts revealed significant relationships between BVT2 and LAND4 ($r = 0.38$, $p < 0.001$), BVT2 and BVT3 ($r = -0.40$, $p < 0.001$), and BVT2 and BVT6 ($r = -0.59$, $p < 0.001$). The relationship between BVT2 and LAND4 is a reflection of the occurrence of this vegetation type in steeper areas. A negative relationship exists between BVT2 and BVT3 and 4, indicating that these vegetation types occur in areas where BVT2 is not present. Therefore, it can be concluded that BVT2 is not acting as a proxy for other variables and appears to be a true representation of the presence of this particular vegetation type.

The continuous RNV variables RNVHA and PRRNV did not enter the model as significant variables. The introduction of PROP measurements enabled the categorisation of properties according to whether they exceeded a particular proportion of RNV, represented as a dichotomous (0/1) variable. Only PROP50 entered the model as a significant coefficient, suggesting that for properties purchased with a proportion of RNV exceeding 50%, the average property value would be decreased by 41% or $73,184. This result suggests that any benefits associated with the presence of BVT2 will be outweighed by the costs by the greatest amount when the proportion of RNV exceeds half of the total property area. Twenty-five percent of the survey respondents had more than 50% RNV.

The possibility that confounding effects may exist between the amount of RNV, the area of land purchased and the area of cleared land needs to be tested. Correlation coefficients estimated between AREA and PROP50, and AREA and PRRNV indicated that such confounding effects were not present in the model. The preferred model from Table 2 was re-estimated using CLEAR instead of AREA. The R^2 values were lower (0.58, 0.55), and the variable GEO4 was no longer significant. On this basis, it was decided to retain the models reported in Table 2.

The preferred log-linear model estimated from the combined Victorian and NSW data (Table 4) contains five significant independent variables of the expected sign. Fifty-three percent of variation in the dependent variable is explained by the regression. The size of the property (AREA) and the presence of a house (HOUSE) have a strong positive influence on property value. The purchase of property in addition to land already owned (ADD), and fences with good condition and placement (RANK2), also have a positive influence on property value. The existence of RNV at a proportion greater than 50% (PROP50) has a negative influence. In comparison to the preferred Victorian model in Table 2, this model explains less of the variation in the dependent variable, the geology variable (GEO4) has dropped out, replaced by the explanatory variable (ADD), which reflects the higher proportion of NSW landholders who were making an additional purchase of land. The remnant vegetation variable PROP50 has a slightly lower estimated coefficient, but is still highly significant, suggesting that for properties purchased with a proportion of RNV exceeding 50%, the average property value would be decreased by 38% or $79,743 (average PRICE for the combined surveys was $209,851).

5. Discussion and conclusions

The decision to purchase land is a very complex one, with a range of factors needing to be taken into consideration. Attempts were made to measure and include as many of these factors as possible in preliminary hedonic models. However, it became evident that only a small proportion of these factors were having a significant influence on the sale value of the property. These factors included consumption, production and vegetation characteristics of the property. It also became evident that the small sample size in NSW was not going to be sufficient to develop a reasonable model to reflect the market in the Murray catchment.

The non-agricultural benefits of RNV

As part of a wider on-farm survey (see Miles *et al.* 1998), respondents were asked to indicate the benefits they believed their RNV provided in terms of a number of environmental services. Of the predetermined benefits listed in the survey, aesthetics was regarded by 89% of Victorian respondents and 93% of NSW respondents as providing a benefit, but a quantitative measurement of this type of on-farm benefit was not attempted. The attitude of respondents was that the presence of trees improved the attractiveness of the landscape, that the look of bare treeless paddocks and hills was highly undesirable, and in some cases that the trees had a spiritual, therapeutic effect. Most of the aesthetic benefits were expressed in terms of visual amenity. It could be that the benefit value of $51,764 calculated from the BVT2 coefficient may be encompassing some of the on-farm aesthetic values associated with the presence of RNV on a property, or acting as a ‘proxy’ for aesthetics.

The dry foothill forest measurement (BVT2) represented in the preferred models is the most predominant RNV type on private land in the northeast catchment, making up 76,480 out of a total of 115,945 hectares of RNV. This BVT is generally restricted to steeper foothills on low fertility soil types. The presence of this variable in the model as a positive and significant coefficient suggests that landholders may be happy to accept the presence of this type of RNV on parts of their property not seen as highly productive and readily accessible, and therefore is not perceived as directly competing for land that supports their major agricultural enterprises. Respondents to the survey (Q49.11) indicated that the presence of RNV on the property was an important factor in their decision to purchase. These sentiments seem to be reflected in the hedonic model by BVT2, but are countered once the RNV exceeds a certain proportion.

The provision of aesthetic values associated with RNV are generally perceived as a public good that benefits the wider community. Fry & Sarlöv-Herlin (1997) suggested that farmers and non-farmers see the same landscape image, but will perceive it differently and with different objectives in mind. What is rarely considered is that individual landholders may also value RNV in terms of the visual amenity benefits it provides. The exchange of property in the market allows a formal expression by landholders of this benefit. The results of this hedonic analysis seem to suggest that there may be an on-farm willingness to pay for the amenity benefits provided by RNV, however it is difficult to know how much of the benefit value apparently associated with BVT2 can be attributed to this factor.

The hedonic pricing model has proved to be a useful method for highlighting the positive and negative aspects of RNV that have influenced sale prices for properties purchased in the last ten years in northeast Victoria. The model appears to be measuring some non-agricultural benefits that landholders attribute to the presence of RNV on their property, while also reflecting that there are also measurable negative impacts on sale values associated with having ‘too much’ RNV. Below this threshold of 50% of RNV, the area or proportion of RNV appears to have little influence on property price.

In a perfect market with full information, property prices should reflect, amongst other things, all costs and benefits associated with RNV. Economic benefits of RNV include increased stock production, increased agricultural production arising from mitigation of land degradation, increased crop production from shelter and shade effects, and timber for firewood and fencing. Any economic value arising from scenery and nature conservation benefits of RNV would also be reflected in property price. Costs of RNV include pest plant and animal control, fire management and fencing. In the landholder surveys, 53% of participants in northeast Victoria and 82% in the Murray catchment currently enjoy a net benefit from their RNV (Miles et al. 1998). With perfect information, a property market and direct surveys should produce the same estimate of net economic value. However, based on the results of this hedonic analysis, the property market is not at present a good measure of the economic value of RNV. Presumably this is primarily due to the lack of information and awareness on the part of both buyers and sellers.

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7. References

Anderson, L.M., Cordell, H.K. (1988) Influence of trees on residential property values in Athens, Georgia (USA): a survey based on actual sales prices. *Landscape and Urban Planning* 15:153-164.

Barrows, R., Gardner, K. (1987) Do land markets account for soil conservation investment? *Journal of Soil and Water Conservation* 42(4): 232-236.

Butler, R.V. (1982) The specification of housing indexes for urban housing. *Land Economics* 58: 96-108.

Clifton, I.D., Spurlock, S.B. (1983) Analysis of variations in farm real estate prices over homogenous market areas in the southeast. *Southern Journal of Agricultural Economics* 15:89-96.

Coelli, T., Lloyd-Smith, J., Morrison, D., Thomas, J. (1991) Hedonic pricing for a cost benefit analysis of a public water supply scheme. *Australian Journal of Agricultural Economics* 35(1): 1-20.

Cropper, M.L., Deck, L.B., McConnell, K.E. (1988) On the choice of functional form for hedonic price functions. *The Review of Economics and Statistics* 70: 668-675.

Ervin, D.E., Mill, J.W. (1985) Agricultural land markets and soil erosion: policy relevance and conceptual issues. *American Journal of Agricultural Economics* 67(3): 938-932.

Freeeman, A.M. (1979) Hedonic prices, property values and measuring environmental benefits: a survey of the issues. *Scandinavian Journal of Economics* 81: 154-173.

Fry, G., Sarlöv-Herlin, I. (1997) The ecological and amenity functions of woodland edges in the agricultural landscape; a basis for design and management. *Landscape and Urban Planning* 37: 45-55.

Gardner, K., Barrows, R. (1985) The impact of soil conservation investments on land prices. *American Journal of Agricultural Economics* 67(3): 943-947.

Garrod, G., Willis, K. (1992a) Valuing goods' characteristics: an application of the hedonic price method to environmental attributes. *Journal of Environmental Management* 34: 59-76.

Garrod, G., Willis, K. (1992b) The amenity value of woodland in Great Britain: a comparison of economic estimates. *Environmental and Resource Economics* 2: 415-434.

Garrod, G., Willis, K. (1992c) The environmental economic impact of woodland: a two-stage hedonic price model of the amenity value of forestry in Britain. *Applied Economics* 24: 715-728.

Geoghegan, J., Wainger, L.A., Bockstael, N.E. (1997) Spatial landscape indices in a hedonic framework: an ecological economics analysis using GIS. *Ecological Economics* 23(3): 251-264.

Graves, P., Murdoch, D.C., Thayer, M.A., Waldman, D. (1988) The robustness of hedonic price estimation: urban air quality. *Land Economics* 64: 220-233.

Griffiths, W.E., Hill, R.C., Judge, G.G. (1993) *Learning and practicing econometrics*. John Wiley and Sons, New York.

Halstead, J.M., Bouvier, R.A., Hansen, B.E. (1997) On the issue of functional form choice in hedonic price functions: further evidence. *Environmental Management* 21(5): 759-765.

Harris, A.H. (1981) Hedonic technique and valuation of environmental quality, **in** Smith, V. Kerry (ed.) *Advances in Applied Microeconomics*. JAI Press, Greenwich, pp 31-49.

King, D.A., Sinden, J.A. (1988) Influence of soil conservation on farm land values. *Land Economics* 64(3): 242-255.

Linneman, P. (1980) Some empirical results on the nature of the hedonic price function for the urban housing market. *Journal of Urban Economics* 8: 47-68.

Lockwood, M., Buckley, E., Glazebrook, H. (1997a) *Remnant vegetation on private property in northeast Victoria.* Johnstone Centre Report No. 94. Johnstone Centre, Albury.

Lockwood, M., Buckley, E., Glazebrook, H. (1997b) *Remnant Vegetation on Private Property in the Southern Riverina, NSW*. Johnstone Centre Report No. 95. Johnstone Centre, Albury.

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

MacKinnon, J.G. (1983) Model specification tests among non-nested alternatives. *Econometric Reviews* 2:85-110.

Marano, W.A.J. (1998) *Factors influencing the market value of remnant native vegetation in South Australia, 1982-1994*. Final report to Environment Australia/Land and Water Resources Research and Development Corporation. University of South Australia, Adelaide (in prep.).

Miles, C.A. (1998) An assessment of the on-farm economic values associated with remnant vegetation in northeast Victoria. BAppSci (Hons) thesis, Charles Sturt University, Albury.

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

Miles, C.A., Lockwood, M., Walpole, S.C. (1998) *Incentive policies for remnant native vegetation.* Johnstone Centre Report No. 108. Johnstone Centre, Albury.

Milton, J.W., Gressel, J., Mulkey, D. (1984) Hedonic amenity valuation and functional form specification. *Land Economics* 60(4): 378-387.

Miranowski, J.A., Hammes, B.D. (1984) Implicit prices of soil characteristics for farmland in Iowa. *American Journal of Agricultural Economics* 66(5): 745-749.

Morales, D.J. (1980) The contribution of trees to residential property value. *Journal of Arboriculture* 6(11): 305-308.

Palmquist, R.B. (1991) Hedonic Methods, **in** Braden, J.B., Kolstad, C.D. (eds) *Measuring the demand for environmental quality*. Elsevier Science, Holland, pp. 77-120.

Palmquist, R.B., Danielson, L.E. (1989) A hedonic study of the effects of erosion control and drainage on farmland values. *American Journal of Agricultural Economics* 71(1): 55-62.

Powe, N.A., Garrod, G.D., Brunsdon, C.F., Willis, K.G. (1997) Using a geographic information system to estimate an hedonic price model of the benefits of woodland access. *Forestry* 70(2): 139-149.

Ramsey, J.B. (1969) Tests for specification error in classical least squares regression analysis. *Journal of the Royal Statistical Society* 31: 250-271.

Reynolds, I.K. (1978) The relationship of land values to site characteristics—some implications for scenic quality management. *Journal of Environmental Management* 6: 99-106.

Rosen, S. (1974) Hedonic prices and implicit markets: product differentiation in pure competition. *Journal of Political Economy* 2: 34-55.

Streeting, M. (1990) *A survey of the hedonic pricing technique*. Resource Assessment Commission Research Paper No. 1, Resource Assessment Commission. AGPS, Canberra.

Tyrväinen, L. (1997) The amenity value of the urban forest: an application of the hedonic pricing method. *Landscape and Urban Planning* 37:211-222.

Valuer General's Office (1996) *Real Estate Values 1996*. Valuer General's Office, Sydney.

White, H. (1980) A heteroskedasticity-consistent covariance matrix and a direct test for heteroskedasticity. *Econometrica* 48: 817-838.

White, K.J. (1993) *SHAZAM user's reference manual Version 7.0*. McGraw-Hill, New York.

Williams, C.H., Rolfe, J., Longworth, J.W. (1993) Does muscle matter? An economic evaluation of live cattle characteristics. *Review of Marketing and Agricultural Economics* 61: 169-189.