Valuing environmental assets on rural lifestyle properties

Maksym Polyakov[a]*, David Pannell[a], Ram Pandit[b], Sorada Tapsuwan[c], Geoff Park[d]

[a] Centre for Environmental Economics and Policy, School of Agricultural and Resource Economics, University of Western Australia, Crawley, WA, 6009, Australia

[b] School of Agricultural and Resource Economics, University of Western Australia, Crawley, WA, 6009, Australia

[c] CSIRO Ecosystem Science, Private Bag 5 Wembley, WA 6014 Australia

[d] North Central Catchment Management Authority, PO Box 18, Huntly, Victoria, 3551, Australia

* E-mail address: maksym.polyakov@uwa.edu.au

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Abstract:

Changing land-ownership patterns transform many rural landscapes from agricultural to multifunctional, which may have significant implications for land management and conservation policy. This paper presents a hedonic pricing model that quantifies the value of the remnant native vegetation captured by owners of rural lifestyle properties in rural Victoria, Australia. Remnant native vegetation has a positive but diminishing marginal implicit price. The value of lifestyle properties is maximized when their proportion of area occupied by native vegetation is about 40%. Most lifestyle landowners would receive benefits from increasing the area of native vegetation on their land. Findings from this study will be used to support decisions about ecological restoration on private lands in fragmented agriculture-dominated landscapes.

Keywords: lifestyle landowners, remnant vegetation, amenity values, spatial hedonic model, Victoria

JEL Classification: Q57, Q15

Introduction

Some rural landscapes in developed countries are changing from agricultural landscapes to multifunctional landscapes. Consumption of natural amenities has been one of the primary determinants of these changes (Irwin *et al.* 2010). Drivers of amenity migration, in which lifestylers, downshifters, economic migrants, and retirees move to rural areas, include the importance placed on natural amenities, the search for a better quality of life, and economic constraints of urban living (Chipeniuk 2004; Gurran 2008). This mode of migration has caused a shift in rural landownership from agriculture-focused traditional farmers to amenity-focused 'lifestyle' owners (Sorice *et al.* 2012).

Lifestyle landowners have diverse cultural contexts and ideas about land and nature, and the majority of them do not consider land use as a primary source of income (Majumdar *et al.* 2008; Mendham and Curtis 2010). The shift of land ownership structure in rural landscapes may have significant implications for future land use and land cover, because the ways landowners view their lands drive land-management preferences (Sorice *et al.* 2012). As the lifestyle landowners do not derive income primarily from agriculture and often have limited local knowledge and experience, there is a risk of mismanagement of the property that could lead to severe resource degradation (Sengupta and Osgood 2003). However, they value the land for its amenity and ecological characteristics more than for its agricultural capabilities (Gill *et al.* 2010), which creates a potential to bring about changes in rural landscapes that provide public goods for society (e.g., ecological restoration).

Commercial farmers have traditionally been targeted by government agencies and natural resources management bodies to promote management practices that enhance conservation. However, there has been less attention paid to engaging with lifestyle landowners (Pannell and Wilkinson 2009). We have a good understanding of the spatial extent and trajectory of the demographic changes in rural landscapes (Barr *et al.* 2005; Luck *et al.* 2011) and the diversity of motivations and preferences of lifestyle landowners (Sorice *et al.* 2012). However, economists have paid little attention to quantifying the benefits lifestyle landowners derive from the on-property and off-property environmental assets (Sengupta and Osgood 2003).

Information about private benefits generated by the environmental assets in rural landscapes is important for designing effective natural resource management policy instruments (Pannell 2008) and management practices that could be adopted by the landowners (Pannell *et al.* 2006). Environmental assets in rural landscapes can provide both public and private benefits. For example, remnant native vegetation provides private recreational and amenity benefits to the landowner as well as public benefits to society by supporting biodiversity and regulating water flows.

The economic value of the privately captured flow of the benefits generated by environmental assets (ecosystem services) in rural landscapes is capitalized in property prices and can be estimated using hedonic pricing (Rosen 1974). The hedonic pricing method has been widely used to analyze amenity values of open space, trees, wetlands, and views, in urban and suburban residential housing markets (Fraser and Spencer 1998; Irwin 2002; Tapsuwan *et al.* 2009; Donovan and Butry 2010). A much smaller segment of the literature explores the values of on-farm recreational and aesthetic ecosystem services (Bastian *et al.* 2002; Torell *et al.* 2005) or the value of both on-farm and off-farm land-based ecosystem services (Ma and Swinton 2011). Fewer still studies have examined the effect of amenities on the values of rural lifestyle properties.

Sengupta and Osgood (2003) studied the effect of remoteness and greenness on the value of ranchettes (small ranches) in Yavapai county in Arizona. They found that isolation is a disamenity that decreases the value of ranchettes whereas greenness increases their value. White and Leefers (2007) analyzed the effect of natural resource amenities on the value of rural residential properties in two counties in Michigan and found that proximity to lakes and open space increases the residential sales price, while proximity to forest does not affect it. We are unaware of any study that attempted to quantify the value of environmental assets on the rural lifestyle properties.

The purpose of this study is to quantify the value of the environmental asset, in this case remnant native vegetation, captured by the value of lifestyle properties in rural Victoria, Australia. We use a spatial hedonic model to estimate the marginal value of remnant native vegetation and to examine whether the value is affected by the extent of native vegetation (asset size) on lifestyle properties. This information will be used to facilitate natural resource management decision making such as targeting ecological restoration programs on private lands.

Methods

Lifestyle landowners derive benefits from the consumption features of their property. Consumption features consist of human-built structures (**B**), which provide a place to live, and amenities associated with the property. Argent *et al.* (2007) defines amenities important for lifestyle landowners as site attributes and location attributes. Site attributes are ecosystem services (**E**) that provide cultural, recreational, and aesthetic amenity values to the landowners. Location attributes (**L**) are accessibility of off-site employment, services, entertainment, and recreation. Furthermore, many lifestyle landholders have an interest in small-scale agricultural production on their land (Pannell and Wilkinson 2009), so ecosystem services related to agricultural production (**A**) can also be important features of lifestyle properties.

Values of these features or characteristics of lifestyle properties cannot be estimated directly by observing their prices, because they are not traded on the market. However, assuming that lifestyle properties are differentiated goods traded on the market, implicit prices of their utility-bearing characteristics can be estimated using hedonic analysis (Rosen 1974). Let $\mathbf{X}_i$ be the vector of the attributes of lifestyle property *i* that consists of the vectors $\mathbf{A}_i$, $\mathbf{B}_i$, $\mathbf{E}_i$ and $\mathbf{L}_i$, and $P_i = p\left(\mathbf{X}_i\right)$ is its price, where $p\left(\cdot\right)$ is a function that describes relationship between price of the lifestyle property and its attributes. Then $p_j = \partial p(\mathbf{X}) / \partial x_j$ is the implicit price of an attribute *j* (Ma and Swinton 2011).

Spatial data, such as property sale prices, often exhibit spatial dependency relationships among observations (Anselin 1988). The presence of spatial dependencies in property sales data causes bias and inconsistent or inefficient coefficient estimates when the ordinary least squares (OLS) method is used to model the data. Testing for the presence of spatial dependencies and estimating spatial models requires an assumption about the way in which observational units are believed to be influencing each other (see Anselin 1988 ; Taylor 2003). This is generally done using a spatial weight matrix **W**, which contains one row and one column for every feature. The cell value for any given row/column combination is the weight that quantifies the spatial relationship between the row and column features. Spatial weight matrices are usually row-standardized, which means that the sum of weights in each row adds to unity, facilitating interpretation of the regression coefficients. There is no consensus among practitioners on the most appropriate type of weight matrix to be used in spatial hedonic models, and the selection of the best matrices has been a challenge to researchers leading to *ad hoc* approaches in practice (Tapsuwan *et al.* 2012). One of the approaches used to define the spatial weight matrix when observations are not immediate neighbors is the inclusion of N nearest neighbors or observations within certain cut-off distance. Among assumptions of weakening spatial relationship with distance, the most common is that the spatial relationship decays proportionally to the inverse distance between the observations (Maddison 2009). To avoid arbitrary specification of the weight matrix, Donovan *et al.* (2007) determine a cut-off distance by visually inspecting the empirical semivariogram constructed from the residuals of an OLS model. In this study, we use an empirical covariogram of OLS model residuals to determine both cut-off distance and the decay function of the spatial relationship for the spatial weight matrix. An empirical covariogram is a covariance between pairs of residuals depending on the distance (lag) between observations and given as:

$$C(h)=\frac{1}{N(h)}\sum_{N(h)}\left(z\left(s_i\right)-\bar{z}\right)\left(z\left(s_j\right)-\bar{z}\right) \quad (1)$$

where $C(h)$ is covariace at lag *h*, $N(h)$ is a number of observations with lag *h*, $z\left(s_i\right)$ is the value of a variable (residual in our case) at point s_i. Covariogram data could be fitted with number of models (Tu *et al.* 2007), among which we selected an exponential model for this study:

$$C\left(h\right)=\sigma\times\exp\left(-\frac{h}{r}\right) \quad (2)$$

where σ is “scale” and r is “range”, both of which are parameters to be estimated. The cutoff distance is then selected based on covariance decay where it reaches 5% of its maximum value. For the exponential covariogram model, the value of covariance reaches 5% of its maximum value at the distance $h=3\times r$.

In our spatial model, two types of spatial dependencies exist: spatial lag relationship and spatial error relationship. A spatial error relationship occurs when the errors of the model are spatially correlated due to unobserved variables or measurement errors in variables related to the location of a property. The spatial error hedonic model is then defined as:

$$\begin{aligned}\mathbf{P}&=\alpha+\mathbf{X}'\boldsymbol{\beta}+\boldsymbol{\varepsilon}\\ \boldsymbol{\varepsilon}&=\lambda\mathbf{W}\boldsymbol{\varepsilon}+\mathbf{u}\end{aligned} \quad (3)$$

where α is the intercept, $\mathbf{X}$ is the vector of the attributes of a property $\boldsymbol{\beta}$ is the vector of parameters to be estimated, $\boldsymbol{\varepsilon}$ is the spatially correlated error term, $\mathbf{W}$ is $n\times n$ spatial weight matrix, λ is the spatial error coefficient and $\mathbf{u}$ is an uncorrelated error term, i.e. $\mathbf{u}\sim N(0,\sigma^2)$.

A spatial lag relationship occurs where the sale price of a property is affected by the sale prices of properties in the neighborhood beyond the shared property characteristics. This contradicts the assumptions of the standard hedonic method in which the value of a composite good is determined by its characteristics. However, in reality, spatial lags can occur when collecting new information is costly and potential buyers use comparable sales from previous time periods to determine the value of the property (Maddison 2009). The spatial lag hedonic model is defined as:

$$\mathbf{P}=\alpha+\mathbf{X}'\boldsymbol{\beta}+\rho\mathbf{W}'\mathbf{P}+\boldsymbol{\varepsilon}, \quad (4)$$

where ρ is the spatial lag coefficient.

Due to simultaneity, spatial error and spatial lag models cannot be estimated using OLS method, so a maximum likelihood or instrumental variables method should be used for estimation. To control for spatial autocorrelation and overcome heteroskedasticity, we apply a general spatial two-stage least squares (GS2SLS) procedure to the data that produces spatial heteroskedastic and autocorrelation consistent (HAC) estimators of the variance-covariance matrix of the model coefficients (Kelejian and Prucha 2010; Piras 2010).

Study area and data

The study focuses on the five Local Government Areas (LGAs) in Central Victoria, Australia, stretching from northern outskirts of Melbourne's metropolitan area to the Murray River (Figure 1). The elevation of the study area ranges from 1013 m in the South to 73 m in the North. The annual rainfall varies between 1200 mm in the south-east to 300 mm in the north-west. Only about 25% of 1.5 million ha in the study region is covered by native remnant vegetation and other woodlands, the rest is being cleared mainly for extensive agriculture (see Table 1). The proportion of remnant vegetation and woodlands varies among LGAs. Public lands, including national, state and regional parks, cover about 18% of the study area. The region is dominated by irrigated (mostly on the north-east) and dry-land agriculture, with some horticulture and lifestyle farming in proximity to major population centers. The population of the area is about 230,000 with the majority of it concentrated in larger towns, including Bendigo, Castlemaine and Echuca.

Property sales data for the State of Victoria were acquired from the Valuer General's Office, Victoria. The records contain information on sales price, sales date, land area, land use, and Standard Parcel Identifiers (SPI) for each property. The SPIs were used to combine sales data records with the state cadastral parcel layer. For this analysis, we use records of properties sold between 1990 and 2011that were classified as lifestyle with an area range from 1 to 20 ha. Properties where land area recorded in the sales database deviates from the area calculated by Geographic Information System (GIS) by more than 10% were excluded from the analysis. If the same property was sold multiple times, only the latest sale record was retained for the analysis. To calculate the proportion of remnant woody vegetation on each property, we use TREEDEN25 GIS dataset that has tree cover information, which is developed by the Department of Sustainability and Environment, Victoria. Tree cover is defined as an area covered by woody vegetation greater than 2 meters in height and with a crown cover greater than 10 percent. We used Victoria Land Systems dataset (Rees *et al.* 2000) to identify dominant soil texture in the study area. In addition, GIS datasets WETLANDS, ISC_REACH2004, and PLM100, developed by the Department of Sustainability and Environment, Victoria, were used to identify lakes, rivers and creeks, and parks. The average annual rainfall data were obtained from the website of the Australian Bureau of Meteorology. The 90 meters resolution Digital Elevation Model (Jarvis *et al.* 2008) was used to calculate slope of the properties. Spatial and tabular data on population of urban centers and localities from 2006 Census of Population and Housing were obtained from Australian Bureau of Statistics website. These data were used to calculate a measure of population accessibility for each observation.

Table 1. Population and land cover statistics of the study area

Local Government Area	Area, thousand ha	Population in 2006	Percent tree cover
Campaspe	451.8	36,209	8.3%
Greater Bendigo	299.9	93,252	33.1%
Hepburn	147.2	13,732	40.7%
Macedon Ranges	174.8	38,360	27.7%
Mitchell	286.2	30,928	25.1%
Mount Alexander	152.9	17,066	36.0%
Total	1512.8	229,547	24.6%

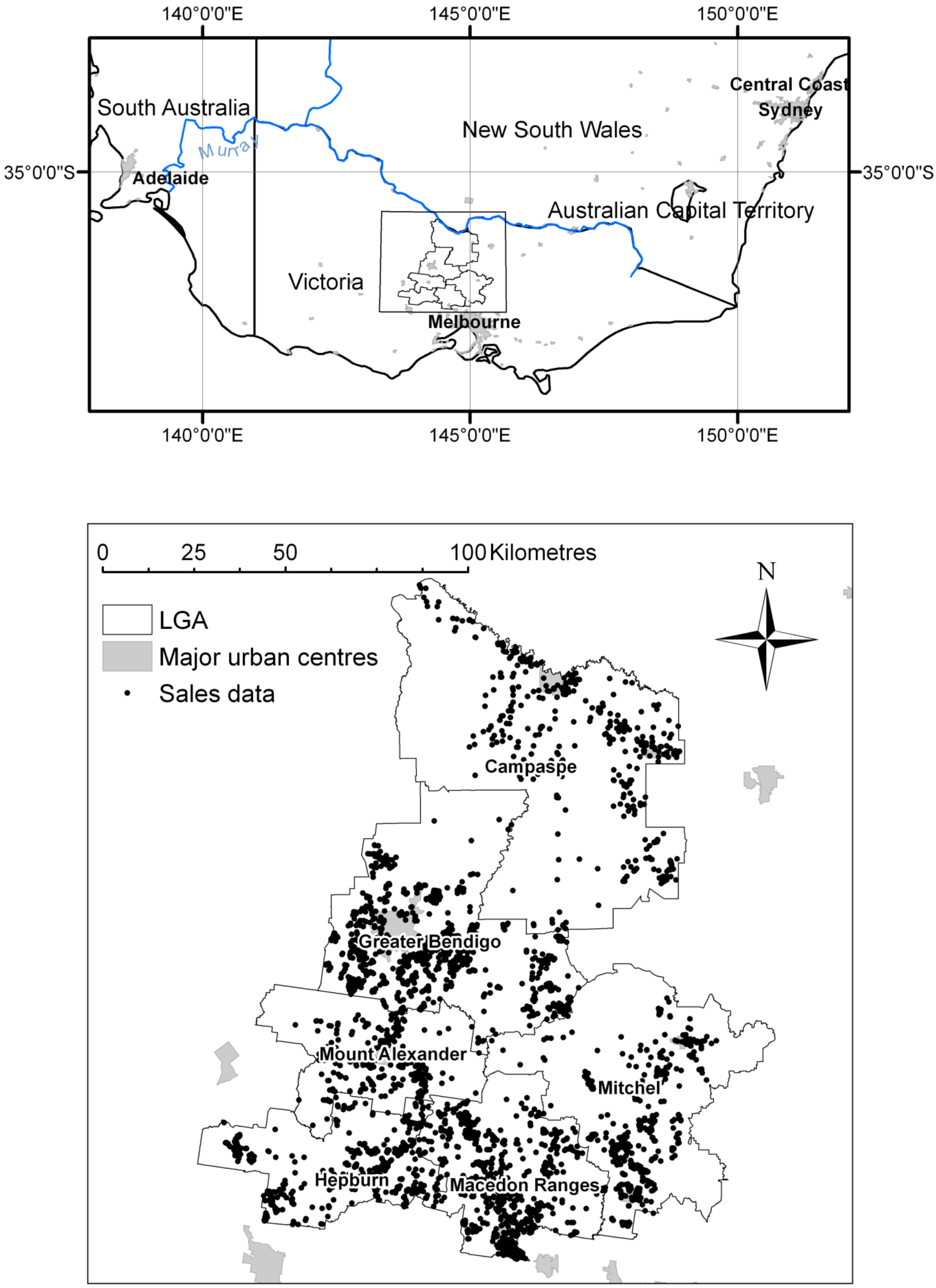

Figure 1. Location of the study area and sales data

Table 2. Descriptive statistics of the variables

Variable	Mean	Standard Deviation	Minimum	Maximum
Price, \$ ha^{-1}	112,436	126,523	1,008	1,816,874
Area, ha	6.3	4.9	1.0	20.0
Bedrooms, ha^{-1}	0.8	0.9	0.0	4.1
Sands	0.02			
Clays	0.88			
Slope, º	2.7	2.1	0.0	20.2
Annual precipitation, mm	692	177	399	1361
Proportion of tree cover	0.27	0.30	0.00	1.00
Distance to river, km	2.3	3.0	0.0	17.7
Distance to lake, km	17.8	12.5	0.0	57.6
Distance to park, km	9.1	8.0	0.0	35.4
PII	95.4	28.1	44.0	175.5
Trend, years	15.3	3.9	0.0	21.5

Empirical model

Using the Box-Cox test we concluded that a hedonic price function with natural log transformed dependent variable, per hectare adjusted sales price of lifestyle properties as a dependent variable *P*, is the most appropriate functional form. Prices were adjusted to the 2011 price level using the Australian consumer price index. To control for diminishing marginal value of land, we included the natural log of property area. Most of the lifestyle properties have houses and other structures; however, only number of bedrooms is available in the database. We used the number of bedrooms divided by the land area in hectares to indicate the level of structural attributes per unit of land (Maddison 2009).

To take account of on-property ecosystem services, we include soil characteristics, slope, precipitation, and the proportion of tree cover. Soil characteristics are represented by two binary variables indicating soil texture, namely sands and clays, with loams being the default texture. Steeper slope could be beneficial for the amenity value if it creates a beautiful view; however, it could be an impediment for agricultural production. In the predominantly dry Australian environment, rainfall is an important factor for agricultural production, and it can also have a positive influence on amenity values through its creation of green landscapes and water availability for domestic uses (Argent *et al.* 2007). Proportion of tree cover on the property characterizes quantity of native remnant vegetation. We hypothesize that native remnant vegetation is an environmental asset that contributes to the amenity value of lifestyle property. We assume that this asset has diminishing marginal returns, which is captured by including a quadratic term for proportion of tree cover variables in the model.

Location attributes that describe accessibility to recreation facilities, are represented by the Euclidean distances to the nearest state, national, or regional park, nearest lake greater than 100 ha, and nearest river or creek. Accessibility to employment, services, and entertainment could be measured by the distances to the populated places such towns or cities. Cities, towns, or other urban centers offer a variety of such amenities. However, the amount and variety is usually greater in places with larger populations. To account for accessibility to these amenities, we use the population interaction index (PII) (Breneman 1997). This index is the inverse distance-weighted population within a certain distance, and has been used to model rural property values and return to rural lands (Livanis *et al.* 2006; Polyakov and Zhang 2008b). It is defined as:

$$PII_i = \sum_{j=1}^{J_i} \frac{Q_j}{D_{i,j}} \quad \forall i \tag{5}$$

where PII_i is the population interaction index for property *i*, Q_j is the population size of the urban center or locality *j*, and $D_{i,j}$ is the Euclidean distance between property *i* and the urban center or locality *j* in meters. We include urban centers and localities within 350 km radius of the property.

Because our dataset spans for 21 years, we included a trend variable in a continuous form to represent each year since January 1, 1990. This variable captures the average annual growth rate of property prices. Descriptive statistics of the variables are presented in Table 1.

Results

Table 3 shows OLS results for the hedonic model of rural land prices. The model explains 75% of the variance of the dependent variable. The empirical covariogram of the OLS residuals is shown in Figure 2. It clearly suggests the presence of non-linear spatial dependency among observations, which curtails after approximately 20 km. The results of nonlinear least squares estimation of exponential covariogram model are presented in Table 4. Comparison of the fitted exponential covariogram plotted against empirical covariogram (Figure 2) with regression residuals suggest a reasonably good fit.

The row-normalized spatial weight matrix **W** was constructed using threshold distance of 18.5 km, which is three times the “range” parameter of the exponential covariogram, and the weights of the individual elements of the matrix are proportional to the covariance predicted using equation (1). We constructed two alternative spatial weight matrices: one is based on 8 nearest neighbours and the other is based on 18.5 km cut-off distance with inverse distance weight. OLS model residuals were tested for autocorrelation. Moran I statistics and results of Lagrange multiplier (LM) and Robust Lagrange multiplier (RLM) tests using three spatial weight matrices are presented in Table 5. The Moran I statistic indicates clustering pattern of the residuals. Both LM and RLM tests indicate the presence of spatial error and spatial lag dependencies; however, spatial error dependency is much more prominent. Furthermore, caution should be exercised when interpreting these results for spatial lag, because this test does not take into account the temporal component. The LM and RLM diagnostic statistic had greater and more statistically significant values in the test using exponential weight specification of spatial weight matrix. Therefore we estimated a spatial error model that uses the later spatial weight matrix.

Table 3. Regression results

Variable	OLS model		Spatial error model	
Intercept	10.8700***	(0.0839)	10.7995***	(0.2079)
log(Area)	-0.7579***	(0.0149)	-0.7554***	(0.0177)
Bedrooms per ha	0.4401***	(0.0304)	0.4344***	(0.0338)
Bedrooms per ha squared	-0.0758***	(0.0089)	-0.0758***	(0.0089)
Sands	0.2251***	(0.0787)	-0.0192	(0.0912)
Clays	-0.2631***	(0.0387)	0.0510	(0.0691)
Annual precipitation	1.6E-4**	(6.9E-5)	-1.6E-4	(1.4E-4)
Slope	-0.0456***	(0.0111)	-0.0169	(0.0104)
Slope squared	0.0037***	(0.0009)	0.0015*	(0.0008)
Proportion of tree cover	0.6436***	(0.1039)	0.5835***	(0.1039)
Proportion of tree cover squared	-0.7072***	(0.1142)	-0.7103***	(0.1138)
log(Distance to river)	-0.0652***	(0.0147)	-0.0619***	(0.0215)
log(Distance to lake)	-0.0465***	(0.0123)	-0.0498*	(0.0302)
log(Distance to park)	-0.0680***	(0.0103)	-0.0966***	(0.0211)
PII	0.0087***	(0.0004)	0.0086***	(0.0012)
Trend	0.0540***	(0.0023)	0.0563***	(0.0023)
Spatial error			0.8515***	(0.0315)
Number of observations	3121		3121	
R2	0.7548			
Adjusted R2	0.7536			

Note: standard errors are in parentheses.
* Significant at 10% level; ** significant at 5% level; *** significant at 1% level.

Table 4. Results of nonlinear least squares fit for empirical covariogram

Parameter	Estimate	Std Error	Approximate 95% Confidence Limits	
Scale	0.0426	0.00264	0.0374	0.0479
Range	6178.3	575.4	5035	7321.6
N	91			
F-statistics	241.5***			

Table 5. Tests for spatial autocorrelation in the OLS residuals

Test	Spatial weight matrix		
	Eight nearest neighbors	18.5 km radius inverse distance weight	18.5 km radius exponential weight
Spatial error dependence			
Moran's I statistics	0.16***	0.11***	0.09***
Lagrange multiplier test	372.16***	873.17***	1566.16***
Robust Lagrange multiplier test	366.81***	663.16***	1342.07***
Spatial lag dependence			
Lagrange multiplier test	5.41**	215.56***	234.12***
Robust Lagrange multiplier test	0.07	5.56**	10.03***

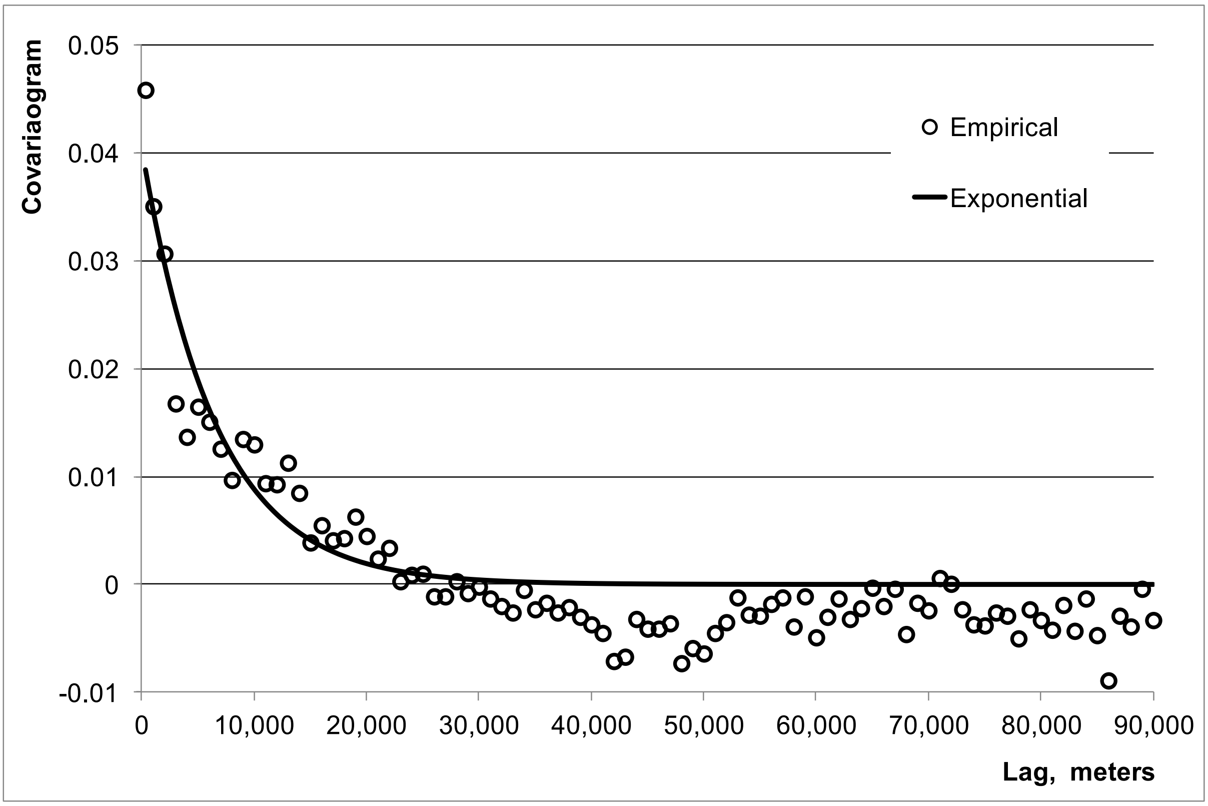

Figure 2. Covariogram of the residuals from the OLS estimation of the value of lifestyle properties

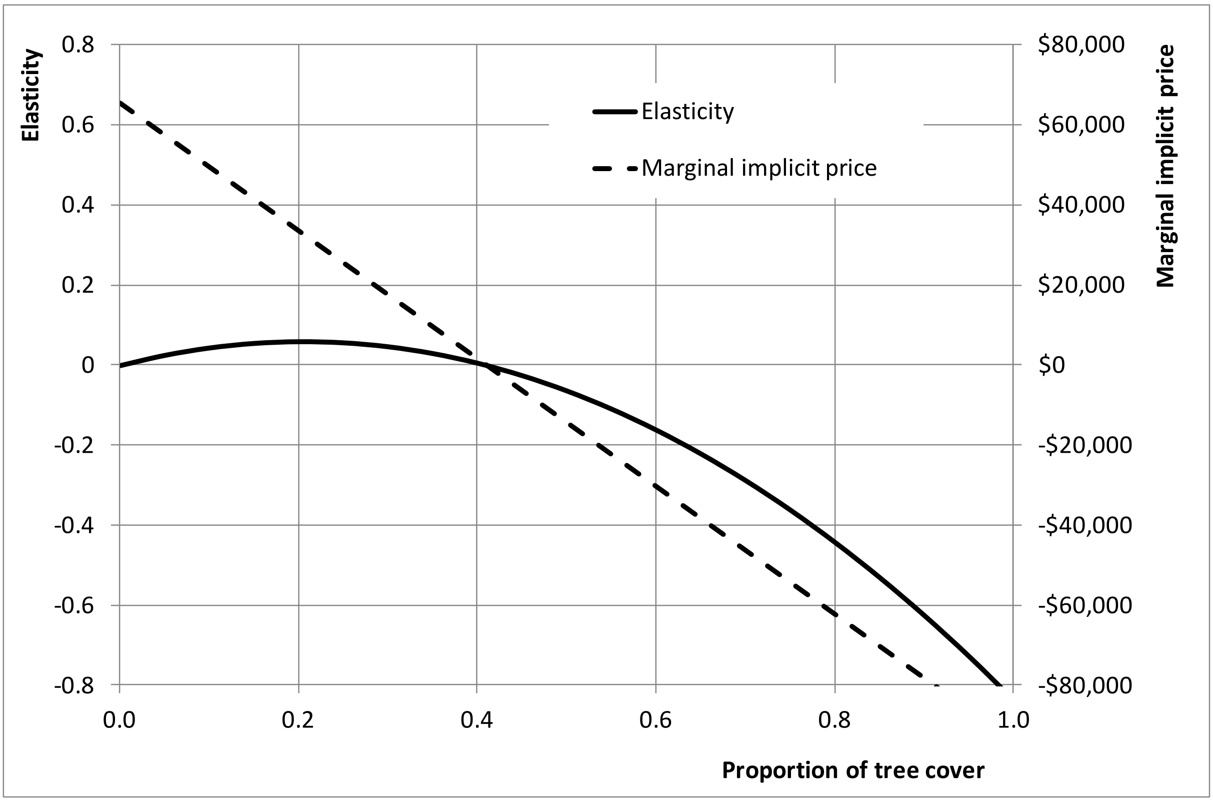

Figure 3. Elasticity of property value with respect to proportion of tree cover and marginal implicit price of the proportion of tree cover

Table 6. Marginal implicit prices and elasticities of statistically significant variables

Variable	Marginal implicit price	Elasticity
Area	-$13,570	-0.76
Bedrooms per ha	$35,578	0.25
Proportion of tree cover	$22,515	0.05
Distance to river	-$5,791	-0.06
Distance to lake	-$1,908	-0.05
Distance to park	-$4,702	-0.10
PII	$963	0.82
Trend	$6,327	0.86

Estimation results of the spatial error model are presented in Table 3. As expected, the spatial error coefficient is positive and significant, confirming the presence of positive spatial relationships. Signs of the coefficient in the spatial model are consistent with the signs in the OLS model except for most of the property characteristics derived from the GIS data such as soil, precipitation and slope, which became insignificant in spatial model.

Per hectare property value decreases with property size, reflecting declining marginal returns, which is consistent with findings of Sengupta and Osgood (2003). Causes for this relationship include subdivision costs, lower liquidity of larger properties, and the lack of market information held by sellers (Chicoine 1981). The bedrooms per hectare coefficient and its squared term indicate that a house adds value to the property, while the house size, represented by the number of rooms, has a diminishing marginal return.

Coefficients of the soil texture binary variables in the OLS model indicate that clays have negative effect and sands have a positive effect on property value comparing to loams. However, in the spatial error model these coefficients became insignificant with reverted signs, which indicate that there are likely omitted variables influencing values of lifestyle properties that are correlated with soil texture variable. Similarly, annual precipitation is positive and significant in the OLS model, which is consistent with our *a priori* expectations; however, it becomes insignificant in the spatial error model. It is worth noting that annual precipitation is correlated with the population interaction index (r=0.58). However, annual precipitation becomes insignificant in the spatial error model even when the population interaction index variable is removed from the model. This indicates that precipitation is possibly not as important in determining values of lifestyle properties as we expected.

Presence of some remnant vegetation increases the value of lifestyle properties; however, its effect is diminishing as indicated by negative coefficient of the quadratic term for proportion of tree cover. Figure 3 presents elasticity of the property value with respect to proportion of tree cover and marginal implicit price of the proportion of tree cover over the range of proportion of tree cover. Optimal proportion of tree cover is about 40%, at which point it increases property value by about $13,500/ha or by about 12% of the average property price. However, tree cover exceeding 80% reduces property value below the value of property with no tree cover.

Location characteristics are shown to be important in determining lifestyle property values. Accessibility of recreational opportunities as measured by distance to lakes, rivers, and parks increase property values. Being located one kilometer closer to the river, lake or park increases the value of the lifestyle property by $5,791/ha, $1908/ha, and $4,702/ha respectively. Population interaction index, a measure of accessibility to employment, services, and entertainment amenities, have a positive effect on lifestyle property values. The elasticity of this variable is 0.82, indicating that increase of population of the urban centers and localities by 1%, or a move 1% closer to populated places, increases the value of a lifestyle property by 0.82%. For example, increase of the population of town 10 km from the property by 10000 people or increase of the population of town 20 km from the property by 20000 people would increase property value by $963/ ha. This is consistent with the effect of population interaction index on land use change along an urban-rural gradient in Georgia (Polyakov and Zhang 2008a) as well as with the effect of remoteness on ranchette prices in Arizona (Sengupta and Osgood 2003). Finally, the time trend variable indicates that the values of lifestyle properties increased by 5.8% per year on average after inflation.

Discussion

Hobby farms, ranchettes, and lifestyle properties are becoming an increasingly large part of multifunctional rural landscapes in developed countries, including Australia. Lifestyle landowners, who have a variety goals and aspirations and are less focused on production goals, could play an important role in management and conservation of these landscapes. In setting conservation priorities it is important to consider not only where the most valuable natural assets are located, but also take into account the willingness and capabilities of people and institutions who would need to take action to protect or enhance those assets (Knight *et al.* 2010).

There is an emerging literature that attempts to explain conservation action of landowners by socio-economic, demographic, and cultural factors (Curtis 2008; Seabrook *et al.* 2008; Raymond and Brown 2011). Our research contributes to this effort by estimating the value that lifestyle landowners place on environmental assets, specifically remnant native vegetation, on their properties. We find that native vegetation has a positive and diminishing marginal implicit price, implying that these environmental assets provide amenity benefits to the landowners. Remnant native vegetation might be valuable to these landholders because of preferences for natural landscapes, aesthetic appearance of natural vegetation, and from the knowledge that they are providing habitat for native plants and animals. The marginal implicit price of remnant vegetation becomes negative at approximately 40% of tree cover, which means that most lifestyle landowners could benefit by re-vegetating part of their properties. This finding is consistent with Race et al. (2010) who found that lifestyle landowners undertake a considerable amount of work to re-vegetate and enhance native vegetation in similar Australian environments. Pannell and Wilkinson also found that lifestyle landholders hold positive views about re-vegetating part of their properties, but that ‘most lifestyle landholders have a strong reluctance to make environmentally beneficial changes that occupy the majority of their land’ (Pannell and Wilkinson 2009, p. 2686), consistent with our finding of negative marginal values at high areas of vegetation.

Findings from this study will be used to support decisions about ecological restoration on private lands in fragmented agriculture-dominated landscapes. They may contribute to this in several ways. Firstly, the finding will contribute to judgments about the likely level of adoption of ecological restoration activities on private land, allowing managers to judge whether adoption is likely to be sufficient to justify investing the transaction costs in a project.

Secondly, they will strengthen information about opportunity costs of land-use change to improve the spatial optimization of revegetation (Polyakov *et al.* 2011). Ecological restoration in working landscapes involves opportunity cost of foregone agricultural production. Information about private values of ecological assets such as remnant vegetation will help to identify priority areas where private benefits of ecological restoration would compensate for loss of agricultural production, thus reducing opportunity cost of ecological restoration projects that generate public benefits.

Thirdly, the findings will help with judgments about the most efficient policy mechanisms to encourage revegetation, for example, using Pannell's public-private benefits framework (Pannell 2008; Pannell and Wilkinson 2009). Adoption and opportunity costs are both relevant factors to consider.

Fourthly, the results may be used as inputs to benefit-cost analyses of projects to encourage revegetation. There has been extensive use of benefit-cost analysis by the regional environmental management body responsible for most of the study region (Pannell *et al.* 2012).

Conclusion

Environmental assets in rural landscapes, such as remnant vegetation, provides private recreational and amenity benefits to the landowner as well as public benefits to the society by supporting biodiversity and regulating water flows. The optimal allocation of rural lands between different uses and management practices depends on the balance between societal and private benefits.

The spatial hedonic property price approach was used to estimate the private benefits of environmental assets on lifestyle properties in rural Victoria, Australia. The estimated property price equation suggests that number of bedrooms, land area, land gradient, accessibility to urban centers and distance to lakes, parks and rivers are statistically significant when spatial dependencies are taken into account. In addition, the statistically significant effect of proportion of tree cover on property price indicates that native vegetation provides amenity benefits to rural land owners but only up to a certain proportion. The optimal proportion of tree cover found to be in our study area around 40% of land area where a 12% increase in average property price can be achieved. However, as tree coverage increases, the rate of benefit decreases and once tree coverage is in excess of 80% property price reduces below the value for 0% tree cover. Lifestyle landholders have been found to put less effort in making environmental beneficially changes to their land when they have to deal with larger areas.

The transition from agricultural land to rural lifestyle properties in areas of high environmental amenity value is likely to continue into the future (Barr *et al.* 2005). As it proceeds, information about private values placed on environmental assets, such as remnant vegetation, will help identify priority areas where private benefits of ecological restoration would compensate for loss of agricultural production. This information is useful in facilitating natural resource management decision making for targeting ecological restoration programs on private lands to ensure that natural resource management policy instruments (Pannell 2008) and management practices are effectively designed and adopted.

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