Paper Submission for 1997 WAEA Meetings
July 13-16, Reno, NV

Relationship Between the Implicit Value of Riverside Property, Environmental Amenities, and Streambank Protection

By

Siân Mooney[1]

[1]Ph.D Candidate, Department of Agricultural and Resource Economics, Oregon State University. Suggestions, comments and assistance from Ludwig Eisgruber, Stephen Polasky and Harold Seely are gratefully acknowledged. This study was partially supported by a grant from the Natural Resources Conservation Service (NRCS) of the United States Department of Agriculture (USDA).

Relationship Between the Implicit Value of Riverside Property, Environmental Amenities, and Streambank Protection

Abstract

Riparian protection and enhancement measures have been targeted primarily on lands used for a consumptive use. The costs of these measures are well documented. This study estimates the marginal implicit value of planting a treed riparian buffer on residential properties. Results show that non-consumptive users of riparian areas also value a stream bank with few trees.

Introduction and Rationale

Riparian and instream restoration/protection programs have received increasing attention as a measure to improve fish and wildlife habitat, stream bank stability and flood protection. Some protection schemes are mandated by law (for example, the Oregon Forest Practices Act); however, many others have been developed that require landowner participation on a voluntary basis. Examples of such programs are the Urban Stream Restoration Program (developed by the California Department of Water Resources in 1995), Riparian Tax Incentive Program; Fish Habitat Improvement Tax Credit Program (both administered by the Oregon Department of Fish and Wildlife); Environmental Quality Incentives Program (administered by the Natural Resources Conservation Service) in addition to many others (Pacific Rivers Council 1994). Many of these programs are developed to restore and protect stream quality and riparian areas on lands used for consumptive uses, such as forestry and agriculture. The costs associated with retiring lands from production (or lowering the intensity of production) are well documented. There are many more stream miles that are adjacent to lands used for non-consumptive uses. The costs (or benefits) of stream and riparian restoration/protection on these lands have not been widely studied. This paper will examine the costs or benefits associated with planting a treed riparian[1] buffer on residential properties with the objective of reducing stream temperature and improving fish habitat. The relationship between the riparian area planted in trees and the sale price of the property is uncertain and is the main focus of this study.

---

[1] The term "riparian area" in trees is not used in the strict sense of being the area of land with vegetation influenced by a water body; rather, riparian area in trees represents any contiguous treed area originating

Economic theory suggests that in the interests of efficiency, resources be allocated in such a way that the marginal value product of benefits are equated across all uses. Riparian areas are an important input into forest and agricultural production but little is known about their value to households in a non-consumptive use.

Conceptual Framework

The theoretical model used in this study was developed by Rosen (1974). The hedonic pricing technique is well suited to provide empirical estimates of the relationship postulated in the theoretical model. It uses information about real market transactions to impute a value for goods and services for which there is no formal market. A behavioral relationship between the observable choice variables and the environmental amenity of interest can be used to calculate the marginal rate of substitution between the variables and identify an implicit price for the amenity of interest. Hedonic price techniques can be used to generate a demand curve for an environmental amenity using a two stage analysis. This study, has generated information about the marginal implicit value of an environmental amenity, the first stage of the analysis. A second stage bid function is not estimated in this study.

If the housing market is in equilibrium and buyers are free to choose a property anywhere in the market; then buyers have optimized their property choice based on the cost of and utility provided by alternative locations (Freeman 1993). The total sale price,

---

at the banks of a river or stream and stretching back into the property.

P_{ri}, of a property *i*, can be expressed as a function of the attributes of the property as represented by the hedonic function (1).[2]

$$P_{ri} = P_r(\mathbf{L}_i, \mathbf{R}_i, \mathbf{N}_i, \mathbf{E}_i) \qquad (1)$$

Where L is a vector of lot characteristics, R is a vector representing the characteristics of the residence, N is a vector of neighborhood characteristics and E is a vector of environmental characteristics for property *i*. Sale price represents the equilibrium price between a buyer and seller in the housing market.

A property buyer faces a utility maximization problem in which they wish to maximize their utility function (2)[3] subject to a budget constraint (3).[4]

$$Max U = U(X, \mathbf{L}_i, \mathbf{R}_i, \mathbf{N}_i, \mathbf{E}_i) \qquad (2)$$

S.t $M - P_{ri} - X = 0$ (3)

Forming the lagrangian and maximizing gives the first order conditions for selecting the optimal level of *j*th environmental amenity e_j, and X (equation (4)) given the constraints faced by the property purchaser. That is, the ratio of the marginal utility derived from other goods and the marginal utility derived from the environmental amenity, is equal to the marginal willingness to pay for another unit of the environmental amenity, namely

$$MU_{e_i} / MU_x = \partial P_{ri} / \partial e_i \qquad (4)$$

Equation (4) indicates that the partial derivative of the hedonic price function (1) with respect to one of its attributes yields the marginal implicit price of that attribute (Freeman 1993).

---

[2] For a more detailed explanation of the following theory, see Freeman (1993).
[3] It is generally assumed that utility is weakly separable in property and its characteristics. This assumption implies that the demand for property characteristics is independent of the prices of other goods (Freeman 1993).

There is no *a priori* functional form suggested for the hedonic analysis, although economic theory does suggest that the sign on the first derivatives be positive for desirable characteristics and negative for undesirable characteristics. Many studies have used a Box-Cox transformation (Box and Cox 1964) to let the data determine the most appropriate functional form (Elad, Clifton and Epperson 1994, Lansford and Jones 1995, Streiner and Loomis 1995).[5] Other studies (Mahan 1996, Kulshreshtha and Gillies 1993) have used functional forms such as linear, semi-log and log-log. Cropper, Leland and McConnell (1988) suggest that the linear, semi-log and log-log forms in addition to linear Box-Cox perform well for hedonic model estimation.[6]

Study Area and data collection

The area chosen for this study is the Mohawk watershed in Lane County, Western Oregon (Figure 1). The area covers approximately 177 square miles and is a mixed use, multiple ownership watershed. A large part of the area is given over to industrial timber holdings (both public and private). The remaining area (approximately 27 square miles) is comprised of small timber holdings, hay land, livestock production and the small rural town of Marcola. There are two property markets within this area; the market for land and improvements to be used for production activities and a market for the amenity/non-

---

[4] The price of X is normalized to 1.
[5] Second stage estimations are sensitive to the functional form selected in the first stage of analysis.
[6] See Freeman (1993) or Mahan (1996) for a discussion of second stage estimation.

consumptive use of land and improvements.[7] The market of interest in this study is that for the amenity/non-consumptive use of property[8], for lifestyle or other reasons.

The data used in this study are collected from three primary sources; actual sales records; a Geographical Information System and aerial photo interpretation. Records of individual sales of land and property throughout Lane County over the period 1987 to 1996 were purchased from the Lane County Department of Assessment and Taxation. A subset of records covering the geographical area of the Mohawk watershed was selected from the total set. Of these records, only those that represented an arms length sale[9] of property were selected for inclusion in this study. Further, sales larger than 25 acres[10] were excluded on the basis that these properties are likely to be purchased for their productive agricultural or other characteristics, rather than their amenity value and, as such, represent sales within a different market.[11] Lots, with residences, that are adjacent to a river or stream were identified using a Geographical Information System (GIS).[12] The length of their water frontage was calculated using tools within ARCVIEW.[13] Aerial photographs of the study region taken in 1995 were provided by the Oregon Department of Forestry, Springfield. The photographs were used to calculate the riparian buffer width

---

[7] A personal interview, stratified random sample, survey of residents within the watershed indicated that many residents owned lots of several acres which were not fully utilized (or even partially in some cases) for agricultural, timber or other productive uses (Mooney and Eisgruber 1997).

[8] The term “property” refers to a lot, upon which a residence is constructed. The term “lot” refers to the parcel of land contained within the property. The term “residence” refers to the residential structure contained within the property.

[9] An arms length sale is a true market transaction. Sales between family members, small changes to the property title, and other similar transactions, were excluded from the analysis.

[10] 25 acres was chosen as a cut off point after examining the distribution of lot sizes contained within the data. There was a natural break between lots less than 25 acres and those of 40 acres and above.

[11] See Pope and Goodwin (1984) for a brief discussion of the forces exerted by productive and consumptive components of land characteristics on lot size.

[12] Taxlot, stream and road coverages for the Mohawk Watershed were purchased from Lane Council of Governments.

[13] ARCVIEW is a commercial GIS software produced by Environmental Systems Research Institute, Inc.

planted to trees on each residential lot that sold between 1987 and 1996.[14] Table 1 lists the variables, and the expected signs of their coefficients, used in the hedonic analysis to estimate the marginal implicit price of a water front location and riparian buffer planted to trees.

Table 1. Variable Definitions and Expected Signs

Variable Definition	Units	Symbol	Expected Sign
Total sale price of the property (payment for land and improvements)	Dollars	SALPRICE	Dependent Variable
Date of sale	Year/month/day	SALDAT	Positive
Size of lot	Acres	ATACRES	Positive
Size of residence	Square feet	SQFT	Positive
Year residence was built	Year (1987 to 1996)	YB	Positive
Dummy variable, reflecting lower quality housing [a]	1 if low quality housing, 0 otherwise	LOW	Negative
Dummy variable, reflecting very high quality housing [a]	1 if high quality housing, 0 otherwise	HIGH	Positive
Dummy variable reflecting those properties within the Marcola school district[b]	1 if within the Marcola school district, 0 otherwise	MARCOLA	---
Length of water frontage	Feet	FRTLGTH	Positive
Total area of the lot, planted to trees along the water frontage	Square feet	AREATREE	---

[a]Medium quality housing is implicitly in the intercept
[b]The Springfield school district is implicitly in the intercept

The dependent variable, SALPRICE, is the reported real market selling price of a property. The value of the lot and the residence are included in this dependent variable. Structural characteristics of the residence are controlled for in the variables SQFT, YB, LOW and HIGH (defined below).

(ESRI).

[14] The width of the riparian buffer planted in trees was calculated using a stereoscope, a magnifying glass and a ruler divided into 100ths of an inch. Calculated widths have not been ground truthed.

An independent variable, SALEDAT, is included to identify the date on which the property was sold. Sale price is expected to be positively related with the year of sale. The lot size (ATACRES) is expected to be positively related to the total sale price of the property.

Structural characteristics of the residence are incorporated in three separate variables. The size of the residence (SQFT) located on the lot is expected to be positively related to the total sale price of the property. The year the residence is built (YB) is also expected to be positively related to sale price reflecting the assumption that a newer home will fetch a higher price, *ceteris paribus*. An intercept dummy variable reflecting the quality of the residential structure (such as, quality of construction materials and design) is added to reflect low (LOW) and high (HIGH) quality housing. A third classification, medium, is implicitly included in the intercept term.

Locational characteristics of the property are also included. There is a difference of approximately 16 miles between properties closest to the major town and those furthest away.[15] This difference in distance translates into an increase in driving time to the closest major town of approximately 20 minutes. A dummy term reflecting school district is included, rather than a distance term, as school districts are highly correlated with distance from the closest large town.[16] MARCOLA is a dummy representing those properties within the Marcola school district, the remaining properties are within the Springfield school district. Descriptive statistics for all variables used are presented in Table 2.

---

[15] This distance was calculated for every residence using ARCVIEW.

[16] Pearson's correlation coefficients (ρ)are generated between all potential model variables using SAS (Statistical Analysis Software). The value, $\rho \approx 0.74$, is found between the variable representing distance

Two environmental variables are included to describe the water front and riparian characteristics of properties that are sold. The length of water frontage (FRTLGTH) is measured for each property and is expected to be positively related to sale price.[17] For those properties with a water frontage, the area of trees planted between the waterfront and the residence (AREATREE) is included.

Table 2. Descriptive Statistics for model Variables

	SALPRICE	SALEDAT	ATACRES	SQFT	YB	FRTLGTH	AREATRE E
Minimum	15000	870302	0.16	672.00	1880	0.00	0.00
Maximum	345000	961122	23.53	4653.00	1996	1204.00	78000.00
Mean	121025	921987	4.07	1707.15	1957	59.78	2357.19

Results

Ordinary least squares (OLS) is used to examine several alternative functional forms. The variables defined in Table 1 are used in each model with slightly different transformations, for example, squared or logged terms. The adjusted R^2 ranges between 0.71 to 0.74. Model results are extremely stable with respect to changes in functional form. Each model has consistently high adjusted R^2 and F-statistics. Parameter signs on significant variables are consistent in all the models evaluated. The results of two model specifications are shown in Table 3. Models 1 and 2 are defined in equations (5) and (6) respectively. Reported standard errors are adjusted by White's correction for heteroscedasticity.[18]

---

from the closest major town and the variable representing school district..

[17] Based on the assumption that a river frontage is a good rather than a bad; supported by results in Kulshreshtha and Gillies (1993).

[18] Breusch-Pagan (1979) tests indicated that heteroscedasticity was present in all models at the 1% level. Parameter estimates are unbiased under the existence of heteroscedasticity, however the estimates are not best (minimum variance) which results in misleading hypothesis tests. White's (1980) correction mechanism was used to correct the standard errors.

$$LN(SALPRICE)_i = \beta_0 + \beta_1 SALEDAT_i + \beta_2 ATACRES_i + \beta_3 SQFT_i + \beta_4 YB_i + \beta_5 LOW_i + \beta_6 HIGH_i + \beta_7 MARCOLA_i + \beta_8 FRTLGTH_i + \beta_9 AREATREE_i + \varepsilon_i \quad (5)$$

$$LN(SALPRICE)_i = \beta_0 + \beta_1 SALEDAT_i + \beta_2 LN(ATACRES)_i + \beta_3 LN(SQFT)_i + \beta_4 YB_i + \beta_5 LOW_i + \beta_6 HIGH_i + \beta_7 MARCOLA_i + \beta_8 FRTLGTH_i + \beta_9 AREATREE_i + \varepsilon_i \quad (6)$$

All coefficients have the expected signs in both model formulations. All coefficients except the dummies LOW and HIGH are significant. The primary variables of interest in this paper are the environmental characteristics of a property; that is, water frontage (FRTLGTH) and the total area of the property planted to a treed riparian buffer (AREATREE). Both FRTLGTH and AREATREE are significant at $\alpha = 0.01$. The total sale price of a property is positively related to the existence of a waterfront and negatively related to an increase in the riparian area planted in trees. This suggests that the existence of a treed riparian buffer strip causes a negative externality upon the property purchaser[19], perhaps because the trees obscure the view of the river.[20]

[19] A treed riparian buffer strip is generally considered to be a measure for stream bank restoration and enhancement. The negative coefficient associated with this measure contradicts the results generated by Streiner and Loomis (1995). The stream bank enhancements discussed in their study were not explicitly described and may not have included large trees.
[20] There are several factors, not accounted for in this study, that could be included to determine which attributes of the riparian buffer were not desirable; for example, the type, height and density of trees.

Table 3. Estimated Hedonic Regressions for Properties within the Mohawk Watershed - 2 Model Specifications

Variable	Model 1 - Coefficient	Model 1- Standard Error	Model 2- Coefficient	Model 2-Standard Error
SALEDAT	1.13E-5**	8.3069E-7	1.096E-5**	7.78E-7
ATACRES	0.0257**	0.0072		
LN(ATACRES)			0.1570**	0.0265
SQFT	0.0003**	4.6566E-5		
LN(SQFT)			0.4795**	0.1029
YB	0.0040**	0.0013	0.0026*	0.0012
LOW	-0.2042	0.1107	-0.1882	0.1060
HIGH	0.1123	0.1205	0.1915	0.1214
MARCOLA	-0.1850**	0.0550	-0.1649**	0.0512
FRTLGTH	0.0005**	0.0001	0.0004**	0.0001
AREATREE	-1.16E-5**	2.2556E-6	-1.19E-5**	2.2645E-6
Intercept	-7.3827**	2.6418	-7.3431**	2.5632
N	153		153	
R^2	0.7374		0.7573	
Adjusted R^2	0.7209		0.7420	
F-stat	44.62		49.56	

** Coefficient significant at $\alpha = 0.01$
* Coefficent significant at $\alpha = 0.05$

The marginal implicit prices of these attributes (measured at their mean values) are shown in Table 4. Results indicate that the mean marginal implicit price of an additional foot of river frontage is in the region of $48.41/ft to $60.51/ft, while an addition of another square foot of trees in the riparian area comes at a cost in the vicinity of $1.40/ft^2 to $1.44/ft^2. If we assume that each tree covers on average 20 square feet, then an additional tree "obscuring" the river would decrease property values by approximately 28 dollars. To illustrate the potential magnitude of decreases in property value, consider the following example. A 40 foot riparian buffer strip on a lot with 60 feet of water frontage results in 2400 square feet of riparian area planted in trees. If the marginal implicit price is assumed to be constant then this would result in a decrease in property value of $3408.[21]

[21] It is more likely that the marginal implicit price will become increasingly negative as a larger proportion of the riparian buffer is planted in trees.

Table 4. Marginal implicit prices of environmental attributes at their mean market values.

Variable	Model 1	Model 2
FRTLGTH marginal price $/foot of frontage	60.51	48.41
ACRETREE marginal price $/square foot of riparian area in trees	-1.40	-1.44

Conclusions

The implicit value of river frontage property and riparian buffers in the non/consumptive use property market were examined using a hedonic pricing technique. Results suggest that while participants within the market are willing to pay a premium for river front property, the existence of a riparian buffer planted in trees serves (on average) to detract from the amenity value of the land. One possible explanation is that the riparian buffer interferes with the river view. This result has important implications for the design of riparian restoration and incentive programs which could target lands used in non-consumptive uses. In areas where there are a large number of residences adjacent to rivers and streams (such as the Mohawk watershed); convincing residential owners of the value and need for riparian buffer strips and instream protection and restoration may be as important as persuading local agricultural or forestry interests. From a political perspective, the findings of this study are important. It is often accepted, *a priori* , that consumptive users of riparian areas (such as, forestry and agriculture) tend to lose economically from riparian buffers planted in trees and those oppose restoration and protection measures. Results from this study suggest that non-consumptive users of waterfront areas also value the stream banks relatively free of trees. This insight calls for innovative approaches, both politically, economically and technologically. Comparisons of the relative marginal products of riparian areas in different land uses could serve to help design economically efficient[22] riparian enhancement schemes.

[22] Economically efficient in the context of achieving fish and wildlife habitat, structural stability or flood protection goals.

References

Box, G. E. P. and D. R. Cox. 1964. An Analysis of Transformations. *Journal of the Royal Statistical Society, Series B* **26**, pp.211-252.

Breusch, T. S. and A. R. Pagan. 1979. A Simple Test for Heteroscedasticity and Random Coefficient Variation. *Econometrica* **47**, pp.1287-94.

Cropper, M. L. , L. B. Deck and K. E. McConnell. 1988. On the Choice of Functional Form for Hedonic Price Functions. *Review of Economics and Statistics* **70(4)**, pp.668-675.

Freeman, A. M. III. 1993. The Measurement of Environmental and Resource Values, Theory and Methods. Resources for the Future, Washington, D.C.

Kulshreshtha, S.N. and J.A. Gillies. 1993. Economic Evaluation of Aesthetic Amenities: A Case Study of River View. *Water Resources Bulletin* **29**, pp.257-266.

Lansford, N. H. and L. L. Jones. 1995. Marginal Price of Lake Recreation and Aesthetics: An Hedonic Approach. *Journal or Agricultural and Applied Economics* **27(1)**, pp.212-223.

Mahan, B. L. 1996. "Valuing Urban Wetlands: A Property Pricing Approach". Unpublished Master's Thesis. Department of Agricultural and Resource Economics, Oregon State University, Corvallis, Oregon.

Mooney, S. and L. M. Eisgruber. 1997. "Draft Summary Results of Mohawk Survey". Department of Agricultural and Resource Economics, Oregon State University, Corvallis, Oregon.

Pacific Rivers Council. 1994. Healing the Watershed: A Citizen's Guide to Funding Watershed and Wild Salmon Recovery Programs, 1st Edition. Pacific Rivers Council, P.O. Box 10798, Eugene, Oregon.

Pope, C. A. and H. L. Goodwin, Jr. 1984. Impacts of Consumptive Demand on Rural Land Values. *American Journal of Agricultural Economics*. Pp.

Rosen, S. 1974. Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economics* **82**, pp.34-55.

Streiner, C and J. Loomis. 1995. "Estimating the Benefits of the Urban Stream Restoration Program". Department of Agricultural and Resource Economics, Colorado State University, Fort Collins, Colorado.

White, H. 1980. A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica* **48**, pp.817-38.