VALUATION OF TREE AESTHETICS ON SMALL URBAN-INTERFACE PROPERTIES

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ABSTRACT. ***A model was developed to predict the value contribution of forest condition on small urban-wildland interface properties. Sample data were collected on property transactions in the Lake Tahoe Basin of California between 1990 and 1994. A variant of the stand density index (SDI) and a tree health measure were added to a list of traditional property characteristics (i.e., location, house and lot size) to express the influence of tree care on property value. These aesthetic characteristics were statistically significant despite the expected dominant influence of the traditional characteristics. Values for the forest density and health characteristics were estimated and reveal a contribution to property value between 5 and 20 percent.***

Keywords: urban-wildland interface, thinning, hedonic valuation, forest aesthetics

A multitude of stresses and demands are threatening the sustainability of America's private forestlands. As, the keynote speaker to the ***Summit on Sustaining America's Forests*** put it, "America's private forests are being rapidly altered by urbanization, fragmentation, and forest health problems." (Sampson 1999). Many of the forest health problems arise indirectly from urbanizing wildlands such as the need to suppress fire, a key ecosystem function, in the urban wildland interface. Landowners need information and economic incentives to invest in practices that will restore and maintain forest health in these urbanizing forested landscapes.

Residential woodland property owners are often unaware of how a healthy, attractive forest condition could add to their total property value. The purpose of this research was to identify and quantify the contributions that forest characteristics can have on woodland residential property value using observations from the Lake Tahoe Basin.

Urban forestry research has focused on the wide spectrum of benefits that trees provide to residential properties, such as wildlife habitat, energy and water savings, pollution reduction, and value-enhancing aesthetics (USDA 1990). Numerous studies have been conducted on the value trees in urban and suburban settings using traditional appraisal methods (e.g., Council of Tree and Landscape Appraisers (CTLA) 1992, Chadwick 1980, Anderson and Cordell 1985). Other researchers have applied similar methods to valuation of rural wooded landscapes (Standiford et. al 1986, Colorado State Forest Service 1979, and Magill 1989). Further studies have investigated the range of stocking and its impact on the condition of the forest (Ritters et. al., 1990). Relatively, little research has been done on the valuation of urban interface forest characteristics of the complete property (Garrod and Willis 1992).

The Shade Tree (Trunk) Formula (CTLA 1992), though very useful, is not well-suited for valuation of practices designed to enhance stand health and amenity values on small urban interface acreages. This formula focuses more on valuation of an individual tree with no explicit consideration given to overall stand conditions. Therefore, a more classical valuation method, such as the hedonic model, is needed. The hedonic model developed follows most closely the works of Garrod and Willis (1992), and Jordan et al. (1985). The contribution of this research resides in the strength and proposed applicability of the empirical model.

The basic idea of the hedonic approach is to determine the contribution made by the characteristics of a good to its market price. Interest naturally focuses on the non-marketable characteristics. In the hedonic model, a property's value is a function of the values of all the characteristics of that property, some of which are common to many properties and some which are unique. Many, if not most, of a property's characteristics cannot be separated from the property. Hence, one must purchase a property to obtain a characteristic such as the house, a view, or aesthetics on the property itself such as trees (Garrod and Willis 1992).

Lake Tahoe Basin - an Ideal Laboratory

The Lake Tahoe Basin (LTB) lies on the border between California and Nevada and includes 84,240 ha (208,000 acres) of land, of which approximately 44,550 ha (110,000 acres) are privately owned and 39,690 ha (97,400 acres) are publicly owned. The LTB forest types are roughly divided by the state border with the Nevada side containing the "east-side" pine type varying between pure stands of Jeffrey pine (***Pinus Jeffreyii***) and a variety of associations where Jeffrey pine makes up a majority of the stocking. The California side consisted mainly of the Sierra Nevada mixed-conifer type (i.e., California white fir (***Abie concolor***), ponderosa pine (***Pinus ponderosa***), sugar pine (***Pinus lambertiana***), incense-cedar (***Libocedrus decurrens***), California black oak (***Quercus kelloggii***) and Douglas-fir (***Pseudotsuga menziesii***)).

The aesthetic created from the current LTB forested environment can be characterized as very unattractive and “unhealthy” due to human-caused overstocking and resultant disease and insect epidemics (Harcourt, 1994). Fire exclusion is the primary cause of the abnormally dense forest. Added to these unnatural conditions was a 10 year drought that further stressed the forest, especially the White fir. The result is massive disease and insect infestation exacerbating the already high drought-induced tree mortality.

Figure 1. Property values in the Lake Tahoe Basin are jeopardized by the high tree mortality on private and public lands.

Under natural conditions, fire would have thinned these stands and provided natural regeneration. However, a century of urbanization has forced exclusion of fire, halting nature's corrective processes. High rates of mortality and diseased survivors have dramatically affected the aesthetic of the LTB and therefore may be linked to the selling price of residential property. Removing trees (thinning) and other treatments could help rectify many of the current problems within the LTB and may be supported if economic returns can be demonstrated. But these treatments must be proactive rather than reactive to save property value.

To convince property owners to invest in preventive treatments usually requires "selling" the owner on the expected benefits from enhancing stand health and aesthetics. These aesthetics are generally fairly obvious in the LTB where residential market values are clearly driven by views and property appearance.

METHODS

A general expression for the theoretical hedonic model follows:

$$\mathbf{p = H'X} + \upsilon$$

Here, the **X** vector represents the observable and quantifiable characteristics of the property, and p is the market price of the property. Thus, the extent to which the market price varies in response to varying levels of X_i expresses its implicit, or hedonic price vector (H', the transpose of H_i coefficients for each X_i). The theoretical error term (υ) reflects not only error in market data but also property uniqueness.

We hypothesized that the traditional housing valuation characteristics (e.g., location, size of the home, size of the property, the views from the property) along with forest aesthetic characteristics would account for a property's price (Witte, et. al. 1979). The following functional expression of equation (1) identifies the property characteristics to empirically estimate property price (PRICE):

$$\mathbf{PRICE = h_1(location\ or\ view) + h_2(house\ size) + h_3(acres) + h_4(\textit{Trees}) +} \varepsilon$$

where Trees is an instrumental variable for a vector of forest aesthetic characteristics, and ε is the observed error term.

Individual variables must be defined for the Trees forest aesthetics instrumental vector. We hypothesized that variables of tree size, number of trees per acre, condition, and species would significantly influence forest property values. Diameter of the tree of average stand basal area (DBH) and trees per acres (TPA) are fundamental variables in describing stand density and, in turn, its aesthetic influence on PRICE. These are typical stand measures and have a well-established methodology in data collection that promotes usefulness. However, as the stand ages, TPA and DBH relate inversely in their contribution to stand density. Therefore, measures that integrate TPA and DBH could be substituted for these variables in ***Trees***. We chose Stand Density Index (SDI) due to its wide acceptability (Reineke 1933). SDI is commonly defined as follows:

$$\mathbf{SDI = TPA} \left[\frac{10}{\bar{d}_q} \right]^{\beta}$$

where TPA = trees per acre, $\bar{d}_q$ = stand quadratic average diameter of TPA, and β is Reineke's slope coefficient relating TPA to $\bar{d}_q$, approximately -1.6 for many North American tree species (Clutter, et. al. 1983).

Due to non-linearities between SDI and PRICE, it is necessary to allow the relationships between TPA, DBH and PRICE to vary. As such we will use a different variable to express the value influence from SDI (SDIVAL):

$$\text{SDIVAL} = \text{TPA}^{\phi} \left[\frac{10}{\text{DBH}} \right]^{\gamma}$$

where ϕ αnd γ are ex post estimable value-related TPA and DBH coefficients, respectively.

Further, variables are needed to express the degree of infection in trees, INFECT, and forest type, NS. The result is the final empirical expression to be modeled:

$$\mathbf{PRICE = H_1(SQFT) + H_2\,(ACRES) + H_3\,(VIEW^2) + H_4(INFECT) + H_5(SDIVAL) +} \ \varepsilon$$

where both of the SDIVAL parameters, ϕ and γ, equal 1.5.

Sample Data

Sample data were collected on the characteristics of property transactions from the California side of the LTB during the summer of 1994 (Hanna 1994). The sample was designed by randomly selecting 100 transactions from over 300 small, 0.1 to 2 ha. (0.3 to 5 ac.), property transactions between 1989 and 1994, stratified into four price strata in accordance with recommendations from local realtors. Although price data was collected in 1994 for home sales over a 5 year period, no accommodation for trends in prices was deemed necessary due to the brevity of the time-series and realtor confirmation that the housing market was essentially flat during this period. On-site observations and verifications were made of all property characteristics deemed relevant based on interviews with realtors and the property purchasers (refer to Appendix for data descriptions). Exploratory analysis was conducted using the full range of variables in an attempt to identify collinearities and means of designing instrumental variables to save degrees of freedom. The result was the set of variables, described in Table 1, to be used in the final empirical model. The sample size was reduced to 76 transactions because some characteristics or prices of sample properties were unverifiable.

For each property, tree groupings were identified and sampled to characterize forested structure, composition and condition. A single 0.081 ha. (0.2 ac) plot was established for each plant grouping and data collected (see Appendix for specific data).

Table 1. Data definitions.

Variable	Definition	Scale
PRICE	Sale price of sample property	$ (verified)
ACRES	Acreage of property sale	Listed
SQFT	Square footage of heated living area	Listed
NEAR-VIEW	View as seen of adjacent property and surroundings (See Appendix Table A1).	1-10
FAR-VIEW	Panoramic view as seen from the property (See Appendix Table A2).	1-10
VIEW	(2*Near View + Far View)/3	1-10
NS	A proxy for forest type (1=Placer Co., 2=Dorado Co.	1-2
DBH	Area weighted average of average dbh by plant group (0.81 ha or 1/5 acre plots) (See Appendix Table A3)	Inches
TPA	Area weighted average of average TPA plant grouping (1/5 acre plots) (See Appendix Table A3)	# per acre
INFECT	Area weighted average of average infection rating by plant group (see Appendix Table A3)	1-4

Note: A plant group is defined in this study as a somewhat homogeneous association of overstory and understory plants, further delineated by their orientation to views to and from the house.

For each property, plant groupings were identified and sampled to characterize forested structure, composition and condition. Variables constituting the ***Trees*** vector (DBH, TPA, INFECT) were created by averaging plant grouping variables weighted by area.

RESULTS

Using the quadratic form of the Box-Cox transformation to address non-linearities, an autoregressive model produced very impressive results (Table 2). The forest type variable, NS, was used as the cross-sectional stratum in Shazam's POOL procedure (White 1979). The results demonstrate a very good fit of the model (80% of the variation in price accounted for by the model).

Table 2. Results of hedonic generalized least square models of PRICE.

Variables and Statistics	**GLS** Coefficients (|t-value|)	Hedonic Price ($/increment)
SQFT	0.0002 (3.32)*	$64/ sqft
ACRES	0.19488 (3.11)*	$60,066/acre
VIEW[2]	0.00477 (7.43)*	$3,482/unit
INFECT	-0.08704 (2.77)*	-$26,390/unit
SDIVAL	0.00014 (2.78)*	$9,071/100
constant	11.591 (73.55)*	$334,009[1]
F-value	56.006	
Buse R^2	0.800	
Log L.F.	-8.409	
df	70	

1. Grand mean property price = $334,009, median property price = $219,500. Hedonic prices were calculated as increments from the grand mean property price.
2. Due to the aesthetic nature of this characteristic, it is possible to create an intervally scaled variable despite efforts to the contrary. Thus, interpretation of the coefficient and hedonic price as an incremental contribution to PRICE can not be made.

* indicates that the two-tailed t-value of the coefficient is significant at the 0.01 level.

Evaluating these coefficients (using Equation 3) at the mean of all variables except SDIVAL permits interpretation of the value influence of SDI constituent terms, TPA and DBH. Figure 2 illustrates the property value effect of TPA for a given DBH. That is, it would require a greater TPA at lower DBHs to influence price than for larger DBHs. Movement along one of these curves indicates the substitution between TPA and DBH while maintaining a constant SDIVAL. Removing the smaller trees, "thinning from below", can immediately increase the average DBH, as illustrated by the dashed line in Figure 2. In addition, such thinning improves the view from and of the home while promoting vigorous growth of the residual trees.

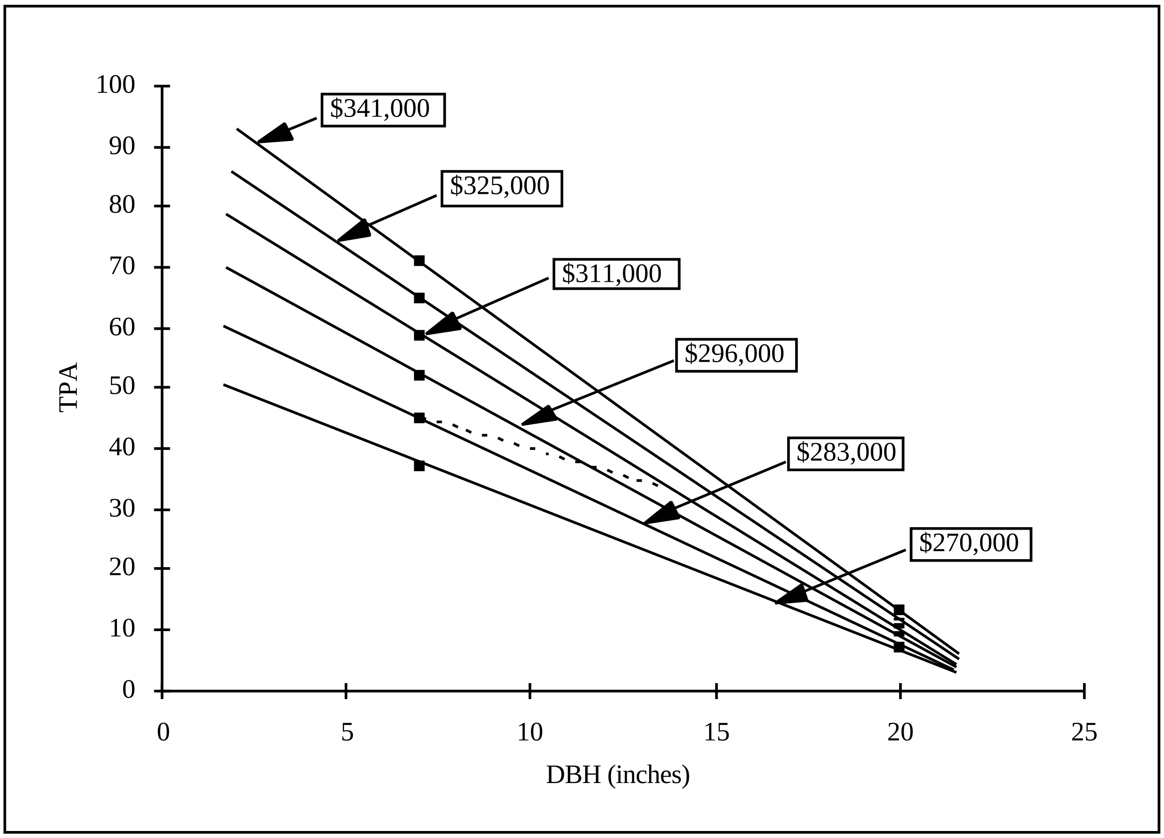

Figure 2. Equal SDIVAL curves between DBH and TPA, evaluated at the mean for all other variables. Dashed line reflects the value effect of a sanitation thinning.

Our results suggest that by thinning an overly dense stand of trees to enhance the residential forested character, the owner can add value to the property. The property shown in Figure 3 is a typical example of such a property. Here, high stand density and tree clearly detract from aesthetic and pose a serious fire hazard.

By removing the diseased trees, trees too close to the house, disrupting live fuel ladders, and some of the younger/smaller trees for view improvement (Figure 4), a significant increase in property value should occur according to our results.

Figure 3. A typical LTB property in need of arboricultural treatment.

The following prediction equation was used to predict the price of 10 observed properties selected to represent the price and size ranges of the total sample:

$$\text{Predicted Price} = \boldsymbol{e}^{(11.591+.0002(SQFT) + .19488(ACRES) + .00477(VIEW^2) -.08704(INFECT) + .00014(SDIVAL))}.$$

The price effect was estimated for a generic 40% TPA "thinning from below" prescription that would increase average stand DBH by about 3 inches (see Table 3). Each of these properties usually have many dozens of trees which is overstated by the TPA value for smaller properties.

The thinning prescription alone was estimated to add from 1 to 3 percent to these property's value. There did not appear to be any correlation between size or price and the magnitude of the thinning enhancement. If the thinned trees were those most heavily infected (reducing their INFECT value to 1.0), then property values could be enhanced an additional 5 to as much as 30 for properties with most infected trees.

Table 3. Predicted value increases from thinning and infected tree removal on ten selected observations across the range of property prices and sizes.

SQFT	ACRES	VIEW	TPA	DBH	INFECT	Predicted Price (PPrice)	PPrice w/ 40% thin	PPrice w/ 40% thin & INFECT=1
1025	0.36	1	126	4.5	2.5	$118,100	$121,000	$137,900
1152	0.35	1.67	82	6.2	4	$107,300	$109,000	$141,500
1104	0.47	1	100	8.4	3	$124,600	$125,750	$149,600
1224	0.3	2	66	3.1	1.5	$131,200	$132,500	$138,400
1800	0.38	5.67	86	7.8	3	$158,400	$160,000	$192,000
1310	0.5	1	183	7.7	3.5	$137,300	$139,200	$173,000
1560	2.07	4	86	6.5	2.5	$198,900	$201,300	$229,400
2765	0.48	5	66	4.6	1	$214,400	$216,500	$216,500
3261	1.1	6	181	7.1	3	$269,300	$276,000	$328,400
3123	1.6	1	105	4.1	1	$298,700	$408,000	$408,000

Figure 4. The same property in Figure 3 after prescribed, value-enhancing thinning (similar view angle).

These estimates are consistent with value estimates for residential trees in the ***Guide for Plant Appraisal*** (stating 7 to 15 percent from uncited studies). Because these thinnings are also designed to promote fire safety, it is reasonable to attribute part of the value-enhancements to reduction in fire risk. Such thinning intensity on these size properties provides a sufficient number of trees and volume for owners to reasonably expect some cost-offsetting revenues given that these interface areas often have active wood markets.

CONCLUSIONS

Our research indicates that the forested character of a property can be valued with a degree of confidence in the methodology equal to that which would be required to estimate marketable values. Certainly, Lake Tahoe represents a real estate market that could be called “high end”, but we do not believe this lessens the relevance of the results. In fact, it merely helped to accentuate the value-contribution of forest aesthetics above the statistical "noise" in these markets.

Stand density and health measures seemed to serve well as proxies for forest aesthetics, especially when used in a more composite or integrative way (e.g., SDI). However, it is possible that the property value enhancements from improved densities and health do not just arise from the aesthetic effects. Fire risk in the Lake Tahoe Basin, like many Western urban interface areas, has become widely recognized by residents recently, and markets may reflect the benefits of reduced fire risk from managed improvements. But such benefits are inherently jointly produced from proper tree/stand care.

Our results should lend support for current efforts to encourage investment in tree and stand care on small forest acreages in the urban interface where wood commodity values are negligible. Tangible benefits from expenditures on improving forest aesthetics can be presented to landowners. Benefits not directly reflected in our estimated values include community landscape benefits, the many social intangibles, and potential revenues from thinned wood material to offset treatment costs. Another unrecognized benefit for landowners is the potential reduction in the cost of , or even likelihood of obtaining, fire insurance. To our knowledge, no insurer in this, or any, fire-prone region uses fire protection landscaping as a determinant of the cost of coverage. Properties treated to resist wildfire should receive a reduced premium just like non-smokers receive lower cost life insurance. Further study into the insurance dimension is needed; as well as involvement with, and education of, the insurance industry to stimulate investment in tree care.

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Appendix

Table A1. Near Viewshed Rating Guide

1	=	NO VIEW possibly along major road or heavy use area.
2	=	VERY POOR, surrounding property heavy overstocking and poor condition
3	=	POOR, characteristics of 1 and 2 but in a modest degree
4	=	BORDERLINE, more (3) attributes than (5)
5	=	FAIR, on side of overgrown or undermanaged
6	=	INDETERMINATE, mild effort to manage condition
7	=	IMPROVING, more (6) attributes than (8)
8	=	GOOD, possibly hilltop and well stocked forest adjacent
9	=	VERY GOOD, near lake with wide view or open space
10	=	EXCELLENT, surrounding property is possibly lake-front or park like forest service land adjacent

Table A2. Far Viewshed Rating Guide

1	=	NO VIEW, possibly along major road or heavy use area
2	=	VERY POOR, surrounding property heavily overstocked and poor condition
3	=	POOR, characteristics of (1) and (2) but in modest degree
4	=	BORDERLINE, more (3) attributes than (5)
5	=	FAIR, on side of overgrown or undermanaged
6	=	INDETERMINATE, on side of mild or effort to manage
7	=	UNENCUMBERED, more (6) attributes than (8)
8	=	GOOD, possibly hilltop and well-stocked forest in the distance
9	=	VERY GOOD, near lake with wide views of mountains or open space
10	=	EXCELLENT, outlying property is possibly lake-front or views of mountain ranges in the distance and or ski slopes

Table A3. Hazard Rating Guide

A. Needle Condition	**Penalty**
Needle Complements:	
Needle complement normal	0
Less than normal complement through crown	0.5
No contrast between upper and lower crown	0.5
Thin complement in upper crown, normal in lower crown: contrast evident	1
Needle Length:	
Needle length normal	0
Needle length shorter than normal. No contrast between upper and lower crown	0.5
Needle short on top and normal below, marked contrast	1
Needle Color:	
Normal	0
Off color	0.5
Fading over entire tree	8
B. Twig and Branch Condition:	
No twigs or branches dead	0
A few scattered dead or dying twigs or branches in live crown	0.5
Many scattered dead or dying twigs or branches in live crown	1
Dead or dying branches forming a hole in top 1/3 of live crown	2
C. Top Crown Condition:	
No top killing	0
Old top kill, green below	0.5
Old top kill, weakness below	2
Current top killing more than 1/2 of live crown	6
Broken top recent less than 1/3 of live crown	1
Broken top recent more than 1/3 of live crown	2
Broken top old, no progressive weakness	0.5
D. Trunk and Root Conditions:	
Mistletoe on main stem, swelling evident	2
Active ***Dendroctonus valens***	2

Active ***Ips*** or ***Soclytus***	8
Stem cankers less than 50% of circumference	2
50-70% of circumference	4
Over 70%	8
Butt and Stem Mechanical or Fire Damage Scars	
5 - 15 % of stem and bark circumference gone	1
16-30 % of stem and bark circumference gone	3
> 31 % of stem and bark circumference gone	5
Fungus visible:	
5 - 15 % of stem basal area affected	3
16 % or more of stem basal area	5
Other Stem Rots:	
Pines	
No fruiting bodies	0
One	2
Two or More	5
Fir	
No fruiting bodies	0
One or More	5
Root Rots	
None present	0
One or More	5
Root damage due to construction:	
0 - 15%	0
16 - 30%	1
31% or more	3

E. Leaning Trees

Less than 3% off of vertical	0
3 - 5% off of vertical	2
Over 5% off of vertical	5

Total penalty scores from categories A, B, C, D, E and F added to determine risk class.

Penalty Score	**Infect Scale**
0	**1**
1 - 4.5	**2**
5 - 7.5	**3**
8 and higher	**4 (dead trees would receive a maximum score)**