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The Impact of Forests and Forest Management on Neighboring Property Values

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Previous hedonic studies have shown the positive contribution of forests to neighboring property values. However, they failed to address the differences in the economic contribution resulting from the changes in forest management practices. This study estimates the contribution of forests and forest management to property values around McDonald-Dunn Research Forest near Corvallis, OR. We investigated the economic effects of proximity to the forest, different forest conditions, and management schemes to neighboring property values using a geographic information system. Proximity to the forest has a positive contribution to property values; this relationship is even stronger for houses closer to the forest. Forest attributes also affect property values. The sales price is lower for property from which clear-cut sites are visible at the time of purchase if all other characteristics of the house are identical.

Keywords forest amenity value, forest management, hedonic price model, nonmarket valuation, property values

As environmental awareness and leisure time have increased, there has been a call for the new forest management that emphasizes supplying environmental amenities. Many homeowners derive aesthetic and ecological amenities such as scenic views, clean water, fresh air, and recreational opportunities from neighboring forests. Although such amenities affect forest neighboring property values positively, there is no clear market signal for forest managers to modify their management practices accordingly. Forest managers can easily overlook the impact of forests and forest management on neighboring properties, resulting in potential conflicts between forest management and neighboring landowners. One way to estimate forest amenity

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values is simply to ask people how much they are willing to pay for them. An alternative is to observe what people are actually paying directly and indirectly in the market. The hedonic price model is a way to observe an implicit price for an amenity in the market price of a commodity such as housing. The use of data describing actual market transactions enables us to avoid some of the problems inherent in hypothetical markets used in contingent valuation.

In this study, we applied the hedonic price model to the housing market around McDonald-Dunn Research Forest near Corvallis, OR, in order to estimate the impact of the forest and forest management on neighboring housing prices. The forest is an asset of Oregon State University and provides unique amenities to the surrounding suburban residential properties. Recreational and educational uses of the forest have grown rapidly in recent years as the population has increased in surrounding areas. There have been concerns raised among local residents over the forest management practices, especially over timber harvests. For example, in 1995, the harvesting of the Cameron Tract along Soap Creek Road brought a public dispute over McDonald-Dunn Forest management. The timber sale raised about $1 million for the university, but many neighbors complained their property values were negatively affected (*Corvallis Gazette-Times* 1995). Even though the forest managers left wider buffers between the clear-cut sites and neighboring properties than the state regulation required, the neighbors felt frustrated that they were unable to influence the forest management decision.

This case is just one example of many public disputes over forest management in the United States, due to the resulting impacts of forest management on property values. When the conflict arises, it would be helpful for the forest managers to know whether the neighbors' claims that their property values were depressed by the timber harvest were in fact valid. It would be even more helpful to estimate the economic impacts of forest management practices, which can be used to design an appropriate payment or compensation scheme between the neighboring homeowners and the forest managers.

By combining the geographic information system (GIS) layers of property locations and forest stands, we were able to measure the distance from each property to the forest boundary, a primary measure of forest amenity. The proximity to the forest represents the level of amenity provided by the forest, which includes visual aesthetics, a sense of serenity, and wildlife viewing as well as accessibility to recreational opportunities. We explored the possible applications of GIS techniques in the hedonic price model for assessing the impacts of different forest management schemes. The techniques developed here can be applied in other hedonic studies for measuring the economic contribution of location-specific amenities to property values. We also explored the issue of choosing a functional form of the hedonic price model for location-specific amenities. The conventional assumptions behind the widely used log-linear functional form may not hold true in the hedonic model estimation for forest amenities. We applied the quadratic Box–Cox model to select the functional form that best explained the data.

Hedonic Property Price Model in Forest Amenity Valuation

In recent years, a number of hedonic price studies have focused on the economic impacts of forests on surrounding residential properties in Europe. Garrod and Willis (1992a; 1992b) measured the amenity value of forests in Britain using a Box–Cox model and a two-stage hedonic price model. They found that the two most important land attributes were proximity to woodland and proximity to water, which raised house prices by 7% and 4%, respectively. They also examined whether a higher proportion of forestland in neighborhoods affected housing prices positively, and compared the contributions of different forest types. An increase in Sitka spruce relative to other cover types depressed house prices, whereas a greater abundance of broad-leaved trees increased them. Price (1995) argued that the hedonic price model is not applicable to scenic beauty because the quality of a scenic view is hard to measure quantitatively. Powe et al. (1997) avoided this issue by focusing on the amenity benefits gained by local residents from access to recreation sites. They used a geographical information system to measure the extent of access to recreation sites and other amenities from a given house. They also considered the amenity aspects of living in close proximity to woodlands or within the park, as being a part of landscape. They argued that the hedonic price model can measure the economic contribution of being in a particular type of a landscape or of the superior access to desirable environmental amenities, even when the quality of a scenic view was ambiguous. Tyrväinen and Miettinen (2000) examined the sales of terraced houses in the district of Salo, Finland. They applied four explanatory variables measuring urban forest amenities, such as the distance to the nearest wooded recreation area, the direct distance to the nearest forested area, the relative amount of forested area in the housing district, and the view from the dwelling window measured by visiting individual locations. As they stated, the data-gathering procedure was very time and labor intensive. They found that housing prices decreased an average of 5.9% as the distance to the nearest forest lands increased by 1 km, and that prices were higher by an average of 4.9% for homes with a forest view.

In the United States, Geoghegan et al. (1997) applied the spatial hedonic model to estimate the implicit value of ecosystem dynamics of surrounding land uses in a 30-mile radius of Washington, DC. They introduced measures of percent open space, diversity, and fragmentation of land uses into the hedonic price model. They also applied the landscape indices developed by landscape ecologists to the pattern of surrounding land uses by using a GIS. They found that more open space in one's immediate neighborhood was valued and that the marginal contribution of increased diversity and fragmentation changed in different landscape settings.

The previous hedonic studies showed the positive contribution of woodlands or forestlands to neighboring properties. However, they failed to address the differences in the economic contribution resulting from the changes in forest management. The visual amenities provided by forests were either ignored or measured by visiting individual locations. In this study, we adopted the explanatory variables measuring the forest amenities from the previous European studies. Furthermore, we explored the possibility of developing measures of forest amenities using GIS techniques that could be applied directly to stand-level forest management.

Conceptual Framework

A house can be thought of as a package of many characteristics, with its price determined by its size, number of rooms, amenities, and proximity to the business center or school. Let the ith house price (p_i) be described as $p_i = p(S_i, l_i, Q_i, N_i)$, which is a function of a vector of housing attributes (S_i), lot size (l_i), a vector of location-specific amenities (Q_i), and a vector of other neighboring characteristics (N_i).

The primary focus of the study was the impact of forest amenities on housing prices. The attributes from the neighboring McDonald-Dunn Forest were of particular interest in this study and measured in several ways. We used the distance from the forest to a property (q_j) as the primary measure of forest attributes. The other forest amenity variables included stand-level information of the nearest stand from a property and the visibility of clearcut sites at the time of property purchase.

We also considered other variables that influence property values. When people decide to purchase a house, they compare the cost of ownership as an investment versus paying rent. If people expect a higher future price while the current mortgage rate is relatively low, buying a house is a lucrative investment and one that affects housing demand. The user cost of capital is the cost of holding a house against expected future earnings, which is determined by the mortgage interest rate, depreciation rate, tax rate, and expected price change (Montgomery 1992). In previous hedonic studies, these factors were often assumed to be the same for all observations for the cross-sectional analysis. Aggregation over time is, however, unavoidable for many hedonic studies, especially in nonmetropolitan areas. Some factors in the user cost of capital may be stable over time, such as depreciation rate or income tax rate. However, severe changes in the expected future price or in the mortgage interest rate can affect the housing price even in a relatively short time period. Higher expected future price resulting from significant population growth or lower mortgage rates will induce lower user cost of capital, and the demand for housing will be increased. The housing price will rise to meet the increased demand in the housing market. Therefore, the hedonic property price model should include the changes in user cost of capital over the time period. We can reasonably assume that there is no interaction between housing characteristics and the user cost of capital. The ith house price function with the user cost of capital can be expanded as Eq. (1).

$$P_i^{\mathrm{ucc}} \approx p(S_i, l_i, Q_i, N_i, \mathrm{UCC}) \tag{1}$$

where p_i^{ucc} is the ith house price, S_i a vector of housing structure, l_i lot size, Q_i a vector of environmental amenity, N_i a vector of other neighboring characteristic, and UCC a vector of user cost of capital.

There are some issues and problems in the estimation of the hedonic property price model [(Eq. (1)]. First, the shape of the hedonic price model is known a priori from economic theory, although the hedonic price function can reasonably be assumed to be concave from below for an amenity like clean air (Freeman 1993). In other words, people are willing to pay more at the margin for cleaner air when the air quality is very poor than when the air is already relatively clear. However, we cannot assume that the marginal utility of a homeowner will diminish faster by increasing forest amenity (q_j) at lower levels. Increasing proximity to the forest may not be more desirable for the homeowners living farther away than for those living close by. For example, a house miles away from the forest may differ little from a house slightly closer if the owner can neither see nor easily access the forest. We know the property price function has an upward slope as the level of forest amenity increases, but its shape is unknown with the increase.

Because there is no functional form supported by economic theory, it is reasonable to apply several functional forms in order to identify the one that fits the data. Halvorsen and Pollakowski (1981) rejected the most common functional forms such as the linear, log-linear, and semilog, and proposed a procedure for choosing a functional form for hedonic price equations by applying the quadratic Box–Cox model. The general form of the quadratic Box–Cox model is as follows:

$$P(\theta) = a_0 + \sum_{i=1}^{m} a_i X_i(\pi) + \frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{m} b_{ij} X_i(\pi) X_j(\pi) + \varepsilon \quad (2)$$

$$\varepsilon \sim N(0, \sigma^2)$$

$$P(\theta) = \frac{(P^{\theta} - 1)}{\theta} \quad \text{where } \theta > 0$$

$$= \log(P) \quad \text{where } \theta = 0$$

$$X_i(\pi) = \frac{(X_i^{\pi} - 1)}{\pi} \quad \text{where } \pi > 0$$

$$= \log(X_i) \quad \text{where } \pi = 0$$

where P is the housing price, X explanatory variables, ε random error, and θ and π Box–Cox parameters. Depending on the values of θ and π, the quadratic Box–Cox model can take many shapes and allows the comparison of the log-likelihood values from each form. For this reason, the quadratic Box–Cox model has been widely adopted for choosing the proper functional form of the hedonic price model. However, Box and Cox's original intention (Box and Cox 1964) was to provide a meaningful and interpretable transformation without introducing bias. The optimal values of θ and π estimated by maximum-likelihood methods can result in a functional form that is too strenuous to have meaningful policy applications in terms of the slope and elasticities.

In this study, we applied the quadratic Box–Cox model to find the functional form that best explained the data set. A simple linear model was also applied to provide the most intuitive estimation of the forest amenity values reflected in property prices. The estimation results were compared with those from the more sophisticated models. The data are limited to the sales records of the residential properties within one mile distance of McDonald-Dunn Research Forest. The Research Forest Planning Team pays special attention to this area as the immediate forest neighbors and keeps the records of the properties, including the addresses and the names of the landowners. The limited data set also helps to reduce the problems with spatial autocorrelation and the correlated impacts of other open spaces in the area.

Data and Variable Selection

The McDonald-Dunn Research Forest comprises 11,500 acres of forest and meadow northwest of Corvallis, OR. The data for the hedonic price model estimation include 2095 properties of primary residential uses within 1 mile of the forest. The response variable for the hedonic price model in this study is the purchase price of selected residential properties. Sales in different years were adjusted to 1987 dollars according to the *Consumer Price Index–All Urban Consumers for All Items Less Shelter* to account for the price inflation outside of the housing market over time.

The housing market has grown rapidly since 1990. Any significant shock that changed the structure of this housing market could be problematic when pooling the data over time. To decide how many years of data could properly be pooled for the analysis, an F-test (the Chow test) was applied to determine whether the estimated regression coefficients differed with the time period. [Note that the Chow test indicates significant structural change in the relationship between the response variable and explanatory variables in the comparison of the sales data before and after 1990 (F statistic = 20.88; p value = 0.00).] Among the residential properties within 1 mile of the McDonald-Dunn Forest, we found 752 sales from 1990 to 1996 with all relevant information available.

Following Palmquist (1984) and Graves et al. (1988), we considered variables known to be significant in determining property price, such as lot size, size of living area, total number of rooms, age of house at time of purchase, public access to roads, and the presence of a garage or basement (Table 1). Because our study area was relatively small and non-metropolitan, some variables important in metropolitan areas were not applicable. For example, the distance to the Corvallis city center from each property did not have a significant impact on the property price.

Some variables not considered in previous hedonic studies were significant factors in the property prices in our study, such as the dummy variables for the year

TABLE 1 Selected Explanatory Variables Used in the Hedonic Price Model Estimation

Name	Description
1996SALES	For houses purchased in 1996 1996SALES = 1, 0 otherwise
1995SALES	For houses purchased in 1995 1995SALES = 1, 0 otherwise
1994SALES	For houses purchased in 1994 1994SALES = 1, 0 otherwise
1993SALES	For houses purchased in 1993 1993SALES = 1, 0 otherwise
1992SALES	For houses purchased in 1992 1992SALES = 1, 0 otherwise
1991SALES	For houses purchased in 1991 1991SALES = 1, 0 otherwise
QUITCLAIM	If the deed type is "quit claimed" then QUITCLAIM = 1
BARGAIN/SALE	If the deed type is "bargain or sale" then BARGAIN/SALE = 1
URBAN	If the house is located in urban area, then URBAN = 1
PUBLIC_ACCESS	If the house has public road access, then PUBLIC_ACCESS = 1
AIRCONDITIONER	If air conditioner is installed, then AIRCONDITIONER = 1
FIREPLACE	If the house has fireplace, then FIREPLACE = 1
BASEMENT	If the house has basement, then BASEMENT = 1
GARAGE	If the house has garage, then GARAGE = 1
STORIES	Number of stories in house
QUALITYINDEX	Housing quality index 1–8
LOT SIZE	Lot size
LIVING AREA	Total living area size
ROOMS	Total number of rooms
AGE	The age of house when it was purchased
DISTANCE	The distance from McDonald-Dunn Forest boundary (ft)

of the property purchase, the deed type, and housing quality index. As discussed previously, a house is an important investment. Because the opportunity cost of owning a property changes, the user cost of capital can explain some variation in the property price change. A dummy variable for each year was applied to capture the fluctuation of the user cost of capital over time. We also checked whether the different types of deeds affected the sales price of the properties. Most houses were sold under warranty deed, but some were cases of "bargain sale" or "quit claim." The housing quality index is a subjective rating, from 1 to 8, made by the assessor based on the shapes, stories, and the materials used (8 being the highest quality).

The primary "focus" variable was the distance from the McDonald-Dunn Research Forest boundary to each property. After accounting for the effect of being close to the forest, we found that it was difficult to separate out the contribution of specific neighboring forest characteristics to the property prices. However, there are differences in location-specific amenities even at the same distance from the forest, and some variation in property price was not explained by distance.

To determine what forest type might have significant impact on property values when proximity to the forest was an important factor, we tried the following ways to represent neighboring forest types. First, the areas around the McDonald-Dunn Forest were grouped according to the neighboring forest areas under distinct management plans (Figure 1). The northern zone of the forest is generally managed to

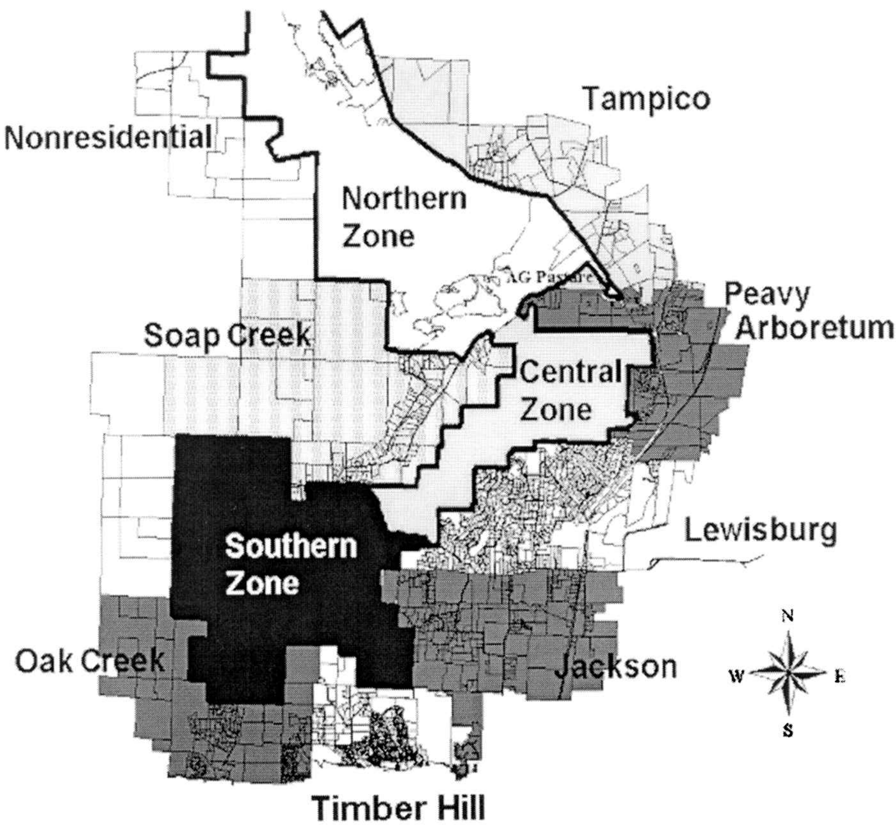

FIGURE 1 Residential area groupings in the McDonald-Dunn Forest Vicinity.

maintain younger, more structurally uniform stands with an even-aged regime, using clear-cutting and commercial thinning. The central zone is managed to create two-story stands using an even-aged approach with longer rotations. This plan involves regeneration methods of clearcutting and shelterwood. The goal in the southern zone is to achieve species composition and structure similar to an older, mid- to late-successional forest. Management here stresses multilayer, uneven-aged stands incorporating harvest methods of single tree and group selection (McDonald-Dunn Forest Planning Team 1993). Table 2 shows the average forest stand information in each zone. There are some agricultural pastures in the northern zone. Those were not included in averaging the forest information of the zone. The northern zone has younger stands with fewer trees per acre than the other two zones. The southern zone has the oldest stands, while the central zone has the tallest stands. The residential areas around these forest zones were grouped as seven neighborhoods: Arboretum, Tampico, Soap Creek, Lewisburg, Oak Creek, Jackson, and Timber Hill. These neighborhood groups have different accessibility and neighborhood characteristics as well as distinct forest amenities. Each property was assigned to a neighborhood, and the neighborhood dummy variable was tested for significance.

Second, stand information for the forest site closest to each property was included to ascertain whether there could be any contribution to the property price from being near a certain forest type. The stand information were collected from the McDonald-Dunn Forest database, such as the number of trees per acre, average tree height, and average stand age, as well as whether the closest site is an agricultural pasture or a meadow instead of a forested land. The composition of the stand was also considered. When a forest site comprises 15 to 50% conifer, it is defined as a hardwood stand. If more than half of the trees in a stand are conifers, it is a conifer stand. If the stand composition is 85% or more conifer, it is classified as a pure conifer stand (see Table 3).

Third, we examined if there is any impact on property price when clearcut sites were visible from the property at the time of purchase. Elevation of the study area [30m resolution digital elevation model (DEM)] was obtained from the U.S.

TABLE 2 Description of Forest Zones

	Northern zone (1)	Central zone (2)	Southern zone (3)	Total
Management scheme	Even aged	Two story	Uneven-aged	
Average number trees per acre	236.88	263.37	263.55	250.77
Average age (years)	52.81	59.95	63.59	58.12
Number of clear-cuts (>10 acres) since 1985	16	13	16	45
Last clearcut in the area	1996	1991	1992	1996
Average height of dominant and codominant trees (ft)	45.17	47.04	42.57	43.93
Average height of the tallest 40 trees (ft)	69.76	77.98	73.76	72.46
Average diameter (in)	5.79	6.38	6.08	5.97
Average crown closure (%)	54.29	62.03	63.11	58.99
Crown ratio	0.34	0.36	0.34	0.34

TABLE 3 Description of Selected Forest Attribute Variables

Location/ stand type	Description
	Area Group Dummy Variables
	If the property is:
ARBORETUM	in Peavy Arboretum area, then ARBORETUM = 1
TAMPICO	in Tampico area, then TAMPICO = 1
SOAP CREEK	in Soap Creek area, then SOAP CREEK = 1
LEWISBURG	in Lewisburg area, then LEWISBURG = 1
OAK CREEK	in Oak Creek area, then OAK CREEK = 1
JACKSON	in Jackson Creek area, then JACKSON = 1
TIMBER HILL	in Timber Hill area, then TIMBER HILL = 1
	Stand Information of the Closest Forest Site
	If the closest forest site to the property is:
AG PASTURE	agricultural pasture, then AG PASTURE = 1
CONIFER	conifer/hardwood (51–85% conifer), CONIFER = 1
HARDWOOD	hardwood/conifer (15–50% conifer), HARDWOOD = 1
PURECONIFER	pure conifer (>85% conifer), PURE CONIFER = 1
OTHERS	meadow or others, OTHERS = 1
TREE/ACRE	Total number of trees per acre
HEIGHT 40	Average height of 40 tallest trees
STAND AGE	Average age, overstory (year)
TREE HEIGHT	Mean height of dominant and codominant species (feet)
CCLOSURE	Crown closure
BIGDEAL	If the closest forest site was clearcut within 5 years before the property purchase, then BIGDEAL = 1
	Visibility of Clear-Cut Site at the Time of Purchase
VISIBILITY	If the clearcut site can be seen from the property, then visibility = 1

Geological Survey database. Elevation of the McDonald-Dunn Forest was increased by mean tree height of dominant and codominant species in each forest site to account for the fact that intervening trees might block the view of any clearcuts. With the adjusted elevation data, the visibility of the clear-cut sites for each year was calculated in a 2-mile radius by using ArcView, Avenue, and ArcInfo GRID. Only clear-cuts greater than 10 acres were considered in the visibility analysis. A dummy variable was used to represent whether any part of a clear-cut site was visible at the time of purchase.

Results

Regression Estimates with Forest Proximity Variable

To choose the proper functional form for the hedonic price model [Eq. (1)], we applied the quadratic Box–Cox model with the primary focus variable being the distance from the McDonald-Dunn Forest boundary to each property. This flexible functional form allowed us to compare the log likelihood values from each model defined by the values of θ and π [Eq. (2)]. We chose the model that had the largest log-likelihood value, which could best explain the data. The optimal values of θ and π were 0.82 and 0.52, respectively (log-likelihood value $= -7539.95$), from the iterated ordinary least-square model.

Among the more interpretable functional forms, the square-root model ($\theta = 1$ and $\pi = 0.5$) was chosen to have the smallest log-likelihood value (-7549.57), which is close to the optimal model. Significance of the interaction terms between independent variables (b_{ij}) in the linear model were tested (F statistic $= 3.02$; p value $= 0.00$). The test showed that some interactions among the explanatory variables significantly affected the response variable. When we tested individual interaction terms in the regression, some interactions between distance and housing structure variables were significant, but the estimated coefficients were very small and had unexpected signs. The interaction of distance with the time dummy variable for 1996 was significant in the regression, suggesting that the proximity to the McDonald-Dunn Forest tends to have had a greater impact on neighboring property prices in 1996. Because we only had the purchase price records through the beginning of 1996, we did not include the interaction term in the main analysis. The contribution of the forest to neighboring property values may have changed over time. However, this possible issue was not pursued for further investigation in this study, and a simplified model without interaction terms was applied.

To check the robustness of the estimation, we compared the estimated regression coefficients from the square root model with those from the linear functional form (Table 4). In both estimations, the explanatory variables describe about 75% of the variation in the property price and all have the expected signs. Most a priori set explanatory variables were included in comparisons across functional forms, except the dummy variables for the purchase in 1991 and 1992. These two variables were insignificant in all functional forms considered. A different selection of explanatory variables, however, did not greatly affect the significance of the distance variable in the regression estimation.

The distance variable had a negative relationship with the property price in both models. The marginal implicit price of the distance from the square root model is as follows:

$$\frac{\partial P}{\partial d_j} = \frac{-61.5}{\sqrt{d_j}} \tag{3}$$

where P is the purchase price (1990 to 1996) and d_j the distance from the forest boundary to the property j (for all equations $d_j = -q_j$). When one unit of square root distance increases, the estimated mean of property price decreases by \$123. The contribution of the forest to neighboring property prices depends on the distance from the property to the forest boundary. For example, a house 100 ft away from the forest is worth about \$1520 more in its purchase price than a house 500 ft away, while a house 500 ft away is about \$1139 more valuable than a house 1000 ft away, if all other characteristics of the house are identical. In the linear model, for each one foot closer to the forest, the house price is worth about \$2.87 more.

Figure 2 shows the projected changes in the average sale price of the selected residential properties (converted to 1997 price level) as distance increases. Recall that if a property is farther away, the attribute from the forest decreases and therefore the distance from the forest (d_j) is a negative measure of location-specific amenity (q_j). With distance, the property's location-specific amenity from the forest decreases

TABLE 4 Regression Estimates of the Square Root and Linear Model

	Square root model		Linear model	
Explanatory variable	Estimates	*T* statistic	Estimates	*T* statistic
Intercept	−128,993.00	−9.32	−45,799.00	−4.54
URBAN	6864.75	2.71	5917.70	2.33
PUBLIC_ACCESS	5793.11	2.66	6617.01	3.06
QUITCLAIM	−81,534.00	−9.71	−80,610.00	−9.51
BARGAIN/SALE	−74,883.00	−11.74	−72,678.00	−11.30
AIRCONDITIONER	7506.00	2.07	7738.15	2.12
FIRE PLACE	3366.69	1.57	2546.23	1.20
STORIES	378.54	1.72	508.59	2.32
QUALITY INDEX	14,523.00	7.38	13483.00	6.69
BASEMENT	−4384.32	−1.72	−5313.81	−2.06
GARAGE	17,535.00	5.61	17,964.00	5.67
1996SALES	40,392.00	13.63	40,010.00	13.38
1995SALES	42,141.00	14.79	42,542.00	14.80
1994SALES	33,844.00	12.85	33,455.00	12.57
1993SALES	17,567.00	7.15	17,882.00	7.21
AGE	−4090.49[a]	−4.89	−411.98	−4.29
LOT SIZE	61.10[a]	4.39	0.07	2.98
LIVING AREA	3214.26[a]	14.07	34.22	14.28
ROOMS	6782.68[a]	1.62	1439.74	2.21
DISTANCE	−123.00[a]	−1.50	−2.81	−3.33
Adjusted R^2	.7528		.7487	

Note. Dependent variable is purchase prices from 1990 to 1996 ($n = 752$).
T value of each coefficient is recalculated with White's consistent estimate of standard error.
[a]Coefficient for the square root of the variables.

along with the price. The square-root functional form indicates that the hedonic price function is convex to an increase in the location-specific amenities from the McDonald-Dunn Forest, which is a decrease in the distance. The homeowner's utility actually increases more rapidly with additional proximity to the forest when he or she is already close to the forest. If a house is far from the forest and does not have many forest amenities, increasing the proximity does not make a big difference in the property price. The conventional assumption of decreasing marginal utility and the concaveness of the hedonic price function may not be applicable in the case of forest amenities.

Regression Estimates with Forest Characteristics

In the previous model, the only forest amenity variable included was the distance to the forest. The contribution of different neighboring forest characteristics to property values depends on both the distance and the forest characteristics. Partial correlation analysis with the residuals was applied to test if any unexplained part of the square-root regression estimation with the distance variable could be accounted for by the neighboring forest characteristics around each property. All of

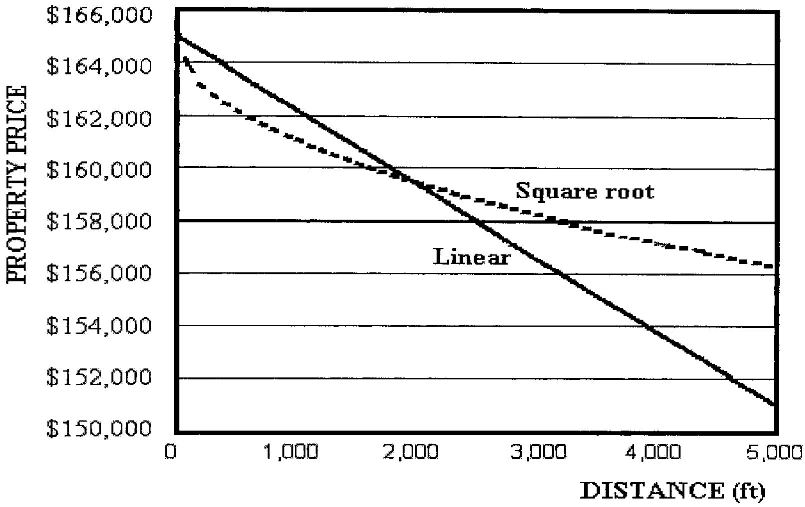

FIGURE 2 Hedonic price functions from the square root and linear models.

the variables that showed significant partial correlation with the residuals from the square-root model were introduced to the regression analysis. Interaction terms between the forest characteristics and distance were also considered, but none of them were significant in the regression after accounting for the forest characteristic variables. Adding five forest characteristic variables increases adjusted R^2 by .7, and all of the explanatory variables explain 76% of variation in property price (Table 5). Most of the variables remain significant and show the same signs. The coefficient for the square root of the distance variable is smaller (bigger in absolute value) with the forest characteristic variables included. In other words, proximity to the forest shows a bigger contribution to the property price when we account for the differences of the neighboring forest.

In the regression, the properties in the Tampico area, which neighbors the even-aged industrial forest, have significantly lower property prices than those in the other areas. Locations in the Lewisburg area have significantly positive impacts on the property price. This area is near forest sites managed for shelterwood stands with tall trees. When the closest forest site to the property is agricultural pasture, the property price is substantially lower. Among the properties near the forest, those close to pure conifer stands, rather than to mixed or hardwood stands, seem to have higher values. The dummy variable for visible clear-cuts from the property does not show significant partial correlation with the residuals or with distance. However, the dummy variable became significant when it was introduced with other neighboring forest characteristics. In other words, when the forest sites clear-cut since 1985 can be seen from the property at the time of purchase, the sales prices are lower if all other characteristics of the property are the same including the neighboring forest characteristics.

Conclusion

One of the management goals of the McDonald-Dunn Research Forest is to be a good neighbor (McDonald-Dunn Forest Planning Team 1993). The forest manage-

TABLE 5 Regression Estimates with Neighboring Forest Characteristics

Explanatory variable	Estimates	T statistic
INTERCEPT	−112,158.00	−7.62
TAMPICO	−15,707.00	−2.24
LEWISBURG	5358.57	1.86
AG PASTURE	−19,663.00	−2.67
PURE CONIFER	2827.75	1.55
VISIBILITY	−12,391.00	−2.18
URBAN	6587.59	2.62
PUBLIC_ACCESS	2330.93	1.02
QUITCLAIM	−83,410.00	−10.06
BARGAIN/SALE	−76,877.00	−12.13
AIRCONDITIONER	8053.94	2.25
FIRE PLACE	3983.60	1.86
STORIES	359.69	1.65
QUALITY INDEX	14,927.00	7.64
BASEMENT	−5884.93	−2.31
GARAGE	15,520.00	4.93
1996SALES	39,704.00	13.53
1995SALES	42,148.00	14.97
1994SALES	34,526.00	13.23
1993SALES	17,712.00	7.29
AGE	−3729.78[a]	−4.40
LOT SIZE	64.13[a]	4.59
LIVING AREA	3187.91[a]	13.88
ROOMS	6311.22[a]	1.51
DISTANCE	−200.94[a]	−2.43
Adjusted R^2	.7597	

Note. Dependent variable is purchase prices from 1990 to 1996 ($n = 752$).
T value of each coefficient is recalculated with White's consistent estimate of standard error.
[a]Coefficient for the square root of the variables.

ment plan is also concerned with the view of the forest from neighboring properties, as well as providing recreational opportunities to the community. The results of this study provide the forest managers the helpful information, specifically whether and how much the forest and the changes in forest management practices affect neighboring property values.

In this study, we found that having the McDonald-Dunn Forest as a neighbor has significant positive impacts on residential property values. The contribution of the forest to neighboring property values diminishes as the distance from the forest increases. The view of clear-cuts has a negative impact on the neighboring property prices, while maintaining mature or tall stands expands the contribution of the forest to property values. The even-aged industrial forest reduces the premium paid for being close to the forest, but the neighboring homeowners do not seem to distinguish the uneven-aged old growth stands from the shelterwood stands with tall trees. The neighboring homeowners also prefer a forest stand with 85% or more conifers.

These results may be used to create a market for forest quality around residential properties. In the case of the 1995 clear-cut, a 200-acre parcel was donated to Oregon State University (OSU) to provide money for the library renovation, as well as the fund for teaching and research into private forest management. Gift conditions maintained that the OSU harvest must raise $1 million for the library and 62 acres were clear-cut for that. If the neighboring homeowners in the area wanted to avoid the clear-cut, they would have needed to bring together this sum of money to pay off the forest manager not to clear-cut. This payment can be spread out over 60 years, which is roughly the rotation age of Douglas fir. The annual payment is about $44,204 with 4% annual interest rate. If 100 neighboring homeowners evenly participated on this payment, the annual payment to avoid any logging in their neighborhood would be $442 per year per household. Using the results from the hedonic model, the decrease in the property value by visible clear-cut is about $16,381 in 1995 dollars per property, which is about $724 per year with the same interest rate over 60 years. Therefore, homeowners may have a financial incentive to compensate the forest managers not to clear-cut when there is no other way to influence forest management decisions in their neighborhoods.

In a previous study (Johnson et al. 1994), slightly less than half of interviewed adjacent homeowners around McDonald Forest were willing to pay up to $350 (1992 dollars, $380 in 1995 dollars) per year to avoid clear-cuts in their backyard, which would be 2 to 3% of the annual payment of a typical home in this area. The negative impacts of visible clear-cuts on property values seem bigger than the willingness to pay expressed by the homeowners in the Johnson et al. study. Some homeowners may feel that they need to be compensated for loss of their property values, given that forest amenity values were capitalized into property prices at the time of purchase. However, forest managers are not obligated to provide forest amenities for their neighbors in most cases. When homeowners cannot influence forest management decisions otherwise, a market solution is one way to send a clear signal to forest managers about the forest conditions that they prefer.

We applied the hedonic price model to the near urban forest area and expanded the possibility of GIS application in measuring location-specific amenities in this study. We also examined the issues in choosing a proper functional form for the hedonic price model of location-specific amenities, and pooling the data over time in nonmetropolitan areas. We estimated the contribution of the forest to each property according to distance and other locational differences. The specific estimation results are influenced by the context, and may not be appropriate to apply directly to other regions. Nonetheless, the results help inform general forest managers on the impacts of forest management practices, and can be used to negotiate conflicts between forest managers and neighboring homeowners to produce forest characteristics that are acceptable to neighbors, while achieving forest management goals.

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