Determinants of Forest Land Prices in Northern Minnesota: A Hedonic Pricing Approach

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Abstract: A hedonic price model was developed to analyze the market for undeveloped forestland in northern Minnesota. The data included 387 forestland parcels purchased in 2001 or 2002. Information describing parcel physical characteristics, amenity features, merchantable timber volume, development trends, terms of financing, and several proximity, distance, and adjacency conditions were tested for their influence on forestland prices. The model's independent variables collectively explained approximately 50% of the variation in per hectare sale price. The method by which forestland sales were financed, road access and density, proximity to population centers, and presence of lake or river frontage had the largest positive influences on per hectare sale prices. Adjacency to public land had an unexpectedly large, negative influence on sale price. Importantly, a parcel's merchantable timber volume was not found to be a significant predictor of forestland sale price. In general, forestland markets were driven by three major influences: land development pressures, presence of or close proximity to a water body, and the use of contract for deed financing. FOR. SCI. 53(1):25–36.

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FROM 1989 TO 2003, the nominal value of forestland in Minnesota increased an average of 13 percent annually (Kilgore and MacKay 2006) This rapid growth in forestland market value is likely to have important and lasting implications on timber supply, forest fragmentation, and outdoor recreation opportunities in the region. What land use and management decisions will current forest owners or future forestland purchasers make in light of rapidly increasing forestland prices? As market values for and taxes on forested land rise, owners may be enticed or forced to sell their land (Wear and Newman 2004). Buchta and Meyhew (2005) reported that forested land in northern Minnesota is quickly being sold, subdivided, and developed, ushering in "dramatic and permanent change." Research suggests that, except for very large forested parcels, the price of forestland in much of the United States is substantially influenced by uses and values other than timber production, reflecting the fact that timber management is often not the primary reason for owning forestland (NFLS 1990). Studies of private forest landowners have repeatedly documented the influences of nontimber property attributes and uses on forestland ownership decisions. For example, Baughman (1988) found Minnesota forest landowners considered game habitat and road access among the most important determinants in purchasing forestland. Birch (1994) found in a survey of Wisconsin private forestland owners that recreation and esthetics ranked higher than timber production as a reason for woodland ownership. In a study of recent purchasers of forestland in Virginia, Kendra and Hull (2005) found that few were motivated to manage timber for economic return. Nationally, Butler and Leatherberry (2005) reported that less than 10% of family forest owners rank timber production as an important or very important reason for owning forestland.

While the importance of nontimber attributes in forestland ownership decisions is fairly well documented, our understanding of the marginal contribution of these characteristics to the price of forestland is not. Direct evidence of landowner willingness to pay for most of these attributes is scant. Only a few studies have investigated the factors influencing forestland prices (e.g., Turner et al. 1991, Roos 1996, Aronsson and Carlén 2000, Scarpa et al. 2000, Kennedy et al. 2002). Lacking is substantial empirical evidence describing the value of important physical and locational property characteristics thought to be major drivers of forestland market prices. The objective of this study was to identify major factors influencing the market prices for forestland in northern Minnesota. To do so, a hedonic price model was developed to identify the contribution that various parcel characteristics have on forestland real estate prices. A major contribution of our research is the development and incorporation of a variety of variables describing nontimber amenity attributes of forestland as well as the land's proximity to amenity features.

Literature Review

The concept of hedonic modeling is based on the idea that the observed price of a house or land parcel is the sum of the unobserved prices of the bundle of attributes associated with that good. Rosen (1974) was the first to postulate

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that houses, or similar heterogeneous products, could be described as single commodities differentiated by their composite characteristics. When a tract of land is bought, the purchase is, in effect, for a bundle of goods, services, and features of that parcel that can not be uniquely acquired. For example, one cannot just purchase a view of a lake, but must purchase property that provides a lake view as well as other amenities and disamenities associated with the property. Because markets do not exist for amenities such as this in isolation, economists have sought to estimate value for such "commodities" by evaluating purchases of other items that possess such features as homes or land parcels. In effect, the specification of a hedonic price function is a way to estimate a home buyer's marginal willingness to pay for various characteristics of a lot or home.

This method has been used by numerous authors to estimate the value of a variety of environmental attributes and amenities, including recreational and aesthetic values of water (Lansford and Jones 1995, Mahan et al. 2000), amenity values of trees and forests (Garrod and Willis 1992a, Tyrväinen and Miettinen, 2000), air quality (Graves et al. 1988), and benefits of open space (Irwin 2002, Hobden et al. 2004). Many applications of this methodology have also been made in the agricultural literature to investigate determinants of agricultural land value (e.g., Chicoine 1981, Faux and Perry 1999, Bastian et al. 2002). The majority of hedonic pricing applications have linked *housing* sale prices to amenities. Our approach was to link the sale price of undeveloped, forested tracts to a variety of parcel-specific and regional amenities and conditions in an effort to better understand their influence on market prices for undeveloped forestland.

Turner et al. (1991) evaluated the effect of a number of parcel and regional proximity characteristics on sale price of unimproved forested land (e.g., forestland without structures) in Vermont. Explanatory variables included size of the parcel, percentage of nonforested area, presence of a frontage road, percentage of parcel with a slope steeper than 15%, population density, rates of population growth for the surrounding county and town, distances to the nearest major highway and commercial ski area, tax rate, and the month of sale. The authors found that presence of road frontage, presence of nonforested land cover on the parcel, population increases in the county, close proximity to major roads and ski resorts, and lower tax rates all contributed to higher sale price per hectare of forested lots.

Roos (1996) found the price of forested land purchased specifically for timber production in Sweden was influenced by the size of the parcel, proportion of productive forestland on the parcel, mean standing volume of timber on the parcel, mean site productivity of the parcel, population density in the county, and month of sale. Variables describing the presence of agricultural land on the parcel and buyer characteristics were found to be insignificant in the model.

Aronsson and Carlén (2000) examined the impact of a large number of explanatory variables on sale price of forest estates in Sweden. The variables describing physical characteristics included parcel size, timber stock, site productivity, and moose density as an indicator of hunting potential. Variables describing buyer and seller characteristics were also examined: buyer and seller income levels, age, education levels, household wealth, marital status, owner of other forested estates, and an interaction term between age and wealth. Of the parcel characteristics, parcel size, growing timber stock volume, site productivity, and moose density were all found to have positive influences on sale price. Of the variables describing the seller, income, wealth, age, and higher education were all significant and positive influences on price. Of the variables describing buyer characteristics, only income had a significant influence on purchase price.

Scarpa et al. (2000) developed a hedonic model to estimate the nontimber value of maple-birch forests in Wisconsin. Three categories of explanatory variables were evaluated: ecological stand attributes, locational attributes, and socioeconomic conditions. Nine variables were computed to represent the number of trees on the stand in three species groups (tolerant, mid-tolerant, and intolerant), indexed by three size classes (pole, small sawtimber, and large sawtimber). Shannon's index was used to calculate values for tree species diversity, tree size diversity, and tree color diversity for each stand. Four variables describing site characteristics were computed: site index, distance to water, average percentage deviation from the horizontal, and distance to roads. Finally, variables identifying land-ownership categories, county population density, and average county household income were calculated. Using a linear model, the variables describing national forest ownership, intolerant species in all three size classes, mid-tolerant species in the two highest size classes, and shade-tolerant species in the two highest size classes were found to be significant predictors of forest value.

Kennedy et al. (2002) explored determinants of forestland prices in northern Louisiana and found that parcel location and tract development potential played important roles in determining forestland value. All of the variables tested in the model were found to be explanatory: presence of a paved access road, length of road frontage, distance to metropolitan areas, value of improvements on the parcel, month of sale, and parcel size.

Many of these authors suggested the need to develop and test additional variables for esthetics, nontimber attributes, and proximity to amenity features associated with forestland. It is here where our research makes a contribution. We develop and explore a set of potential explanatory variables for forestland prices, borrowing both from hedonic studies of residential markets and the few forestland hedonic studies. In addition to the impact that parcel characteristics themselves exert over sale price, we explore the influence of adjacent land cover, forest cover type, and ownership. While some such "proximity" variables have been examined in other hedonic studies, they have been studied primarily for their influence on residential home sale prices rather than forestland parcel prices.

Given that many purchasers of forestland have reasons other than timber production for buying and owning forested parcels, we hypothesized that a parcel's amenity attributes, more than timber harvesting value and potential, would be important indicators of forestland price. We also hypothesized that characteristics of adjacent parcels might well exert an influence over forestland prices, just as other authors have shown them to be influential in residential markets (Geoghegan et al. 1997). Having a better idea of how neighboring land conditions have an impact on forestland markets will provide insight into how the value of forestland changes if conditions change not only on current forestland parcels, but on the surrounding forestland base. Given accelerating trends in forestland fragmentation, parcelization, and urban development and expansion, this information will be useful to county planners, land appraisers, and policy makers.

Data

Our data consisted of information on 387 sales of unimproved forest parcels (forestland without any structures), ranging in size from 4.05 to 126.67 ha (10 to 313 acres) that were transacted in St. Louis County, MN in 2001 or 2002 (Figure 1) [1]. Located in northeastern Minnesota and home to 200,000 people, St. Louis County is the largest county east of the Mississippi River, encompassing nearly 18,000 km^2 (St. Louis County, Minnesota 2005). The county's northern and southern borders adjoin Ontario, Canada and the north shore of Lake Superior, respectively. With over 500 lakes, parts of a national park and national forest, the Boundary Waters Canoe Area Wilderness, and four state parks within its borders, the county is known for its extensive recreational, aesthetic, and tourism amenities. Duluth, the largest city in the county, is a major seaport on Lake Superior. Outside of Duluth, mining and wood and paper industries dominate.

Forty-three percent of Minnesota's 6.6 million hectares of forestland are privately owned (University of Minnesota 2004); 304,000 of these hectares are owned by forest industry and 248,000 by other corporate entities. The remaining

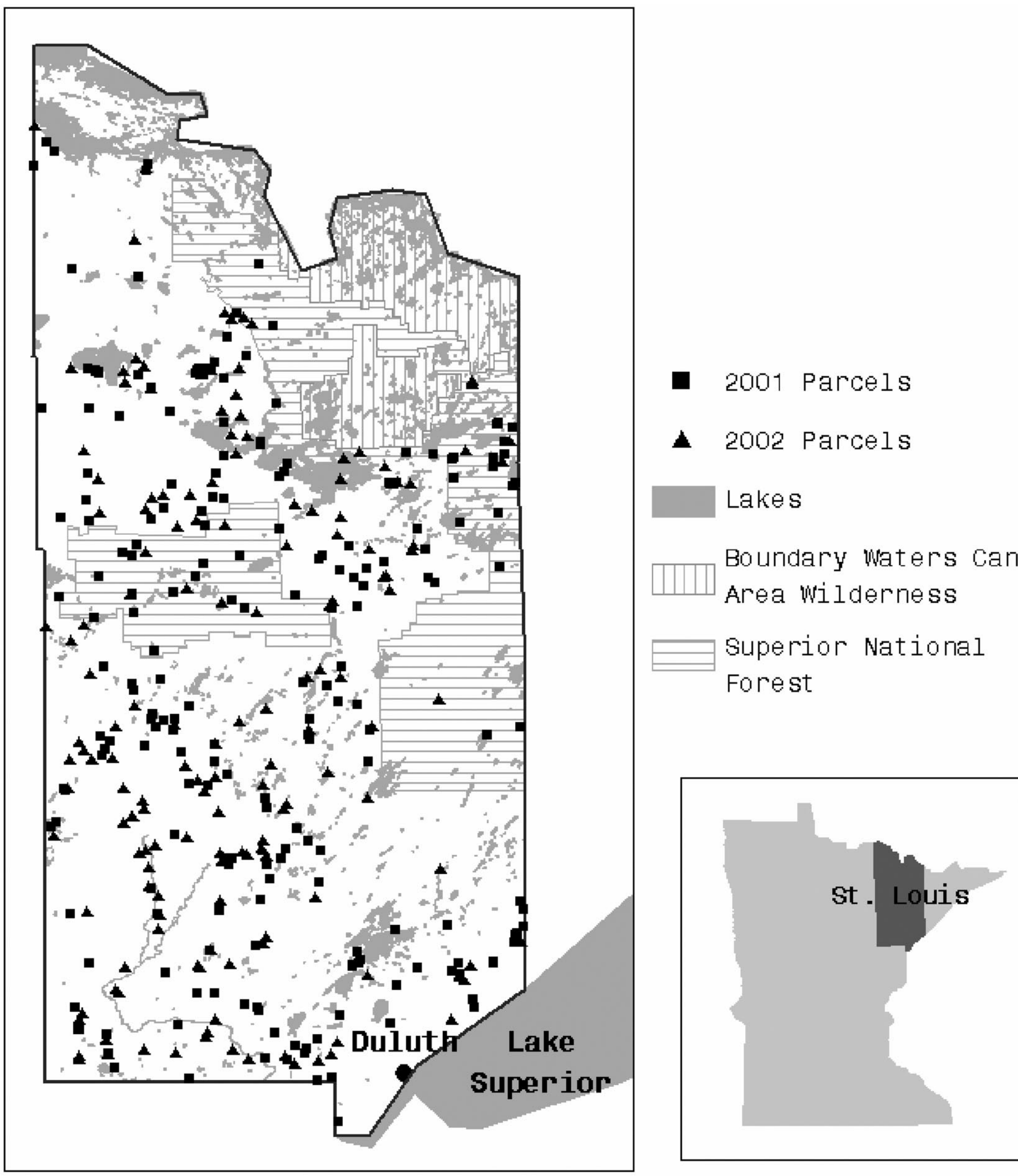

Figure 1. Location of the 387 sales transactions in St. Louis County, MN.

2.3 million hectares of private forestland is owned by individuals, estimated to number 150,000 (USDA Forest Service 1990). In general: (1) the tracts are small, averaging 26 ha; (2) the majority of the forest owners do not live on their land; (3) land tenure is typically long (e.g., median length of ownership is 23 years); and (4) individuals own forestland for many reasons, the most common being wildlife-related, such as habitat or hunting. Timber management ranks low on the list of reasons why Minnesota's forestland is owned by individuals, yet in 2003 over half of the total timber volume harvested in the state came from private forests (Baughman 1988, Rathke 1993, Cervantes 2003, Minnesota DNR 2003, Donnay et al. 2005).

A forested parcel was defined in the study as any land with trees as the major vegetation, regardless of land use. To identify such parcels, sales of all land classified for tax purposes by the Minnesota Department of Revenue as undeveloped timber lands and seasonal recreational land were included. The percentage of forested land on the parcels averaged 71%, with shrubland and wetlands making up the largest share of nonforested land cover. Sales of parcels that were smaller than 4.05 ha (10 acres) were omitted from the study due to the likelihood that such parcels were of a different market: that of sale exclusively for residential home site or vacation home development purposes.

The dependent variable used in the model was the sale price per hectare, adjusted by the monthly consumer price index (CPI) (US Bureau of Labor Statistics 2004). The CPI was used to translate the reported sale price of forestland over the 2-year study period to inflation-free dollars. All sale prices were adjusted to a common date (i.e., January, 2001) and, as such, the reported sale price estimates reflect the purchasing power of the consumer's dollar at that time.

Data were gathered from several different sources. From the St. Louis County Assessor's office, Field Card and Certificate of Real Estate Value (CRV) data were obtained for each sale parcel used in the study. Data on the CRV include the sale price, acreage, date, legal description, parcel identification number, and the buyer, seller, and taxpayer names and addresses. The CRV also contains information on how the purchase was financed and the method of conveyance (e.g., warranty deed versus contract for deed). The Field Cards provide descriptions of various site characteristics (e.g., water frontage, access to parcel) and assessor's notes and opinions on the features of each forest parcel. Based on information recorded on the CRVs about the buyer, we estimated that approximately 95% of the buyers were households, with the remainder consisting of corporations, recreational clubs, investment firms, and land development companies. The frequency of the types of forestland purchasers in our data set was very similar to Minnesota's forestland market overall, where 92% of the forestland parcels sold in Minnesota between 1989 and 2003 came from individuals, with 96% of the buyers of those parcels also being individuals (Kilgore and MacKay 2006)

The boundaries of each study parcel were digitized in a GIS (ArcInfo 8.3) using St. Louis County plat books, legal descriptions from the St. Louis County Assessor's Office, public land survey polygons (section and townships), and ancillary locational attribute data such as roads, lakes, and railways. Census variables and boundaries were obtained from the US Census website (www.census.gov), and road lines were obtained from the Minnesota Department of Transportation. The ownership of land adjacent to the study parcels was determined using GAP stewardship data. Countywide land and forest cover data were obtained from the Forest Resources Department, University of Minnesota, and consisted of classified Landsat satellite imagery from 2000. Data for timber growing stock volume were obtained from Forest Inventory and Analysis Database (FIADB) (www.fia.fs.fed.us/tools-data/data/) for the most recent inventory year which, for Minnesota, was 2003.

Model Specification

The general price model that we estimated is represented by the equation

$$P = f(F_i, R_i, S_i, L_i), \tag{1}$$

where F_i = forest parcel characteristics, R_i = recreational and aesthetic features, S_i = sales characteristics, and L_i = parcel locational characteristics.

Little theoretical basis exists to guide selection of a functional form for a hedonic price model. However, following Rosen (1974), most researchers choose a functional form that allows price to vary nonlinearly as a function of the level of the individual parcel characteristics. Cropper et al. (1988) and Taylor (2003) suggest that the simpler functional forms, such as the linear and semi-log, are usually the most appropriate in empirical applications involving unobserved and "proxy" variables, as is the case with our study. To evaluate the fit of different functional forms to our data, we used a linear Box-Cox transformation (Box and Cox 1964) of the dependent variable, as others have done when specifying a functional form for a hedonic model (e.g., Spritzer 1982, Garrod and Willis 1992b, Faux and Perry 1999, del Saz-Salazar and Garcia-Menéndez 2005). In estimating the transformation, a general form for the implicit price function is represented as

$$P^{(\lambda)} = \alpha + \beta X + \varepsilon, \tag{2}$$

where P is the price/ha of the parcel, α is the intercept, β is the matrix of coefficients, X is the matrix of explanatory variables, and ε is an error term. $P^{(\lambda)}$ is a Box-Cox transformation of the dependent variable, which takes the following forms:

$$P^{(\lambda)} = (P^{(\lambda)} - 1)/\lambda, \quad \lambda \neq 0, \tag{3}$$

$$P^{(\lambda)} = \ln P, \qquad \lambda = 0.$$

The TRANSREG procedure in SAS 9.1 was used to evaluate a range of lambda values from −3 to 3 and select the one that maximized the log-likelihood function. A lambda of one suggests a linear model may provide a good fit for the data. A lambda equal to zero suggests that the natural log of the dependent variable be taken and a semi-log functional form used. Other values of lambda suggest more complex transformations be taken, resulting in difficult interpretations of results. The Box-Cox analysis of our data yielded a lambda equal to 0.1. Given a lambda value so close to zero and the ease of

Table 1. Independent variables tested in hedonic model for effect on price of Minnesota forest land

Variable	Variable Description	Expected effect on price/ha
Parcel size		
HECTARES	Size of parcel in hectares	−
Parcel land cover		
SHRUB%	Percentage shrubland	−
Land cover in 8.05 km (5-mile) buffer		
AGBUF%	Percentage agriculture	−
H20BUF%	Percentage lake or river	+
WETBUF%	Percentage wetland	−
Forest cover type within parcel		
REDPINE%	Percentage red pine forested area	+
WHTPINE%	Percentage white pine forested area	+
TAM%	Percentage tamarack forested area	−
Timber growing stock volume		
VOL	m^3/ha of merchantable timber	+
Recreation and aesthetic features		
LAKEFRT	Binary variable (1 if lake frontage present on the parcel, 0 otherwise)	+
RIVERFRT	Binary variable (1 if river frontage present on the parcel, 0 otherwise)	+
PUB__ADJ	Binary variable (1 if parcel adjacent to public land, 0 otherwise).	+
Sales transaction information		
DATE	Year and month of sale (values range from 1 for January 2001 to 24 for December 2002)	+
CONTDEED	Binary variable (1 if Contract for Deed financing used, and 0 otherwise)	+
Population and land development		
SEAS%	Percentage of seasonal homes within 8.05 km radius buffer of each parcel.	+
DELTA__PD	Change in population density between the 1990 and 2000 census for the 8.05 km buffer	+
Proximity to population centers		
TOWN	Distance in km to the nearest census designated ′populated place′ with 500 or more people	−
RD__DENSITY	Road density: km of road per square km in the buffer surrounding each parcel	+
Road access		
ACCESS	Binary variable (1 if parcel is adjacent to a public road, 0 otherwise)	+

interpretation of a semi-log model, we chose to use the semi-log form for our empirical application. Ordinary least-squares regression was chosen as the estimation method because it is an appropriate method to use with a continuous dependent variable and because an inspection of the residual plot indicated that the residuals were randomly distributed throughout the range of the dependent variable.

Model Variables

Table 1 identifies the variables we hypothesized would influence the per hectare sale price of forestland in northern Minnesota.

Parcel Size

Parcel size in hectares (HECTARES) was included as an explanatory variable. Increasing parcel size was hypothesized to negatively influence sale price. Price per hectare typically declines as size of a parcel increases, although this effect is usually most pronounced with smaller parcel size (see, for example, Roos (1996), Aronsson and Carlén (2000), Hancock Timber Resource Group (2000), Kennedy et al. (2002), Kilgore and MacKay (2006)).

Land Cover within Parcel and 8.05 km (5-Mile) Buffer

Land cover data for each parcel and within an 8.05 km buffer surrounding each parcel were computed using a 2000 land cover classification of St. Louis County. Categories of land cover that were computed include percentage developed area [2], agriculture, grassland, forest, open water, wetland, and shrubland. The only one of these parcel-specific land cover categories included in the hedonic model was percentage of shrubland (SHRUB%). We hypothesized that shrubland would function as a proxy for edge habitat associated with forestland. Edge habitat is beneficial for several game (e.g., grouse) and nongame species (e.g., some songbirds). Given the importance of wildlife as an amenity and recreation objective among family forest owners (Butler and Leatherberry 2005, Donnay et al. 2005), we hypothesized this variable would have a positive effect on price, particularly if a purchaser was interested in hunting or wildlife watching. The other land cover categories were not included either because they weren't found in great enough abundance on the parcels or were not hypothesized to be explanatory. Turner et al. (1991), in their hedonic study, found a variable measuring the percentage of nonforested land on forested parcels to positively influence sale price.

Land cover within the 8.05 km buffer surrounding each parcel was estimated using the same land cover categories. Of these land cover categories, variables for percentage agriculture (AGBUF%), open water (H20BUF%), and wetland (WETBUF%) were tested in the model. Sale price per hectare was hypothesized to be positively influenced by the percentage of open water in the buffer to reflect recreation potential close to the parcel, the value of which we expected would be capitalized by buyers in their bid price for forestland. The percentage of agriculture and wetlands were both hypothesized to have negative influences over sale price, as we also expected these land uses to be disamenities that were capitalized into forestland bid prices. Agricultural land (AGBUF%) was assumed to be negatively correlated with sale price, as this land cover represents low recreation and wildlife potential. Sale price per hectare was hypothesized to be negatively influenced by percentage wetland, as this is often unsuitable land for development, timber production, wildlife habitat, and many forms of recreation. None of the other forestland hedonic studies have included variables describing adjacent land cover.

The land cover data described above were further broken down into more specific forest cover type categories for the portion of each parcel classified as forested. We developed three such variables that we hypothesized might be reflective of recreational, aesthetic, or timber value. These three variables were percentage of red pine (REDPINE%), percentage of white pine (WHTPINE%), and percentage of tamarack (TAM%). Mature red and white pine stands were hypothesized to have a positive influence on price due to high potential to generate economic rent from timber production as well as their aesthetic appeal (Butler and Leatherberry 2005). We used tamarack stands as a proxy for a forested wetland and, as such, expected this variable to be negatively related to price as it might reflect conditions unsuitable for development, wildlife, and/or recreation.

Timber Growing Stock Volume

We derived estimates of timber growing stock volume, or merchantable timber, on the parcels using the Forest Service's Forest Inventory Analysis (FIA) data. The variable (VOL) was measured in m^3/hectare and was included in the model as an indicator of the timber quality or harvesting potential on the parcel. The FIA database defined timber growing stock volume as the volume of commercial species that meets certain merchantability standards, and do not include rough cull or rotten cull trees. The definition and equation for growing stock volume were determined using FIADB documentation (www.fia.fs.fed.us/tools-data/data/). Using FIA ground plot data, growing stock volume was calculated for each ground plot in our study area. Using ArcGIS Spatial Analyst, a surface was interpolated from the plot data using an inverse distance weighting function. The location of the center of each study parcel was determined. The growing stock volume of each parcel was then estimated by overlaying the centerpoints of the parcels with the growing stock volume surface layer. We hypothesized that the greater opportunity to generate economic rent associated with a larger value of the VOL variable would be capitalized into higher sale prices, particularly if a purchaser was interested in owning forestland with the intent to manage timber. Roos (1996) and Aronsson and Carlén (2000) both found variables describing standing timber volume to have a positive influence on forestland prices.

Recreational and Aesthetic Features

Given that previous studies have shown nontimber property attributes, in particular recreational and amenity features, are important reasons for owning forestland, variables were included to capture the influence of such amenities (e.g., Baughman 1988, Birch 1994, Turner et al. 1991, Aronsson and Carlén 2000). Two dummy variables were developed to indicate whether a parcel had lake (LAKEFRT) or river frontage (RIVERFRT). These variables were hypothesized to have a positive impact on parcel price. Again, it is important to note that the parcels in our data set were at least 4.05 ha (10 acres), and not of a smaller size that would typically be sold only as home development lots, which is a different land market.

A binary variable was also developed specifying whether a parcel was adjacent to public land (PUB__ADJ). We hypothesized this variable would be positively correlated with parcel sale price as it might represent enhanced access to public lands for recreation, as well as a degree of insularity from development.

Sales Transaction Information

A categorical variable (DATE) was created to control for the month and year of sale. This variable was expected to be positive, as real forestland prices have increased in Minnesota for over a decade (Kilgore and MacKay 2006). Roos (1996) and Kennedy et al. (2002) found this variable to be a positive indicator of price in their hedonic studies. A dummy variable (CONTDEED) was also included in the model to indicate whether the sale was financed on a contract for deed. Contract for deed is a method of financing in which the seller acts as a bank, providing a loan to the buyer. When land is sold on a contract for deed, the seller and buyer enter into a contractual agreement specifying the terms by which the seller will receive present and future payments for the land from the buyer. Once the terms of the contract (i.e., loan) are satisfied, the property's deed is transferred from the seller to the buyer. Kilgore (2006) found contract for deed financing to have a large and positive impact on the sale price of forestland. Given the higher cash equivalent prices associated with contract for deed sales, we anticipated that this variable would have a positive impact on sale price in our study as well.

Population and Land Development

Two variables were created from the 2000 US Census data and measured at the block level, which is the smallest reporting level of census geography. These variables were included as proxies for development pressures surrounding each study parcel. Percentage seasonal housing density of the total housing density (SEAS%) was computed for an 8.05-km buffer surrounding each parcel. Change in population density in the 8.05-km buffer surrounding each parcel between 1990 and 2000 was represented by the variable DELTA__PD. These census change data were obtained from work by Radeloff et al. (2005) [3]. Guided by the findings of Turner et al. (1991) and Roos (1996) that higher county population densities led to increased sales prices of forested lots, we hypothesized the effect of the census variables would be positive, particularly in those parts of our study area where development was extensive

Table 2. Mean values and ranges of independent variables in the hedonic model

Variable	Unit	Mean	Minimum	Maximum	Std. Dev.
PRICE/HA	$/ha	2323.98	57.78	20,808.29	2,788.36
HECTARES	ha	19.22	4.05	126.67	15.60
SHRUB%	%	6.40	0.00	54.93	8.75
AGBUF%	%	5.46	0.12	22.08	4.21
H20BUF%	%	6.07	0.09	44.40	7.54
WETBUF%	%	14.67	2.48	38.70	6.40
REDPINE%	%	4.45	0.00	61.18	8.12
WHTPINE%	%	7.02	0.00	100.00	11.70
TAM%	%	11.78	0.00	72.06	12.69
VOL	m^3/ha	64.72	0.00	234.13	39.94
LAKEFRT	Presence/absence	0.08	0.00	1.00	N/A
RIVERFRT	Presence/absence	0.05	0.00	1.00	N/A
PUB__ADJ	Yes/no	0.70	0.00	1.00	N/A
DATE	Month and date*	11.88	1.00	24.00	6.75
CONTDEED	Yes/no	0.12	0.00	1.00	N/A
SEAS%	%	26.41	0.57	85.57	20.64
DELTA__PD	Change in %	0.41	−11.33	28.14	3.18
TOWN	km	16.26	0.76	49.75	9.46
RD__DENSITY	km/km^2	0.63	0.04	1.97	0.33
ACCESS	Yes/no	0.56	0.00	1.00	N/A

* Values of the DATE variable, which represented the month and year of sale, ranged from 1 to 24. For example, a sale in January of 2001 would be assigned a DATE of 1.

Table 3. Hedonic model results

Variable	Coefficient	Standard error	Variance inflation factor	Marginal implicit price†
LAKEFRT	1.45706**	0.13166	1.18505	7,653.61
RIVERFRT	0.92041**	0.16289	1.06061	3,509.95
RD__DENSITY	0.45777*	0.18368	3.36145	1,063.85
CONTDEED	0.26092*	0.10424	1.06405	692.83
ACCESS	0.20076**	0.07281	1.17838	516.69
PUB__ADJ	−0.16745*	0.07736	1.13777	−423.63
DELTA__PD	0.03745**	0.01183	1.27392	87.03
AGBUF%	−0.03083**	0.01189	2.25197	−71.65
TAM%	−0.01796**	0.00287	1.19171	−41.74
H20BUF%	0.01648**	0.00589	1.35063	38.30
DATE	0.01523**	0.00506	1.04661	35.39
TOWN	−0.01341**	0.00483	1.87759	−31.16
REDPINE%	0.01046*	0.00455	1.22552	24.31
SEAS%	0.00929**	0.00265	2.68941	21.59
WETBUF%	−0.00794	0.00606	1.35063	−18.45
SHRUB%	−0.00652	0.00427	1.25574	−15.15
HECTARES	−0.00891**	0.00224	1.09959	−20.71
WHTPINE%	0.00357	0.00307	1.15759	8.30
VOL	−0.00062	0.00090	1.16843	−1.45
Intercept	7.16081**	0.28003		
R^2	0.5508			
Adjusted R^2	0.5276			
F-Value	23.69**			
Number of observations	387			
Mean price/ha	$2323.98			

** Significance at the 1% level; *Significance at the 5% level.
† The marginal implicit price is based upon the mean price per hectare.

and/or increasing (e.g., in areas around population centers and in rural areas with attractive amenities for seasonal home construction).

Proximity to Population Centers

A variable was developed that measured the distance in kilometers to nearest populated places, as defined by the US Census. Distances were measures as actual road distances versus straight-line distances. This variable measured the distance from the parcel to the closest populated place of at least 500 people (TOWN). Longer distances to populated places were expected to be associated with lower sale prices, as there is value to being located close to the services and amenities of a town center (e.g., Kennedy et al. 2002). Thus, we expected the coefficient on this variable to be negative. A variable measuring road density within the 8.05-km buffer of any parcel was created (RD__DENSITY). This was viewed as an indicator of development and growth pressure, with higher densities expected to be associated with higher sale prices.

Road Access

A binary variable indicating road access to the parcel (ACCESS) was computed [4]. The sign on this variable was hypothesized to be positive, as purchasers are likely to pay a premium for a parcel with ready access, as was found by Turner et al. (1991) and Kennedy et al. (2002).

Results

Table 2 contains the mean values and ranges of the explanatory variables. Table 3 presents the results of the regression analysis of Equation 1 that was conducted using SAS, version 9.1. Of the 19 variables included in the semi-log model, 15 were significant (11 at the 1% level, 4 at the 5% level).

Multicollinearity is often an issue with hedonic pricing models. However, no definitive rules exist for determining whether multicollinearity is a serious problem in a particular hedonic application. To investigate the issue of multicollinearity, a correlation matrix was generated to test for relationships among the independent variables. The analysis showed no correlation exceeding 0.44, with this highest correlation occurring between the variables RD__DENSITY and AGBUF%. While this indicates some degree of relationship between these two variables, it did not seem great enough to exclude one or the other variables. Correlations between the remaining pairs of variables were considerably smaller. Turner et al. (1991) reported correlations up to 0.45 in the set of explanatory variables used in their hedonic model.

The variance inflation factor (VIF) was estimated for each of the independent variables as another check on multicollinearity (Table 3). Kennedy (1985, p. 153) suggested that a VIF value greater than 10 is a serious indicator of a multicollinearity problem with a model. The highest-value VIF for our model was 3.36 for the RD__DENSITY variable, again suggesting that multicollinearity was not a serious problem with our model. A Durbin-Watson test was performed to check for spatial autocorrelation in the data. The value for the statistic was 1.793, indicating little likelihood of spatial autocorrelation in the data. Kennedy (1985, p. 101) suggests that a Durbin-Watson statistic of approximately 2 indicates no spatial autocorrelation.

Parcel Size

The HECTARES variable exhibited the characteristically negative relationship between size of parcel and price per hectare, although the impact of parcel size in our model was small. For every one hectare increase in size, the average price per hectare fell by 0.89%.

Land Cover

The variable measuring percentage of shrubland (SHRUB%) within the parcels was found to be insignificant in the model at the 10% level. The lack of significance of the variable may suggest that purchasers were indifferent to the level of nonforested cover on the parcel, or that shrubland was not a good proxy for edge habitat.

Of the land cover types in the 8.05-km (5-mile) buffer surrounding each parcel, percentage of open water (H20BUF%) had a positive influence on price, while percentage of agriculture (AGBUF%) had a negative relationship with parcel price. The variable measuring the percentage of wetland in the buffer (WETBUF%) was insignificant in the model at the 10% level. On average, for each percentage increase of open water and agricultural land on a parcel, sale prices per hectare were 1.65% higher and 3.08% lower, respectively. The marginal implicit price of each percentage increase in open water in the buffer, evaluated at the mean price per hectare of the forested parcels, yielded a premium of $38 per hectare [5]. The positive relationship of the open water variable likely reflects an amenity value associated with proximity to a lake or river, while the negative relationship with the amount of agricultural land in the buffer suggests land uses inconsistent with the objectives of many forest owners (e.g., lack of tree cover, limited hunting and recreation potential).

Two variables associated with type of forest cover were found to hold some explanatory power, although their impact on price was slight. On average, for each percentage increase of red pine (REDPINE%) and tamarack (TAM%) on a parcel, sale prices per hectare were 1.05% higher and 1.80% lower, respectively. We were not able to discern the different cover type size in our land cover classification to test whether buyers differentiated large- versus small-diameter red and white pine forests. Tamarack species are found in boggy, marsh areas and may be an indication of lack of development and/or recreational potential. Percentage of white pine (WHTPINE%) was insignificant in the model at the 10% level.

Timber Growing Stock Volume

The variable measuring standing merchantable timber volume on the parcels (VOL) was not significant in the model at the 10% level. This could suggest that purchasers are unaware or ambivalent to the value associated with managing the parcel for timber production. It could also indicate that forestland purchasers simply do not differentiate forestland value according to tree size.

Recreational and Aesthetic Features

By far, the two most important determinants of forestland price in our study were presence of lakefront (LAKEFRT) and riverfront (RIVERFRT), respectively. Forested parcels with the presence of lake frontage commanded a price premium of 329% in price per hectare over parcels without lake frontage. Presence of river frontage increased the average price per hectare by 151% [6]. These results indicate that buyers highly value direct access to rivers and lakes, but also recognize and hold different values for lake versus river frontage.

The coefficient on the adjacency to public land variable (PUB_ADJ) was found to be significant, but negative, which was unexpected. We had hypothesized that this variable would carry a positive sign, since adjacency to public land could be seen as a beneficial extension of one's property for recreational purposes, thereby adding value to the parcel purchased. However, given the large percentage of public land in the county and region, it appears that adjacency to public land may be an undesirable feature of a forested parcel. Model results indicate that forest parcels adjacent to public lands sold for approximately 15% less per hectare than the average parcel sale price. The marginal implicit price of adjacency to public land, evaluated at the mean price per hectare of the forested parcels, yielded an estimate of $423 in decreased parcel value per hectare. We suggest that given the large amount of public land in the county, there may be little incentive to buy property abutting it due to possible negative externalities such as hunter trespass, off-highway vehicle damage, noise, or vandalism.

Sales Transaction

The use of contract for deed financing (CONTDEED) was found to be a strong explanatory variable in the model. Buyers paid, on average, approximately 30% more on price per hectare than if other financing methods had been used, a premium of $692 per hectare. Possible explanations of this could be the buyer's inability to access capital markets, high transaction costs associated with market financing, and greater flexibility for both buyer and seller in defining terms for financing the forestland purchase (Kilgore 2006).

The significance of the DATE variable suggests an upward trend in real per hectare forestland prices over time of approximately 1.5% per month over the 2-year study period. This is to be expected, as Kilgore and MacKay (2006) found that real forestland prices have been increasing in northern Minnesota for over a decade.

Population and Land Development

Higher prices occurred in regions in which the population, measured as change in population density (DELTA__PD), is growing. Price per hectare increased by 3.7% for every unit increase in population density. The percentage of seasonal housing, SEAS%, also had a positive, albeit small, influence on price per hectare, commanding a 0.93% premium in sale price for each percentage increase in seasonal housing. Both variables are indicative of growing development pressures in the region.

Proximity to Population Centers

Road density (RD__DENSITY) also proved to have a positive influence on forestland prices, again suggesting that in more developed areas, sale prices are likely to be higher due to land development and availability pressures. A one unit (km of road per square km) increase in road density in the 8.05 km buffer in which a parcel was found increased sale price by approximately 46%.

Distance to a populated place of at least 500 people (TOWN) also provided to be an explanatory variable. The sign on the coefficient was negative, indicating that there is a declining value (−1.3%) for each additional kilometer that separates a parcel from a population center. This could be a function of land availability pressures and higher land prices associated with developed or developing areas, or it could signal a premium that purchasers are willing to pay to be near retail establishments.

Road Access

Road access to a parcel, ACCESS, was found to be a highly explanatory variable, as would be expected. Road access increased average parcel size price by 22%, a premium of $516 per hectare. In general, people value ready access to parcels they purchase.

Testing for Model Robustness

To test for robustness of the model, we compared the estimated coefficients of our semi-log model when run with the full 387 records to one in which half of the parcels were included. Half of the parcels in each year of sale were randomly selected for inclusion in this subset model. Both models explained a little over 50% of the variation in per hectare sale price and had all of the signs on the coefficients in common. Of the variables with the largest coefficients, all six are in common with both models, and in almost the same order in terms of parameter size. The level of significance did change for a few of the variables in comparing the full to half-data set models. The significance of the variables representing road access (ACCESS) and population change (DELTA__PD) were both 1% lower in the submodel than in the full model. Similarly, the submodel variable RD__DENSITY dropped from 5 to 7% significance, PUB__ADJ dropped from 5% to 12% significance, and REDPINE% from 5% to 17% significance. The significance of two other variables improved in the submodel, with CONTDEED increasing from 5 to 1% significance, and WETBUF% increasing from 19 to 7% significance. Overall, these findings suggest a robust model for estimating implicit price functions of Minnesota forestland.

Although the inclusion of 19 independent variables in the model might seem like a large number, we suggest that these variables are all important in explaining the market for forestland. To illustrate this, we ran a submodel that included only those six variables from Table 3 with the largest coefficients, as well as the HECTARES and DATE variables. We found the adjusted R^2 dropped to 30%. This suggests that the significant independent variables reported in Table 3 are important in explaining forest price variations, even though their individual coefficients may be small.

Influence of Water Frontage on Implicit Prices

Our model found lake and river frontage were the most important determinants of forestland prices. The 50 parcels in our data set containing water frontage ranged in size from 4.06 to 80.94 ha (10 to 200 acres) and were, on average, only slightly smaller than the non-waterfront forestland parcels (19.53 ha versus 17.01 ha). Moreover, their characteristics were not distinct from the 337 nonwater parcels such that they should, a priori, be excluded from our data set [7]. However, given the dominant role the variables LAKEFRT and RIVERFRT had on forestland prices, we wanted to assess, ex post and in a purely exploratory manner, whether the effect of other model variables on price would have been remarkably different had the 50 waterfront parcels not been included in the data set.

To do so, we reran the model without these 50 waterfront parcels and without the two frontage variables, and compared the results to those of our original model. The signs of all the model coefficients were the same in both models, and all variables except one remained significant at $P = 0.05$. Additionally, the difference in implicit prices was less than 10 percent and/or \$10/ha for all but three variables, suggesting the marginal value of most forestland physical and sale attributes is not heavily influenced by the presence of lake or river frontage. Future forestland hedonic pricing studies may want to develop candidate models that further explore the degree to which implicit prices are different for parcels with and without water frontage.

Summary and Implications

The model results point to three major positive influences on forestland markets in northern Minnesota. First, land development pressures around population centers signal one major influence of higher sale prices. As population centers in the county, such as Duluth, continue to spread outward, land availability declines, signaling a premium for forested parcels. The model found several proxies for land development pressure to be important drivers of forestland prices. Second, recreational amenities or potential, both on the parcel itself and as a function of the parcel's location in the landscape, are also major influencers of forestland value. In particular, the presence of either lake or river frontage on the forested parcel were the dominant influencers of premiums paid for forestland. Third, although not a function of the parcel's characteristics or features on the landscape, the method by which forestland is sold also has considerable influence on sale price, with contract for deed financing commanding a substantial market premium.

Adjacency to public land was found to have a negative influence on property prices, which was somewhat surprising. Results have been mixed, however, in previous studies that included the effect of adjacency to public land on property values. David (1968) found that properties were more valuable if they were directly adjacent to public land. Gartner et al. (1996), however, found that adjacency to public land had a negative influence on sale price of residential homes. They attributed this negative relationship to trespass issues associated with living next to publicly accessible land. In our study, we suggest that the negative influence on property price when adjacent to public land had to do with the large percentage of public land in the county. Given the abundance of this land type, there is no additional value in being located next to it. In fact, the model indicates the market discounts private forestland located adjacent to public land. This likely had to do with issues of desired privacy. Also, we suspect that many purchasers have intentions of hunting on their land and as such, desired a buffer between their land and public land since it is often difficult to control unwanted hunter trespass from neighboring public lands.

The results of our analysis have several implications for resource management and policy. First, the results support our hypothesis that nontimber factors are important drivers of forestland values. A parcel's merchantable timber volume was not a significant driver of forestland prices. In contrast, our variables that approximated recreational and aesthetic conditions (LAKEFRT, RIVERFRT, H20BUF%, REDPINE%) were shown to have a positive impact on forestland sale prices. This suggests that timber harvesting is not the only reason for owning forestland parcels, which, in turn, has implications for long-term timber supply, production, and management in the northern part of the state. Having a better understanding of the type of forest parcels or forest characteristics that are commanding high prices may help planners and managers in the region anticipate trends in forestland development or fragmentation. An additional issue that our findings suggest may be of concern to public land managers in this region is the possibility of increased recreational pressures on public lands as private forested land is sold off. Several large mining and timber companies have significant land holdings in northern Minnesota. Historically, these companies have often allowed people access to their lands for recreational purposes for a small lease fee. If these company land holdings are divided and sold, opportunities for recreation on these private lands may decline, which could signal increased demand for and usage of public lands in the region for recreation, particularly for hunting.

The high premiums that purchasers were willing to pay for lake and river frontage may indicate intent to use such properties for the development of vacation home sites. If this is true, this could signal increasing rates of subdivision, parcelization, and fragmentation of forestland in the region. Another implication of our analysis is that people simply value Minnesota's lakes and rivers. Given this, there is incentive for government agencies to develop policies that ensure the quality of these aquatic resources is protected. There is also incentive for agencies such as the USDA Forest Service to ensure they manage their lands in the region to maintain healthy aquatic systems and to provide recreational access. Although our analysis did not focus on how water quality may affect purchaser's willingness to pay for land with access to a river or lake, other hedonic studies have shown that declining water quality translates into lower purchase prices and tax base (Krysel et al. 2003). Finally, our findings should be useful to real estate appraisers, tax assessors, and lending institutions that are in need of information and means to make accurate assessments of forestland in an open market for taxation and other purposes, such as valuation of conservation easements.

Endnotes

[1] The Superior National Forest contains considerable in-holdings and is not a contiguous block of federally owned land. This explains the location of parcel sales located within the boundaries designated as the Superior National Forest in Figure 1.

[2] Developed land use included parking lots, malls, major highways, single-family residential developments, single-lane highways, and sparse development.

[3] This data set contains 1990 housing and population densities adjusted to 2000 block boundaries, so that change estimates from 1990 to 2000

can be made without corruption from changes in block boundaries (silvis.forest.wisc.edu/projects/WUI__Main.asp).

[4] Categories of roads, obtained from the Minnesota Department of Transportation, used to determine road access included interstate highways, US trunk highways, MN trunk highways, county state aid highways, municipal state aid streets, and county roads.

[5] The marginal implicit price of each continuous independent variable is calculated as the price per hectare multiplied by the regression coefficient. Using the mean sale price per hectare, the marginal implicit "value" of an additional percentage of open water in the buffer is 0.01648 * $2,323.98 = $38.30. The marginal price of each variable is constant over the range of data in our analysis.

[6] Although the percentage impact of a continuous variable is the regression coefficient multiplied by 100, a different calculation must be used for dummy variables in a semi-log equation. According to Halvorsen and Palmquist (1980), the percentage impact of a dummy variable is calculated as $\{\exp(\beta) - 1\} * 100$, where β is the regression coefficient. For example, the percentage impact of lake frontage on average parcel price is calculated as $\{\exp(1.45706) - 1\} * 100 = 329\%$. Similarly, the marginal implicit price of a dummy variable in a semi-log form is calculated using the expression $\{\exp(\beta) - 1\} *$ (mean sale price per hectare). To illustrate, the per hectare marginal implicit price of lake frontage is calculated as $\{\exp(1.45706) - 1\} *$ $2,323.98 = $7,653.61.

[7] The Cook's D statistic, which measures the change in parameter estimates caused by the removal of an observation and is a means of testing for outlier observations, was computed for our model with the 19 variables and 387 parcels. The value of the Cook's D statistic for each observation in our data was less than 0.0416. Chatterjee et al. (2000, p. 104) state that a Cook's D value greater than 1 implies an outlier problem. Our analysis based on the Cook's D diagnostic test suggests that the water frontage parcels were not likely to have undue influence on the value of the model parameters.

Literature Cited

Aronsson, T., and O. Carlen. 2000. The determinants of forest land prices: An empirical analysis. *Can. J. For. Res.* 30:589–595.

Bastian, C.T., D.M. McLeod, M.J. Germino, W.A. Reiners, and B.J. Blasko. 2002. Environmental amenities and agricultural land values: A hedonic model using geographic information systems data. *Ecol. Econ.* 40:337–349.

Baughman, M.J. 1988. Natural resource characteristics preferred by woodland buyers in northern Minnesota. *Nor. J. Applied For.* 5(1):69–70.

Birch, T.W. 1994. Private forest-land owners of the northern United States. *USDA For. Serv. Res. Bulletin* NE-136.

Box, G., and D. Cox. 1964. An analysis of transformations. *J. Royal Stat. Soc., Ser. B.* 26:211–243.

Buchta, J., and R. Meyhew. 2005. Subdividing the north country. *The Star Tribune* [Minneapolis], Oct. 16, 2005. p. A1.

Butler, B.J., and E.C. Leatherberry. 2005. *National woodland owner survey: 2004 preliminary results*. USDA Forest Service, available online at www.fs.fed.us/woodlandowners/. Last accessed May 2, 2006.

Cervantes, J.C. 2003. *Characteristics of Minnesota's nonindustrial private forest landowners.* PhD Dissertation, Department of Forest Resources, University of Minnesota, St. Paul, MN.

Chatterjee, S., A. Hadi, and B. Price. 2000. *Regression analysis by example*, 3rd ed. John Wiley and Sons, New York. 359 p.

Chicoine, D.L. 1981. Farmland values at the urban fringe: An analysis of sale prices. *Land Econ.* 57(3):353–362.

Cropper, M.L., L. Deck, and K.E. McConnell. 1988. On the choice of functional form for hedonic price functions. *Rev. Econ. and Stats.* 70(4):668–675.

David, E.L. 1968. Lakeshore property values: A guide to public investment in recreation. *Resources Res.* 4:697–707.

del Saz-Salazar, S., and L. Garcia-Menéndez. 2005. Public provision versus private provision of industrial land: A hedonic application. *Land Use Policy* 22:215–223.

Donnay, J.S., M.A. Kilgore, and S.A. Snyder. 2005. *A look at past and present forest landowner preferences and intentions in northern Minnesota*, Staff Paper #184. Department of Forest Resources, University of Minnesota. St. Paul, MN. 79 p.

Faux, J., and G.M. Perry. 1999. Estimating irrigation water value using hedonic price analysis: A case study in Malheur county, Oregon. *Land Econ.* 75(3):440–452.

Garrod, G.D., and K.G. Willis. 1992a. The environmental economic impact of woodland: A two-stage hedonic price model of the amenity value of forestry in Britain. *Applied Econ.* 24:715–728.

Garrod, G.D., and K.G. Willis. 1992b. Valuing goods' characteristics: An application of the hedonic price method to environmental attributes. *J. Env. Man.* 34:59–76.

Gartner, W.C., D.E. Chappelle, and T.C. Girard. 1996. The influence of natural resource characteristics on property value: A case study. *J. Travel Res.* 35:64–71.

Geoghegan, J., L.A. Wainger, and N.E. Bockstael. 1997. Spatial landscape indices in a hedonic framework: An ecological economics analysis using GIS. *Ecol. Econ.* 23:251–264.

Graves, P., J. Murdoch, M. Thayer, and D. Waldman. 1988. The robustness of hedonic price estimation: Urban air quality. *Land Econ.* 64:220–233.

Halvorsen, R., and R. Palmquist. 1980. The interpretation of dummy variables in semilogarithmic equations. *Amer. Econ. Rev.* 70(3):747–775.

Hancock Timber Resource Group. 2000. *Taking advantage of the wholesale discount for large timberland tracts*. Hancock timber research report, R-00-1. Hancock Timber Resource Group, Boston, MA.

Hobden, D.W., G.E. Laughton, and K.E. Morgan. 2004. Green space borders—A tangible benefit? Evidence from four neighborhoods in Surrey, British Columbia, 1980–2001. *Land Use Policy* 21(2):129–138.

Irwin, E. 2002. The effects of open space on residential property values. *Land Econ.* 78(4):465–480.

Kendra, A., and R.B. Hull. 2005. Motivations and behaviors of new forest owners in Virginia. *For. Sci.* 51(2):142–154.

Kennedy, P. 1985. *A guide to econometrics*. MIT Press, Cambridge, MA. 238 p.

Kennedy, G.A., L.R. Vendeveer, S.A. Henning, N. Huizhen, and D.L. Deckard. 2002. Estimating tract value relationships in the north Louisiana timberland market. *Southwestern Econ. Rev.* 28(1):123–134.

Kilgore, M.A. 2006. The impact of contract for deed financing on Minnesota forest land markets. In Review.

Kilgore, M.A., and D.G. MacKay. 2007. Trends in Minnesota's forest land real estate market: potential implications for forest land uses. *Nor. J. Applied For.* In press.

Krysel, C., E.M. Boyer, C. Parson, and P. Welle. 2003. *Lakeshore property values and water quality: Evidence from property sales in the Mississippi Headwaters region*. Report of the Mississippi Headwaters Board, Bemidji, MN. Available online at www.mississippiheadwaters.org, last accessed Dec. 15, 2006. 56 p.

Lansford, N., and L. Jones. 1995. Marginal price of lake recreation and aesthetics: An hedonic approach. *J. Agric. Applied Econ.* 27(1):212–223.

Mahan, B.L., S. Polasky, and R.M. Adams. 2000. Valuing urban wetlands: A property price approach. *Land Econ.* 76:100–113.

Minnesota Department of Natural Resources. 2003. *Minnesota's forest resources*. Division of Forestry, St. Paul, MN.

NFLS. 1990. *Northern forest lands study of New England and New York*. USDA For. Serv., Rutland, VT.

RADELOFF, V.C., R.B. HAMMER, S.I. STEWART, J.I. FRIED, S.S. HOLCOMB, AND J.F. MCKEEFRY. 2005. The wildland-urban interface in the United States. *Ecol. Applic.* 15(3): 799–805.

RATHKE, D.M. 1993. *An evaluation of Minnesota's timber property tax laws*. M.S. thesis, University of Minnesota, Dept. of Forest Resources, St. Paul, MN.

ROOS, A. 1996. A hedonic price function for forest land in Sweden. *Can. J. For. Res.* 26:740–746.

ROSEN, S. 1974. Hedonic prices and implicit markets: Product differentiation in perfect competition. *J. Polit. Econ.* 82(1):34–55.

ST. LOUIS COUNTY, MINNESOTA. 2005. Retrieved May 12, 2005, from www.co.st-louis.mn.us/index.htm.

SCARPA, R., J. BUONGIORNO, J. HSEU, AND K.L. ABT. 2000. Assessing the non-timber value of forests: A revealed-preference, hedonic model. *J. of Forest Econ.* 6(2):83–107.

SPRITZER, J. 1982. A primer on Box-Cox estimation. *Rev. Econ. and Stats.* 64(2):307–313.

TAYLOR, L. 2003. The hedonic method. P. 331–393 in *A primer on nonmarket valuation*, Champ, P., K. Boyle, and T. Brown (eds.). Kluwer Academic Press, The Netherlands.

TURNER, R., C.M. NEWTON, AND D.F. DENNIS. 1991. Economic relationships between parcel characteristics and price in the market for Vermont forestland. *For. Sci.* 37(4):1150–1162.

TYRVÄINEN, L., AND A. MIETTINEN. 2000. Property prices and urban forest amenities. *J. Env. Econ. and Man.* 39:205–223.

UNIVERSITY OF MINNESOTA. 2004. Department of Forest Resources, Minnesota Forest Resources Information Cooperative. Available online at mfric.cfans.umn.edu/allstats.html, last accessed Dec. 15, 2006.

US BUREAU OF LABOR STATISTICS. 2004. *Consumer price indexes.* Retrieved December 16th, 2004, from www.bls.gov/cpi/cpifaq.htm.

USDA FOREST SERVICE. 1990. *Minnesota forest statistics*, 1990, Revised. Resource Bulletin NC-158, North Central Forest Experiment Station, St. Paul, MN.

WEAR, D.N., AND D.H. NEWMAN. 2004. The speculative shadow over timberland values in the U.S. south. *J. of Forestry* 102(8):25–31.