Intra-Regional Amenities, Wages, and Home Prices: The Role of Forests in the Southwest

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ABSTRACT. *Forests provide non-market goods and services that people are implicitly willing to pay for through hedonic housing and labor markets. But it is unclear if compensating differentials arise in these markets at the regional level. This empirical question is addressed in a study of Arizona and New Mexico. Hedonic regressions of housing prices and wages using census and geographic data show that forest area carries an implicit price of between $27 and $36 per square mile annually. Compensating differentials at the regional level suggest that care must be taken when applying the travel cost method to value regionally delineated characteristics.* (JEL Q23, R14)

I. INTRODUCTION

As traditional resource extraction has become relatively less important in regional economies of the American West, the amenity values of forests and other natural features have received more attention. Instead of seeking out areas that, for example, hold the promise of a large paycheck from logging or mining jobs, migrants may seek out areas that offer a large so-called "second paycheck" derived from the value of the natural landscape. This economic behavior can have observable effects in the markets for housing and labor.[1]

As argued by some authors (e.g., Niemi, Whitelaw, and Johnston 1999), a second paycheck may be derived from forests because these areas contain many of the characteristics that people value and make

economic decisions over, such as abundant recreation opportunities, open space, and the availability of wilderness experiences. Further, forests provide several non-market ecosystem services, such as watershed and airshed management, soil quality protection, and habitat protection. Individuals who value these characteristics may be willing to pay, through compensating differentials in labor and housing markets, for access to these non-market goods and services. A portion of the first paycheck (i.e., money income) may be forfeited in favor of a larger second paycheck.

Compensating differentials have been shown to exist in labor and housing markets for large-scale amenities (e.g., climate) at the inter-regional level (Roback 1982; Hoehn, Berger, and Blomquist 1987; Blomquist, Berger, and Hoehn 1988; Costa and Kahn 2003), and in housing markets for local or neighborhood amenities (Ridker and Henning 1967; Cheshire and Sheppard 1995; Acharya and Bennett 2001). Studies that include forest resources have also shown that proximity to forests is capitalized into local housing prices (Shultz and King 2001; Kim and Johnson 2002; Kim

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[1] See Niemi, Whitelaw, and Johnston (1999) for a discussion of the second paycheck. Also, Garber-Yonts (2004) provides a thorough review of literature related to the impact of natural characteristics on migration, hedonic prices, and local economic conditions.

and Wells 2005) and wage differences between cities (Schmidt and Courant 2006). Lacking in the literature, however, is an understanding of how forests (and other natural characteristics) impact economic behavior within a particular region. Whether or not forest amenities are important in the housing or labor markets (or both) within a region remains an empirical question.[2]

The purpose of this paper is to examine compensating differentials for forest amenities in housing and labor markets in the southwestern United States, composed of Arizona and New Mexico. This region provides an excellent opportunity to answer the research questions asked in this paper. The region is characterized by wide variation in the size, type, and location of forest characteristics and their proximity to large population centers. A unique geographic information system (GIS) data set from the U.S. Forest Service Southwestern region allows these characteristics to be precisely measured. Hedonic regressions are estimated for housing prices and wages using publicly available Census data, GIS calculations of landscape features, and data enumerating outdoor recreation sites. An empirical framework pioneered by Roback (1982) and developed by Hoehn, Berger, and Blomquist (1987) is used to determine the existence of hedonic premiums for forest amenities in housing and labor markets and the implicit prices faced by Southwest region residents for these amenities.

Compensating differentials imply that the supply of forest amenities at the regional level is policy relevant. National forests in the United States, under the management of the U.S. Department of Agriculture's Forest Service, undergo a periodic regional planning process.[3] In the Forest Service's Southwestern region, this planning process involves regional teams formed to ensure coordinated revisions of all individual forest plans.[4] Knowledge of the importance of forest resources at the regional level would aid in determining the economic impact of regional forest policy decisions and how management decisions conform to the public's preferences.

Beyond the implications for forestry policy, the answer to the empirical question posed here may indicate a role for forest amenities in rural development policy. For example, if forests and other natural characteristics generate wage differentials within the region (e.g., between rural and urban areas), attributing observed wage differences to other factors can lead to erroneous policies. It is also possible that jurisdictional boundaries prevent local communities from internalizing the market effects of forest policies (Schmidt and Courant 2006). Recognition of these roles for forests, if they exist, suggests that an important component of rural economic development policy may include preservation of the natural features that people find amenable.

The results of this study may also be important for the application of non-market valuation techniques within the region. Two issues arise if the characteristic to be valued is generating compensating differentials. First, an endogeneity problem arises if labor market earnings are used (e.g., as an independent variable) to estimate a demand relationship for a characteristic that generates a wage differential; the preferences an analyst seeks to measure with non-market valuation techniques may determine an individual characteristic thought to be an exogenous demand shifter.

Second, the data-generating process behind some valuation techniques may itself be endogenous to the preferences of interest. An example of this problem is outlined in Randall's (1994) "Difficulty with the

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[2] Hand (2006) investigated labor market compensating differentials for linguistic enclave amenities in the Southwest, but did not incorporate regional variation in natural amenities.

[3] The regional planning process was set forth in the final rule for National Forest System Land Management Planning, Federal Register, v.70 n.3, January 5, 2005, pg. 1055.

[4] See "Southwestern Region Revision Plan Strategy" April 21, 2006. http://www.fs.fed.us/r3/plan-revision/strategy.shtml, accessed 9/19/2006.

Travel Cost Method.'' In the context of regional forests, compensating wage or housing-price differentials imply that people are choosing their residential locations based on forests. To the degree that preferences for forests are related to recreation travel, observed travel cost (i.e., distance) would be endogenous. Further, the travel cost would not reflect the full price of recreation site access, including the price paid through compensating differentials to live closer to a particular site. Schmidt and Courant (2006) suggest that failing to account for location choices may lead to underestimates of the value of recreation access.

These issues begin to describe a role for regionally delineated natural amenities that is more deeply ingrained in local and regional economies than the sum of their market and non-market values. Answering the empirical question of whether forests are important determinants in hedonic housing and labor markets will indicate the degree to which this role may impact regional and local forest policy decisions.

II. HOUSING PRICES AND WAGES IN A REGIONAL HEDONIC FRAMEWORK

Forest characteristics have been unambiguously shown to affect labor and housing markets in a variety of empirical settings. Among these are studies of the wage and housing-price effects of interregional differences in forest access (Schmidt and Courant 2006) and local forest access (Kim and Wells 2005). The primary empirical question in this paper is whether forest characteristics that vary regionally are in fact amenities that significantly affect regional housing-price and wage differentials.

The basic idea behind compensating differentials in housing and labor markets is that individuals purchase a bundle of characteristics tied to a heterogeneous good in the marketplace (see Rosen 1974). In the context of regional forests, the bundle of characteristics is tied to where one lives and works. Someone living in Mora County,

New Mexico, (population about 5,100) has access to a different set of forest, outdoor recreation, and other characteristics than someone living in downtown Phoenix, Arizona. Further, the labor market opportunities are unique to each place. These differences define the bundles that people make decisions over and may give rise to compensating differentials.

The underlying model used here for the empirical analysis is most similar to that in Roback (1982). The key theoretical results, with notation reflecting the application to regional forest characteristics, are presented here to inform the empirical approach.[5]

Individuals derive utility from goods consumption (X, a numeraire good, sold at a constant price), land used for housing (L, sold at price p), and the amenity characteristics (f, forests, in this case) associated with a location. An individual lives in one of the J locations in the region, $j = 1,\ldots, J$. A convenient way of thinking about the consumer's problem is that they select X and L, conditional on f_j and subject to the budget constraint, to maximize utility. This yields an indirect utility function, $V = V(p, w, f_j)$, where w is an individual's wage rate (assuming that income is wholly derived from wage earnings). Firms also operate in both the labor and land markets, producing X and selling in a perfectly competitive market at the numeraire price. Thus, the firm's unit cost function depends on the price of land, wages, and forest characteristics, or $C(p, w, f_j) = 1$.

In equilibrium, utility and costs must be equalized across all J locations; a location that offers real utility gains or cost savings compared to an individual's or firm's current location would induce migration behavior. Since forest characteristics are associated with a particular location and assumed fixed, land prices and wages must adjust in each location to equalize utility

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[5] Several theoretical advances have been made since this model was developed (e.g., Hoehn, Berger, and Blomquist 1987), but the Roback model is more appropriate to this application because the study area does not have endogenous geographic borders.

and costs across the region. The model must satisfy,

$$V_0 = V(p_j, w_j, f_j) \quad \forall j, \qquad [1]$$

$$C(p_j, w_j, f_j) = 1 \quad \forall j, \qquad [2]$$

where V_0 is a constant, and land prices and wages are now associated with the particular locations to reflect the equilibrium adjustment mechanism. The first equation defines utility equality of individuals across all areas, while the second defines production cost equality. Totally differentiating equations [1] and [2], noting that $dV = dC = 0$ in equilibrium, and solving for the two unknowns dw/df and dp/df yields partials that are functionally equivalent to equations [4] in Roback (1982):

$$\frac{dw}{df} = \frac{V_f C_p - V_p C_f}{D}, \qquad [3]$$

$$\frac{dp}{df} = \frac{V_w C_f - V_f C_w}{D}, \qquad [4]$$

where $D = -V_w C_p + V_p C_w < 0$.

As noted in Roback (1982) and Hoehn, Berger, and Blomquist (1987), the signs of the partials in [3] and [4] depend on the sign of C_f (V_f is assumed to be positive). Characteristics that are amenable to individuals may or may not affect productivity for firms. If $C_f > 0$ (the amenity is unproductive), then $dw/df < 0$ and $dp/df \leq 0$ or ≥ 0. If $C_f < 0$ (the amenity is productive), then $dw/df \leq 0$ or ≥ 0 and $dp/df > 0$. In the case that amenities do not matter for firms, both partials are unambiguously signed less than zero and greater than zero, respectively.

The partials of equations [3] and [4] are not equal to zero only under certain conditions: movements across the landscape result in changes in amenity levels, individuals cannot occupy the same space in time, and it is costly for individuals to access amenities in areas where they do not live. The first condition is met by the fact that the characteristics of interest, those represented by forests, vary widely across the

study region. The second condition is assumed as in Roback (1982). The final condition is the most relevant for estimating compensating differentials within a region. Some areas within the study region considered in this paper will more plausibly meet this condition than others. For example, people may live and work in the greater Phoenix area but commute across geographic areas as defined by the available data; such behavior violates the underlying assumption. How this issue may affect the empirical results is discussed as necessary below.

The partial derivatives of [3] and [4] are what traditional hedonic studies seek to estimate. Beginning with housing price, forest amenities are but one feature that impact the price of an individual dwelling unit (i.e., not all dwellings in location j are the same price). The price of a house is a function of its structural (square feet, number of bedrooms), neighborhood (crime rates, school quality), and forest (forest views, recreation opportunities) characteristics. The hedonic price function specifies the price of house i in location j as

$$P_{ij} = P_{ij}(S_i, N_j, F_j), \qquad [5]$$

where $\mathbf{S}$, $\mathbf{N}$, and $\mathbf{F}$ represent vectors of structural, neighborhood, and forest amenity characteristics, respectively. It is assumed that the neighborhood and forest characteristics are common to all housing units in a given geographic area j.[6]

Converting equation [5] into an econometric model yields

$$P_{ij} = \alpha_0 + \beta' S_i + \gamma' N_j + \delta' F_j + v_i, \qquad [6]$$

where v_i is the assumed zero-mean random error and $\boldsymbol{\alpha}$, $\boldsymbol{\beta}$, $\boldsymbol{\gamma}$, and $\boldsymbol{\delta}$ are the parameter vectors to be estimated. The implicit marginal housing price of a forest characteristic f is $\partial P_{ij}/\partial f = \delta$.

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[6] This assumption is not necessary to carrying out a hedonic price estimation, but is driven by the geographic specification of the available micro data, described below.

Hedonic wage estimation is conceptually similar. The traditional framework specifies that workers have preferences over a vector of job characteristics (e.g., risk of injury or working conditions). In the case of examining hedonic wages for forest amenities, however, the concern is not with the characteristics of each job, but the landscape characteristics that are tied to the area where one works. The same bundle of forest amenities that may influence hedonic housing prices may compensate workers for lower wages.

Estimation of the hedonic wage must incorporate other factors that affect the wage, namely productivity factors. The most common method is to extend the Mincer (1974) wage equation to include the vector of job characteristics. In this case, a vector of landscape characteristics is added that includes forest amenities. The hedonic wage equation is,

$$W_{ij} = \pi_0 + \phi' Y_i + \psi' N_j + \zeta' F_j + \mu_i, \qquad [7]$$

where W_{ij} is the natural log of individual i's hourly wage, $\mathbf{Y}$ is a vector of individual human capital characteristics and $\mathbf{N}$ and $\mathbf{F}$ are defined above. Neighborhood and forest amenity characteristics should be included to the extent that the geographic areas correspond to labor markets. Note that in the econometric model i, indexes individual wages and characteristics, rather than particular jobs.

The empirical approach adopted in this paper is most similar to Hoehn, Berger, and Blomquist (1987) and Blomquist, Berger, and Hoehn (1988), where hedonic regressions for the housing market (equation [6]) and wage earners (equation [7]) include a common bundle of amenities. The focus of this paper is the importance of forest amenities, so the bundle includes measures of forest area, recreation sites, and other natural amenities that vary across the region.

Hoehn, Berger, and Blomquist (1987) show that the hedonic results from only one market can be misleading. Depending on the specific assumptions made about the production effects of amenities (i.e., a

productive, neutral, or unproductive amenity for firms), the observed sign of the amenity wage and housing-price effect can be positive or negative. Thus, any calculation of the implicit amenity price requires both housing and wage differentials.

Equations [6] and [7] can be estimated in linear, logged, log-linear, or some other form.[7] Wage equations, for example, are generally estimated with a log-linear specification (which is derived from its underlying human capital investment theory (Mincer 1974)). In contrast, Hoehn, Berger, and Blomquist (1987) and Blomquist, Berger, and Hoehn (1988) use a Box-Cox search over possible specifications to determine the specification for both equations that best fits the data. This latter method is adopted here in pursuit of flexibility and goodness of fit.

III. DATA

The housing-price and wage regressions are estimated on a matched sample of wage-earner housing units. That is, each observation has a reported wage, rent or house value, individual characteristics, and housing characteristics. Estimates of equations [6] and [7] are conducted with individual-level data from the 2000 Public Use Microdata Series (PUMS), 5% sample for Arizona and New Mexico (Ruggles et al. 2004). This data gives individual responses to the long form of the 2000 decennial census. Detailed data is available for each respondent on income and earnings, education attainment, race and ethnicity, housing characteristics, labor market participation, and a variety of other variables. Individuals are identified to geographic areas, called Public Use Microdata Areas (PUMAs), with a population of at least 100,000. PUMAs are used to calculate the vector of site-specific characteristics that vary across the landscape and to compile other geographic-based data. The study

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[7] See Freeman (2003, ch.11) for a discussion of different functional forms for housing models.

region is composed of 51 PUMAs, 36 in Arizona and 15 in New Mexico.

Dependent Variables and Population

The two dependent variables are housing price and wages. Housing price is defined as the annual contract rental cost or imputed annual rent. For those households in the sample who rent their dwelling unit, the reported contract monthly rent is multiplied by 12 to obtain annual rent. Households with owner-occupants report the current value of the dwelling. Annual rent is imputed by multiplying this value by an annual discount rate of 7.5%; annual rent for owners is estimated as the income they are earning on that property as an investment, which is assumed to be approximately equal to what they could earn if it was being rented to tenants.[8] Top-coded observations of rent and house value ($1,700 per month and $999,998 respectively) are excluded from the sample.

The sample for the housing equation is all households from the 2000 PUMAS in Arizona and New Mexico who either own or rent their residence (excluding group quarters). Households with imputed observations for ownership status (owner-occupied versus rental), housing value, or rent are excluded.[9] One departure from previous studies is the inclusion of households with 10 or more acres of property. Previous work was generally concerned with urban and suburban residents, so excluding these households ensured that the sample reflected the population and behavior of interest. Although a small portion of our sample (about 1.2%), the population of interest in the intra-regional case includes those living in rural areas who may have dwellings on more than 10 acres.

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[8] The 7.5% figure was used in Costa and Kahn (2003). Hoehn, Berger, and Blomquist (1987) and Blomquist, Berger, and Hoehn (1988) use a discount rate of 7.85% estimated from a separate source.

[9] The PUMAS data often uses reported characteristics to impute other missing data. These are dropped since the characteristics used to impute data are often the same ones used in the hedonic regressions.

The hourly wage is constructed from reported earnings and work behavior. That is,

$$W_i = wageinc_i/(uhrs_i \times wkswrk_i), \qquad [8]$$

where $wageinc_i$ is reported yearly wage income, $uhrs_i$ is usual hours worked per week, and $wkswrk_i$ is number of weeks worked in 1999.

The sample for the wage equation is restricted to wage-earning men and women between the ages of 18 and 64. Those who did not earn wage income, worked fewer than four weeks in 1999, and usually worked fewer than ten hours per week were eliminated from the sample. This sample was created to capture only workers who are closely tied to the wage-earning labor market. Like the housing sample, observations with imputed data were dropped.

The final sample used to estimate [6] and [7] is the intersection of the housing and wage samples. That is, only those observations with complete data under the criteria in both samples are retained for estimation; all observations are household heads under the Census definition. This results in a sample of 36,375 male and 15,285 female household heads.

Independent Variables

The primary interest in the empirical estimates is measures of natural characteristics, and specifically those measures that relate to forest resources. A comprehensive vector of site-specific characteristics has been gathered, including different measures of forest area, recreation sites, water features, hazardous waste sites, recreation-related businesses, and community characteristics. However, several of these measures may exhibit collinearity when included in empirical estimates (see Section 4). Table 1 describes the geographically coded independent variables retained for estimation.

The independent variables that measure forest characteristics in a PUMA are the proportion of PUMA land in U.S. Forest Service (USFS) area (AREA_FS) and Congressionally designated wilderness area

TABLE 1

DESCRIPTIONS OF GEOGRAPHIC INDEPENDENT VARIABLES

Variable	Description (Source)	Mean	Std. Dev.
AREA_FS	Percentage PUMA area in USFS National Forests and Grasslands (GIS, USFS)	.098	.172
AVG_FS	Mean percentage USFS area in contiguous PUMAs (GIS, USFS)	.117	.082
AREA_WILD	Percentage PUMA area in Congressionally designated wilderness areas (GIS, USFS)	.022	.054
AVG_WILD	Mean percentage wilderness area in contiguous PUMAs (GIS, USFS)	.024	.023
SURFACE	Area of surface water bodies (excludes streams), sq. miles (Natl. Atlas)	16.02	46.72
HAZ_COUNT	Number of EPA-designated CERCLA hazardous waste sites (EPA)	6.45	7.74
FS_REC	Number of USFS recreation sites (NORSIS)	17.0	9.12
FED_REC	Number of non-USFS federal recreation sites (NORSIS)	20.17	36.47
FSFED_REC	Number of USFS and other federal rec. sites (NORSIS)	37.16	40.08
URBAN	Urban residence: Maricopa Arizona, Pima Arizona, Bernalillo, New Mexico counties (binary, GIS)	.667	.471
DENSITY	Persons per sq. mile in resident's PUMA	1,658.0	1,969.1
DENS2	Square of density	6,625,957	10,500,000

Sources: GIS indicates calculation of polygon- or line-format GIS files for each PUMA; USFS: United States Forest Service Southwestern Region, http://www.fs.fed.us/r3/gis/datasets.shtml; National Atlas: http://nationalatlas.gov/atlasftp.html#hydrogm; EPA: U.S. Environmental Protection Agency CERCLA database, http://www.epa.gov/enviro/html/cerclis/index.html; NORSIS: National Outdoor Recreation Supply Information System, USFS Southern Research Station.

(AREA_WILD). USFS area is generally expected to be an amenity, but its designation for multiple uses (including recreation and extractive uses) distinguishes USFS area from wilderness area. Wilderness area, like USFS area, is expected to carry a positive implicit price reflective of recreation, ecosystem services, and passive use values (Phillips 2004). Although these measures are generally thought to be amenable, wildfire risk may offset the positive implicit prices to some extent (Kim and Wells 2005).

Recreation access is measured by the number of recreation sites managed by the USFS (FS_REC) and those managed by other federal agencies (FED_REC). The sum of these two measures (FSFED_REC) is used to estimate shadow prices for recreation sites in general. Recreation sites include camping, hiking, boat launches, and picnic sites.

The other site-specific data used in estimation include square miles of surface water area (SURFACE), number of CERCLA hazardous waste sites (HAZ_COUNT), population density and its square (DENSI-TY and DENS2), and urban status (UR-BAN). The forest area measures and surface water area are calculated for each PUMA using GIS calculations. Hazardous waste site counts and recreation sites are available at the county level; PUMAs are mostly defined as one or more counties, so the county-level data is aggregated across the appropriate counties. Recreation site data is gathered from the National Outdoor Recreation Supply Information System (NORSIS), which lists the number of several different types of recreation sites and opportunities for every county in the United States.[10]

There are three counties that are somewhat problematic for dealing with county-level data: Maricopa County and Pima County in Arizona, and Bernalillo County in New Mexico. These three urban centers are separated into several PUMAs (22 for Maricopa, seven for Pima, and five for Bernalillo county). Given data availability,

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[10] The NORSIS data is maintained by Carter Betz at the USFS Southern Research Station. Contact information available at http://www.srs.fs.usda.gov/trends/betz.html.

TABLE 2

DESCRIPTIONS OF HOUSING AND WAGE STRUCTURAL VARIABLES

		Men		Women	
Variable	Description	Mean	Std. Dev.	Mean	Std. Dev.
Housing Variables					
ANN_RENT	Annualized contract rent or dwelling value, $	9,544.4	7,330.0	7,554.3	5,117.3
ACRE9	Property size, 1–9 acres	.122	.328	.087	.282
ACRE10	Property size, greater than 9 acres	.013	.114	.010	.098
CONDO	Condominium status, binary	.016	.126	.044	.205
BEDS	Number of bedrooms	2.76	1.08	2.43	.991
AGE5	Structure age, 2–5 years	.163	.369	.131	.338
AGE10	Structure age, 6–10 years	.111	.315	.098	.297
AGE20	Structure age, 11–20 years	.229	.420	.249	.433
AGE30	Structure age, 21–30 years	.221	.415	.229	.420
AGE40	Structure age, 31–40 years	.096	.295	.101	.301
AGE50	Structure age, 41–50 years	.076	.264	.084	.278
AGE60	Structure age, 51–60 years	.026	.160	.033	.179
AGE61	Structure age, 61 or more years	.026	.158	.034	.182
Wage Variables					
LNWAGE	Natural log of hourly wages	2.76	.685	2.50	.646
EDUC	Years of education	13.9	2.82	14.1	2.40
EXP	Potential years of experience, =age-EDUC-6	21.3	11.0	20.1	11.5
EXP2	Square of EXP	575.9	508.6	537.0	505.5
MARRIED	Marital status, binary	.729	.445	.218	.413
IMMIG	Immigrant status, binary	.143	.351	.092	.289
BLACK	Race: Black, binary	.020	.138	.030	.171
ASIAN	Race: Asian/Pacific islander, binary	.018	.133	.014	.117
NATIVE	Race: Native American/Alaska Native, binary	.037	.189	.066	.248
RACE2	Race: Two or more races, binary	.138	.345	.123	.329
NOENG	Speaks English not well or not at all, binary	.046	.210	.024	.152
TRANTIME	Transit time to work, minutes	22.2	19.4	18.8	17.1

Notes: ANN_RENT and LNWAGE are the dependent variables. ANN_RENT is the un-transformed value; results are reported with the appropriate Box-Cox transform.

the approach adopted here is to assign the county-level value to all of the PUMAs in that county.

The independent variables for the housing-price equation include categorical variables for property acreage (ACRE9, ACRE10), condominium status (CONDO), number of bedrooms (BEDS), and structure age (AGE). The wage equation independent variables include education (EDUC), potential experience and its square (EXP, EXP2), marital status (MARRIED), immigration status (IMMIG), race indicators (BLACK, NATIVE, ASIAN, RACE2), English language proficiency (NOENG), and transit time to work (TRANTIME). Table 2 describes these variables.

IV. EMPIRICAL RESULTS

Estimation Issues

Any hedonic estimation involves several econometric issues that must be addressed in order to obtain efficient and reliable results. As mentioned above, a flexible Box-Cox search is used to determine the most efficient functional form. Using maximum likelihood estimation, the generic Box-Cox search estimates,

$$\frac{Y^{\lambda_1} - 1}{\lambda_1} = \alpha + \sum \beta_k \frac{X_k^{\lambda_2} - 1}{\lambda_2} + \varepsilon, \qquad [9]$$

where Y is a dependent variable, $\mathbf{X}$ is a vector of k independent variables, and λ_1,

λ_2, α, and β are parameters to be estimated. Estimates of $\lambda_1 = 0$ and $\lambda_2 = 0$ correspond with a log-log specification, while $\lambda_1 = 1$ and $\lambda_2 = 1$ is the linear model. Any functional form where the Box-Cox parameters are between -1 and 1 is possible.

The transformation parameter for the continuous independent variables was estimated as $\lambda_2 = 1$. For the housing-price equation, $\lambda_1 = 1$ was estimated as 0.25 for men and 0.38 for women. The wage equation estimates of λ_1 ranged between 0.007 and 0.05, but the logged form of the wage variable (i.e., $\lambda_1 = 0$) is used to avoid additional computation costs and to allow for simple comparisons of the human capital model to other Mincer-type wage equations in the literature.

There also exists the possibility that wages affect housing prices and housing prices affect wages. As in Blomquist, Berger, and Hoehn (1988), a fully simultaneous model is not estimated because calculations of implicit prices using estimations from both markets require reduced form estimates, where the effect of wages on housing prices (and vice versa) is implicit. However, the possibility remains that there are unobserved factors that affect the error terms in both equations. Estimates using a seemingly unrelated regression (SUR) revealed significant, if small, correlation between the error variances of the wage and housing-price equations (see Griffiths, Hall, and Judge 1993, 550); for this reason, SUR estimates are used throughout.[11]

Given the large vector of site-specific measures collected as independent variables, another concern is that the data will exhibit multicollinearity. In the case of imperfect multicollinearity, estimates of coefficient standard errors will be large and coefficients sensitive to empirical specification changes (Gujarati 1978, 178). Preliminary regressions using the full vector and sub-vectors of the

geographic independent variables exhibited these problems and correlation coefficients between the independent variables confirmed this suspicion. To reduce the consequences of multicollinearity, a subset of geographic variables is sought that are jointly independent.[12] The independent geographic variables described in the previous section, AREA_FS or AREA_WILD, SURFACE, HAZ_COUNT, and FSFED_REC, satisfy the condition of joint independence.

Finally, any econometric exercise that deals with geographic data must consider the possibility of spatially-dependent relationships. Spatial econometric problems arise when data is autocorrelated in space (Anselin 1988). As is the case with time-series data that is autocorrelated, estimates that do not correct for autocorrelation will be inefficient.

The spatial nature of the amenity data collected by PUMA or county suggests that spatial relationships could be present in the PUMS data. Several methods are available to correct for this potential problem. One option is to specify a spatially autocorrelated model, where error correlation between observations is not zero (i.e., the off-diagonals of the error covariance matrix are not zero). In this case, where the data set yields tens of thousands of observations, such an approach is not feasible because of the size of the spatial weights matrix required for estimation.[13]

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[11] The results reported in Blomquist, Berger, and Hoehn (1988) do not use a SUR model, although the authors note that the cross-equation error correlations are significant. The coefficient estimates reported here were more sensitive to the restriction of error independence than in Blomquist, Berger, and Hoehn (1988).

[12] The method for selecting variables follows the suggestion of Gujarati (1978, 184), where ordinary least squares regressions of one independent variable on the other variables are used to identify significant linear relationships between the independent variables. A set of variables is acceptable if the regression of each variable on the other variables all do not reject joint independence. All F-tests for the combinations in the results did not reject independence at the 95% confidence level.

[13] Kim, Phipps, and Anselin (2003) estimated spatial hedonic models with spatial data organized similarly to the data used here. The authors specified a contiguity-based spatial weights matrix, where all observations within a sub-district (like a PUMA in our data) were considered neighbors. This same approach is conceptually possible with the data in this paper, but the 609 total observations in Kim, Phipps, and Anselin (2003) are significantly more manageable than the 50,000-plus observations used here. A promising related method that deserves attention in this context has been developed by Conley (1999).

The second method is to control explicitly for those spatial characteristics that generate autocorrelation. This approach is more feasible with the current dataset because it only requires additional vectors of independent variables. For example, it may be that the characteristics of nearby places affect housing prices and wages in a particular area; Albuquerque, New Mexico, has very few forest amenities within the city limits, but large tracts of wilderness and National Forest areas just outside the city. As a first attempt to control for amenities in close places, the average measure of forest area (AVG_FS or AVG_WILD) in contiguous PUMAs is added as an independent variable for observations in a given PUMA.

SUR Results

The seemingly unrelated regression (SUR) in this context works well in explaining housing prices and wages in the region. Equations [6] and [7] are estimated and reported separately for men and women and reported in Tables 3 and 4, respectively.[14] Two primary specifications that are representative of the best fit and have been purged of multicollinearity are reported: one using USFS area measures (AREA_FS and AVG_FS) and the other using wilderness area measures (AREA_WILD and AVG_WILD).

The structural variables in the housing and wage equations are all of the expected sign and highly significant. For example, property acreage and number of bedrooms increases housing value, while years of education and experience increase wages. A test for error correlation between the equations showed that the SUR estimation is indeed justified; a correlation of about 0.20 for men and 0.18 for women was present for all specifications and was always significant.[15]

For both men and women, the proportion of the PUMA in forest area is positive and significantly associated with housing values, and a larger proportion of forest area in contiguous PUMAs is associated with higher housing prices. Further, it appears that forest area in contiguous PUMAs is more important than forests in the household's own PUMA; the housing equation coefficients for AVG_FS and AVG_WILD are larger than AREA_FS and AREA_WILD for men, and AVG_WILD is larger than AREA_WILD for women.

Own-PUMA forest area does not appear to directly affect wages, but nearby forest area is associated with lower wages (a negative coefficient indicates that larger values of that characteristic compensate for lower wages). For both men and women, the coefficients for AVG_FS and AVG_WILD are negative and significant while AREA_FS and AREA_WILD are positive and not significant. In other words, people do not trade wages for forest area where they work, but they will accept lower wages to live and work in an area where forests are closely accessible.

The coefficients for the forest area measures unambiguously indicate that forest area is amenable. But the estimates for the other geographic features are more difficult to interpret. Hazardous waste sites (HAZ_COUNT) are negatively associated with housing prices, which is the expected sign, but the sign is also negative in the wage equation. The coefficients for surface water area (SURFACE) and recreation sites (FSFED_REC) are also the same sign in both equations. Proper interpretation and any meaningful perspective of the magnitude of the results in a SUR framework require calculations of the total implicit prices.

Total Implicit Prices

The above discussion highlights the necessity of considering both housing and labor markets in tandem. For example, how do we interpret coefficient estimates that are

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[14] Interacting a categorical variable for gender with all of the other independent variables confirmed that both the wage and housing-price equation should be estimated separately for men and women (i.e., all of the gender interactions were jointly significant).

[15] See Griffiths, Hall, and Judge (1993) for the relevant Breusch-Pagan test statistic.

TABLE 3
MEN, SUR REGRESSION RESULTS AND IMPLICIT PRICES (OBSERVATIONS = 36,375)

Variable	Housing ($\lambda_1 = .25$)		Wage ($\lambda_2 = 0$)		Implicit Price ($)	
ACRE9	2.86***	2.66***				
ACRE10	2.08***	4.16***				
CONDO	−1.03***	−.912***				
BEDS	2.80***	2.81***				
URBAN	2.75***	2.38***				
DENSITY	.001***	.001***				
DENS2	1.5e-7***	−1.3e-7***				
EDUC			.068***	.068***		
EXP			.033***	.033***		
EXP2			−.0005***	−.0005***		
MARRIED			.145***	.145***		
IMMIG			−.041***	−.041***		
URBAN			.125***	.129***		
BLACK			−.120***	−.120***		
ASIAN			.031	.031		
NATIVE			.071***	−.072***		
RACE2			−.041***	−.040***		
NOENG			−.099***	−.098***		
TRANTIME			.002***	.002***		
DENSITY			2.7e-5***	2.4e-5***		
DENS2			−9.1e-9***	−8.7e-9***		
AREA_FS	5.32***		.039		36.30	
AVG_FS	7.17***		−.084*		80.86	
AREA_WILD		12.6***		.045		85.73
AVG_WILD		32.8***		−.373***		365.01
SURFACE	−.005***	−.005***	−.0004***	−.0005***	14.78	16.51
HAZ_COUNT	−.167***	−.149***	−.003***	−.003***	3.76	12.78
FSFED_REC	.006***	.006***	4.9e-5	8.5e-5	4.59	5.00
R^2	.3888	.3862	.2188	.2189		
Residual corr.					.1985	.1991

Notes: Structure age variables are suppressed for brevity. Residual correlations between the equations are significant at the 99% level. Implicit prices are calculated as follows: Housing: $\partial p/\partial f = b_{fh} * ann\_rent^{(1-\lambda_1)}$ where b_{fh} is the coefficient for characteristic f from the housing equation and *ann_rent* is the calculated annual rent evaluated at the sample mean. Wages: $\partial w/\partial f = b_{fw}*wage\_inc$ where *wage_inc* is the annual wage earnings evaluated at the sample mean. The prices for the area variables are converted to per square mile figures using average PUMA area. All implicit prices are annualized.

***, **, and * indicate 99%, 95%, and 90% confidence levels, respectively.

of the expected sign in one market, but the unexpected sign in the other market? What we wish to calculate is the total marginal implicit price for a characteristic, taking into account that characteristic's effect in both markets.

The indirect utility function can be used to describe what individuals are willing to trade on the margin for access to forests. Differentiating the indirect utility function and rearranging, noting that $dV = 0$ in equilibrium, yields,

$$\frac{V_f}{V_w} = -\frac{V_p}{V_w}\frac{dp}{df} - \frac{dw}{df}. \qquad [10]$$

By Roy's identity and the assumption that the quantity of land purchased for housing is 1, $-V_p/V_w = 1$. Noting that V_f/V_w is the marginal rate of substitution between f and the numeraire good, the implicit price of forest characteristic f is

$$P_f = \frac{dp}{df} - \frac{dw}{df}. \qquad [11]$$

The two terms on the right side of equation [11] are simply partial derivatives of the two hedonic price functions. Thus, in the case of an amenity, the housing-price partial and wage partial need not be positive and negative, respectively, for a total implicit price to be positive.

TABLE 4

WOMEN, SUR REGRESSION RESULTS AND IMPLICIT PRICES (OBSERVATIONS = 15,285)

Variable	Housing ($\lambda_1 = .25$)		Wage ($\lambda_2 = 0$)		Implicit Price ($)	
ACRE9	5.32***	5.22***				
ACRE10	10.2***	10.4***				
CONDO	−3.06***	−2.65***				
BEDS	5.44***	5.42***				
URBAN	4.81***	4.14***				
DENSITY	.003***	.002***				
DENS2	−3.8e-7***	−3.0e-7***				
EDUC			.086***	.086***		
EXP			.030***	.030***		
EXP2			−.0005***	−.0005***		
MARRIED			.014	.013		
IMMIG			8.6e-5	.0002		
URBAN			.154***	.168***		
BLACK			−.068***	−.069***		
ASIAN			.056	.057		
NATIVE			.032	.030		
RACE2			−.060***	−.058***		
NOENG			−.058*	−.055*		
TRANTIME			.002***	.002***		
DENSITY			7.8e-6	6.9e-6		
DENS2			−3.3e-9*	−3.0e-9*		
AREA_FS	12.8***		.022		27.52	
AVG_FS	11.6***		−.301***		97.98	
AREA_WILD		33.2***		.010		71.46
AVG_WILD		50.1***		−1.19***		396.58
SURFACE	−.015***	−.016***	−.0002***	−.0003***	4.16	5.84
HAZ_COUNT	−.536***	−.501***	−.004***	−.004***	−18.55	−11.67
FSFED_REC	.007**	.010***	.0004***	.0004***	−9.25	−10.37
R^2	.2946	.3862	.2188	.2189		
Residual corr.					.1839	.1844

Notes: Structure age variables are suppressed for brevity. Residual correlations between the equations are significant at the 99% level. Implicit prices are calculated as follows: Housing: $\partial p / \partial f = b_{fh} * ann\_rent^{(1 - \lambda_1)}$ where b_{fh} is the coefficient for characteristic f from the housing equation and *ann_rent* is the calculated annual rent evaluated at the sample mean. Wages: $\partial wl \partial f = b_{fw} * wage\_inc$ where *wage_inc* is the annual wage earnings evaluated at the sample mean. The prices for the area variables are converted to per square mile figures using average PUMA area. All implicit prices are annualized.

***, **, and * indicate 99%, 95%, and 90% confidence levels, respectively.

Calculating implicit prices for the forest amenities begins to clarify some of the econometric results; total annualized marginal implicit prices for the two specifications are reported in the last two columns of Tables 3 and 4. As expected from the coefficient estimates, proportion of USFS forest area has a positive marginal implicit price of about $36 per square mile for men and $27 per square mile for women. When measured by wilderness area, the implicit prices are higher, between $70 and $85 per square mile. Nearby forest area appears to be more "expensive" on the margin, with USFS area in contiguous PUMAs priced between $80 and $100 per square mile, and between $360 and $400 for wilderness area in contiguous PUMAs. It should be noted that the implicit price for own-PUMA forest area is entirely generated by compensating differentials in the housing market, while contiguous-PUMA forest area prices are generated in both the housing and labor markets.

To put these numbers in perspective, suppose a household moves within the greater Phoenix area, from the North Valley to the west (AZ PUMA 103 to 101). In the specification with the USFS measure of forest area, the move results in

an increase in forest area in contiguous areas of about 2.8% and an annual additional payment of about $270. A move from Sandoval County, New Mexico, to Taos, New Mexico (NM PUMA 500 to 200) increases own-PUMA forest area by 8.5% and decreases contiguous-PUMA forest area by 1.4%, resulting in a net payment of about $1,290 per year.

Although these implicit prices generally support the idea of forest areas as amenities, two questions remain. First, should nearby forest area carry a larger price than forests in one's own PUMA? Most of the households in the sample work in one of the three urban areas of greater Phoenix, Tucson, and Albuquerque. These areas represent the largest source of employment opportunities. But each of these areas is surrounded by nearby forest areas; households may be organizing residential location choices and commuting behavior to live close to amenable forest areas and urban employment opportunities. Under this scenario, it is plausible that nearby forests are more highly valued than forests in one's own PUMA.

On the other hand, it could be that people live in amenable areas and commute to higher wage areas that are disamenable. This would reduce the observed wage price for nearby forest area as households access both high amenities and high wages. Additional regressions using a sample of households that did not commute between PUMAs showed that the AVG_FS and AVG_WILD wage coefficients did not vary from the full sample reported here.[16] This finding is consistent with recent work related to the proximity of forests. Schmidt and Courant (2006) found that the proximity of forests (and other "nice places") near to urban areas is associated with lower wages; people don't need forests in their backyard to accept lower wages, as long as forests are "close enough."

The second question is whether the wilderness area measure should exhibit a larger implicit price than the USFS mea-

sure. Recall that the variables selected for the empirical specifications were chosen in part to purge multicollinearity from the data set. To some degree the forest measures are picking up amenable characteristics of other collinear independent variables not directly estimated. Since there is less wilderness area than USFS area (about 2% of the region's land area is in wilderness, while more than 10% is USFS land), smaller changes in the independent variable are picking up the total amenity value of forests as compared to the USFS measure. Thus, it is not unexpected that the wilderness area yields a larger implicit price. This indicates care must be taken when comparing the magnitudes of the implicit prices as each measure may partially proxy for other types of highly correlated forest characteristics.

Interpretation of the other geographic variables is aided by the calculation of implicit prices, but also raise difficult questions. The implicit price for surface water area is always positive for men and women, between about $5 and $15 per square mile per year. This implicit price is paid through lower wages that outweigh lower housing prices in PUMAs with more surface water area. The implicit prices appear to vary by gender for hazardous waste sites and recreation sites. Hazardous waste sites have a negative implicit price for women, but a positive price for men. The opposite is the case for recreation sites; a positive price is observed for men and a negative price for women.

Several plausible explanations for these findings exist that do not contradict the theory and general results in this paper. For example, hazardous waste sites are associated with economic development; while they are probably disamenable, people will seek out areas with good employment opportunities. This phenomenon was demonstrated by Gawande et al. (2000), where net in-migration was shown to be positively associated with hazardous waste sites up to a threshold level where the relationship becomes negative. Thus, a "wrong" sign on the HAZ_COUNT im-

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[16] Results available upon request.

plicit price does not necessarily violate the underlying model.

There are also reasons to believe that men and women will exhibit different attitudes toward environmental characteristics, particularly hazardous waste sites. Bord and O'Connor (1997) observe that women tend to exhibit more concern, on average, than men for environmental issues, and that this gender difference may be due to differential perceptions of risk. In this case, a greater concern for the risks posed by hazardous waste sites by women could account for the negative implicit price estimated for women (between −$12 and −$18) and the positive price for men (up to $18).

Similar reasoning could account for the opposite signs on the implicit prices for recreation sites for men and women. If recreation demand behavior differs significantly by gender, then the implicit prices for recreation sites would also vary by gender. The results reported here are consistent with this reasoning if the gender differences in recreation demand are such that men preferred the type of recreation measured by FSFED_REC.

V. CONCLUSIONS

This paper has proposed the open empirical question of whether forest and other natural amenities are important determinants of hedonic housing prices and wages at the regional level. While it has been shown in previous work that forest amenities matter at a local scale, and other characteristics (e.g., climate) matter inter-regionally, it is not known if regional variation in broad indices of environmental characteristics (e.g., forests) affects housing prices and wages. Results suggest that people make regional housing and labor market decisions based in part on the availability of forest resources, as well as other environmental measures. The proportion of land reserved in public forests, as measured by United States Forest Service land or Congressionally designated wilderness areas, carries a positive implicit marginal price within the Southwest, meaning

that people are willing to pay through the housing and labor markets to live in areas with larger forest tracts. Although no attempt is made here to estimate the welfare impacts of forest areas, it is clear that the annual payment in the region for forest areas is large and significant.

A significant finding is that forests impact both the housing and labor markets, indicating that forests are deeply ingrained in the economy of the Southwest. However, the pattern of this impact differs in each market. Forest area in a household's own geographic area is associated with higher housing prices, while forest area in contiguous geographic areas is associated with higher housing prices and lower wages. People appear to make trade-offs between several characteristics of real value: access to employment opportunities, commuting time to work, amenable landscapes where they live, and access to nearby amenities.

As mentioned in the introduction, the role for forests in the regional economy can have implications for rural development policy and non-market valuation within the region. One conclusion from the results is that a portion of the wage gap between urban areas and forested rural areas is due to compensating differentials for forests. That is, the second paycheck represented by forests is offsetting a reduced first paycheck from money income in amenable locations. Economic development policies that do not recognize the role of forest amenities in the region's wage structure may not be effective, particularly if the policies involve development of the resources that generate the second paycheck. Put another way, the development or preservation of natural resources "has less to do with the kinds of jobs that result than with the social and environmental amenities created or destroyed in the process," (Power and Barrett 2001, 18). The results presented here appear to confirm this view of economic development policies.

This indicates a potentially fruitful avenue of future research. If forest and other natural characteristics are important deter-

minants of wages, then wage estimates (and policies that rely on them) will suffer from omitted variable bias. Further, it may be that there exist systematic relationships between amenable landscape characteristics and the human capital characteristics of people who seek them, as suggested in Graves, Arthur, and Sexton (1999). Regional amenities may also explain empirical findings of a negative relationship between wages and unemployment (see Blanchflower and Oswald 1994); part of the tradeoff for the second paycheck may be higher unemployment in addition to lower wages.[17] Omitted variable bias in the wage structure and incorporation of unemployment as an additional dimension are topics for future empirical investigation.

Two issues arise from the results with respect to non-market valuation: the endogeneity of income and the endogeneity of the data-generating process. The former, which is derived from the significant impact of forests on wage earnings in the region, may be a problem for any non-market valuation technique that seeks to value regionally delineated characteristics that generate compensating wage differentials. The latter issue is more germane to a particular valuation technique, the travel cost method (TCM). It is succinctly summarized by Randall's critique of TCM that "recreational preferences may have influenced the choice of residential location," (Randall 1994, 90). The hedonic evidence suggests that forests are, in part, determining where people live and work in the region, and thus their access to recreation opportunities.

For each of these implications it is vital to answer the question of what makes forests amenable. Is it open spaces, recreational opportunities not quantifiable by the number of sites, or the fact that they are publicly-provided lands that matter to people (e.g., culturally, socially, or historically)? Are forests valued for their many uses, or the fact that they provide a

beautiful view? Forests provide a vast array of non-market goods and services. Any of these could account for the hedonic premiums that forest areas exhibit, and could be the focus of future research.

A limitation of the findings is related to the spatial nature of the public data used in estimation. Individuals are identified to geographic areas of at least 100,000 people; some of these areas within the study region are very small, while others are large. This raises two potential problems. First, the larger the area is geographically, the more difficult it is to reliably connect individuals within that area to the measured landscape characteristics. Second, the large differences in rural and urban settlement patterns in the region create a difficulty in interpreting the empirical results. That is, the importance of forest areas in small urban areas with small amounts of forest area may be different than in large rural areas with large forested tracts.

Data currently available may not be up to the task of fully capturing the natural amenity story in housing and labor markets at the regional level. The U.S. Forest Service, Southwestern region is currently planning a survey that will address some of these inadequacies by gathering individual survey responses that locate households to particular zip codes or points on the map. This level of response may provide future research with more refined measures of natural amenity access, such as distance to forest sites and the type of land cover surrounding each household. Such detailed information would also allow for direct tests of geographic aggregation bias.

It should also be noted that the estimation of implicit prices occurs in an equilibrium framework. As mentioned at the outset, forest characteristics may be affecting migration patterns within the region. Migration is fundamentally a disequilibrium concept, whereas hedonic theory assumes that utility differences between locations have already been eliminated. Examining the relationship between forest characteristics and migration behavior would help

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[17] Thanks to an anonymous reviewer for pointing out this connection.

form a more complete picture of the role of these characteristics in the region.

References

Acharya, Gayatri, and Lynne Lewis Bennett. 2001. "Valuing Open Space and Land-Use Patterns in Urban Watersheds." *Journal of Real Estate Finance and Economics* 22 (Mar.): 221–37.

Anselin, Luc. 1988. *Spatial Econometrics: Methods and Models*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Blanchflower, David G., and Andrew J. Oswald. 1994. "Estimating a Wage Curve for Britain." *The Economic Journal* 104 (Sept.): 1025–43.

Blomquist, Glenn C., Mark C. Berger, and John P. Hoehn. 1988. "New Estimates of Quality of Life in Urban Areas." *American Economic Review* 78 (Mar.): 89–107.

Bord, Richard J., and Robert E. O'Connor. 1997. "The Gender Gap in Environmental Attitudes: The Case of Perceived Vulnerability to Risk." *Social Science Quarterly* 78 (Dec.): 830–40.

Cheshire, Paul, and Stephen Sheppard. 1995. "On the Price of Land and the Value of Amenities." *Economica* 62 (May): 247–67.

Conley, T. G. 1999. "GMM Estimation with Cross Sectional Dependence." *Journal of Econometrics* 92 (Sept.): 1–45.

Costa, Dora L., and Matthew E. Kahn. 2003. "The Rising Price of Nonmarket Goods." *American Economic Review* 93 (May): 227–32.

Freeman, A. Myrick III. 2003. *The Measurement of Environmental and Resource Values, Theory and Methods*. 2nd ed. Washington D.C.: Resources for the Future.

Garber-Yonts, Brian E. 2004. "The Economics of Amenities and Migration in the Pacific Northwest: Review of Selected Literature with Implications for National Forest Management." General Technical Report PNW-GTR-617. Pacific Northwest Research Station, U.S.D.A. Forest Service.

Gawande, Kishore, Alok K. Bohara, Robert P. Berrens, and Pingo Wang. 2000. "Internal Migration and the Environmental Kuznets Curve for US Hazardous Waste Sites." *Ecological Economics* 33 (Apr.): 151–66.

Graves, Philip E., Michelle M. Arthur, and Robert L. Sexton. 1999. "Amenities and the Labor Earnings Function." *Journal of Labor Research* 20 (Summer): 367–76.

Griffiths, William E., R. Carter Hall, and George G. Judge. 1993. *Learning and Practicing Econometrics*. New York: John Wiley and Sons, Inc.

Gujarati, Damodar. 1978. *Basic Econometrics*. New York: McGraw-Hill.

Hand, Michael. 2006. "Are Enclaves Amenities? An Empirical Investigation in the Southwest United States." *Economics Bulletin* 10 (Aug.): 1–7.

Hoehn, John P., Mark C. Berger, and Glenn C. Blomquist. 1987. "A Hedonic Model of Interregional Wages, Rents, and Amenity Values." *Journal of Regional Science* 27 (Nov.): 605–20.

Kim, Chong Won, Tim T. Phipps, and Luc Anselin. 2003. "Measuring the Benefits of Air Quality Improvement: a Spatial Hedonic Approach." *Journal of Environmental Economics and Management* 45 (Jan.): 24–39.

Kim, Yeon-Su, and Rebecca L. Johnson. 2002. "The Impact of Forests and Forest Management on Neighboring Property Values." *Society and Natural Resources* 15 (10): 887–901.

Kim, Yeon-Su, and Aaron Wells. 2005. "The Impact of Forest Density on Property Values." *Journal of Forestry* 103 (Apr./May): 146–51.

Mincer, Jacob. 1974. "Progress in Human Capital Analyses of the Distribution of Earnings." Working Paper 53, NBER.

Niemi, Ernie, Ed Whitelaw, and Andrew Johnston. 1999. "The Sky Did Not Fall: The Pacific Northwest's Response to Logging Reductions." Tech. rep. ECONorthwest.

Phillips, Spencer. 2004. "The Economic Benefits of Wilderness: Focus on Property Value Enhancement." Policy Brief 2. Washington, D.C.: The Wilderness Society.

Power, Thomas Michael, and Richard N. Barrett. 2001. *Post-Cowboy Economics*. Washington, D.C.: Island Press.

Randall, Alan. 1994. "A Difficulty with the Travel Cost Method." *Land Economics* 70 (Feb.): 88–96.

Ridker, Ronald G., and John A. Henning. 1967. "The Determinants of Residential Property Values with Special Reference to Air Pollution." *The Review of Economics and Statistics* 49 (May): 246–57.

Roback, Jennifer. 1982. "Wages, Rents, and the Quality of Life." *The Journal of Political Economy* 90 (Dec.): 1257–78.

Rosen, Sherwin. 1974. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." *The Journal of Political Economy* 82 (Jan./Feb.): 34–55.

Ruggles, Steven, Matthew Sobek, Trent Alexander, Catherine A. Fitch, Ronald Goeken, Patricia Kelly Hall, Miriam King, and Chad Ronnander. 2004. *Integrated Public Use Microdata Series: Version 3.0*. Minneapolis, Minn.: Minnesota Population Center.

Schmidt, Lucie, and Paul N. Courant. 2006. "Sometimes Close is Good Enough: The Value of Nearby Environmental Amenities." *Journal of Regional Science* 46 (Dec.): 931–51.

Shultz, Steven D., and David A. King. 2001. "The Use of Census Data for Hedonic Price Estimates of Open-Space Amenities and Land Use." *Journal of Real Estate Finance and Economics* 22 (Mar.): 239–52.