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Protected Area Designation, Natural Amenities, and Rural Development of Forested Counties in the Continental United States

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ABSTRACT Policy makers who wish to spur economic development in rural forests face challenges that include population decline and poverty. Protected land and natural amenities enhance the quality of life and prospects for economic development, but there is limited research on how different types of protected land or natural amenities affect the rural forest economy. We use county level variables for protected areas differentiated by access and extractive use, and natural amenities differentiated by climate, water area, and topography to explain spatial variation in labor and built space markets. Results show that temperate summers and water area increase wages and housing prices and explain more than 30 percent of the spatial differences in wages, housing price, employment density, built space percent, human capital, and local road density. Protected area decreases wages, but, if open access, increase housing prices and human capital and explain more than 20 percent of the spatial differences in human capital, built space percent, and local road density.

Introduction

Economic development in rural areas is commonly thought to lag behind the rest of the U.S., as measured by job growth, earnings, and other quality of life indicators (Sofranko and Samy 2003; Stabler 1999). Weber et al. (2005) observe persistent poverty is disproportionately found in rural counties. Explanations for this include the lack of adequate scale to capture agglomeration economies (Fujita, Krugman, and Venables 1999; Stabler 1999) and structural shifts in the economy away from natural resources that favor urban areas (Mazie and Killan 1991). However, there are also prospects for growth in rural America. Some rural areas could grow by becoming bedroom communities that promise a higher quality of life than nearby prosperous cities (Lasley and Hanson 2003). Another growth opportunity would be to promote natural capital that supports recreational industries and retirement communities (Deller, Lledo, and Marcouiller 2008; Johnson and Beale 2002).

We examine how the type of protected areas and natural amenities affect the spatial variation of economic development in rural forests. The types of protected areas differ based on access and extractive use, and the types of natural amenities include the climate, topography, and water area. The rural forests are the counties in the continental U.S. with more than thirty percent of land in forests and a population percent below 100 people per square mile. The protection of land matters for rural areas that tend to have more recreational opportunities, scenic terrain, and public land to drive

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local economic growth (Rasker and Hansen 2000; Vias and Carruthers 2005). However, fast growing areas can also experience increased pollution and traffic congestion which lead to a reduction in the quality of life (Gabriel, Mattey, and Wascher 2003). A permitted decline in natural capital from population pressure and inadequate protection of local resources could even spur out-migration and a fall in tourism (Rickman and Rickman 2011). Looking at all counties in United States the divide between urban and rural is strongly evident, and agglomeration is a major driver of economic development differences (Wu and Gopinath 2008). However, rural economies without thick labor and housing market rely more on agricultural and forestry activities, natural capital, and access to public land and less on returns from agglomeration for development (Rickman and Wang 2015).

Roback (1982) focuses on the role of wages and land rents in allocating workers to locations with various quantities of amenities. Assuming freely mobile factors of production, the low wages in a county might not be bid up by firms in search of lower labor costs if the supply of workers continues to rise because of natural capital. The natural capital acts as compensation for a low wage. Agglomeration economies, or production with increasing returns, is pulled disproportionately toward areas with good market access (Fujita, Krugman, and Venables 1999). High housing prices may not make households move away from a county because agglomeration enables strong productivity and high wages. These compensating differentials are useful for understanding spatially uneven development and identifying what endowments are most influential for economic growth.

Protected areas and natural amenities may influence spatial variation in economic development of forested counties in the rural continental United States according to type of access or type of amenity. An empirical model of the labor and land markets examines if the types of protected areas and natural amenities affect differences in market outcomes across space. Accurate empirical estimation of a market requires a distinction between endogenous variables, such as the prices of labor and land that are determined within a demand and supply system, and exogenous variables that are determined outside the market. One type of natural capital (e.g., open access protected area) may influence market growth more than another type of natural capital (e.g., water area). We seek to determine the relative contribution of the public access and amenity factors to rural development outcomes, and these contributions are derived and shown in the final table of the results. This helps policy makers to direct scarce investment resources toward industries associated with those natural capital types.

The use of protected forests for multiple uses has become more common as forest policy objectives go from managing for a single or dominant use to managing for compatible forest uses, and even for sustaining the ecosystem health of the forest (Stevens and Montgomery 2002). Heavy cutting makes forests less effective at regulating runoff and impairs recreation value, but preservation of the natural forest only for benefit of the water supply or recreation puts a stop to industrial use. The use of forests for multiple management goals has consequences for the relative ratio of natural to physical capital that forests offer rural communities, and the chosen portfolio of capital influences economic development in those communities. Information about the contributions of particular types of natural capital to development found in this paper can inform the tradeoffs involved in the multiple use management.

The role of natural amenities, recreation, and public lands as drivers of in-migration and economic development in rural counties has received much attention (see Charnley et al. 2008 for review). Natural amenities are elements of the environment (e.g., climate, water bodies, coastlines, mountains, and forests) that attract people. McGranahan (1999) found that population growth between 1970 and 1996 in nonmetropolitan counties in the U.S. was greatest in those counties ranked highest according to an amenity index based on climate, topography, and water area. Counties with recreation-based economies and public lands are also associated with in-migration. Johnson and Beale (2002) found that nonmetropolitan counties with high levels of recreation-linked employment, income, and housing had double the rate of population growth in the 1990s compared with all nonmetropolitan counties. Frentz et al. (2004) found that average percentage population growth between 1970 and 2000 in all U.S. counties with federal lands (wilderness, national parks, national monuments, and roadless areas) was higher than in counties without federal lands, regardless of metropolitan status or region. We expand on this literature by suggesting how labor and built space markets adjust to the in-migration of population toward the natural capital in rural forests.

While natural amenities, recreation, and public lands are positively correlated with in-migration, how amenities influence regional economic growth is subject to debate (e.g., Charnley et al. 2008). Places with more natural amenities and environmental protections are thought to attract tourists and new residents, create jobs (especially in the service sector), and stimulate economic development. This view is supported by Deller et al. (2001), who estimate reduced-form equations for population, income, and employment growth in non-metropolitan counties between 1985 and 1995 and find that amenity and quality of life variables positively influence growth. Lorah and Southwick (2003) provide empirical evidence that counties in the western U.S. with more protected federal lands have higher population, income, and employment growth between 1970 and 2000 than counties with less protected public land. Johnson and Beale (2002) suggest that increased recreational activity, the appeal of second homes, and the influx of people into rural areas all create a demand for housing and for an expanded business, service, and governmental infrastructure to support it. We provide more evidence in our analysis about the role of access to protected land and amenities on economic development outcomes in rural forests counties in particular.

Conversely, results of econometric models suggest that broad land use policies that protect natural amenities neither help nor hinder the growth of nearby economies. Lewis et al. (2003) find that wage growth in forested counties in the northern U.S. between 1990 and 1997 did not vary systematically with the county shares of public land under preservation and multiple-use management. Furthermore, increases in net migration associated with increasing multiple-use lands did not affect wage growth. Rosenberger et al. (2008) found that designated wilderness areas did not affect the timing of transitions of local economies in the Appalachian region of the U.S. from dependence on extractive industries (e.g., timber harvesting, mining, agriculture) toward service and information technology industries. This paper does not tackle the question of whether amenities influence recent changes in economic development, which can occur over decades or longer, but rather whether the types of natural capital, found over the long run, explain compensating differentials observed in current labor and housing markets.

The balance of this article includes an explanation of the equilibrium in the theoretical model to explain the spatial distribution of economic activity. Next, there is a description of the data sources and the empirical model of the labor and housing markets to examine the contributions of protected land and natural amenities to spatial variation in the location decisions of firms and households. Lastly, we present the results of the empirical model and suggest directions for future research in the conclusion.

Equilibrium in the Theoretical Model

The theoretical model is adapted from a long line of literature on the quality-of-life hedonic pricing approach which analyzes how the location decisions of firms and households influence the spatial variation in economic development (Beeson and Eberts 1989; Gabriel and Rosenthal 2004; Glaeser and Tobio 2008; Roback 1982; Wu and Gopinath 2008). Locations differ by endowments like accumulated human, physical, and natural capital, and economic geography. Factors that directly affect households' location decisions are referred to as natural capital and denoted by site-specific

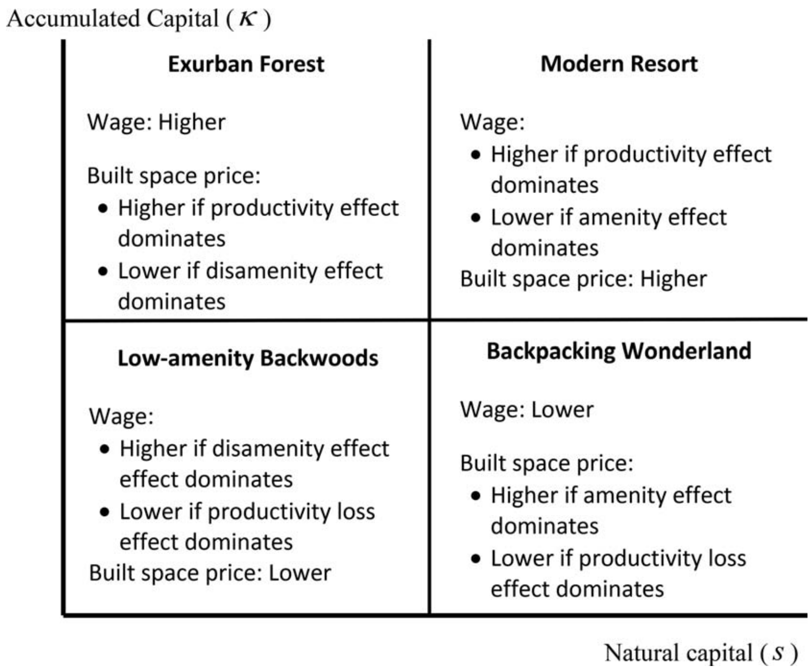

FIGURE 1. SPATIAL VARIATION IN BUILT SPACE PRICES AND WAGES BASED ON LEVELS OF ACCUMULATED CAPITAL AND NATURAL CAPITAL.

characteristics s. Factors that directly affect firms' location decisions are referred to as accumulated capital and denoted by κ. Given an equilibrium distribution of firms and households across space, wage and housing price differences can be found as functions of s and κ.

We present a theoretical model derived in Roback (1982) to support the graphical description, found in Figure 1, of why equilibrium wages and built space prices could differ across rural forest locations. Greater details on the derivation of this standard model can be found in Roback (1982), Wu and Gopinath (2008), and others. Households have identical preferences defined over residential space (h), a numeraire non-housing good (z), labor activity for income (l), and natural capital (s). At each location, the problem of the household is to choose quantities of z, h, and l, given the quantity of s at the location, to satisfy a budget constraint.

$$\max_{h,z,l} \; U(z,h,l;s) \text{ subject to } wl+I=z+ph \tag{1}$$

where p is the rental payment for housing, and I is the non-labor income.

Associated with equation (1) is the indirect utility function, $V(w,p;s,I)$, which gives the maximum achievable utility given the wage, non-labor income, housing payment, and level of natural capital. The market equilibrium condition for households, who are fully mobile, is given by

$$V(w,p;s,I)=\bar{V} \tag{2}$$

where $\bar{V}$ is an exogenous utility level common to all rural forest countries. Wages and housing payments adjust to equalize to $\bar{V}$ in all locations, or some households have the incentive to move.

Firms utilize an identical production function $Q(l,k,m;\kappa)$ where m is the built space, capital k, and labor used in production, given a location's accumulated level of physical and human capital κ. Remoteness is intended to represent a lack of both accumulated physical and human capital. The problem for the firm is to minimize total production cost by choosing m, k, and l, given the quantity of κ, while achieving a desired level of production y.

$$\min_{l,k,m} \ wl+rk+pm \ \text{subject to} \ Q(l,k,m;\kappa)=y \tag{3}$$

where r is the unit cost of capital.

Associated with equation (3) is the cost function, $C(w,p;\kappa,y)$, which gives the minimum achievable production cost given the wage, level of production, built space rental payment, and the accumulated capital. Assuming mobility on the part of the firms, wages and rents adjust to equalize costs to a constant level $\bar{C}$ for all rural forest counties.

$$C(w,p;\kappa,y)=\bar{C} \tag{4}$$

A land developer has costs $c(d;w,\kappa)$ that depend on the built space constructed, d, for a given wage and level of accumulated capital. The problem of the developer is to maximize profit, given a wage and quantity of κ, by choosing a quantity of built space d to construct.

$$\max_{d} \ \pi(d;w,\kappa)=pd-c(d;w,\kappa) \tag{5}$$

The supply of built space from the developer increases with the equilibrium price of built space and the accumulated capital, but decreases with the wage the developer pays to workers.

Natural forests provide opportunities to enhance quality of life and may also increase productivity at work. This pushes the iso-utility, $V(w,p;s,I)$, and the iso-cost curves, $C(w,p;\kappa,y)$, upward, and this increases built space prices but leaves the wage indeterminate (Figure A1). The wage might be higher if the productivity effect dominates or lower if the amenity effect dominates. Alternatively, greater accumulation of human and physical capital will boost productivity but can negatively affect natural forests. Corporations may disrupt rural landscapes by buying family farms, and the growth of cities can create traffic and pollution. As the iso-utility curve shifts down and the iso-cost line shifts up, the wage increases but the change in the housing price is indeterminate. A lower housing price results if the dis-amenity effect outweighs the higher productivity.

The categories of rural forest locations implied by spatial variation in accumulated capital and natural capital are illustrated in Figure 1. Locations with a high wage and an indeterminate built space price are at the top left. These locations may be on the outskirts of a metropolitan area with high levels of accumulated capital. The low natural capital of the exurban area makes built space prices less than at other rural forest locations. The category at the top right refers to the locations with high accumulated capital and high natural capital. Such places may become resort destinations where skilled artisans cater to the wealthy who vacation or retire there. Housing is expensive, but wages could be low if workers are willing to accept low income for attractive scenery.

The bottom two categories in Figure 1 indicate the expected wages and built space prices in the locations where accumulated capital is low. The lower right category suggests locations with higher natural capital must have a lower wage, but there is an uncertain built space price. The housing price could be higher if outdoor enthusiasts choose to purchase second homes or retirees decide to settle there. The locations with low accumulated capital and low natural capital in the bottom left category

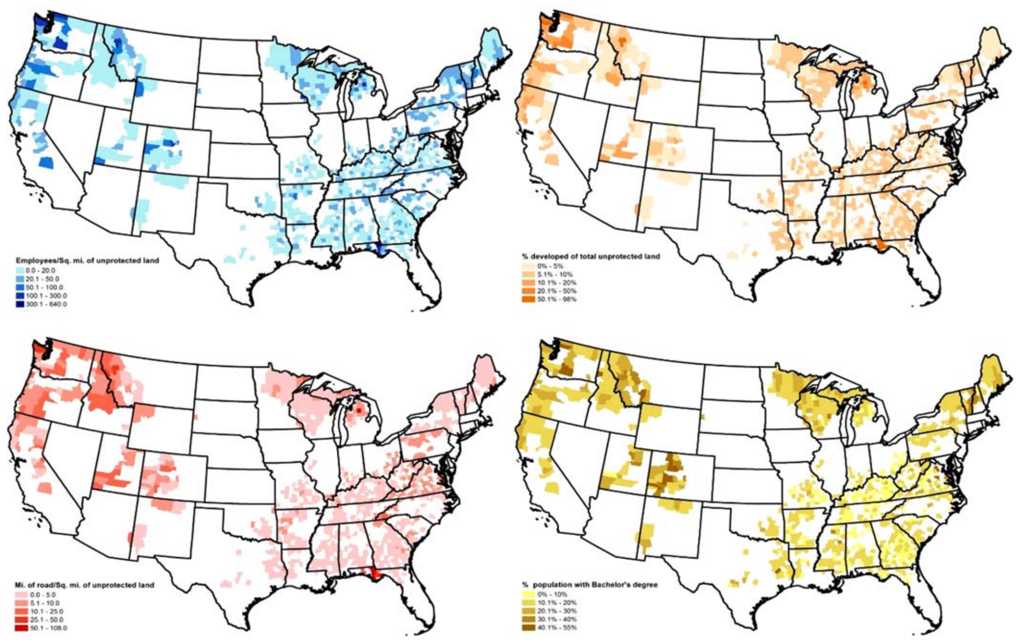

FIGURE 2. SPATIAL DISTRIBUTION OF EMPLOYMENT, LAND WITH BUILT SPACE, LOCAL ROAD, AND HUMAN CAPITAL INTENSITIES FOR RURAL FOREST COUNTIES IN THE CONTINENTAL UNITED STATES.

have low built space prices since no firms or households want to be there. Wages could be higher if workers leave the area faster than firms. For example, a unique natural resource could be available in a desolate location, and the resource extraction company offers generous wages to retain workers.

Data

We use cross-sectional, county-level data of rural forests in the continental U.S. for the year 2000 to estimate the structural model described in the next section.[1] A rural forest county has more than thirty percent of land in forest cover based on the 2001 National Land Cover Database (NLCD; Homer et al. 2007) and a population percent less than 100 persons per square mile based on the Census Summary File 2 (U.S. Department of Commerce, Census Bureau 2000b). The decision to use thirty percent or more land in forest cover is based on the ranking of all continental counties by the percent of land in forest cover above the 80th percentile. A population percent of less than 100 persons per square mile includes counties with exurban areas that have Census blocks that exceed the minimum population percent requirements in the Census definition of rural (U.S. Department of Commerce, Census Bureau 2000c). The use of a density measure of 100 persons per square mile of all land rather than private land means that counties with a lot of public land look more urban on the private land. This definition for rural forests means there is a final sample of 905 U.S. counties (Figure 2). Table 1 shows the summary statistics for the variables in the empirical model using data from multiple sources.

Data on employment and average wage per job are taken from CA34, a publication of the Bureau of Economic Analysis (BEA), U.S. Department of Commerce (2000). The median home value in a county, and the percent of workers with a bachelor's degree, as a measure of human capital, is calculated using data from the Census Summary File 3 (U.S. Department of Commerce, Census Bureau

TABLE 1. DESCRIPTIVE STATISTICS OF RURAL FOREST COUNTY DATA (905 COUNTIES).

Name of variable	Unit	Mean	Standard deviation	Minimum	Maximum
Employment density	Employees per square mile of unprotected land	20.06	29.60	0.33	637.96
Wage income	$per employee	22,167	4,187	11,508	51,701
Built space percent	Percent built space of total unprotected land	7.31	8.88	0.28	98
Housing price (county median)	$per house	80,366	34,928	33,400	369,100
Human capital	Percent of population with bachelor's degree	14.04	7.00	4.90	54.80
State and local road density	Miles per square mile of total unprotected land	5.33	6.98	1.44	107.08
Agriculture percent	Percent farm land of total unprotected land	41.15	23.91	0	90.9
Unprotected forest percent	Percent of unprotected forest of total land	52.57	13.28	26.05	90.5
Natural amenities	Index	3.68	0.99	2	7
Temperate summer	Index—Low winter-summer gap, 1941-70	0.42	1.05	−1.68	6.50
Topography	Index—Low value is the Plains and high value is the Mountains.	0.45	1.05	−1.19	1.84
Natural log of water area	Index	0.06	0.87	−2.35	2.35
Seasonal	Percent of houses defined as seasonal	10.15	11.75	0.40	75.39
Protected land percent	Percent of total land that is protected prior to 1980	38.39	39.42	0	95
P_OA1 percent	Percent of land protected, open access, without extractive use	5.64	16.06	0	95
P_OA2 percent	Percent of land protected, open access, with extractive use	21.53	31.54	0	95
P_Restrict percent	Percent of land protected with restricted or closed access	11.27	16.35	0	95
Remoteness	Index	5.92	2.33	1	9

TABLE 1. *CONTINUED*

Name of variable	Unit	Mean	Standard deviation	Minimum	Maximum
Commute	Percent of workers who commute outside the county for work	6.75	10.04	0	64.5
Interstate density	Interstate highway miles authorized by Eisenhower per square mile of total unprotected land	0.055	0.22	0	3.94
Nonwage income	$per person	13,154	3,508	1,341	39,100
Retiree concentration	Percent of population older than 65	14.73	3.19	3.00	28.50
Regional controls					
Western	= 1 if in the Mountain and Pacific time zones[a]	0.14	–	–	–
Midwestern	= 1 if in the Heartland or Midwest[b]	0.16	–	–	–
Northeast	= 1 if north of the Mason-Dixon line[c]	0.08	–	–	–
Distance from ocean	Miles	261	194	0	901
Distance from Great Lakes	Miles	488	368	0	1,609
Eco-zone	Ecological regions	45.79	15.38	1	66

[a]The states are Arizona, California, Colorado, Idaho, Montana, Oregon, Utah, and Washington.
[b]The states are Illinois, Indiana, Michigan, Minnesota, Ohio, and West Virginia.
[c]The states are Maine, New Hampshire, New York, Pennsylvania, and Vermont.

2000d). The land cover that is built or forested is based on the 2001 NLCD. The percent of developed (NLCD classes 21–24) and unprotected forest land (NLCD classes 41–43) comes from the division of the area of the land covers by the total unprotected land. Unprotected land is the land outside protected areas defined by the national inventory of protected areas (PAD-US version 1.3) managed for biological diversity and other natural, recreational, and cultural uses (U.S. Geological Survey, Gap Analysis Program 2012). The land in farms divided by the total unprotected land gives the percent of agricultural land (U.S. Department of Agriculture, National Agricultural Statistics Service 2002).

Our measures of natural capital are protected areas and natural amenities. The PAD-US has information about the level of access and the management of the protected areas. The protected areas we use are established prior to 1980 to examine their exogenous influence on spatial development. The three levels of access are open access, restricted access, and closed. The open access sites require no special permits for public access to the site during regular hours. The restricted access sites require a special permit for access, and closed means no public access is allowed. Management measures distinguish between biodiversity or multiple use goals for the open access sites by either allowing natural disturbance events to proceed naturally and preventing extractive use, suppressing natural disturbances and preventing extractive use, or permitting extractive uses.

The level of natural amenities in a county is estimated using the component of a natural amenity index developed by the USDA's Economic Research Service (McGranahan 1999). The index measures physical characteristics of a county area that enhance the location as a place to live. These include measures of climate, topography, and water areas. The six factors are warm winter (average January temperature), winter sun (average number of sunny days in January), temperate summer (low winter-summer temperature gap), summer humidity (low average July humidity), topographic variation (topography scale), and water area (water area proportion of total county area).

The level of accumulated capital is represented by road densities, non-wage income, seasonal housing percentage, percentage of workers that commute outside the county, and remoteness. The density of the local and state roads and the Eisenhower interstate highway system for each county, as measures of physical capital, are calculated from road lengths with the Census Bureau, U.S. Department of Commerce, Census Bureau (2006). Nonwage income is the difference between a county's per capita personal income and wage income from the BEA file CA1-3 (U.S. Department of Commerce, Bureau of Economic Analysis 2000). Nonwage income is a measure of financial capital that includes proprietor and rental income, dividend and interest income, social security, and other transfer payments. The percentage of the housing stock that is seasonal and the percentage of workers that commute outside the county for work is calculated using data from the Census Summary Files 1 and 3, respectively (U.S. Department of Commerce, Census Bureau 2000a,e).

An index of remoteness comes from the urban influence codes developed by the USDA's Economic Research Service (U.S. Department of Agriculture, Economic Research Service 2003). The classification scheme distinguishes metropolitan counties by the population size of their metro area, and nonmetropolitan counties by the degree of urbanization and adjacency to a metro area. The three metro and six nonmetropolitan categories indicate trends in population percent and metro influence. The six non-metropolitan counties are based on three urban-size categories according to total urban population, and each of the three urban-size categories are divided by whether or not the county is adjacent to one or more metro areas.

Regional dummies, proximity to ocean sized water bodies, and ecological regions are meant to represent the laws, regulations, and other production costs and natural capital not captured by variables in the structural equations. After observing that results with state dummies are similar to the results with regional dummies, degrees of freedom are preserved by using only regional dummies. Dummy variables for regions include the Pacific and Mountain states, the Heartland and Midwest states, and the states north of the Mason-Dixon, with the Southern states the omitted variable.[2] Other control variables for location include the distance to the closest ocean and to the Great Lakes, and the level III ecological regions according to the Commission on Environmental Cooperation (1997). The parameter estimates for the regional controls are shown in Tables A1 and A2.

Empirical Model

To arrive at the steady state spatial equilibrium, the empirical approach supposes the dynamic process of household and firm migration is costless although in reality all counties need not be at the same stage of adjustment. This suggests that the best that can be done with cross-section data is a snapshot of a temporally dynamic equilibrium. Kuh (1959) indicates that estimates from a cross-section model can approximate fully adjusted long-run coefficients. However, these estimates should be used with caution in their application to time series processes.

The effect of protected land densities, and other exogenous factors for natural capital and accumulated capital, on the prices and quantities of labor and built space is econometrically analyzed by adopting a linear system of simultaneous equations (equations 6–9).

$$\text{Labor demand density}: L_i^d=\alpha_0+\alpha_1\bar{w}_i+\alpha_2\bar{p}_i+\sum_{k=1}^{K}\alpha_3^k\bar{\kappa}_{ki}+\varepsilon_{1i} \tag{6}$$

$$\text{Labor supply density}: L_i^s=\varsigma_0+\varsigma_1\bar{w}_i+\varsigma_2\bar{p}_i+\sum_{s=1}^{S}\varsigma_3^k\bar{s}_{si}+\varepsilon_{2i} \tag{7}$$

$$\text{Built space demand percent}: D_i^d=H_i^d+M_i^d=\vartheta_0+\vartheta_1\bar{w}_i+\vartheta_2\bar{p}_i+\sum_{s=1}^{S}\vartheta_3^s\bar{s}_{si}+\sum_{k=1}^{K}\vartheta_4^k\bar{\kappa}_{ki}+\varepsilon_{3i}, \tag{8}$$

$$\text{Built space supply percent}: D_i^s=\theta_0+\theta_1\bar{p}_i+\sum_{k=1}^{K}\theta_2^k\bar{\kappa}_{ki}+\varepsilon_{4i}, \tag{9}$$

where i is an index of the county, $\bar{w}$ and $\bar{p}$ are the mean of $\bar{w}$ and $\bar{p}$, $(\bar{s}_{1i},\bar{s}_{2i},\ldots,\bar{s}_{Si})$ is a vector of variables for natural capital that correspond to the mean of $(s_{1i},s_{2i},\ldots,s_{Si})$ at county i, $(\bar{\kappa}_{1i},\bar{\kappa}_{2i},\ldots,\bar{\kappa}_{Ki})$ is a vector of variables that represent accumulated capital that correspond to the mean of $(\kappa_{1i},\kappa_{2i},\ldots,\kappa_{Ki})$ at county i, and αs, ςs, ϑs, θs are parameters, and the εs are error terms.

The explanatory variables include endogenous variables (i.e., wage, housing price, human capital, local and state road density, agricultural percent, unprotected forest percent) that are determined simultaneously with equations 6 through 9 to improve the efficiency of the estimation and exogenous variables for instruments (i.e., excluded exogenous variables of a simultaneous equation) are used to obtain consistent coefficient estimates. Instrumental variables include the variables for protected lands, natural amenities, and accumulated capital. Protected land variables include open access areas with or without extractive use and restricted access areas, and natural amenity variables include temperate summers, topography, and water area. Accumulated capital variables include remoteness, non-wage income, seasonal housing, commute for work outside the county, and the density of the Eisenhower interstate highway system.

Human capital embodies the knowledge and skills from accumulated education and work experience, measured as the percent of the population with a bachelor's degree. The human capital equation (10) is specified the same as the supply curve for labor. The density of local and state roads is a measure of accumulated physical capital shown in equation (11).

$$\text{Human capital}:\ B_i=\varphi_0+\varphi_1\bar{w}_i+\varphi_2\bar{p}_i+\sum_{s=1}^{S}\varphi_3^k\bar{s}_{si}+\varepsilon_{5i}, \tag{10}$$

$$\text{Local and state road density}: LR_i=\upsilon_0+\upsilon_1D_i^s+\upsilon_2HW_i+\varepsilon_{6i}, \tag{11}$$

where HW_i is the density of interstate highways, φs and υs are parameters, and ε_{5i} and ε_{6i} are error terms. Both are assumed endogenous because human capital is determined simultaneously with the labor market and the local and state road densities are jointly determined with the market for built space.

The system of equations includes the percent of agriculture and unprotected forests (equations 12 and 13).

$$\text{Agricultural percent}: AG_i = \psi_0 + \psi_1 D_i^s + \psi_2 LR_i + \psi_3 FO_i + \sum_{s=1}^{S} \psi_4^s \bar{s}_{si} + \sum_{k=1}^{K} \psi_5^k \bar{\kappa}_{ki} + \varepsilon_{7i}, \quad (12)$$

$$\text{Unprotected forest percent}: FO_i = \gamma_0 + \gamma_1 D_i^s + \gamma_2 LR_i + \gamma_3 AG_i + \sum_{s=1}^{S} \gamma_4^s \bar{s}_{si} + \sum_{k=1}^{K} \gamma_5^k \bar{\kappa}_{ki} + \varepsilon_{8i}, \quad (13)$$

where ψs and γs are parameters, and ε_{7i} and ε_{8i} are error terms. The modeling of these land use variables is important for rural areas with few other sources of accumulated capital, and the variables are also endogenous because they are jointly determined with the market for built space. Several exploratory specifications tried nonlinear variables and dummy variables for natural amenities, remoteness, and protected areas, as well as interaction variables for road and built space percent, natural amenities, and protected areas. However, the nonlinear and interaction variables did not increase the fit, and these were dropped from the specifications.

Table 2 indicates the instrumented variables for each equation based on the results of the Wu-Hausman (Wu 1974; Hausman 1978) check of endogeneity of suspected explanatory variables. The instruments are chosen based on the criteria of relevance and validity (Wooldridge 2003). Relevance dictates that instruments be correlated with the instrumented variables, and this is commonly gauged with an F-statistic that rejects the null hypothesis that the joint effect of the instruments is zero at a 1 percent significance level (Stock and Watson 2007). Table 2 indicates that the F-statistic is not always significant for the instrumented variable, and this means the standard errors on the estimates will be larger than if stronger instruments were available. To check if the instruments are valid, a regression of the instruments on the error term of each structural equation should show no correlation. The χ^2 tests for each equation accept the null hypothesis that instruments are valid at the 1 percent level (Sargan 1958).

To estimate the parameters for equations (6–11), we apply the steps of the three-stage least square estimator (3SLS). First, we performed a regression of each endogenous variable on a set of instrumental variables, which are the excluded exogenous variables of the equations. Second, the predicted values of the endogenous variables are substituted into the right-hand sides of the equations. Finally, the equations are estimated with a seemingly unrelated regression estimator to handle contemporaneously correlated errors.

We check for spatial lag dependence and spatial autocorrelation, using the residuals from the 3SLS estimator, with a series of Lagrange multiplier (LM) tests which have desirable aspects not found in other tests such as the Moran's I-test. The MATLAB code for generating the spatial weight matrices $\mathbf{W}$, and the spatial econometric model is available from the Spatial Econometrics Toolbox. Robust LM tests have power even if two types of spatial dependence are present (Anselin 1988). Robust LM tests are conducted for spatially correlated errors and the spatial autoregressive process (Anselin et al. 1996), and these indicate the spatial lag model.

Using LM tests of spatial dependence with alternative weights matrices, the inverse distance and contiguity matrices are less significant than the nearest-neighbor weight matrices. The benefit of k-nearest-neighbors weighting matrices (as opposed to the inverse distance weights) is that they eliminate the possibility of islands, or observations having no neighbors (Anselin and Bera 1998). To

TABLE 2. TEST OF THE STRENGTH AND VALIDITY OF THE INSTRUMENTS.

Equation	Instrumented variables	Excluded exogenous instrumental variables	*F*-statistics on the instrumented variables[a]	χ^2-statistics for the test of over-identifying restrictions[b]
Labor supply	Wage, Built space percent, Housing price	Remoteness, Commute, Retiree concentration, Interstate density, Seasonal	15*, 10, 62*	0.18
Human capital supply	Wage, Built space percent	Remoteness, Commute, Nonwage income, Retiree concentration, Interstate density, Seasonal, Commute	15*, 11	4.32
Labor demand	Wage, Human capital, State and local road density, Agricultural percent, Built space percent	Temperate summer, Topography, Natural log of water area, P_OA1 percent, P_OA2 percent, P_Restrict percent, Seasonal, Nonwage income, Retiree concentration, Interstate density	12*, 13*, 15*, 16*, 9	2.42
Built space area supply	Housing price, State and local road density, Agricultural percent, Unprotected forest percent	Temperate summer, Topography, Natural log of water area, Remoteness, Commute, P_OA1 percent, P_OA2 percent, P_Restrict percent, Seasonal, Nonwage income, Retiree concentration, Interstate density	62*, 12*, 14*, 18*	4.78
State and local road density	Built space percent	Temperate summer, Topography, Natural log of water area, Remoteness, Commute, P_OA1 percent, P_OA2 percent, P_Restrict percent, Seasonal, Nonwage income, Retiree concentration	13*	5.98

TABLE 2. *CONTINUED*

Equation	Instrumented variables	Excluded exogenous instrumental variables	F-statistics on the instrumented variables[a]	χ^2-statistics for the test of over-identifying restrictions[b]
Built space area demand	Housing price, Human capital	Interstate density, Commute of adjacent counties, Remoteness of adjacent counties, Topography of adjacent counties	16*, 12*	4.20
Agricultural percent	State and local road density, Unprotected forest percent, Built space percent	Remoteness, Commute, Seasonal, Nonwage income, Retiree concentration, Interstate density	12*, 18*, 10	5.11
Unprotected Forest percent	State and local road density, Agricultural percent, Built space percent	Remoteness, Commute, Seasonal, Nonwage income, Retiree concentration, Interstate density	12*, 14*, 10	5.32

[a]A F-statistic with an asterisk rejects the null hypothesis that the joint effect of the instruments is zero at a 1 percent significance level (Stock and Watson 2007). The F-statistics for an instrumented variables correspond to the order of the instrumented variables in the second column.
[b]The null hypothesis of the χ^2-statistic is that all instruments are uncorrelated with the error. An asterisk indicates the χ^2-statistic is significant at the 1 percent level.

ensure our estimates are robust to the choice of weighting matrix, we examined three different k-nearest-neighbors weighting matrices for the estimation. We find estimation results do not differ notably across the nearest-neighbor weighting matrices, and the four nearest-neighbors is chosen because this has the best fit. The simultaneous equation system using a spatial lag structure, $\mathbf{y}=\rho\mathbf{W}\mathbf{y}+\mathbf{X}\boldsymbol{\beta}+\boldsymbol{\varepsilon}$, is estimated following Kelejian and Prucha (2004), where ρ is the spatial lag coefficient.

Results

We estimate three specifications of the empirical model that differ based on whether protected land or natural amenities are separated by type or aggregated as indices. Examining protected areas and natural amenities by type provides information about whether particular characteristics of the protected areas and natural amenities explain the spatial variation in economic development. The base model uses three types of natural amenities (temperate summer, topography, water area) and three types of protected areas (open access without extractive use, open access with extractive use, and restricted access). Model 2 replaces the three types of protected area with all protected areas. The third model replaces the three types of natural amenities with the index for all six natural amenities included in McGranahan (1999). The parameter estimates from all three models are generally consistent (Tables 3–5). Most coefficients are statistically significant at the 10 percent level, and the coefficient signs are consistent with theory.

The structural form of the empirical model allows an examination of how the demand and supply sides of the labor and built space markets respond to the exogenous variables for protected areas and natural amenities when controlling for the endogenous variables such as human capital, state and local road density, and land uses. A reduced-form model can identify the net effect of the exogenous variables, which directly and indirectly influence demand and supply through the endogenous variables in the structural model, on the market outcomes. The reduced-form coefficient estimates determine the relative contribution of the exogenous variables to spatial differences in economic development.

Results of the structural form of the empirical model. The estimated coefficients on the protected land variables are negative in the labor supply equation and positive in the human capital equation in the base model and model 2 (Table 3). The protected land increases the share of the population with a college education, but the supply of labor without a college education falls. Quality of life attracts the educated, but this does not increase employment seekers in low-skill industries. The coefficients on the protected land variables are unexpectedly negative in model 3 of the human capital equation, and this suggests natural amenity variables by type are needed for correct specification of the human capital equation. The built space demand equation (Table 4) has negative coefficients on the protected land variables. Protected land percent may still increase the demand for built space, but this occurs indirectly through a rise in human capital rather than as a direct shift of the demand curve.

The natural amenities do not attract labor without a college education according to the insignificant coefficients on the natural amenity types in the base model and the index in model 2 (Table 3). Similar to protected areas, the natural amenities in rural areas do not provide a draw for low-skill workers. However, in the human capital supply equation, the natural amenities are positive and significant for all the models. The variable for topography is an especially strong attractor for the educated population holding the endogenous built space percentage constant. There is a significant and negative coefficient on topography in the build space demand equation which may be due to a low

TABLE 3. PARAMETER ESTIMATES OF THE STRUCTURAL MODEL (LABOR MARKET).

	Base model		Aggregate protected land (Model 2)		Aggregate natural amenities (Model 3)	
	Coefficient	*t* Value	Coefficient	*t* Value	Coefficient	*t* Value
Labor supply (Employment/Total unprotected area)						
Intercept	−174.71*	−3.12	−76.16	−1.33	−118.30*	−2.21
Wage	0.000651*	4.14	0.000536*	3.55	0.000759*	4.82
Natural amenities	–	–	–	–	0.419	0.44
Temperate summer	1.02	1.17	0.941	1.09	–	–
Topography	0.275	0.35	0.306	0.39	–	–
Natural log of water area	0.555	0.70	0.678	0.85	–	–
Protected land percent	–	–	−0.129*	−5.85	–	–
P_OA1 percent	−0.119*	−2.95	–	–	−0.111*	−2.72
P_OA2 percent	−0.147*	−5.45	–	–	−0.147*	−5.43
P_Restrict percent	−0.112*	−2.73	–	–	−0.110*	−2.65
Built space percent	15.39*	6.49	15.85*	6.41	16.49*	9.9
Nonwage income	−0.0012*	−6.43	−0.0013*	−6.53	−0.0013*	−6.59
Housing price	0.000249*	7.22	0.000269*	10.04	7.29E-05*	1.93
Spatial lag coefficient (All models)			0.452*	20.21		
Human capital supply (Percent of population with a bachelor's degree)						
Intercept	−3.01	−0.86	−3.36909	−0.98	−1.78	−0.52
Wage	0.00019*	3.89	0.00019*	3.86	0.00019*	3.83
Natural amenities	–	–	–	–	3.04*	4.88
Temperate summer	1.38*	1.98	1.43*	2.09	–	–
Topography	2.91*	2.07	2.68*	1.96	–	–
Natural log of water area	1.26*	3.21	1.28*	3.27	–	–
Protected land percent	–	–	0.049*	2.22	–	–
P_OA1 percent	0.085*	2.46	–	–	−0.161*	−4.76
P_OA2 percent	0.049*	2.20	–	–	−0.113*	−4.83
P_Restrict percent	0.043	1.45	–	–	−0.149*	−4.58
Built space percent	−0.759*	−2.83	−0.616*	−3.09	−0.522*	1.81
Spatial lag coefficient (All models)			0.750*	10.12		
Labor demand (Employment/Total unprotected area)						
Intercept	275.43*	7.00	419.92*	8.80	257.33*	5.38
Wage	−0.00031*	1.75	−0.00034*	−1.89	−0.00033*	−1.91
Human capital	2.03*	2.07	6.60*	4.73	4.10*	3.74
State and local road density	−13.04*	−13.67	−18.60*	−12.92	−11.40*	−9.61
Remoteness	0.322	0.67	0.287	0.58	1.10	0.237
Commute	−0.055	−0.34	−0.043	−0.24	−0.012	−0.06

TABLE 3. *CONTINUED*

	Base model		Aggregate protected land (Model 2)		Aggregate natural amenities (Model 3)	
	Coefficient	*t* Value	Coefficient	*t* Value	Coefficient	*t* Value
Agriculture percent	−2.21*	−7.25	−3.54*	−9.81	−1.81*	−5.07
Unprotected forest percent	−2.10*	−2.60	−2.68	−3.02	−3.77	−2.86
Built space percent	15.61*	16.17	−3.55*	−9.87	−2.25*	−6.02
Spatial lag coefficient (All models)			0.558*	13.56		

Note: An asterisk (*) indicates statistical significance at the 10 percent level.

demand for commercial built space because of the rugged terrain. The temperate summer and water area amenities do not have significant coefficients in the demand for built space equation in the base model and model 2, but the index for natural amenities is positive and significant in model 3. The demand for built space responds positively to a suite of natural amenities but not strongly to any one amenity if the endogenous human capital variable is held constant.

Other variables that influence the built space demand equation are the percentage of housing for seasonal use, percentage of workers that commute outside county, non-wage income, and the retiree concentration. The negative coefficient on the percentage of seasonal housing in all models suggests that communities with resorts have few other industries with the demand for built space. The positive coefficient on the percentage of workers who commute outside the county means that commuting increases incomes for workers and increases built space demand. Non-wage income has a positive coefficient, and this suggests some of the income is used for spending on residential and commercial space. The concentration of retirees has a negative coefficient which suggests built space demand is negatively associated with retirement communities.

Results of the reduced form of the empirical model. We use the reduced form of the empirical model to examine how the type of protected land and natural amenity influences the labor and built space markets, human capital, and the road and land use densities (Table 6). This is useful to policy makers that want to know if the expansion or promotion of a particular type of natural capital will, on net, change a feature of economic development rather than how the natural capital affects the individual supply or demand of markets holding other endogenous variables constant.

The coefficient estimates on protected areas in the reduced-form model indicate that none of the protected land area types are associated with employment density, but one or more of the protected area types affect each of the other indicators of economic development. The protected areas with open access and no extractive use are associated with a greater percentage of built space and agriculture. Residents of counties with densely built land and agriculture have more access to protected areas without extractive use, but there is no observed relationship with the wage or the housing price. The counties with open access protected areas and extractive use have lower wages but higher housing prices and road densities. An additional percentage of open access protected land raises the predicted housing price by $170. This pattern for the wage and house prices suggests these counties fit into the bottom right quadrant of Figure 1 where there is a lot of natural capital but a limited amount

TABLE 4. PARAMETER ESTIMATES OF THE STRUCTURAL MODEL (BUILT SPACE PERCENT MARKET).

	Base model		Aggregate protected land (Model 2)		Aggregate natural amenities (Model 3)	
	Coefficient	*t* Value	Coefficient	*t* Value	Coefficient	*t* Value
Built space area supply (Developed area/Total unprotected area)						
Intercept	−15.08*	−4.05	−20.67*	−6.74	−19.00*	−4.72
Housing price	4.02E-06	1.43	2.97E-6	1.35	1.84E-05*	6.64
State and local road density	1.01*	21.17	5.22E-06*	3.31	0.933*	20.04
Agriculture percent	0.123*	4.55	0.944*	22.48	0.140*	5.45
Unprotected forest percent	0.126*	4.76	0.181*	9.44	0.161*	5.24
Spatial lag coefficient (All models)			0.0005*	7.23		
State/Local road density (Road Miles/Total unprotected area)						
Intercept	1.69	1.18	1.633	1.13	1.62	1.11
Interstate density	2.79*	4.91	2.82*	6.55	2.96*	4.80
Built space percent	0.724*	22.12	0.731*	36.63	0.732*	20.03
Spatial lag coefficient (All models)			0.974*	9.37		
Built space area demand (Developed area/Total unprotected area)						
Intercept	−50.61	−1.18	−58.61*	−2.17	73.24	0.37
Housing price	−0.00065*	−1.65	−0.00062*	−1.75	−0.00067*	−1.69
Natural amenities	–	–	–	–	14.12*	1.78
Temperate summer	−0.279	−0.38	−0.794	−0.99	–	–
Topography	−16.49*	−2.59	−6.55*	−2.52	–	–
Natural log of water area	0.234	0.15	1.081	1.15	–	–
Protected land percent	–	–	−0.190	−1.41	–	–
P_OA1 percent	−0.852*	−1.97	–	–	−1.92*	−2.30
P_OA2 percent	−0.733*	−1.96	–	–	−1.51*	−2.27
P_Restrict percent	−0.175	−1.06	–	–	−1.12*	−2.08
Seasonal	−1.92*	−2.18	−0.772*	−2.08	−1.72*	−1.98
Human capital	6.64*	1.76	7.37*	1.84	9.12*	2.31
Nonwage income	0.0031*	1.81	0.0011	1.50	0.0044*	2.03
Remoteness	0.124	0.77	0.092	0.92	0.222	0.58
Commute	1.32*	1.93	0.580*	1.65	3.055*	2.78
Retiree concentration	−5.54*	−2.03	−2.03*	−1.81	−10.99*	−2.33
Spatial lag coefficient (All models)			0.0006*	12.16		

Note: An asterisk (*) indicates statistical significance at the 10 percent level.

TABLE 5. PARAMETER ESTIMATES OF THE STRUCTURAL MODEL (AGRICULTURAL AND FOREST PERCENT).

	Base model		Aggregate protected land (Model 2)		Aggregate natural amenities (Model 3)	
	Coefficient	*t* Value	Coefficient	*t* Value	Coefficient	*t* Value
Agricultural percent (Agricultural area/Total unprotected area)						
Intercept	127.76*	10.94	128.10*	10.25	111.16*	9.49
Natural amenities	–	–	–	–	−1.99*	−3.74
Temperate summer	0.464	0.46	0.991	1.51	–	–
Topography	1.86	0.93	1.39	1.12	–	–
Natural log of water area	1.49*	3.48	1.61*	3.49	–	–
Protected land percent	–	–	0.094*	3.91	–	–
P_OA1 percent	0.077*	4.04	–	–	0.067*	4.09
P_OA2 percent	0.007*	2.86	–	–	0.005*	2.11
P_Restrict percent	0.084*	4.94	–	–	0.091*	5.71
State and local road density	−1.21*	−2.30	−3.44*	−9.84	−0.823*	−1.90
Unprotected forest percent	−1.22*	−8.89	−1.14*	−8.72	−0.951*	−8.74
Built space percent	1.660*	3.28	3.69*	12.32	1.352*	3.24
Spatial lag coefficient (All models)			0.553*	8.93		
Unprotected forest percent (Unprotected forest area/Total unprotected area)						
Intercept	102.67*	17.1	106.72*	14.68	113.87*	19.22
Natural amenities	–	–	–	–	−2.53*	−4.05
Temperate summer	0.523	0.70	1.22	1.49	–	–
Topography	2.63*	2.43	2.23	1.52	–	–
Natural log of water area	1.70*	4.27	1.56*	3.78	–	–
Protected land percent	–	–	0.087*	7.65	–	–
P_OA1 percent	0.074*	5.15	–	–	0.092*	5.70
P_OA2 percent	0.007*	2.84	–	–	0.007*	2.46
P_Restrict percent	0.079*	5.28	–	–	0.111*	5.73
State and local road density	0.138	0.26	−1.33*	−2.17	0.425	0.81
Agriculture percent	−0.799*	−7.63	−0.774*	−5.34	−0.975*	−5.64
Built space percent	0.319	0.58	1.60*	2.39	0.173	0.31
Spatial lag coefficient (All models)			0.653*	15.83		

Note: An asterisk (*) indicates statistical significance at the 10 percent level.

of physical and human capital. The restricted access protected areas are associated with lower wages and higher densities of built space, state/local roads, and agriculture. A rise in restricted access protected areas by 1 percent lowers wage income by $33. These places could fit into either of the bottom two quadrants of Figure 1. If restricted access protected areas represent valuable natural capital, then, similar to the places with open access land and extractive uses, the bottom right quadrant will be correct for those counties.

Table 6. Parameter Estimates of the Reduced-Form Equations.

Independent variables	Wage		Employment density		Housing price		Built space percent	
	Coeff.	*t* Value	Coeff.	*t* Value	Coeff.	*t* Value	Coeff.	*t* Value
Intercept	29490*	27.34	17.80	1.15	73381*	8.86	1.42	0.54
Temperate summer	704.4*	4.24	6.27*	1.80	9212*	7.52	1.10*	1.78
Topography	264.7*	1.80	1.00	1.26	4129*	5.89	−0.648*	−1.74
Natural log of water area	927.5*	5.20	7.38*	3.34	6117*	5.80	1.49*	3.07
Seasonal	−6.43	−0.43	−0.275*	−2.18	471*	3.57	−0.072*	−2.15
P_OA1 percent	−11.92	−1.56	−0.001	−0.02	17.21	0.30	0.033*	1.73
P_OA2 percent	−10.21*	−2.02	−0.033	−0.48	170.7*	4.64	0.014	0.65
P_Restrict percent	−33.27*	−3.40	0.059	0.88	−5.48	−0.12	0.092*	3.20
Remoteness	−393.20*	−4.69	−0.317	−0.33	−310.2	−0.56	0.149	0.88
Commute	30.90*	2.39	−0.029	−0.25	48.24	0.66	0.0035	0.12
Nonwage income	−0.251*	−4.29	0.0003	0.42	4.10*	9.33	0.0001	0.72
Retiree concentration	−95.66*	−1.89	−0.248	−0.67	−4075.7*	−5.96	0.121	1.25
Interstate density	−360.1	−0.53	36.85*	1.96	4609.31	1.06	13.24*	1.95
	Human capital		State/Local Road density		Agricultural percent		Unprotected forest percent	
Intercept	14.19*	8.32	−0.513	−0.2	28.4*	8.04	47.50*	15.62
Temperate summer	1.20*	4.41	1.01*	1.72	−2.26*	−2.97	0.490	0.96
Topography	0.405*	1.85	−0.379	−1.37	−8.01*	−12.89	8.45*	17.17
Natural log of water area	0.718*	2.40	0.890*	2.05	3.61*	4.99	−0.458	−0.69
Seasonal	0.119*	3.85	−0.006	−0.27	−0.153*	−2.38	0.122*	2.09
P_OA1 percent	0.003	0.31	0.006	0.46	0.139*	3.52	0.097*	3.63
P_OA2 percent	0.035*	3.79	0.029*	1.76	0.033	1.26	−0.068*	−3.43
P_Restrict percent	−0.0061	−0.53	0.047*	2.70	0.135*	3.13	−0.021	−0.77
Remoteness	−0.198*	−1.65	0.173	1.07	0.131	0.5	−0.068	−0.29
Commute	−0.027	1.42	0.003	0.11	0.053	0.93	−0.047	−1.07
Nonwage income	0.0003*	3.19	0.0001	1.06	0.0003*	1.71	−0.0002	−1.14
Retiree concentration	−0.407*	−3.53	0.031	0.51	0.019	0.11	0.578*	3.39
Interstate density	1.180	0.97	13.36*	3.38	6.73	1.50	−0.67	−0.32

Note: An asterisk (*) indicates statistical significance at the 10 percent level.

The coefficients on the natural amenity types indicate at least one type of amenity affects each of the economic development indicators. Places with temperate summers and large water areas have higher wages, housing prices, human capital, and densities of employment, built space, and roads. A rise in the index for temperate summer by one increases the predicted housing price by $9,212 and the wage income by $704. Rugged topography is associated with higher wages, housing prices, human capital, and unprotected forests but lower built space and agriculture. These findings suggest

TABLE 7. RELATIVE CONTRIBUTIONS OF ALTERNATIVE FACTORS TO SPATIAL VARIATION IN ECONOMIC DEVELOPMENT BETWEEN THE TOP AND BOTTOM 25 PERCENT OF FOREST COUNTIES.

	Wage		Housing price		Employment density		Built space percent	
	%	$	%	$	%	Jobs/sq mile	%	Share
Explained difference								
Temperate summer	17.40	275	24.72	11966	12.78	1.27	15.15	0.416
Topography	2.00	31.66	6.86	3319	1.97	0.195	−7.04	−0.193
Natural log water area	18.92	299	5.65	2735	34.52	3.434	21.71	0.597
Seasonal	0.40	6.33	8.29	4015	10.54	1.048	−4.05	−0.111
P_OA1 percent	0.06	1.02	0.08	36.31	−0.01	−0.001	6.66	0.183
P_OA2 percent	−1.66	−26	10.50	5083	−0.43	−0.042	4.21	0.115
P_Restrict percent	10.41	164	−0.04	−20.44	1.30	0.129	27.07	0.744
Remoteness	35.06	554	1.18	571	5.38	0.535	−1.72	−0.047
Commute	0.68	10.81	0.09	43.89	−0.44	−0.044	0.19	0.005
Nonwage income	9.45	149	32.91	15933	−0.25	−0.024	0.82	0.022
Retiree concentration	7.70	121	9.31	4506	2.35	0.233	3.19	0.087
Interstate density	−0.43	−6.79	0.46	221	32.28	3.211	34.01	0.935
Total	100	1581	100	48412	100	9.95	100	2.75
Total difference								
Explained	16	1581	69	48412	25	9.95	26	2.75
Unexplained	84	8353	31	21501	75	30.1	74	7.82
Total	100	9934	100	69913	100	40.1	100	10.57

	Human capital		State/Local Road density		Agricultural percent		Unprotected forest percent	
	%	Share	%	Miles/sq mile	%	Share	%	Share
Explained difference								
Temperate summer	25.36	1.129	26.09	1.05	12.52	2.05	2.06	0.287
Topography	3.83	0.170	−8.39	−0.337	74.39	12.20	88.96	12.40
Natural log water area	8.15	0.362	6.58	0.265	11.65	1.91	0.69	0.096
Seasonal	24.59	1.095	−1.43	−0.057	2.65	0.435	4.71	0.656
P_OA1 percent	0.33	0.014	1.21	0.048	1.83	0.299	4.30	0.598
P_OA2 percent	21.06	0.937	26.50	1.067	−4.91	−0.804	−5.70	−0.795
P_Restrict percent	−0.24	−0.011	12.67	0.510	2.00	0.328	−0.28	−0.039
Remoteness	2.96	0.132	−1.51	−0.060	−0.19	−0.031	−0.35	−0.049
Commute	1.36	0.061	−0.02	−0.001	0.84	0.137	0.58	−0.049
Nonwage income	14.78	0.658	5.29	0.213	−0.51	−0.084	−0.50	−0.069
Retiree concentration	−3.43	−0.152	0.44	0.017	0.01	0.002	5.56	0.775
Interstate density	1.26	0.056	32.57	1.31	−0.29	−0.047	−0.03	−0.004

Table 7. *Continued*

	Human capital		State/Local Road density		Agricultural percent		Unprotected forest percent	
	%	Share	%	Miles/sq mile	%	Share	%	Share
Total	100	4.45	100	4.02	100	16.40	100	13.94
Total difference								
Explained	29	4.45	51	4.02	35	16.40	33	13.94
Unexplained	71	11.16	49	4.04	65	30.71	67	28.40
Total	100	15.61	100	8.06	100	47.11	100	42.34

counties with plentiful natural amenities are suited to the top right quadrant of Figure 1. As accumulated capital like human capital and road densities increase in the counties with strong amenities, the counties go from the bottom to the top right quadrant. A large percent of seasonal housing is associated with counties that have lower densities of employment, built space, and agriculture but higher housing prices and human capital. These counties also go with the top right quadrant.

Remote counties have lower wages and human capital, and counties with more non-wage income have lower wages but higher housing prices, human capital, and agriculture. A large concentration of retirees is associated with counties that have lower wages, housing prices, and human capital. The counties with more interstate highways have denser employment, built space, local roads.

Relative contributions of the independent variables. A useful application of the reduced-form estimates is the determination of the relative contribution of an exogenous variable (e.g., protected land percent) to an economic development indicator (e.g., housing price). This relative contribution identifies how much the variable explains the difference between the economic development indicator, such as the housing price, at the top 25 percent of high price counties and the bottom 25 percent of low price counties. Equations (A6–A8) in the Appendix indicate the steps taken to calculate the relative contribution of the exogenous variables to the explained spatial differences in housing price.

The contribution of the exogenous variables is calculated for the wage, employment density, built space percent, human capital, local road density, agricultural percent, and unprotected forest percent, and these are shown in Table 7. The exogenous variables successfully explain more than 50 percent of difference in housing prices and local road density, respectively, between the top and bottom 25 percent of counties. However, the exogenous variables explain less than 30 percent of the differences in wage, employment density, built space percent, and human capital.

Most of the explained difference in wage between top-wage and bottom-wage counties is attributable to remoteness. The temperate summers, water area, and protected areas with restricted access also have a role in explaining the predicted difference in wage. The predicted difference in housing price is principally explained by non-wage income from profit and investment returns. Temperate summers and open access protected areas with extractive use also contribute to the predicted difference in housing prices.

Water area, interstate highway density, and temperate summers are the largest contributors to spatial differences in the density of employment. The predicted difference in built space percentage is explained largely by interstate highway density, protected areas with restricted access, and water area. The prominent role of the interstate highway system in contributing toward denser employment and built space is evident, but the amount of water area which is valuable both as an amenity and for navigable commerce has a major role. Predicted spatial differences in human capital across counties are explained by temperate summers, seasonal housing, open access protected areas, and non-wage income. Here the quality of life factor associated with protected areas and natural amenities explains most of the variation in human capital.

The interstate highway system, protected areas, and temperate summers are the primary contributors to the predicted difference in the density of local roads. The interstate highways are the primary explanatory factor, but natural capital related to the climate and protected open space also has a major role in the size of the local infrastructure. The key explanatory factor in the predicted spatial differences in the densities of agriculture and unprotected forest is topography.

Conclusions

We examine how different types of protected land (e.g., open access with and without extractive use, restricted access) and natural amenities (e.g., climate, topography, and water) influence spatial variation in rural forest economic development. The types of natural capital are examined in a structural model of the labor market (i.e., wage, human capital, and employment density), built space market (i.e., housing price, local infrastructure, and built space percent), and the land market (i.e., agricultural and unprotected forest percent). Remoteness, interstate highway density, water area, and temperate summers explain most of the spatial differences in the labor market. Human capital as a component of the labor market has spatial variation determined by the percentage of seasonal housing and open access protected areas. Spatial differences in the built space market are explained mostly by non-wage income, temperate summers, interstate highway density, and protected areas. These finding suggest that, while not always the primary determinant of economic outcomes, at least one type of natural capital has a major secondary role in explaining the variation in economic development.

Based on the results of the reduced-form model, counties with protected areas appear to have lower wages and may have higher housing prices (bottom right quadrant in Figure 1). The influence of protected areas on wage does not differ by type of protected area, but open access protected areas increase housing price while restricted access areas have no influence on housing price. The results suggest that protection of land attracts educated laborers who accept a lower wage because the natural capital acts as compensation. The accumulation of human capital may eventually move the counties with protected areas to the top quadrants of Figure 1, but our model cannot say how long this might take. Restricted access areas, where the primary benefit is open space rather than recreation, explain spatial differences in wage more strongly than the other protected area types. However, open access protected areas better explain spatial differences in housing price than restricted access sites. Additional research might reveal why open space versus recreation benefits have different effects on wages and housing prices.

Temperate summers, topography, and water area (namely all the natural amenities) raise wages and housing prices, indicating that counties with a lot of natural amenities tend to be in the top right quadrant of Figure 1. The water area and temperate summer amenity types are stronger explanatory factors of spatial differences in wage than topography, and the temperate summers variable most strongly explains spatial differences in housing price. Temperate summers are the amenity type that best explains if a county has a high wage and housing price, and the water area is the best determinant of high wages. Counties with attractive natural amenities more so than protected areas appear to accumulate greater human and physical capital. However, the results do indicate that both natural amenities and protected areas are associated with counties that have stronger economies than counties with natural amenities alone, and policy makers should view protected areas as an important part of their portfolio of natural capital in a county.

Remoteness is important for explaining differences in wage but not for the other measures of economic development. This is likely because rural counties depend less on agglomeration than urban counties. Non-wage income strongly explains the predicted differences in housing price and human capital. This could mean policies to attract investors such as reducing business regulation and encouraging start-ups are important for increasing property values and attracting educated workers. The strong contribution of the interstate highways to employment, built space, and roads suggests that federal infrastructure effectively enlarges the markets for products and labor and thereby attracts new firms and households.

Protected land and natural amenities are found to be a relevant explanation for the spatial variation of economic development, similar to other studies (e.g., Deller, Lledo, and Marcouiller 2008). A major limitation of the model is the inability to examine how economic development changes in response to increases in protected area or the education of the labor force over time. Counties transition to different quadrants in Figure 1 as the relative levels of capital across counties change, but the speed at which this occurs cannot be determined from this model. Also, a more detailed look at the types of extractive and recreational uses that occurs in these protected area would provide greater insight into how policy can enhance the multiple uses of forests and simultaneously help economic development. The National Outdoor Recreation Supply Information System (Betz 1997) and the Johnson and Beale's (2002) recreation index are potential sources for these explanatory variables. Poudyal, Hodges, and Cordell (2008) found that counties with man-modified recreational attractions, substantial land use diversity, and water amenities have the greatest potential for attracting retirees. Another valuable extension would be to look closer at how different types of non-labor income affect spatial variation in economic development where there are protected areas (Lawson, Rasker, and Gude 2014). The presence of spatial autocorrelation indicates that whatever policy is pursued to improve the economic development of the rural forests that this will have spillover effects on the surrounding counties.

NOTES

1. The county is a political unit where many economic development policies develop. The 2010 Census would have been preferred, but the 2011 National Land Cover Database (NLCD) was not released until 2015 after this study began. The steady state spatial equilibrium changes slowly over time suggesting the findings remain relevant for policies today.
2. The Pacific and Mountain states are Arizona, California, Colorado, Idaho, Montana, Oregon, Utah, and Washington. The Heartland and Midwest states are Illinois, Indiana, Michigan, Minnesota, Ohio, and West Virginia. The states north of the Mason-Dixon are Maine, New Hampshire, New York, Pennsylvania, and Vermont.

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Appendix

The description of equilibrium in theoretical model and the associated labor and built space demand and supply equations (equations A1–A5) is shown below. The steps to find the relative contributions of the exogenous variables to housing price disparities are shown in equations A6–A8. Table A.1 and A.2 show the parameter estimates for the regional controls of the structural models estimated in the paper.

Equilibrium. The downward sloping lines represent w and p combinations that equalize the cost for a given level of κ. Suppose $\kappa' > \kappa$, the wages and built space prices must be higher where the accumulated capital is greater to equalize cost in both locations. These equilibria are marked C and D in Figure A1. Otherwise, firms would have the incentive to move to the κ' location. Likewise, the upward sloping lines represent w and p combinations with equal utility for a given level of s. For $s' > s$, equal utility at the two locations means the s' location either has higher housing prices and lower wages for households to be indifferent between the places (equilibria A and C).

Based on Roy's identity, the indirect utility (2) can be used to produce the Marshallian demand for housing and the supply equation for labor. Likewise, based on Shepard's lemma, the iso-cost function (4) can produce the factor demands (i.e., the labor demand and urban space demand). Thus, an equivalent way to examine the spatial equilibrium in wages and urban space prices is from the supply and demand functions for the urban space and labor markets. The problems shown in (1), (3), and (5) can be solved to yield the supply and demand functions for the markets. The solution of (1) yields the housing demand and labor supply functions:

$$h^d = h(w, p; s, I) \tag{A1}$$

$$l^s = l(w, p; s, I). \tag{A2}$$

The shifters of housing demand and labor supply (equations A1 and A2) are the level of natural amenities and non-wage income. Likewise, the solution of (A3 and A4) produces the demand functions of built space and labor, and the solution of (A5) yields the supply function for the built space.

$$m^d = m(w, p; \kappa, y) \tag{A3}$$

$$l^d = l(w, p; \kappa, y), \text{ and} \tag{A4}$$

$$d^s = d(w, p; \kappa). \tag{A5}$$

Shifts in built space and labor demand (equations A3 and A4) depend on accumulated capital and the optimal level of production, and shifts in the supply of built space (equation A5) depend on accumulated capital.

Steps to find the relative contributions of the exogenous variables to housing price disparities. Suppose the predicted housing price for group m is:

$$\bar{\hat{p}}^m = \frac{1}{N}\sum_{i\in G^m} \hat{p}_i = \frac{1}{N}\sum_{i\in G^m}\left(\phi_0 + \sum_{s=1}^{s'} \phi_1^s s_{si} + \sum_{k=1}^{k'} \phi_2^k \kappa_{ki}\right) = \phi_0 + \sum_{s=1}^{s'} \phi_1^s \bar{s}_{\text{s}}^m + \sum_{k=1}^{k'} \phi_2^k \bar{\kappa}_{\text{k}}^m \tag{A6}$$

where $m = T, B$ indicates the top and bottom 25% of counties (sorted by the housing price), G^m is the set of county indices for group m, N is the total number of counties in the top or bottom 25 percent group, $(s_{1i}, s_{2i}, \ldots, s_{s'i})$ is a vector of exogenous natural capital, $(\kappa_{1i}, \kappa_{2i}, \ldots, \kappa_{k'i})$ is a vector of

Table A1. Parameter Estimates of the Regional Controls of the Structural Model.

	Combined natural amenities (Model 1)		Disaggregate natural amenities (Model 2)		Agriculture and forest percent not endogenous	
	Parameter	*t* Value	Parameter	*t* Value	Parameter	*t* Value
Labor supply (Employment/Total unprotected area)						
Western	14.26	1.12	−9.37	−0.45	30.11	3.68
Midwestern	−16.45	−2.95	−26.37	−4.43	−15.84	−4.98
Northeast	−0.92	−0.2	−12.61	−1.91	0.99	0.29
Distance from ocean	−0.017	−1.22	−0.04	−2.75	−9.71e-3	−1.5
Distance from Great Lakes	−0.046	−2.15	−0.09	−4.46	−0.03	−4.01
Eco-zone	−0.42	−1.87	−0.82	−3.58	−0.25	−1.94
Human capital supply (Percent of population with a bachelor's degree)						
Western	34.66	6.52	5.69	1.03	7.17	2.72
Midwestern	12.31	5.65	0.94	0.53	2.55	2.45
Northeast	15.51	7.95	4.77	2.54	5.37	4.77
Distance from ocean	0.04	8.99	0.01	1.2	518e-3	2.46
Distance from Great Lakes	0.06	8.96	3.81e-3	0.6	1.95e-3	0.71
Eco-zone	0.68	8.32	0.12	1.84	0.09	2.38
Labor demand (Employment/Total unprotected area)						
Western	−331.20	−5.02	−100.34	−3.2	−21.25	−1.06
Midwestern	−152.37	−5.52	−43.08	−3.5	−32.83	−4
Northeast	−191.95	−5.56	−78.85	−4.25	−39.77	−3.31
Distance from ocean	−0.46	−6.87	−0.11	−4.33	−0.05	−2.88
Distance from Great Lakes	−0.66	−6.62	−0.15	−3.75	−0.05	−2.31
Eco-zone	−7.49	−6.87	−2.15	−4.57	−0.96	−2.96
Agricultural percent (Agricultural area/Total unprotected area)						
Western	−14.32	−2.78	−23.64	−3.47	–	–
Midwestern	−7.06	−3.75	−8.12	−3.93	–	–
Northeast	−7.25	−3.84	−9.69	−4.76	–	–
Distance from ocean	−0.02	−6.82	−0.02	−5.6	–	–
Distance from Great Lakes	−0.04	−9.37	−0.04	−7.81	–	–
Eco-zone	−0.37	−5.12	−0.33	−4.38	–	–
Forest percent (Forest area/Total unprotected area)						
Western	−13.96	−2.67	−21.80	−4.02	–	–
Midwestern	−5.76	−3.21	−5.65	−3.56	–	–
Northeast	−5.86	−3.45	−7.18	−4.69	–	–
Distance from ocean	−0.02	−6.8	−0.02	−5.77	–	–
Distance from Great Lakes	−0.04	−9	−0.02	−7.64	–	–
Eco-zone	−0.33	−5.19	−0.26	−4.63	–	–

Note: An asterisk (*) indicates statistical significance at least at the 10 percent level.

TABLE A2. PARAMETER ESTIMATES OF THE REGIONAL CONTROLS OF THE STRUCTURAL MODEL.

	Combined natural amenities (Model 1)		Disaggregate natural amenities (Model 2)		Agriculture and forest percent not endogenous	
	Parameter	*t* value	Parameter	*t* value	Parameter	*t* value
Developed area supply (Developed area/Total unprotected area)						
Western	−8.00	−7.55	−7.69	−7.66	−8.84	−10.17
Midwestern	2.99	4.86	2.75	4.97	2.71	5.4
Northeast	2.00	2.93	2.02	2.99	1.99	3.14
Distance from ocean	2.88e-3	2.02	2.69e-3	2.03	1.80e-3	1.48
Distance from Great Lakes	9.71e-3	5.51	8.15e-3	5.32	5.95e-3	4.75
Eco-zone	0.01	0.48	6.90e-3	0.25	−0.02	−0.66
State/Local road density (Road miles/Total unprotected area)						
Western	6.77	10.43	6.82	10.64	6.92	10.91
Midwestern	−2.06	−5.14	−2.05	−5.2	−2.12	−5.5
Northeast	−1.72	−3.48	−1.70	−3.5	−1.68	−3.46
Distance from ocean	−1.83e-3	−1.94	−1.83e-3	−1.97	−1.70e-3	−1.86
Distance from Great Lakes	−4.35e-3	−4.57	−4.36e-3	−4.63	−4.41e-3	−4.72
Eco-zone	9.54e-3	0.49	9.79e-3	0.51	0.01	0.59
Developed area demand (Developed area/Total unprotected area)						
Western	−79.24	−4.82	−76.70	−3.04	−11.03	−6.23
Midwestern	4.89	2.2	21.56	2.26	2.37	3.98
Northeast	−36.94	−2.62	−70.33	−1.98	0.94	0.41
Distance from ocean	8.19e-4	−0.7	3.32e-4	1.5	6.08e-4	0.3
Distance from Great Lakes	2.78e-3	2.5	9.32e-3	4.2	5.88e-3	3.8
Eco-zone	−0.73	−4.06	−0.66	−2.43	−0.04	−1.05

Note: An asterisk (*) indicates statistical significance at least at the 10 percent level.

exogenous accumulated capital variables, and the ϕ's are the coefficients of the reduced-form equation of housing price.

The difference of the housing price for the top and bottom groups is:

$$\hat{\bar{p}}^{T}-\hat{\bar{p}}^{B}=\sum_{s=1}^{s'}\phi_1^s\left(\bar{s}_s^T-\bar{s}_s^B\right)+\sum_{k=1}^{k'}\phi_2^k\left(\bar{\kappa}_k^T-\bar{\kappa}_k^B\right) \tag{A7}$$

where $\bar{s}_s{}^m$ and $\bar{\kappa}_k^m$ are the average of the corresponding variables for group m. Dividing equation (A7) by $\hat{\bar{p}}^{T}-\hat{\bar{p}}^{B}$, the formula showing the relative contribution of the rural forest endowments is:

$$1=\sum_{s=1}^{s'}\phi_1^s\left(\frac{\bar{s}_s^T-\bar{s}_s^B}{\hat{\bar{p}}^{T}-\hat{\bar{p}}^{B}}\right)+\sum_{k=1}^{k'}\phi_2^k\left(\frac{\bar{\kappa}_k^T-\bar{\kappa}_k^B}{\hat{\bar{p}}^{T}-\hat{\bar{p}}^{B}}\right). \tag{A8}$$

The terms on the right-hand side of equation (A8) indicate the share of the explained difference in the housing price between the two groups of counties attributable to the exogenous variables of rural forests.

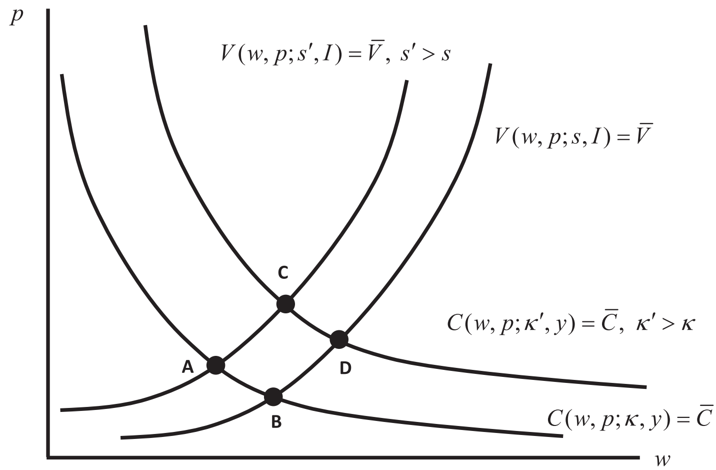

FIGURE A1. THE EQUILIBRIUM LEVEL OF WAGE AND BUILT SPACE PRICE FOR FOUR LOCATIONS THAT HAVE DIFFERENT LEVELS OF ACCUMULATED CAPITAL AND AMENITIES.