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The Effects of Environmental Amenities on Agricultural Land Values

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ABSTRACT. *Ascribing agricultural land values solely to productive capacity does not accurately capture the impact of environmental amenities on western land prices. We analyze rural land prices in Wyoming using a hedonic price model. Geographic information systems data includes on-parcel wildlife and fish habitat, scenic view attributes, and distance to protected federal lands. Feasible generalized least squares is used to address spatial autocorrelation and heteroskedasticity. Results indicate that environmental amenities contribute to land values. Examination of the marginal effects of amenities on parcel price furthers these conclusions. Environmental amenities contributions to land prices may guide resource allocation decisions across diverse demands.* (JEL Q24)

I. INTRODUCTION

Rural agricultural lands provide many public goods (e.g., biodiversity, climate regulation, rural culture, and open space), as well as qualities that impact agricultural production. These lands are therefore demanded by diverse interests including agricultural production, conservation or preservation, and residential development. There is an increased need to understand what factors impact agricultural land values in rural land markets. This is especially true for rural land markets in the Intermountain West, where amenity-driven vacation- and trophy-home development is increasingly competing with agriculture for land. A better understanding of the factors impacting land values should improve resource allocation as it relates to land acquisition or protection. The objective of this article is to evaluate the impact of environmental amenities, notably scenic views, and productive characteristics on agricultural land values. We use a hedonic price model (HPM) estimated with parcel-level data to capture the influence of scenic views, recreational opportunities, wildlife habitat, and productive capacity on exurban agricultural land prices.

Background

The literature on the determinants of agricultural land values generally uses the HPM to relate property values or land sale prices to specific land attributes. This literature largely concentrates on agricultural land surrounding rapidly developing urban centers (Geoghegan, Wainger, and Bockstael 1997; Cavailhès and Wavresky 2003; Isgin and Forster 2006). Consistent with competitive land market theory (see Capozza and Helsley 1989), this HPM literature indicates that agricultural (e.g., crop prices and yields), development (e.g., house characteristics and proximity to urban centers), and amenity (e.g., open space) characteristics are capitalized into observed agricultural land prices. Agricultural parcels closer to urban centers or with valued amenities will command higher prices due to higher development pressure.

Studies of agricultural land price determinants applied at the urban fringe are unlikely to capture agricultural land price determinants accurately in more rural settings. The Intermountain West provides an excellent example of the potential issues. Given the few large metropolitan areas (e.g., Denver, CO, and Salt Lake City, UT), the residential development

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consuming agricultural land in the Intermountain West bears little resemblance to analyses of the suburban sprawl that is prevalent in the literature. The Western public lands, scenic views, wildlife, rapid in-migration, and demand for recreation all define a unique set of land values and conversion risks.

Development in these highly rural land markets is often characterized by demands for large-lot trophy, vacation, or retirement properties in addition to factors of agricultural production (Gosnell, Haggerty, and Travis 2006). Many of the typical determinants of agricultural land prices on the urban fringe (e.g., access to employment, health care, and education) are likely to be less important than environmental amenities (e.g., access to recreation and scenic views). Parcel-level attributes that uniquely comprise recreational and visual values are essential to understanding ex-urban development threats to amenity-rich rural agricultural lands.

Individual parcel data that has defined amenity types and levels provides opportunities to determine attribute impacts on property values. HPMs that do not accurately capture the relevant amenities both overestimate the contribution of agricultural characteristics to land prices and underestimate potential development pressure. Plantinga, Lubowski, and Stavins (2002), for example, use aggregate data for the contiguous United States to estimate the county-level share of agricultural land values attributable to development potential. Their results, which are similar to estimates provided by Livanis et al. (2006), imply that development option value accounts for 5% or less of agricultural land values for most counties in the Intermountain West. Aggregate data, however, may mute the potential impact of amenities desirable to in-migrants. Amenity characteristics need to be more precisely measured to disentangle the influence of agricultural productivity from scenic and environmental amenities in amenity-rich rural land markets (Bergstrom and Ready 2009).

The contribution of this research is to provide a more accurate depiction of amenity values and their potential contribution to agricultural lands prices in rural amenity-driven land markets. This is accomplished by estimating a HPM using parcel-specific data on agricultural and amenity attributes. A unique data set of arm's-length sales and geographic information systems (GIS) data permits focusing on attributes believed to influence amenity-rich land markets. These characteristics include proxies for access to, and quality of, environmental attributes, and specific measures of view attributes available on each parcel. Omission, or improper measurement, of amenity values could create allocation inefficiencies in rural land markets.

Literature Review

Previous research has analyzed specific amenity values (see Bergstrom and Ready 2009). Many of these studies focus on the spillover effects of amenities to neighboring residential properties (for a review see McConnell and Walls 2005) as opposed to the onsite contribution of amenities to land values. Others focus to varying degrees on the contributions of specific amenities including wildlife habitat/recreation (Bastian et al. 2002; Henderson and Moore 2006), river access/fishing quality (Bastian et al. 2002; Sengupta and Osgood 2003), scenic views (Bastian et al. 2002; Paterson and Boyle 2002; Sengupta and Osgood 2003; Cavailhès et al. 2009), and surrounding land use/fragmentation (Geoghegan, Wainger, and Bockstael 1997). Though results vary across applications, there is a general consensus that amenities are significant determinants of agricultural land prices and that using specific measures of amenity characteristics can improve HPM estimates.

Some studies have also taken advantage of GIS and satellite data to improve the measurement of amenity characteristics. Johnston et al. (2001) use GIS data to create indicator variables, which identify the presence or absence of parcel-specific amenities. GIS data is also used to create explanatory variables measuring distance between parcels and amenities (Huang et al. 2006; Sengupta and Osgood 2003; Johnston et al. 2001). Several researchers use GIS to create spatial measures that more precisely capture amenity characteristics. Examples include using GIS to measure (directly or with indices) the proportion of land surrounding a parcel in various land uses

TABLE 1
Agricultural Productivity Variable Names, Predicted Signs, and Definition

Variable	Hypothesized Sign	Definition
CDACRE	(Dependent)	The dependent variable is nominal price per deeded (privately owned) acre, in dollars, of the agricultural land sales.
TAUM	Negative	Total animal unit months (AUMs) on deeded acres and assured leases. The expected sign reflects the declining value of additional lands.
IRRPAST	Positive	Pastureland productivity measured by taking a weighted average of total AUMs on irrigated land and pasture, divided by deeded acres.
WIRRPAST	Positive	IRRPAST times a dummy variable for western Wyoming counties.
STBLM	Indeterminate	Measures how state and/or Bureau of Land Management land leases contribute to per acre sales price. STBLM is measured in AUMs per deeded acre.
IMPR	Positive	Assessed value of agricultural improvements divided by deeded acres.
TREND	Indeterminate	Time trend for 1989 to 1995, defined as 1 for 1989 to 7 for 1995.

or land cover (Geoghegan, Wainger, and Bockstael 1997; Ready and Abdalla 2005), using GIS to measure characteristics of parcel specific views (Bastian et al. 2002; Paterson and Boyle 2002; Cavailhès et al. 2009), and using satellite data to create measures of green vegetation (Sengupta and Osgood 2003; Nivens et al. 2002).

The existing literature demonstrates a wide array of alternative HPM approaches for valuing agricultural land amenities. Few of the existing applications, however, consider amenity-rich rural areas facing the mounting development pressures typical of the Intermountain West. Many studies address spatial autocorrelation (Huang et al. 2006; Kopits, McConnell, and Walls 2007); yet, there is a paucity of research that simultaneously addresses spatial autocorrelation and heteroskedasticity. The data employed here are both cross-sectional and place specific. Wide variation in land values suggests the potential for nonconstant error variance, as is common with many types of cross-sectional data. Problems associated with cross-sectional data (beyond misspecification and collinearity) and spatially related amenity attributes require diagnoses and, if present, remediation. We extend the existing literature by (1) examining the determinants of agricultural land values in rural amenity-driven land markets and (2) simultaneously correcting the HPM for cross-sectional heteroskedasticity and spatial autocorrelation.

II. METHODS

Data Sources

A HPM model is estimated using Farm Credit Service appraisals of arm's-length sales from 1989 to 1995. The properties are agricultural parcels located in the state of Wyoming. Parcels, taken from every county save Teton, form a random statewide sample (which results in 22 of 23 counties represented). The sample ($n = 220$) is constructed to reflect the diversity of agricultural lands across the state. Teton County is omitted as it consists of mostly public lands, has little production agriculture, and is a very expensive, exclusive real estate market. As such it is viewed as an outlier in relation to the other 22 Wyoming counties. Variables used to capture agricultural productivity and amenity attributes are defined in Tables 1 and 2,[1] and summary statistics are provided in Table 3.

[1] Since Wyoming is a nondisclosure state (i.e., final land sale prices are not public record), the Farm Credit Service data is the most recent and most comprehensive sale price data available for Wyoming. Despite the age of the data, we

TABLE 2

Amenity Variable Names, Predicted Signs, and Definition

Variable	Expected Sign	Definition
ELK	Indeterminate	Percentage of parcel consisting of elk habitat
FISHW	Positive	Parcel-specific measure of angling quality
WFISHW	Positive	FISHW times an indicator variable for western Wyoming counties
DECI	Indeterminate	Visible deciduous tree percentage of total view
SHRUB	Negative	Visible shrub land percentage of total view
RIPA	Indeterminate	Visible riparian percentage of total view
ALPINE	Positive	Visible high mountain (alpine) percentage of total view
WALPINE	Positive	ALPINE times an indicator variable for western Wyoming counties
STD10	Positive	Roughness of view, measured in standard deviations from the average visible height
WSTD10	Positive	STD10 times an indicator variable for western Wyoming counties
DFEDL	Negative	Shortest linear distance to the nearest national park, monument, or wilderness area

TABLE 3

Descriptive Statistics of Variables used in the Hedonic Price Model

Variable	Mean	Std. Dev.	Min.	Max.
CDACRE	461.88	475.94	28.54	2,875.00
TAUM	1,447.77	1,919.17	12.00	12,480.00
IRRPAST	2.74	3.66	0.12	17.50
WIRRPAST	1.20	2.33	0.00	10.42
STBLM	0.05	0.13	0.00	2.96
IMPR	58.81	170.15	0.00	1,822.50
ELK	0.09	0.26	0.00	1.00
FISHW	2.34	4.74	0.00	43.84
WFISHW	1.07	4.19	0.00	43.84
DECI	0.92	5.90	0.00	53.07
SHRUB	7.57	14.41	0.00	60.16
RIPA	1.59	5.86	0.00	52.15
ALPINE	0.42	3.25	0.00	35.97
WALPINE	0.06	0.16	0.00	1.47
STD10	85.48	164.25	1.95	2,238.11
WSTD10	36.66	67.79	0.00	355.86
DFEDL	57.43	41.00	5.70	138.75
TREND	5.18	1.56	1.00	7.00

Note: $n = 220$.

The dependent variable for the HPM estimation is nominal price per deeded (privately owned) acre, following Xu, Mittelhammer, and Torell (1994), Spahr and Sunderman (1998), Bastian et al. (2002), and Torell et al. (2005). The productivity variables are assumed to positively impact price per acre as factors of production (Table 1). The amenity variables are derived from parcel-level GIS measurements (Table 2).

expect that our model and results are relevant to the current land market. Neither a decline in the continued importance of amenities as a determinant of land values nor any significant structural change in Wyoming land markets has occurred in the past 20 years. Phone interviews with certified rural appraisers indicate that amenity values are still important in the Wyoming agricultural land market, and agricultural land values seem on par with the late 1990s in a number of amenity-laden counties in the state, given the recent economic downturn (J. Rinehart, Western United Realty, personal communication, July 18, 2012; L. Spence, Farm Credit Services, personal communication, July 27, 2012).

Each parcel is digitized by longitude and latitude for inclusion of spatially precise determinants of land value. Model specification and variable construction follow Bastian et al. (2002); the modeling effort exploits several price determinants similar to the framework of Torell et al. (2005).

The dependent variable is dollars per deeded acre (CDACRE). This reflects the privately owned resources as well as the value of access to those resources leased from public lands accruing to the landowner upon sale. TAUM is the total of the productive units measured in animal unit months (AUM) so as to account for both crop and forage resources. This variable is thought to have a negative sign, as larger operations tend to have smaller per acre values. IRRPAST is a weighted average of the AUM values, consisting of both subirrigated pasture and irrigated lands divided by deeded acres. This is a measure of overall production quality, as weighted by irrigated lands, and deemed a priori to have a positive parameter sign. WIRRPAST is the product of IRRPAST multiplied by an indicator variable for western Wyoming counties, with the same sign as proposed for IRRPAST. STBLM indicates the amount of state and Bureau of Land Management (BLM) lands leased by the property owner. The use of public lands for grazing continues to be a contentious issue in the West and as such may be viewed as an uncertain or less-valued resource.[2] Agricultural improvements (e.g., silos, barns, pens) should increase the value of a parcel (see IMPR).

Amenity attributes provide insights into land value in this region of the United States and the following highlight key measures. The proportion of elk habitat on each parcel (ELK) is used to capture big game habitat and associated recreational amenities as well as potential wildlife-livestock forage competition. The FISHW variable measures on-parcel angling productivity. It is calculated by taking the meters of stream on a parcel multiplied by the calculated GIS-weighted productivity (fish species population density) divided by deeded acres.

Several variables define view-related amenities (see Germino et al. [2001] for detailed explanation of using GIS techniques to construct view variables). Each variable captures the percentage of total (360°) view available from 2 m above the centroid of each parcel. Four land-cover categories (SHRUB, RIPA, ALPINE, and DECI) characterize the views from each parcel. SHRUB encapsulates the sagebrush steppe and scrub landscape thought to be both less preferred for visual content and less valuable as livestock forage. RIPA represents riparian areas expected to offer views of fauna and flora, as well as subirrigated pasture for hay production and livestock grazing. ALPINE signifies views of the snow-covered high peaks, for which the Rocky Mountain region is noted. DECI indicates visible tree cover separate from coniferous species. STD10 offers the relief or topography of the view from up to 10 km from the parcel's centroid. The measure is derived as a sum of deviations from a uniform horizon. It is expected that a rugged horizon view is preferred to flat prairie (Germino et al. 2001).

Several interaction variables convey a hypothesized difference in the way land attributes may be uniquely priced in the western region as compared to the other regions. Four attributes are expected to affect agricultural land price differently within the western region: AUM measures of irrigated lands productive capacity (WIRRPAST), fish habitat quality (WFISHW), alpine view (WALPINE), and roughness of view (WSTD10). It is expected that the more mountainous areas contiguous to public lands and having trout streams in the western region of Wyoming would offer price premiums due to the existence of a greater level of scenic and environmental amenities. These amenities are thought to complement or even supplant the value derived from agricultural productivity.

[2] Although Sunderman and Spahr 1994 show that state and BLM leases are valued differently, we combine the two for several reasons. Access to public grazing resources to explain part of parcel value serves to improve model estimation and the robustness of the amenity parameters of interest. We have insufficient unique observations for each lease type (a majority of those that have state leases tend to have BLM leases). The combined variable improved the overall efficiency of the parameter estimates and model, capturing the impact of public grazing resources on parcel value.

We also include a simple time trend to control for other unobserved time variant factors (e.g., population growth) that occurred during the study period (TREND), consistent with Torell et al. (2005) and Spar and Sunderman (1998).

Hedonic Price Model

The constructed and subsequently estimated HPM builds on work reported by Bastian et al. (2002). They found, using similar data, that linear and log-linear forms offered similar results and goodness of fit. We examined Box-Cox, log-linear, and linear specifications. The Box-Cox model iterations did not converge. We chose the linear specification over the log-linear model based on goodness of fit.

The spatially explicit and cross-sectional parcel data may lead to heteroskedasticity and spatial autocorrelation. A White's test (1980) indicates the presence of heteroskedasticity; however, past literature suggests that tests for heteroskedasticity may be sensitive to the presence of spatial autocorrelation (Anselin 1990, 1995). Anselin and Rey (1991) and Anselin (1995) also indicate that the standard Moran's I and Lagrange multiplier tests for detecting spatial autocorrelation may be sensitive to other issues such as nonnormality and heteroskedasticity. In such cases, Anselin (1995) recommends the test proposed by Kelejian and Robinson (K-R test) (1992). The K-R test for detecting spatial autocorrelation is applied using SpaceStat (Anselin 1995). Results indicate that spatial errors are the appropriate concern.

A spatial distance band is the boundary within which land parcels are thought to be spatially correlated. This band is a functional radius determined by the last statistically significant measure of spatial influence between nearby parcels; thus, error terms of parcels outside the distance band are independent (Dubin 1988). The K-R test indicates that a spatial distance band of 54 miles is appropriate for the land parcel data (i.e., 54 miles is the maximum radius where there is a statistical relationship between error terms). The 54-mile radius roughly approximates the east-west extent of the basin and range topography of Wyoming. For the sample analyzed, it appears that buyers, sellers, and real estate agents apparently view other farm and ranch properties within the 54 mile band as being valid comparators when discovering price or defining price expectations. The model is estimated using the 54-mile spatial weights matrix remedying spatial autocorrelation. A Breusch-Pagan test, however, indicates that heteroskedasticity persists.

Addressing Heteroskedasticity and Spatial Autocorrelation

A two-step feasible generalized least squares (FGLS) approach is chosen to correct for both heteroskedasticity and spatial autocorrelation. The FGLS model is based on a decomposed error (see equation [1] below) containing random, spatial, and heteroskedastic components. Consider the following HPM specification, where $i = 1, \ldots, n$ denotes parcels:

$$y_i = \sum_{k=1}^{K} \beta_k^{ag} X_{k,i}^{ag} + \sum_{j=1}^{J} \beta_j^{amenity} X_{j,i}^{amenity} + U_i, \qquad [1]$$

where y_i is the price (dollars/acre) of parcel i, β_k^{ag} are K parameters on agricultural productivity variables, $X_{k,i}^{ag}$ are K agricultural productivity variables for parcel i, $\beta_j^{amenity}$ are J parameters on amenity variables; and $X_{j,i}^{amenity}$ are J amenity variables for parcel i. The aggregated error term, U_i, is decomposed as follows:

$$U_i = \xi_i + U_i^h + U_i^{se}, \qquad [2]$$

where ξ_i is the random homoskedastic error term; U_i^h is the decomposed heteroskedastic error term; and U_i^{se} is the decomposed spatial error term.

This estimation procedure first addresses heteroskedasticity and then spatial autocorrelation. Belsley, Kuh, and Welsch (1980) suggest transforming the original equation by using the residual values to weight the heteroskedastic data. Auxilliary regressions of the estimated errors against the independent variables are utilized to test various potential weights (see Ramanathan 1989). The most appropriate weight is found to be the absolute

TABLE 4
FGLS Hedonic Price Model

Variable	Parameter Estimate	Std. Err.	Asymptotic t-Value
CONSTANT	191.26	16.53	11.57***
TAUM	−0.02	0.00	−13.62***
IRRPAST	52.71	1.02	51.31***
WIRRPAST	−24.67	1.32	−18.58***
STBLM	−243.6	23.7	−10.28***
IMPR	1.20	0.03	38.29***
ELK	−172.53	18.73	−9.20***
FISHW	10.64	1.66	6.39***
WFISHW	16.44	3.28	5.01***
DECI	−2.49	0.14	−17.41***
SHRUB	−3.21	0.19	−17.01***
RIPA	−6.50	1.65	−3.93***
ALPINE	0.17	0.79	0.21
WALPINE	582.01	11.87	49.00***
STD10	0.08	0.06	1.40
WSTD10	1.85	0.07	25.44***
DFEDL	−1.39	0.08	−16.37***
TREND	19.54	2.21	8.84***
LM (ERROR) DF = 1	0.0006		0.980
Pseudo R^2	0.68		

Note: $n = 220$.
*** Significant at the 1% level.

value of the ordinary least squares residuals $(1/|e_i|)$ (see Wasson 2005). The absolute values of the residuals are used to correct heteroskedasticity as follows:

$$y_i^* = \sum_{k=1}^{K} \beta_k^{ag} Z_{k,i}^{ag} + \sum_{j=1}^{J} \beta_j^{amenity} Z_{j,i}^{amenity} + U_i^*, \qquad [3]$$

where $y_i^* = y_i(1/|e_i|)$, $Z_i^{ag} = X_i^{ag}$ weighted by $1/|e_i|$, $Z_i^{amenity} = X_i^{amenity}$ weighted by $1/|e_i|$; and $U_i^* = U_i^{se} + \xi_i$.

After correcting for heteroskedasticity, we tested for spatial autocorrelation using the Lagrangian multiplier test (LM). Results indicated the presence of spatial autocorrelation. We use the process suggested by Anselin (1995, 208) to correct for spatial autocorrelation. The process adjusts the error term as follows:

$$U_i^{**} = (\lambda \mathbf{W})_i U_i^{se} + \xi_i, \qquad [4]$$

where $\mathbf{W}$ is the spatial weights matrix, and λ is the autoregressive coefficient.

We create the spatial weights matrix using the centroid of each parcel. The final FGLS spatial error model is then estimated. The LM statistic indicates that spatial errors are corrected in the FGLS model. The corrections provided in equations [1]–[4] yield consistent estimates and improve parameter efficiency given the presence of heteroskedasticity and spatial autocorrelation. The FGLS HPM provides an efficient and robust explanation of land value.

III. RESULTS

Most of the amenity measures of land attributes are significant contributors to parcel price (Table 4). The value of fishing quality across the state (FISHW), the value of fishing quality in the western region (WFISHW), the value of alpine view in the western region (WALPINE), and the value of roughness of view in the western region (WSTD10) all positively and significantly increased price per acre ceteris paribus. Productive lands with on-site fishing and scenic views command a higher price.

Results indicate that the variable for irrigated lands in AUM per acre (IRRPAST) and the value of improvements per acre (IMPR) reflect increased productivity or value and thus lead to higher prices, ceteris paribus. The

IMPR variable is the value of improvements (houses, barns, pens, for example) divided by deeded acres. Thus, an additional dollar of improvements increases the value of the deeded property by more than a dollar ($1.20). The variable for the total AUM representing parcel size (TAUM), weighted average irrigated AUM per acre (WIRRPAST) in the western region, the value of state or BLM-leased AUM per acre (STBLM), the value of deciduous tree view (DECI), the value of shrub view cover (SHRUB), the value of riparian view (RIPA), and the value of increasing distance to federal points of interest (DFEDL) negatively and significantly decreased price per acre, ceteris paribus. The value of the additional unit of production (TAUM) is decreasing, as seen in the estimation results. Public lands leased for grazing (STBLM), though additional productive resources, may incur management costs and instability of access due to controversy associated with public lands grazing. Lastly, TREND is positive, indicating, as expected, that nominal price per deeded acre generally increases over time in the data set.

The SHRUB, DECI, and RIPR may also contribute to land management costs by competing with forage or as riparian areas leading to submerged pasture lands for portions of the grazing season. Opportunity costs may be associated with the aforementioned view components that detract from the aesthetic values. The closer a parcel is to premier amenity public lands (parks, monuments, wildernesses indicated by DFEDL), the higher the price a parcel commands.

The price per acre in the western region of Wyoming does not increase (as in the other Wyoming regions) as the productivity of land (WIRRPAST) increases. It was assumed that increases in AUM quality increase on-parcel agricultural productivity and therein increase land price per acre in all counties, including the western region of Wyoming. A possible explanation of the estimated outcome is that western landowners and land purchasers value land productivity less when compared to other attributes. The western section of the state is at a higher elevation with a shorter growing season relative to the other regions of the state, resulting in lower productive capacity. Agricultural land as a capital asset in agricultural production may not be seen as a profitable option when compared with the fee-generating opportunities of amenities as well as possible option value associated with future development payment.

The quality of fishing in the western section of Wyoming positively affects parcel price. Increasing fishing quality may provide agricultural landowners supplemental income by affording recreational fishing fee opportunities (Inman, McLeod, and Menkhaus 2002). Secondly, a recreational or amenity land buyer may pay a premium for land containing quality fishing streams.

Alpine view and roughness of view across the state are not significantly found to affect agricultural land price. Alternately, alpine views (WALPINE) increase the price per acre when considering the western region of Wyoming. Views of increasing uniform expanses of certain vegetation in the western region are less preferable than jagged, alpine horizons. An increase in price per acre is found as the percentage of western region roughness of view or standard deviations WSTD10 increases on a parcel. The roughness of view variable contribution provides a premium to agricultural land price in view of the dramatic relief of pristine mountain peaks. Overall, these results point toward the importance of scenic and environmental amenities in explaining agricultural land values. This suggests that agricultural productivity is only one category of attributes that may be demanded in western rural land markets.

Validity of the HPM: Comparisons across Wyoming Regions

To confirm the impact of amenities on rural agricultural land values, assessed property values and prices predicted with this HPM are compared to the observed parcel prices. The state of Wyoming assesses agricultural land values for tax purposes. The valuation is based on productive value and thus provides a meaningful comparison to estimates including amenity values. The state's valuation formula (see Spahr and Sunderman 1998, and provided in the Appendix) and this HPM are used, respectively, to estimate parcel values in

TABLE 5

Comparisons of Predicted Sale Prices to the Observed Sales Price Statewide and by Regions

Region	Mean Prices ($/Acre)	Difference (from Market Price)	Observations	S.D.	t-Value	$Pr > \|t\|$
Statewide						
DFGLS	451.26	10.61	220	17.48	0.61	0.54
STATUTE	374.74	87.13	220	32.85	2.65	0.009
MARKET	461.87	—	220	—	—	—
Eastern Region						
DFGLS	325.77	− 12.16	105	11.55	− 1.05	0.3
STATUTE	325.34	− 11.72	105	33.70	− 0.35	0.73
MARKET	313.62	—	105	—	—	—
Central Region						
DFGLS	348.48	57.61	38	43.38	1.33	0.19
STATUTE	304.75	101.34	38	72.46	1.40	0.17
MARKET	406.09	—	38	—	—	—
Western Region						
DFGLS	673.11	18.47	77	42.29	0.44	0.67
STATUTE	476.64	214.93	77	71.52	3.01	0.004
MARKET	691.57	—	77	—	—	—

Notes: DFGLS is our model's predicted per acre parcel value; STATUTE is the state calculated value; and MARKET is the actual sale value. t-Statistics and p-values indicate the difference between estimated prices (DFGLS and STATUTE) and the observed price (MARKET), respectively.

three submarkets:[3] eastern, central, and western. Finally, a means difference t-test is used to determine whether mean predicted values are significantly different from zero and significantly different from the mean observed price.

Means test results indicate that both the state's valuation method (STATUTE in Table 5) and our HPM model (DFGLS in Table 5) accounting for amenities perform well in the eastern and central submarkets (Table 5). In the amenity-rich western market, however, mean assessed values are significantly different than observed prices. The state's valuation underestimates observed price by over 30%, on average, in the western market. Our HPM predicts land price well compared to observed market prices across the western submarket. The reported tests show that the DFGLS model does not predict something statistically different from the actual data, but for the statewide analysis and the western region there is a statistical difference between our predictions (which are not different from the actual data) and what the predicted values of the parcels are for taxation purposes (STATUTE). Thus, we conclude that DFGLS does a better job of predicting value than STATUTE (taxation) formulas in the high-amenity areas, and the difference at the state level is likely being driven by high-amenity parcels compared to the average.

These comparisons highlight the importance of accounting for amenity characteristics in amenity-rich land markets, such as western Wyoming. Parcel value based solely on agricultural production characteristics systematically underestimates value. These results also highlight the importance of using detailed parcel-specific amenity measures. The comparison of predictions suggests that amenities account for over 30% of mean parcel value in western Wyoming. Assuming

[3] Counties included in each submarket: eastern = Campbell, Crook, Weston, Converse, Niobrara, Goshen, Platte, Laramie, and Albany; central = Natrona, Sheridan, Johnson, Carbon, Big Horn, Hot Springs, and Washakie; and western = Fremont, Park, Lincoln, Uinta, and Sublette.

TABLE 6
Mean Contributions to Predicted Hedonic Price Model Land Price

Variable	Parameter Estimate	Mean Value	Mean Contribution to Predicted Agricultural Land Price ($/acre)
CONSTANT	191.26	1.00	191.26
TAUM	− 0.02	1,447.77	− 28.96
IRRPAST	52.71	2.74	144.43
WIRRPAST	− 24.67	1.20	− 29.60
STBLM	− 243.6	0.05	− 11.45
IMPR	1.20	58.81	70.57
ELK	− 172.53	0.09	− 15.53
FISHW	10.64	2.34	24.90
WFISHW	16.44	1.07	17.59
DECI	− 2.49	0.92	− 2.29
SHRUB	− 3.21	7.57	− 24.30
RIPA	− 6.50	1.59	− 10.34
WALPINE	582.01	0.06	34.92
WSTD10	1.85	36.66	67.82
DFEDL	− 1.39	57.43	− 79.83
TREND	19.54	5.18	101.22

Note: All variables are statistically significant at or above the 5% level.

TABLE 7
Amenity Premiums ($/acre)

Region	Alpine View	Roughness of View	Fishing Quality
Western	$93.52	$202.64	$82.44
Central	$0	$0	$28.59
Eastern	$0	$0	$18.16
State	$30.02	$65.22	$43.08

amenity values are highly correlated with future development rents, our model suggests that development potential may account for a much larger portion of agricultural land values than the 5% estimated by Plantinga, Lubowski, and Stavins (2002) with aggregate state-level data.

Contribution of Amenities to Agricultural Land Values

Marginal effects of land characteristics on parcel price are offered in Table 6 for the statewide sample. Per acre measures of attributes are derived for the state and the three aforementioned subregions. Region-specific value components per acre are obtained by taking mean values of amenity variables for the respective regions and then multiplying by the parameter estimates.

The presence of amenity attributes leads to higher parcel prices per acre (see Table 7). View components, specifically alpine vistas and roughness of view, and on-parcel angling substantially increase parcel value. Amenity premiums are particularly profound in elevating land values for the amenity-driven western Wyoming land market. A 10-unit change in the elevation of the horizon (i.e., roughness of view), for example, increased parcel value by more than $200 per acre. This represents nearly half of the statewide average price per acre, and nearly one-third of the average price in the western region.

Conversely, parcels with other attributes command lower per acre prices (see Table 8). More big-game wildlife habitat, increasing distance from federal lands, and a greater amount of less desirable land cover tend to decrease parcel values. Notably, eastern region parcels experience a larger loss in value when further from federal lands. The eastern region of Wyoming has less public land than the central and western regions. The western

TABLE 8

Disamenity Penalties ($/acre)

Region	Land Cover	Distance from Federal Lands	Wildlife
Western	−58.06	−43.77	−28.92
Central	−38.09	−56.90	−13.06
Eastern	−20.80	−114.58	−4.84
State	−38.09	−71.75	−15.16

Note: The specific changes that yield the marginal effect are as follows: a 1% change in the percentage of shrub as sagebrush and deciduous trees as willows and cottonwoods (together as Land Cover); a one-mile change in the distance from national parks and monuments as well as wilderness areas; and a 1% change in the amount of wildlife habitat.

region, in contrast, is known for national parks and forested public lands. Proximity to unique, amenity-rich public lands convey property value; the converse reduces parcel price.

The western region is most affected by the amount of sagebrush and deciduous trees. as compared to the others. Wildlife, specifically elk, competes with livestock for forage while also contaminating or consuming winter feed stocks. Big game may also be a nuisance to rural residential home owners. The western region experiences the greatest decline in parcel price on the margin in comparison to other areas. Amenities play an essential role in understanding the difference between western, central, and eastern Wyoming land markets. Likewise, numerous regions in the Intermountain West have amenity-relevant land markets.

IV. CONCLUSIONS

This research indicates how agricultural land's productivity and amenity characteristics both influence land price. The attributes are deemed important to diverse interests impacting the demand for agricultural lands in the West (or wherever environmental amenities might occur). The literature addresses the importance of accounting for productive and amenity attributes in both estimated land price and rent-generating abilities. Not including amenity attributes results in not fully accounting for land price variation. Incomplete land model specification fails to give a proper value for agricultural land in areas with high amenity concentration. It can lead to omitted variables problems and model misspecification. A better understanding of how amenities are capitalized into rural land prices should improve resource allocation as it relates to land markets and preservation policies. The extent to which the data set utilized for this research is unique in the GIS construction of the explanatory variables is not replicated in other studies to our knowledge.

TABLE 9

Percentage of Selected Amenity to Total Estimated Value

Region	Amenity %
West	56.20
Central	8.20
East	5.57
State	30.94

The FGLS model provides an efficient, robust estimation of agricultural land price. Results also indicate that correcting for heteroskedasticity and spatial autocorrelation provides an improved HPM estimation. The values arising from an approach proscribed by Wyoming statue for agricultural land valuation also do not perform as well. Amenity premiums and penalties are derived that indicate the amounts that amenity attributes increase or decrease parcel value. Amenities play a modest role statewide and a key role in the western region in determining agricultural land values. They may also be overlooked when property tax assessments are derived.

Amenity attributes play a large role in amenity-rich areas, such as western Wyoming (see Table 9). Amenity values constitute roughly 5% to 60% of the sampled parcel's value. The average across the sample is nearly one-third amenity-driven value. Omitting the amenity characteristics for Wyoming and particularly the western region therefore constitutes a mis-estimation of parcel price. Amenity attributes are an important, in some cases essential, component of agricultural land value. Aggregate data produce coarse land value estimations. These tend to mask or even confute the role of local amenity values.

This research documents the role amenities have in determining agricultural parcel price. Amenities that are spatially precisely measured may also be drivers in the market prices of agricultural lands throughout the region. These outcomes offer insights into targeting the location of amenity protection. Moreover, these results suggest that amenities that might be attractive to nonagricultural interests could affect potential development values for in-migrants. Future research should expand the tests of amenity types that may be determinants of agricultural prices. The type, location, and quality of various amenities may have key roles as per recreation, ecosystem services, aesthetic values, and rural quality of life in local, state, and federal, as well as private, land conservation efforts.

APPENDIX: WYOMING STATE STATUTE AGRICULTURAL LAND VALUATION

Wyoming agricultural land is valued only on productivity for taxation purposes. The productive land asset formula by Wyoming statute follows Spahr and Sunderman (1998):

$$L = R\frac{I}{A},$$

where L is the productive land value, R is the AUM dollar rent value, I is the five-year moving average capitalization rate, and A is the AUM productive quality value per acre.

The dollar rent price per AUM is formulated per parcel using the respective county average for the sale year. The capitalization rate of 7.752% is the same capitalization rate used by Spahr and Sunderman (1998) to address the Wyoming statute discount rate. The AUM per acre productivity is taken from the sample data. The productive land asset values determined as above are averaged across each region and then statewide for the study period.

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