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ORIGINAL PAPER

The impact of trails on property values: a spatial analysis

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Abstract Convenient and local access to open green space is highly valued in many communities, particularly those comprised largely of individuals who participate in natural resource outdoor recreation. Understanding the value outdoor recreation communities place on access to open space is critical for informing policy decisions on land use including zoning and other restrictions, government open space purchases, and open space access points such as trailheads. In this article, we analyze the impact of trail access on property values in Ogden, Utah, using spatial hedonic pricing models. We consistently find substantial premiums for properties located closer to trailheads. Using a spatial Durbin error model, we find a 0.6% direct effect premium for each minute closer in driving time to the nearest trailhead, and a 1.4% premium when accounting for the total impact. We also find direct premiums between 0.4 and 1.9% for each minute closer in driving time to individual trailheads in this region. Additionally, homes adjacent to trailheads do not experience negative spillovers that homeowners may experience from increased traffic and congestion.

JEL Classification Q51 · R21 · R11 · Z30

1 Introduction

Green open space near urban areas provides many ecosystem services, including aesthetic value, water and air filtration, wildlife habitat, and area for recreation activities. This green space is of particular importance in communities comprised of many

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outdoor enthusiasts who value convenient and local access to participate in natural resource outdoor recreation. Empirical regional growth studies find that people who place value on these natural resource-based amenities will relocate to enjoy these attributes (Carruthers and Vias 2005; Wu and Mishra 2008; Eichman et al. 2010). Understanding the value outdoor recreation communities place on access to open space as an urban green amenity is critical for informing policy decisions on land use, including zoning and other restrictions, government open space purchases, and improving the accessibility of the open space.

Proximity to trails is often highly valued as a green amenity, providing positive value for properties (Melichar and Kaprova 2013; Asabere and Huffman 2009; Nicholls and Crompton 2005; Sander and Polasky 2009). While green open space may overall increase property values, it is also possible that green spaces that are contiguous to homes may adversely affect property values due to increased pedestrian and dog traffic, potential crime, and generally, loss of privacy. Identifying the full value of physical access is difficult due to interrelated effects of proximity, which can result in insignificant effects for access (Nicholls and Crompton 2005). Additionally, researchers must account for the presence of spatially correlated unobservables due to omitted variables and the feedback or spillovers from variables (Parent and vom Hofe 2013; Herath et al. 2015).

The purpose of this paper is to analyze the impact of trail access on property values in Ogden, Utah. We use spatial hedonic pricing methods on a dataset of residential property transactions for the years 2014–2016. Travel time is calculated from each sold house to trailheads around the city. We separate the effect of trail access with proximity to public open space by controlling for various location factors, including views, distance to the mountains, elevation, and trailhead adjacency. Estimation using standard hedonic models and spatial specifications identifies the price gradient for travel time from trailheads to residential properties.

This research makes two main contributions to the literature. First, we identify the value homeowners in an urban outdoor recreation community place on accessibility to trails. Recently, hedonic studies have examined the impact trails have on property values, and find that trail proximity increases the value of homes (Nicholls and Crompton 2005; Sander and Polasky 2009; Asabere and Huffman 2009). A limitation of the prior literature is that the housing markets studied may not provide an accurate picture of the value of trails in outdoor recreation communities such as those found in the Rocky Mountain West. Outdoor recreation communities often have explicit objectives of promoting, enhancing, and maintaining access to outdoor recreation. One way to meet their objectives is by adding and improving trail access points, where such projects compete for funds dedicated to any number of projects to enhance outdoor recreation or public green space in the community. Understanding the value of this accessibility is therefore critical for policymakers to justify these expenses. Second, we use a spatial hedonic method to estimate valuations for trail access in general as well as for specific trailheads in different areas of the city. We disentangle the effect of general proximity to mountains and open space, elevation, and view with the accessibility of this space, while at the same controlling for spatial dependency in property values, and correcting for potentially spatially correlated omitted variables with a spatial Durbin error model (SDEM).

To preview our results we find significant, positive values for proximity to trailheads in Ogden, Utah. Large valuations are unsurprising as Ogden is known as a city with many outdoor enthusiasts. Each minute saved in driving time to the nearest trailhead is associated with a 0.6% premium when considering the direct effect, and a 1.4% premium when including the indirect effects. We also find travel times to trailheads in different areas of the city have different price gradients. The direct premiums for the different trailheads range from 0.4 to 1.9% for each minute closer in driving time. We also find travel times to trailheads in different areas of the city have different price gradients. Furthermore, accounting for the indirect effects of these trailheads results in much larger valuations than only looking at direct effects.

The outline of the paper is as follows: The first section below explores the literature and theoretical foundation of the hedonic pricing model and explains methods to control for spatial dependence. Section 3 presents the study area and data used for analysis, while Sect. 4 presents the econometric specifications. Section 5 discusses the results, and Sect. 6 concludes.

2 Background and literature

Amenities provide significant value to residential property values. Empirical research has found significant positive relationships between home values and many natural amenities (Geoghegan et al. 1997; Izon 2016), including open space (Geoghegan 2002; Irwin 2002; McConnell and Walls 2005; Abbott and Klaiber 2010), urban forests (Tyrvainen and Miettinen 2000; Garrod and Willis 1992; Hjerpe et al. 2016; Sander et al. 2010), and views (Benson et al. 1998; Bourassa et al. 2004; Sander and Polasky 2009).

Trails in urban areas provide use benefits, such as recreation, and nonuse benefits, which may include option values, bequest values, or values associated with the pleasure that one may experience by watching families and pets get out and enjoy the outdoors. Proximity and accessibility of natural amenities are related, but certain individuals may place a greater value on the proximity amenity, deriving utility from the scenic views and nearby natural habitat for wildlife, while other individuals may value the accessibility of this green space for outdoor recreation activities or options to participate in outdoor activities. The relationship between home values and access to these natural amenities through proximity to trailheads has recently been explored with the results demonstrating that the value of proximity and access depends on the community studied. For example, Asabere and Huffman (2009) found a significant and positive impact from some trailheads in the San Antonio, Texas area, whereas Nicholls and Crompton (2005) found a significant and positive impact for physical access to a greenbelt in only one of the three communities studied in the Austin, Texas area. Researchers using spatial hedonic methods have found trailheads (Parent and vom Hofe 2013) and proximity to a greenbelt (Herath et al. 2015) are both positively valued.

While it is relatively easy for cities to get accurate estimates for the costs of building and expanding trails and their access points, the benefits, in terms of the value of these trails to the local community, are often less well known. Furthermore, trail access points within a municipality are valued differently; thus, varying estimates of the monetary value of amenities would improve urban planning decisions, allowing an explicit understanding of the benefits of specific trailheads.

3 Study area and data

Our study area is the city of Ogden, Utah, including the municipalities of North Ogden and South Ogden. All regions are part of the Ogden-Clearfield, Utah Metropolitan Statistical Area. Ogden is largely an urban city with a population of nearly 120,000 (including North and South Ogden). The city encompasses an area of 26.6 square miles. The city is bordered by the mountains to the east, and two rivers on the north and south that eventually converge west of the city. The straight-line distance from the mountain edge to the furthest western edge of the city is 5 miles. The city is a grid with many straight-shot roadways going east–west and north–south. Ogden is recognized, both locally and nationally, as an outdoor recreation community with easy access to an extensive trail system adjacent to the city's eastern edge. A map of Ogden home sales and the trailhead locations is presented in Fig. 1.

Ogden's trails are of multi- or mixed use, used by hikers, mountain bikers, back-country skiers, alpine mountaineers, rock climbers, ice climbers, and equestrians. We include trailheads in the city with established parking facilities. The trailheads provide access to unpaved, single-lane trails, some of which contour the mountains while weaving in and out of several canyons and providing access to aesthetic streams and waterfalls, while other trails have significant uphill gradients often extending to nearby mountain peaks. An iconic waterfall just above the city of Ogden is accessible from the East Bench trails, with the most direct access from the 29th Street trailhead, followed by the 22nd Street trailhead (refer to Fig. 1). All trails in the area converge to the Bonneville Shoreline Trail (BST) system, which follows the shoreline of the ancient Lake Bonneville. Ongoing efforts aim at expanding the BST system to stretch 150 miles from the Idaho border to Nephi, Utah, thus connecting many areas along the Wasatch Mountains. These trails, and the access the trails provide to the Wasatch Mountains, are a significant positive amenity for four season outdoor recreationists. Overall, Ogden provides an excellent opportunity to study the impacts of a high-quality trail system.

Arm's-length transactions in Ogden were collected for 2711 single-family residential properties from June 2014 through May 2016. We utilize all transacted single-family properties in the greater Ogden area for that time period due to the close proximity of the city to the trailheads. Multiple Listing Service (MLS) data included the home sales price, location, and structural and property characteristics. Market transactions overcome potential bias that may occur in assessed values when estimating non-market amenities (Cotteleer and van Kooten 2012). We link the house to an elementary school quality grade scored by the Utah State Board of Education (USBE), calculated as the three-year average from 2012–2013 through 2014–2015. View is calculated as a dummy variable based on the property description specifying whether there was a view of the mountain from the property. Distance and location variables are calculated using ArcGIS Euclidean distance measurements. Google Maps

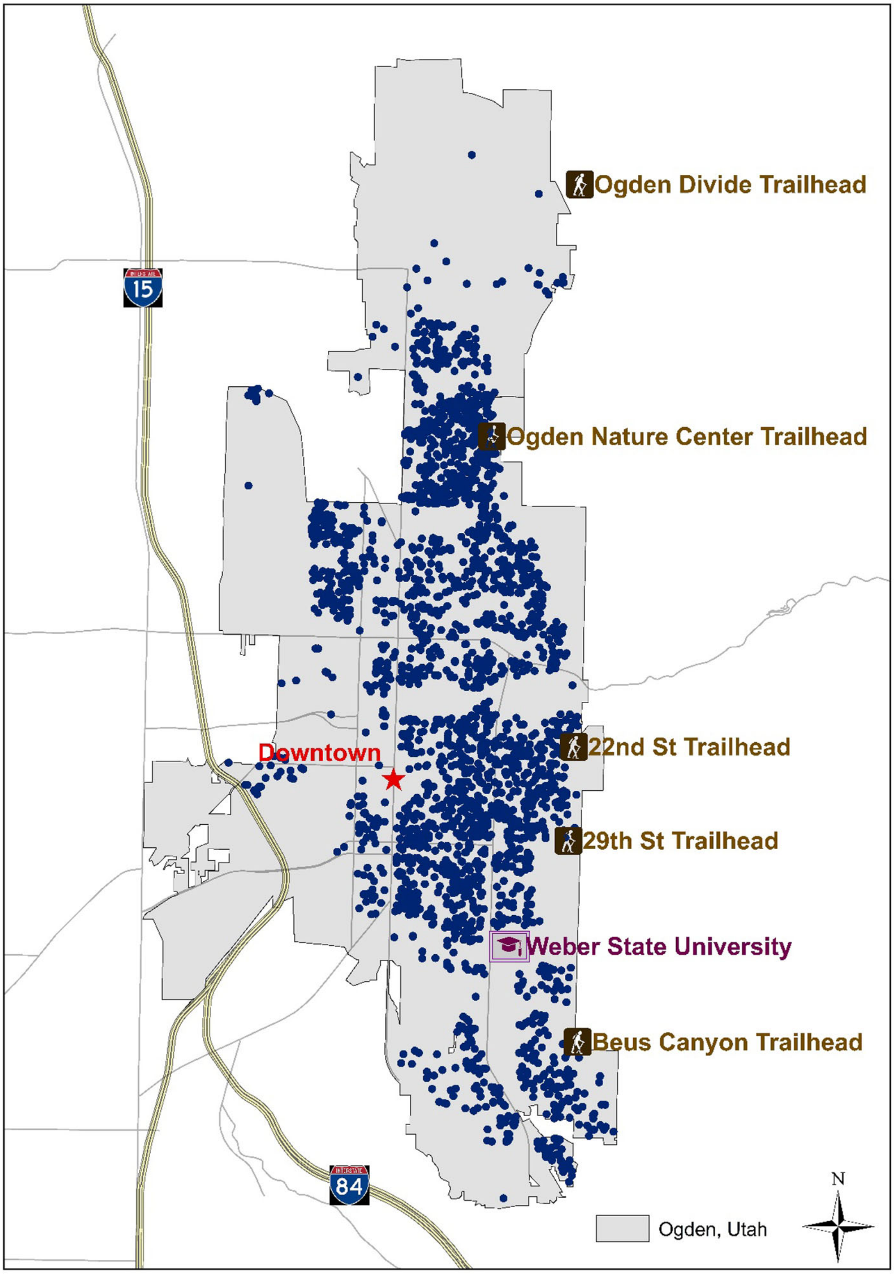

Fig. 1 Ogden home sales and trailheads

API is used to calculate the driving travel time by private vehicle from each property to each trailhead and to the city's Central Business District. We used multiple metrics for trailhead adjacency, specified as whether the property is located within concentric buffers indicating distances of 100, 200, and 500 feet from the trailhead. Variable names, descriptions, and sources are provided in Table 1.

Table 2 shows the descriptive statistics of the data. Given the geographic layout of the city, it is not surprising that all properties in the study are located within a 13-min drive to at least one of the trailheads, yet there is greater variation for specific trailheads ranging from 1 min to over 20 min. The average travel time to a property's nearest trailhead is 5.52 min, and the average travel time to specific trailheads is around 10 min to just over 17 min. Located by the mountains, Ogden has significant variation in elevation throughout the city. The average elevation is 4463 feet above sea level, but properties range between 4241 and 5250 feet above sea level. The mountain peaks rise 4000 feet above the city, resulting in 72% of the houses having a view of the mountains. The houses in our dataset were built on average in the year 1964. Each house has on average of 3.47 bedrooms, 2.12 baths, and 2005 square feet. Approximately 44% of the properties have fireplaces, 62% have air conditioning, and 2% of the houses have a pool. Despite the notable outdoor amenities, houses in Ogden still tend to be affordable with the average price of $160,408, measured in 2016 USD.

4 Econometric methods

Hedonic pricing is rooted in the idea that consumers acquire a product because of the characteristics of that product (Lancaster 1966). Rosen (1974) laid out the theoretical underpinnings for hedonic valuation of markets for differentiated goods where the market clearing price $p(z) = p(z_1, z_2, \ldots, z_n)$ is a function of the bundle of characteristics of the commodity. Since that time, the hedonic pricing method has been applied to measure how housing prices are affected by environmental goods and services such as open spaces and public greenways (Nicholls and Crompton 2005), urban air quality (Harrison and Rubinfeld 1978; Nelson 1978; Kim et al. 2003), and trails (Asabere and Huffman 2009; Parent and vom Hofe 2013).

4.1 Linear model

Hedonic price models frequently estimate the price of a house log-linearly (Palmquist 1984; Cropper et al. 1988). We use the semi-log specification for three reasons. First, the semi-log model assumes that access to amenities is capitalized into the home price in similar proportions, thus allowing for easy interpretation of partial derivatives. For example, the partial derivative represents the percentage change in price given a one-unit change in the independent variable. Second, while recent research suggests examining different hedonic functional forms (Parmeter et al. 2007; Kuminoff et al. 2010), the majority of recent hedonic studies estimating the value of environmental amenities still utilize a semi-log specification (Neumann et al. 2009; Baranzini and Schaerer 2011; Yoo et al. 2014; Gibbons 2015; Gibbons et al. 2014; Schlapfer et al. 2015). By using a semi-log specification, our results can be more easily compared to previous research. Third, we ran a Box–Cox test which rejected the linear–linear specification model ($p < 0.001$) and log–log model ($p < 0.001$), but failed to reject the hypothesis that the dependent variable should be logarithmic ($p = 0.348$), and

Table 1 Variable names and definitions

Variable	Definition	Source
Sale price	The sold price of the home in 2016 US dollars	MLS
Structural attributes		
Square footage	The size of the house measured in square feet	MLS
Age	The property's age at the time it sold	MLS
Acreage	The size of the lot measured in acres	MLS
Bathrooms	The number of bathrooms in the house	MLS
Bedrooms	The number of bedrooms in the house	MLS
Fireplace	Dummy variable denoting whether the house has a fireplace	MLS
Pool	Dummy variable denoting whether the house has a pool	MLS
Air conditioning	Dummy variable denoting whether the house has air conditioning	MLS
HOA Fee	The monthly fee for the homeowner's association (=0 if there is no homeowner's association)	MLS
Geographic attributes		
Nearest trailhead	Travel time in minutes to the nearest trailhead	Google Maps
22nd St.	Travel time in minutes to the 22nd St. trailhead	Google Maps
29th St.	Travel time in minutes to the 29th St. trailhead	Google Maps
East Bench	Travel time in minutes to nearest East Bench trailhead (22nd or 29th St.)	Google Maps
Ogden Divide	Travel time in minutes to the Ogden Divide trailhead	Google Maps
Ogden Nature Center	Travel time in minutes to the Ogden Nature Center North trailhead	Google Maps
North Ogden	Travel time in minutes to nearest North Ogden trailhead (Ogden Divide or Ogden Nature Center)	Google Maps
Beus Canyon	Travel time in minutes to the Beus Canyon trailhead	Google Maps
Adjacent	Dummy variable denoting whether the house is adjacent to a trailhead	ArcGIS
View	Dummy variable denoting whether the house has a mountain view in the property's description	MLS
Elevation	Elevation above sea level (feet)	ArcGIS
Mountain	Euclidean distance to the mountains (miles)	ArcGIS
Ogden CBD	Travel time in minutes to Ogden City's Central Business District	Google Maps
Neighborhood attributes		
School quality (0–600)	Elementary school quality averaged for the years 2013–2016	USBE
Income	Median income of the property's census block group	Census 2010
Black	Percentage of the population that is black in the property's block group	Census 2010
Hispanic	Percentage of the population that is Hispanic in the property's block group	Census 2010

Table 1 continued

Variable	Definition	Source
White	Percentage of the population that is white in the property's block group	Census 2010
High school	Percentage of the population with only a high school education in the property's block group	Census 2010
College	Percentage of the population with a high school education in the property's block group	Census 2010

Table 2 Descriptive statistics

Variables	Mean	SD	Min	Max
Sale price (USD 2016)	160,408	89,790.19	20,000	1,275,000
Structural				
Square footage	2005.71	905.31	525	9122
Age	50.01	32.91	0	139
Acreage	0.19	0.13	0.1	2.58
Bathrooms	2.12	0.88	1	6
Bedrooms	3.47	0.99	1	10
Fireplace	0.44	0.50	0	1
Pool	0.02	0.15	0	1
Air conditioning	0.62	0.49	0	1
HOA Monthly Fee	14.47	43.85	0	600
Geographic				
Nearest trailhead (min)	5.52	2.30	1	13
22nd St. (min)	9.41	3.39	1	21
29th St. (min)	10.75	4.07	1	24
East Bench (min)	8.92	3.48	1	21
Ogden Divide (min)	17.41	5.46	1	30
Ogden Nature Center (min)	9.13	4.51	1	20
North Ogden (min)	9.12	4.51	1	20
Beus Canyon (min)	12.97	5.01	1	27
Adjacent	0.06	0.24	0	1
View	0.72	0.45	0	1
Elevation (feet)	4463.59	176.53	4241.40	5250
Mountain (miles)	1.15	0.67	0.018	4.017
Ogden CBD (min)	6.31	3.11	1	17
Neighborhood				
School quality (0–600)	321.21	43.58	253	394
Income	51,158	19,558	11,118	131,394
Black	0.01	0.02	0	0.08
Hispanic	0.26	0.17	0	0.64

Table 2 continued

Variables	Mean	SD	Min	Max
White	0.81	0.12	0.53	1
High school	0.25	0.09	0.06	0.55
College	0.21	0.14	0	0.61

that independent variables should be linear ($p = 0.234$). Therefore, we specify the hedonic function as:

$$\ln P = \beta_1 S + \beta_2 G + \beta_3 N + \beta_4 T + \varepsilon. \quad (1)$$

The dependent variable, $\ln P$, is the natural log of the arm's-length transaction real price of single-family home. The term S is a vector of structural explanatory variables including house and parcel characteristics such as square footage, parcel acreage, year built, number of bedrooms, bathrooms, the presence of a pool and fireplaces; the term G is a vector of geographic attributes including travel time to the trailheads, view of the mountains, travel time to the Central Business District, Euclidean distance to the mountains, and a variable representing homes that border a trailhead; and the term N is a vector of neighborhood characteristics including elementary school quality and socioeconomic characteristics of the neighborhood. Lastly, the term T is comprised of a set of year and quarterly fixed effects, included to capture time-varying or seasonal effects.

4.2 Spatial models

The linear regression specification above ignores any spatial dependence between observations in the data that is not captured directly by the observed neighborhood attributes. However, house prices tend to be spatially correlated as neighboring houses are inherently more similar than houses farther away. Location fixed effects at the neighborhood level is a common method to model the correlation and has been shown to reduce bias in economic values (Kuminoff et al. 2010), but this imposes sharp artificial geographic breaks and a uniform relationship within the regions (Bockstael 1996). It is possible to fix the uniform relationship within regions by interacting the fixed effects with explanatory variables, but this quickly uses up degrees of freedom and the researcher is left with the problem of deciding which variables to interact (McMillen and Redfearn 2010).[1]

[1] In addition to spatial fixed effects (Abbott and Klaiber 2010) and spatial parametric models (Anselin 1988), there are a wide variety of other techniques used to correct for spatial data issues, including geographically weighted regression (McMillen 2010), mixed geographically weighted regression (Helbich et al. 2013), generalized additive models (Hastie and Tibshirani 1990), and semi-parametric models (McMillen 2003). An overview and application of spatial econometric techniques as it applies to hedonic price models for a housing sample in Norway is presented by Osland (2010).

Spatial specifications provide one solution by directly modeling the spatial correlation (Anselin 1988). Spatial parametric models explicitly specify the nature of the spatial dependence. The spatial Durbin error model (SDEM) is a generalized spatial model that incorporates both spatial error dependence (SEM) and the spatial lag of independent variables (SLX). The SDEM is best used when there is the possibility for local spillovers (Lesage 2014). Local spatial dependence assumes that spillovers are easier to transmit within than between geographic regions, such as neighborhoods. Because we are modeling house prices at a fine spatial scale, we are more concerned with localized spatial effects than global spatial spillovers. Gibbons and Overman (2012) outline common identification problems in the spatial autoregressive model, consequently arguing the reduced-form parameter estimates from SLX are preferable for informing policy. Vega and Elhorst (2015) also recommend the SLX model absent strong theoretical justification for an alternate specification. We therefore use the SDEM, which allows for both the advantages of the SLX, but also adds flexibility by allowing the model to simplify to the SEM depending on the model fit (Lesage 2014). The SDEM is specified as

$$
\begin{aligned}
y &= X\gamma_1 + WX\gamma_2 + \varepsilon \\
\varepsilon &= \lambda W\varepsilon + u \\
u &\sim N\left(0, \sigma^2\right),
\end{aligned}
\tag{2}
$$

where y is a function of a spatial weight matrix W, used to spatially lag the explanatory variables X and the error term, ε. In a hedonic house price model, the spatial lagging of independent variables allows for the characteristics of neighboring houses to influence the price of a given home. The marginal implicit price associated with an attribute consists of direct effects due to the change in the amount of the house's attribute, and indirect effects due to marginal changes related to characteristics of neighboring homes. Finally, u is a normally distributed error term. When $\gamma_2 = 0$ this model simplifies to the typical SEM. If the SEM is the correct specification, OLS estimates of the standard errors are biased since OLS estimation ignores the error structure (Dubin 1988), and thus a SEM will improve the precision of the estimated parameters (Osland 2010). If $\lambda = 0$, the resulting model is SLX, which accounts for spatial lags in the independent variables. The SDEM is particularly advantageous because it allows flexibility without requiring the researcher decide which of the many spatial models to use when dealing with localized spatial effects.

While a common critique of spatial parametric approaches is based on the difficulty in motivating the choice of the spatial weights matrix with economic theory (Bell and Bockstael 2000), there is growing support for modeling the spatial dependence even if the true spatial weights matrix is unknown (Corrado and Fingleton 2012; LeSage and Pace 2014). Further, spatial fixed effects may not remove spatial autocorrelation when the data actually exhibit spatial lag or error dependence (Anselin and Arribas-Bel 2013). LeSage and Pace (2014) show that spatial weight structures are reasonably robust to various specifications. In our research context, absent a theoretical motivation that would suggest a particular weights matrix specification, we use a log-likelihood selection procedure that is generally successful at selecting robust model specifications (Stakhovych and Bijmolt 2009). Models were run with different spatial weight approaches: inverse distance matrices and n-nearest neighbors ($n = 1$–30).

5 Results

Table 3 presents the regression results for the estimation of the standard, non-spatial, hedonic pricing model. Column 1 is the baseline model without any spatial or neighborhood controls. Column 2 controls for neighborhood characteristics including elementary school quality, and socioeconomic variables at the census block group level. Column 3 explicitly controls for different neighborhoods by using spatial fixed effects at the Neighborhood Scout designated neighborhood boundaries. Neighborhood Scout designations are 10 times more finely grained than the average zip code and use crime data, public school ratings, and demographics such as population, migration, lifestyle suitability, walkability, cultural character, education, incomes, ages, employment, and diversity. For brevity of presentation, outputs for quarterly and yearly fixed effects are omitted. All control variables except the travel times are standardized to mean 0, standard deviation of 1, to facilitate convergence in the later spatial models.

Beginning with the structural and location characteristics, we find that nearly all of these variables are statistically significant with the expected sign. Square footage and property acreage both have significantly positive associations with house price. However, the marginal effects of both variables diminish as the variable size increases due to the statistically significant negative parameter on the squared term. House age also has a significant quadratic relationship. Older houses correspond to lower sales prices, but at a diminishing rate as age increases. The number of bedrooms and bathrooms, and the presence of a fireplace all have positive relationships with house prices. Pools have a negative relationship, but the effect is statistically insignificant in most models, on sales price, likely to the high upkeep (pools in Ogden are almost all heated due to the cold night temperatures), and there are fewer households interested in purchasing a house with a pool. Air conditioning has a positive influence on house prices. Unsurprisingly, houses at higher elevation also have higher sales prices; each standard deviation (176 feet) higher in elevation is associated with 6.5–9.4% higher home values. Ogden frequently has temperature inversions that result in poor air quality, which is mitigated by living at higher elevations above the smog. High elevations also correspond to better views. While we explicitly control for the presence of a view, which also has a strong, positive relationship, we are not able to differentiate between the quality of different views. Proximity to the mountains is not statistically significant in any of the specifications, likely being picked up by the elevation variable. Travel time to Ogden's CBD has a negative price gradient, as there is a premium for houses with a shorter driving time to downtown.

Column 2 presents regression results with the inclusion of neighborhood and socioeconomic indicators. The relationship between the structural attributes and house prices remains largely unchanged from the results presented in Column 1. Houses in areas with higher-quality schools are found to have no relationship with higher sale prices once you control for socioeconomic neighborhood attributes. Education levels and racial composition of neighborhoods are the main socioeconomic drivers of house

Table 3 Linear regression results nearest trailhead—dependent variable: real log sale price (2016 USD)

Variables	1	2	3
Nearest trailhead	− 0.014**	− 0.010**	− 0.015**
	(0.004)	(0.004)	(0.005)
Adjacent	0.007	0.022	0.002
	(0.016)	(0.015)	(0.016)
Square footage	0.278**	0.269**	0.263**
	(0.021)	(0.021)	(0.021)
Square footage-squared	− 0.115**	− 0.110**	− 0.098**
	(0.019)	(0.020)	(0.020)
Age	− 0.313**	− 0.358**	− 0.348**
	(0.023)	(0.023)	(0.024)
Age-squared	0.132**	0.174**	0.176**
	(0.024)	(0.024)	(0.024)
Acreage	0.088**	0.082**	0.087**
	(0.011)	(0.011)	(0.011)
Acreage-squared	− 0.043**	− 0.042**	− 0.044**
	(0.010)	(0.009)	(0.009)
Bathrooms	0.017*	0.013+	0.016*
	(0.008)	(0.007)	(0.007)
Bedrooms	0.035**	0.038**	0.038**
	(0.007)	(0.006)	(0.006)
Fireplace	0.027**	0.020**	0.020**
	(0.005)	(0.005)	(0.005)
Pool	− 0.007	− 0.004	− 0.007+
	(0.004)	(0.004)	(0.004)
Air conditioning	0.060**	0.054**	0.049**
	(0.005)	(0.005)	(0.005)
HOA Monthly Fee	− 0.043**	− 0.047**	− 0.037**
	(0.007)	(0.008)	(0.007)
View	0.019**	0.017**	0.016**
	(0.005)	(0.005)	(0.005)
Elevation	0.077**	0.045**	0.017
	(0.006)	(0.008)	(0.015)
Mountain	− 0.004	0.012	0.014
	(0.011)	(0.011)	(0.016)
Ogden CBD	− 0.018**	− 0.048**	0.043*
	(0.007)	(0.007)	(0.017)
School quality		0.005	
		(0.006)	
Income		0.013	
		(0.008)	

Table 3 continued

Variables	1	2	3
Black		− 0.034**	
		(0.006)	
White		− 0.019+	
		(0.010)	
Hispanic		− 0.068**	
		(0.014)	
High school		0.048**	
		(0.006)	
College		0.057**	
		(0.010)	
Constant	11.818**	11.799**	11.803**
	(0.025)	(0.025)	(0.053)
Observations	2711	2711	2711
R-squared	0.782	0.801	0.812
Location FE	No	No	Neighborhoods
Quarter FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Robust standard errors in parentheses
All non-trailhead variables are standardized with mean 0, standard deviation of 1
** $p < 0.01$, * $p < 0.05$, + $p < 0.1$

prices in this area; however, school quality and income are moderately correlated with college education and racial composition, suggesting the effect of school quality on housing in this area is captured through socioeconomic factors.

Column 3 presents regression results from a model controlling for neighborhood attributes with spatial fixed effects using Neighborhood Scout designated boundaries. Again, the effects of most structural and geographic attributes remain similar. One change is that elevation is no longer significantly associated with house price, likely due to the limited variation in elevation within neighborhoods.

The results of all three models presented in Table 3 indicate that trailheads are highly valued in Ogden, as closer access to the trail network is capitalized into house prices.[2] For each minute closer to the nearest trailhead there is between a 1.0 and 1.5% premium for house prices. Table 4 presents three identical models (full results are given in "Appendix" Table 7) exploring the premium for different trailheads within Ogden rather than only the nearest trailhead. We were only able to include the minimum travel

[2] The results in this paper are best interpreted as capitalization measures. Stronger assumptions are needed to extrapolate our findings of a capitalization effect into willingness-to-pay (WTP) since household sorting behavior may cause there to be a correlation between latent household characteristics and trail accessibility (Kuminoff and Pope 2014). For example, if a new trailhead were introduced, the adjustment to the hedonic function would cause households' WTP to not equal the capitalization effect (Kuminoff and Pope 2014). We thank an anonymous reviewer for drawing our attention to this dynamic.

Table 4 Linear regression results different trailheads—dependent variable: real log sale price (2016 USD)

Variables	1	2	3
East Bench trailheads	− 0.028**	− 0.021**	− 0.014**
	(0.004)	(0.004)	(0.005)
North Ogden trailheads	− 0.007*	− 0.001	− 0.002
	(0.003)	(0.003)	(0.005)
Beus Canyon trailhead	− 0.010**	− 0.007**	− 0.008**
	(0.001)	(0.001)	(0.002)
Adjacent	− 0.017	0.008	0.001
	(0.016)	(0.015)	(0.016)
Constant	12.163**	12.013**	11.947**
	(0.051)	(0.052)	(0.075)
Observations	2711	2711	2711
R-squared	0.789	0.804	0.813
Structural controls	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes
Neighborhood controls	No	Census variables	Neighborhood FE
Quarter FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Robust standard errors in parentheses
** $p < 0.01$, * $p < 0.05$, + $p < 0.1$

time for trailheads in different areas of the city due to the high correlation in travel time to two pairs of trailheads: the 22nd and 29th Street trailheads (correlation 0.85) and the Ogden Divide trailhead and the Ogden Nature Center trailhead (correlation 0.93). Therefore in regressions which include multiple trailheads, the minimum travel time from the 22nd and 29th Street trailheads is calculated as the East Bench trailheads, and the minimum travel time from Ogden Divide and Ogden Nature Center is calculated as the North Ogden trailheads.[3] We also tested the correlation of other geographic variables in our dataset and found the strongest correlation exists between elevation and distance to the mountains with a correlation of − 0.5746. We further explored the variance inflation factor (VIF) due to concerns about multicollinearity. All variable have a VIF under 6, suggesting multicollinearity is not a significant concern. Referring to Column 1, the coefficients on all three of the trailheads are negative and statistically significant at the 0.05 level; these trails have the expected relationship that the closer a home is to a trailhead, the higher the value, *ceteris paribus*. Adding in neighborhood attributes (Column 2) or neighborhood fixed effects (Column 3), we find the magnitude of the point estimate to decrease for all three trailheads, and North Ogden trailheads are no longer statistically significantly related to house prices. However, the East Bench

[3] Combining the valuation of these trailheads also makes intuitive sense due to the overlap in the trails for which they provide access.

Table 5 Spatial Durbin error model regression—dependent variable: real log sale price (2016 USD)

Variables	SDEM (1)			SDEM (2)		
	Direct	Indirect	Total	Direct	Indirect	Total
Nearest trailhead	−0.007*	−0.013+	−0.020*			
	(−1.997)	(−1.904)	(−2.035)			
East Bench trailheads				0.024**	−0.056*	−0.080**
				(−7.158)	(−2.286)	(−3.115)
North Ogden trailheads				−0.016**	−0.036+	−0.052*
				(−5.213)	(−1.811)	(−2.322)
Beus Canyon trailhead				−0.006**	−0.014*	−0.021**
				(−4.384)	(−2.354)	(−3.110)
Adjacent	0.048*	0.093+	0.141*	0.010	0.024	0.034
	(2.911)	(1.824)	(2.181)	(0.606)	(0.568)	(0.588)
Observations		2711			2711	
AIC		−847.08			−868.48	
Structural controls		Yes			Yes	
Geographic controls		Yes			Yes	
Neighborhood controls		No			No	
Quarter FE		Yes			Yes	
Year FE		Yes			Yes	

Simulated z values in parentheses
** $p < 0.01$, * $p < 0.05$, + $p < 0.1$

trailheads and the Beus Canyon trailhead are statistically significant at the 0.01 level throughout all specifications.

The East Bench trailheads are the most highly valued, associated with a 1.4–2.8% increase in home values for each minute less in driving time to the trailheads. Using an average house price of $160,000, each minute closer to an East Bench trailhead corresponds to a premium between $2240 and $4480. The North Ogden trailheads are valued less; they are associated with a 0–0.70% premium for each minute less in driving time, corresponding to a premium of $0–$1120 for the average priced home. The Beus Canyon trailhead in southern Ogden is valued between 0.8 and 1.0% of home values, resulting in a $1280–$1600 premium for each minute less in driving time to the trailhead, again for a home valued at $160,000.

Results from the SDEM yield similar signs and significance of coefficients for the structural and location variables to the prior regressions. The condensed findings focusing on the relationship between trailheads and house prices are shown in Tables 5 and 6. (The full results are given in Tables 8, 9 in "Appendix.") The best fitting model used an inverse distance matrix with a cutoff distance of a half mile (Table 5 Column 1: AIC = −847.08), while the second best was 18-nearest neighbor matrix (for the same specification: AIC = −835.63). The λ parameter is statistically significant ($p < 0.01$) in all four SDEM regressions with parameter estimates between 0.928 and 0.974, demonstrating significant spatial correlation in the residuals. Access to

Table 6 Spatial Durbin error model regression with neighborhood variables—dependent variable: real log sale price (2016 USD)

Variables	SDEM (1)			SDEM (2)		
	Direct	Indirect	Total	Direct	Indirect	Total
Nearest trailhead	– 0.006^{+}	– 0.008^{+}	– 0.014^{+}			
	(– 1.742)	(– 1.694)	(– 1.772)			
East Bench trailheads				– 0.019**	– 0.028*	– 0.047**
				(– 5.631)	(– 2.565)	(– 3.633)
North Ogden trailheads				– 0.010**	– 0.015^{+}	– 0.025*
				(– 2.993)	(– 1.753)	(– 2.170)
Beus Canyon trailhead				– 0.004**	– 0.006*	– 0.011**
				(– 2.749)	(– 2.339)	(– 2.712)
Adjacent	0.048**	0.059*	0.108*	(0.022	0.032	0.054
	(3.233)	(2.276)	(2.761)	(1.305)	(1.165)	(1.250)
Structural controls		Yes			Yes	
Geographic controls		Yes			Yes	
Neighborhood controls		Yes			Yes	
Observations		2711			2711	
AIC		– 930.47			– 938.01	
Quarter FE		Yes			Yes	
Year FE		Yes			Yes	

Simulated z values in parentheses
** $p < 0.01$, * $p < 0.05$, $^{+}p < 0.1$

any trailhead is associated with a direct effect of between 0.6% (when controlling for neighborhood variables in Table 6) and 0.7% (when not including neighborhood attributes in Table 5) increase in home values for each minute closer the house is located to a trail, smaller than the OLS parameter. However, the total effect is between 1.4% (controlling for neighborhood attributes) and 2.0% (without neighborhood attributes). It is important to note the total impact is smaller when controlling for neighborhood attributes in comparison with regressions that omit neighborhood attributes (Table 5). Failing to account for neighborhood characteristics likely results in biased estimates due to omitted spatial variables. From the second model presented in Table 6, we find each minute closer to the East Bench trailheads is associated with a 1.9% higher home price, each minute closer to the Beus Canyon trailhead is associated with a 0.4% higher home price, and the North Ogden trailheads are associated with a 1.0% premium for each minute less driving time to the trailhead. These estimates are lower than those in Table 5, which omit neighborhood attributes. Additionally, accounting for the indirect effects of these trailheads results in much larger valuations than only looking at direct effects. For example, proximity to the East Bench trailheads is associated with a 4.7% premium for each minute saved in driving time from a home to a trailhead when looking at the total effect, which is approximately three times larger than when only considering the direct effect. The Beus Canyon trailhead's total effect is a 1.1% premium, again approximately three times larger than the direct effect only. Finally, North Ogden trailheads' total effects are a 2.5% premium for each minute less driving time to the trailhead. Again, these estimated premiums for living closer to trailheads are smaller in Table 6 where socioeconomic and neighborhood characteristics are included in the model than in Table 5. Based on both economic theory and the AIC, we believe the models in Table 6 are preferable, and the inclusion of neighborhood controls in the SDEM provides unbiased estimates of the trailhead premium.

We also test to see whether adjacency to a trailhead is associated with an additional premium, or whether concerns from increased pedestrian and dog traffic, potential crime, and loss of privacy negatively impact house prices. The presented results measure adjacency using the 500-foot buffer to ensure there are a reasonable number of observations adjacent to the trailheads. The results are consistent across most specifications, and the results using smaller buffers yield insignificant results for all specifications; however, there are very few observations within the smaller buffers. We find no statistically significant effect for adjacency to these trailheads in all OLS specifications or SDEM specifications that measure individual trailheads. We do find a premium for adjacent properties in the SDEM that only considers travel time to the nearest trailhead; however, this result is not robust to all specifications. The insignificant or positive parameter estimates suggest any potential negative externalities from being located directly next to the trailhead are countered by the benefits from easier access to the trailheads.

6 Conclusion

Empirical research evaluating the benefits outdoor recreation communities derive from access to open space as an urban green amenity is an important contribution to local policy discussions. While other studies have investigated the premium for green open space and access to that open space, our research advances prior research by using spatial hedonic models to value trail access in an area in the Rocky Mountain West.

Our study focuses on a community with many outdoor enthusiasts. In this community we find positive and significant valuation of trailheads. An SDEM model was used to address spatial dependence in the error term as well as localized spatial spillovers. We also examine the price gradient for travel times for different trailheads within the city. Specifically, we find decreasing the travel time for residents of just one minute on average to the closest trailhead would be associated with an increase in property values by 0.6% in the most conservative direct effect estimate to 1.4% when also accounting for indirect effects. We also examine the price gradient for travel times for different trailheads within the city. We find substantial variation in these gradients, and that specific trailheads in the city are highly valued. The direct premiums for the different trailheads are 1.9, 1.0 and 0.4% for each minute closer in driving time, using results from the preferred model that includes neighborhood controls.

Understanding the impact of trailheads is particularly valuable for urban planners interested in a range of issues from tax revenue collection, environmental justice, and the design of urban areas for improving the quality of life for residents. However, continued research is needed to examine the long-term demographic changes to the

Rocky Mountain West that increasing green amenities may cause. There also might be feedback from these demographic changes that increase or plateau valuation of trail-heads, for example if the trails become congested, as well as impact the community in numerous other ways. Furthermore, the increased property values associated with travel time to trailheads may unintentionally price certain populations out of neighborhoods. Overall, we conclude there is a large premium for better access to trails, measured as shorter driving times to trailheads, and there is no negative price impact for houses located directly adjacent to the trailheads.

Appendix

See Tables 7, 8, and 9.

Table 7 Linear regression results different trailheads—dependent variable: real log sale price (2016 USD)

Variables	1	2	3
East Bench trailheads	– 0.028**	– 0.021**	– 0.014**
	(0.004)	(0.004)	(0.005)
North Ogden trailheads	– 0.007*	– 0.001	– 0.002
	(0.003)	(0.003)	(0.005)
Beus Canyon trailhead	– 0.010**	– 0.007**	– 0.008**
	(0.001)	(0.001)	(0.002)
Adjacent	– 0.017	0.008	0.001
	(0.016)	(0.015)	(0.016)
Square footage	0.269**	0.266**	0.259**
	(0.021)	(0.021)	(0.021)
Square footage-squared	– 0.105**	– 0.105**	– 0.095**
	(0.020)	(0.020)	(0.020)
Age	– 0.317**	– 0.354**	– 0.342**
	(0.023)	(0.023)	(0.024)
Age-squared	0.144**	0.176**	0.173**
	(0.024)	(0.024)	(0.024)
Acreage	0.086**	0.080**	0.088**
	(0.011)	(0.011)	(0.011)

Table 7 continued

Variables	1	2	3
Acreage-squared	− 0.041**	− 0.040**	− 0.044**
	(0.009)	(0.009)	(0.009)
Bathrooms	0.016*	0.012+	0.015*
	(0.008)	(0.007)	(0.007)
Bedrooms	0.035**	0.038**	0.037**
	(0.007)	(0.006)	(0.006)
Fireplace	0.025**	0.020**	0.020**
	(0.005)	(0.005)	(0.005)
Pool	− 0.008+	− 0.005	− 0.007+
	(0.004)	(0.004)	(0.004)
Air conditioning	0.056**	0.052**	0.048**
	(0.005)	(0.005)	(0.005)
HOA Monthly Fee	− 0.040**	− 0.045**	− 0.036**
	(0.007)	(0.008)	(0.007)
View	0.017**	0.016**	0.016**
	(0.005)	(0.005)	(0.005)
Elevation	0.074**	0.030+	0.034+
	(0.016)	(0.017)	(0.018)
Mountain	0.030*	0.019	0.019
	(0.014)	(0.014)	(0.018)
Ogden CBD	0.072**	0.022	0.057**
	(0.017)	(0.017)	(0.020)
School quality		− 0.003	
		(0.006)	
Income		0.018*	
		(0.008)	
Black		− 0.027**	
		(0.006)	
White		− 0.027**	
		(0.010)	
Hispanic		− 0.072**	
		(0.015)	
High school		0.052**	
		(0.006)	
College		0.052**	
		(0.010)	
Constant	12.163**	12.013**	11.947**
	(0.051)	(0.052)	(0.075)
Observations	2711	2711	2711

Table 7 continued

Variables	1	2	3
R-squared	0.789	0.804	0.813
Location FE	No	No	Neighborhoods
Quarter FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Robust standard errors in parentheses
All non-trailhead variables are standardized with mean 0, standard deviation of 1
** $p < 0.01$, * $p < 0.05$, $^{+}$ $p < 0.1$

Table 8 Spatial Durbin error model regression—dependent variable: real log sale price (2016 USD)

Variables	SDEM (1)			SDEM (2)		
	Direct	Indirect	Total	Direct	Indirect	Total
Nearest trailhead	−0.007*	−0.013^{+}	−0.020*			
	(−1.997)	(−1.904)	(−2.035)			
East Bench trailheads				−0.024**	−0.056*	−0.080**
				(−7.158)	(−2.286)	(−3.115)
North Ogden trailheads				−0.016**	−0.036^{+}	−0.052*
				(−5.213)	(−1.811)	(−2.322)
Beus Canyon trailhead				−0.006**	−0.014*	−0.021**
				(−4.384)	(−2.354)	(−3.110)
Adjacent	0.048*	0.093^{+}	0.141*	0.010	0.024	0.034
	(2.911)	(1.824)	(2.181)	(0.606)	(0.568)	(0.588)
Square footage	0.253**	0.490**	0.743**	0.246**	0.561*	0.807**
	(13.383)	(2.763)	(4.026)	(11.314)	(2.279)	(3.179)
Square footage-squared	−0.097**	−0.188*	−0.286**	−0.090**	−0.205*	−0.295**
	(−5.131)	(−2.430)	(−3.217)	(−4.413)	(−2.043)	(−2.659)
Age	−0.252**	−0.489**	−0.742**	−0.256**	−0.584*	−0.839**
	(−10.142)	(−3.006)	(−4.455)	(−10.447)	(−2.426)	(−3.425)
Age-squared	0.088**	0.170*	0.258**	0.097**	0.222*	0.319**
	(3.537)	(2.505)	(3.064)	(3.919)	(2.162)	(2.758)
Acreage	0.082**	0.160*	0.242**	0.079**	0.181*	0.260**
	(7.780)	(2.551)	(3.561)	(7.176)	(2.349)	(3.225)
Acreage-squared	−0.038**	−0.075*	−0.113**	−0.036**	−0.082*	−0.119**
	(−4.370)	(−2.309)	(−2.993)	(−4.031)	(−2.144)	(−2.737)
Bathrooms	0.020**	0.038*	0.058*	0.020*	0.045	0.064^{+}
	(2.665)	(1.977)	(2.298)	(2.655)	(1.590)	(1.925)
Bedrooms	0.036**	0.069**	0.105**	0.036**	0.082*	0.118**
	(6.086)	(2.578)	(3.516)	(5.797)	(2.170)	(2.883)
Fireplace	0.025**	0.049**	0.075**	0.023**	0.053^{+}	0.076*
	(5.382)	(2.754)	(3.660)	(4.516)	(1.903)	(2.451)

Table 8 continued

Variables	SDEM (1)			SDEM (2)		
	Direct	Indirect	Total	Direct	Indirect	Total
Pool	− 0.008^{+}	− 0.015	− 0.023	− 0.008*	− 0.018	− 0.026
	(− 1.801)	(− 1.457)	(− 1.622)	(− 2.084)	(− 1.328)	(− 1.556)
Air conditioning	0.057**	0.111**	0.168**	0.054**	0.124*	0.179**
	(10.965)	(2.664)	(3.841)	(10.094)	(2.189)	(3.007)
HOA Monthly Fee	− 0.041**	− 0.080**	− 0.122**	− 0.038**	− 0.087*	− 0.126**
	(− 5.841)	(− 2.635)	(− 3.576)	(− 5.661)	(− 2.245)	(− 2.994)
View	0.022**	0.042*	0.064**	0.019**	0.042^{+}	0.061*
	(4.367)	(2.133)	(2.733)	(4.050)	(1.783)	(2.259)
Elevation	0.003	0.006	0.009	0.050**	0.115*	0.165**
	(0.344)	(0.050)	(0.138)	(3.385)	(2.054)	(2.518)
Mountain	− 0.034**	− 0.067^{+}	− 0.101*	0.041**	0.093^{+}	0.134*
	(− 3.071)	(− 1.657)	(− 2.026)	(3.037)	(1.772)	(2.133)
Ogden CBD	− 0.081**	− 0.158*	− 0.239**	− 0.016	− 0.037	− 0.053
	(− 8.739)	(− 2.120)	(− 2.862)	(− 0.822)	(− 0.682)	(− 0.733)
Observations		2711			2711	
AIC		− 847.08			− 868.48	
Quarter FE		Yes			Yes	
Year FE		Yes			Yes	

Simulated z values in parentheses
All non-trailhead variables are standardized with mean 0, standard deviation of 1
** $p < 0.01$, * $p < 0.05$, $^{+}$ $p < 0.1$

Table 9 Spatial Durbin error model regression with neighborhood variables—dependent variable: real log sale price (2016 USD)

Variables	SDEM (1)			SDEM (2)		
	Direct	Indirect	Total	Direct	Indirect	Total
Nearest trailhead	− 0.006^{+}	− 0.008^{+}	− 0.014^{+}			
	(− 1.742)	(− 1.694)	(− 1.772)			
East Bench trailheads				− 0.019**	− 0.028*	− 0.047**
				(− 5.631)	(− 2.565)	(− 3.633)
North Ogden trailheads				− 0.010**	− 0.015^{+}	− 0.025*
				(− 2.993)	(− 1.753)	(− 2.170)
Beus Canyon trailhead				− 0.004**	− 0.006*	− 0.011**
				(− 2.749)	(− 2.339)	(− 2.712)
Adjacent	0.048**	0.059*	0.108*	(0.022	0.032	0.054
	(3.233)	(2.276)	(2.761)	(1.305)	(1.165)	(1.250)
Square footage	0.250**	0.307**	0.557**	0.246**	0.364**	0.610**
	(13.495)	(3.635)	(6.144)	(12.359)	(2.932)	(4.713)

Table 9 continued

Variables	SDEM (1)			SDEM (2)		
	Direct	Indirect	Total	Direct	Indirect	Total
Square footage-squared	− 0.096**	− 0.117**	− 0.213**	− 0.091**	− 0.135*	− 0.226*
	(− 5.170)	(− 3.303)	(− 4.458)	(− 4.738)	(− 2.549)	(− 3.534)
Age	− 0.306**	− 0.375**	− 0.682**	− 0.300**	− 0.444**	− 0.744**
	(− 13.589)	(− 3.822)	(− 6.669)	(− 14.814)	(− 3.004)	(− 4.899)
Age-squared	0.136**	0.166**	0.302*	0.135**	0.199**	0.334**
	(5.989)	(3.434)	(4.925)	(6.668)	(2.796)	(4.118)
Acreage	0.078**	0.095**	0.173**	0.076**	0.113**	0.189**
	(6.723)	(3.560)	(5.248)	(7.336)	(2.737)	(4.038)
Acreage-squared	− 0.038**	− 0.047**	− 0.085**	− 0.037**	− 0.054*	− 0.091**
	(− 4.285)	(− 3.245)	(− 4.094)	(− 4.502)	(− 2.534)	(− 3.388)
Bathrooms	0.016*	0.020+	0.036*	0.016*	0.024+	0.040*
	(2.525)	(1.945)	(2.279)	(2.515)	(1.769)	(2.108)
Bedrooms	0.038**	0.046**	0.084**	0.038**	0.056**	0.095**
	(6.100)	(3.226)	(4.614)	(5.999)	(2.621)	(3.770)
Fireplace	0.020**	0.024**	0.044**	0.019**	0.028*	0.048**
	(3.869)	(2.656)	(3.348)	(4.236)	(2.276)	(2.990)
Pool	− 0.006	− 0.007	− 0.013	− 0.006	− 0.008	− 0.014
	(− 1.461)	(− 1.305)	(− 1.407)	(− 1.406)	(− 1.175)	(− 1.296)
Air conditioning	0.052**	0.064**	0.117**	0.051**	0.076**	0.127**
	(10.490)	(3.454)	(5.596)	(9.841)	(2.887)	(4.497)
HOA Monthly Fee	− 0.046**	− 0.057**	− 0.103**	− 0.043**	− 0.064**	− 0.107**
	(− 5.471)	(− 2.937)	(− 4.079)	(− 5.834)	(− 2.880)	(− 4.162)
View	0.020**	0.024*	0.043**	0.018**	0.026*	0.044**
	(4.296)	(2.558)	(3.359)	(3.931)	(2.154)	(2.806)
Elevation	− 0.008	− 0.010	− 0.019	0.021	0.030	0.051
	(− 0.715)	(− 0.701)	(− 0.717)	(1.169)	(1.082)	(1.144)
Mountain	− 0.013	− 0.015	− 0.028	0.033*	0.048*	0.081+
	(− 1.067)	(− 1.014)	(− 1.055)	(2.286)	(1.663)	(1.945)
Ogden CBD	− 0.092**	− 0.113**	− 0.205**	− 0.036*	− 0.054	− 0.090+
	(− 10.667)	(− 2.933)	(− 4.490)	(− 2.282)	(− 1.520)	(− 1.799)
School quality	0.003	0.004	0.007	− 0.004	− 0.005	− 0.009
	(0.546)	(0.507)	(0.528)	(− 0.647)	(− 0.626)	(− 0.644)
Income	− 0.001	− 0.001	− 0.002	− 0.003	− 0.004	− 0.007
	(0.040)	(0.009)	(0.023)	(− 0.308)	(− 0.383)	(− 0.359)
Black	− 0.028**	− 0.035**	− 0.063**	− 0.023**	− 0.034*	− 0.057**
	(− 4.910)	(− 2.942)	(− 3.984)	(− 4.400)	(− 2.425)	(− 3.220)
White	− 0.024*	− 0.029+	− 0.053*	− 0.028**	− 0.042+	− 0.070*
	(− 2.293)	(− 1.788)	(− 2.054)	(− 2.760)	(− 1.882)	(− 2.294)

Table 9 continued

Variables	SDEM (1)			SDEM (2)		
	Direct	Indirect	Total	Direct	Indirect	Total
Hispanic	−0.071**	−0.087**	−0.157**	−0.064**	−0.095*	−0.160**
	(−5.201)	(−2.708)	(−3.703)	(−4.783)	(−2.402)	(−3.269)
High school	0.043**	0.053**	0.096**	0.041**	0.060**	0.101**
	(7.858)	(3.637)	(5.662)	(6.712)	(2.861)	(4.272)
College	0.049**	0.060**	0.109**	0.050**	0.074**	0.125**
	(5.245)	(3.302)	(4.543)	(5.251)	(2.659)	(3.733)
Observations		2711			2711	
AIC		−930.47			−938.01	
Quarter FE		Yes			Yes	
Year FE		Yes			Yes	

Simulated z values in parentheses
All non-trailhead variables are standardized with mean 0, standard deviation of 1
** $p < 0.01$, * $p < 0.05$, $^{+}$ $p < 0.1$

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