QUANTIFYING THE VALUATION OF URBAN GREEN SPACE PROXIMITY AMONG PHYSICALLY ACTIVE COMMUNITIES

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QUANTIFYING THE VALUATION OF URBAN GREEN SPACE PROXIMITY AMONG PHYSICALLY ACTIVE COMMUNITIES

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Mathematical Economics

Abstract

Urban and urban-adjacent green spaces have become more relevant for home buyers in the United States in recent years, with greater preference for the inclusion of natural environments within urban and suburban areas. The dominant explanation for this phenomenon is the mental and physical health advantages associated with physical activity and social spaces. Previous research has also determined that homeowner willingness-to-pay varies across urban green space type, size, and access while also varying across neighborhood and region. However, no studies have been conducted focusing on urban green spaces within physically active communities. This study uses data from Boulder County, Colorado and the United States Geological Survey to analyze the correlation between proximity to urban green spaces and property sale prices in a community which prioritizes healthy and sustainable living. The results in this study found that proximity to cemeteries, city-owned open space, city parks, national forest, and recreational spaces were positively correlated with property sale price, while proximity to county-owned open space, city-designated natural lands, and undeveloped green spaces were negatively correlated with property sale price. This supports previous conclusions regarding urban green space type and property prices, while expanding the literature on how physically active "outdoorsy" communities value urban green spaces.

KEYWORDS: (Green Space, Hedonic Pricing Model, Housing Prices, Geographic Information Systems)
JEL CODES: (Code, Code, Code)

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Introduction

The role of green space in urban communities has been a topic of interest for researchers, especially as health benefits associated with immersion in nature continue to come to light. Spending time in nature is widely accepted as having a positive impact on physical and mental health. Green spaces provide various health benefits by providing psychological relaxation and stress alleviation (WHO, 2016), while also providing essential ecosystem services, including mitigating the negative effects of urban heat islands (Aram, 2019). Additionally, there is evidence to suggest that green spaces allow for increased sociability (Enssle, 2020) and general quality of life (Boland, 1999). Mental health concerns among younger generations in developed countries continue to increase (Botha, 2023) and it is largely agreed that social ties play a beneficial role in the maintenance of psychological well-being (Kawachi, 2001). Thus, access to green spaces in urban and suburban environments is becoming increasingly important to new home buyers (Chen, 2022).

It is a well-documented fact that some houses that are similar in physical characteristics (square footage, number of beds/baths, property size, etc) will exhibit variation in sale prices. One potential driver of this price variation is proximity to urban green space (Kabisch, 2016). In addition to proximity, green space size (Neumann, 2009) and type (Hu, 2022) are also important in homeowner willingness-to-pay. While amenity access has been explored in-depth in the American Midwest (Hu, 2022) and Europe (Laszkiewicz, 2019), there is a noticeable gap in the existing literature of analysis conducted in the American Southwest. On a similar note, many studies attempt to generalize the impacts of urban green space on the general consumer; therefore

individuals living within a community that emphasizes physical activity within nature as a shared attribute may exhibit different results in relation to urban green spaces.

The premise of this study is to quantify the impact that proximity to urban green spaces has on property sales within a community that prioritizes physical activity and engagement with green spaces. The city of Boulder, Colorado remains tightly tied to its identity as an outdoorsy, physically active community of nature-lovers and adventurers. Thus, it is appropriate to use pre-pandemic housing sales and the geospatial location of urban and urban-adjacent green spaces in Boulder as a basis for the model.

This study uses a hedonic pricing model to predict property sale prices in Boulder, Colorado. Hedonic pricing models apply a multivariate regression to explain the price of a product using the attributes it possesses - in this study, each property has several characteristics (physical details about the property itself and linear distances to the nearest urban green space types) associated with it, along with a sale price. Thus, by estimating the coefficients of these characteristics, the hedonic pricing model will quantify the value that homeowners place on each attribute, allowing the study to identify the weight consumers place on distances to urban green space types. The physical property characteristics included in the model will be square footage of the property itself, the above-ground square footage of the house/structure on the property, the age of the house/structure (as of 2020), and the market subsection of Boulder the property is listed in. Urban green space types will include both city- and county-owned open space, community gardens, cemeteries, recreational spaces, city-designated natural lands, undeveloped land, National Forest lands, and golf courses in and around the city of Boulder. To best represent changes in property sale prices, the hedonic pricing model will

interpret percentage changes in property price using age of the house, house square footage , plot square footage, market area, and distances to each of the 9 urban and urban-adjacent green space types.

The results show that proximity (that is, decreased distance) to the public cemetery, city-owned open space, city parks, National Forest, and recreational spaces were correlated with increases in property sale price. Conversely, decreased proximity from county-owned open space, natural lands, and undeveloped land is correlated with increased property sale price. Increased age of a house is associated with a decrease in property price, while increased above-ground square footage of the house and increased property square footage both are correlated with increased property sale prices.

Most notably, for every percentage increase in distance from National Forest, property sale prices decreased by 0.091%, indicating that individuals have a higher willingness-to-pay for properties closer to National Forest land. The National Forest lands in this study were clustered at and around the base of the mountains west of Boulder, which likely demonstrates a preference for easy access to urban-adjacent green spaces with public access. To further support this, there was decreased willingness-to-pay for proximity to county-owned open space, which does not have an emphasis on residential services (and is not always publicly accessible). Within the city itself, proximity to recreational spaces experienced the highest willingness-to-pay by homeowners; for every percent increase in distance from these such sites, property sale prices are expected to decrease by 0.067%, supporting recreational green spaces as a valuable commodity for individuals within the community.

Because the study was only conducted for 6 years of property sales in the city of Boulder, it is limited in scale. Property sale prices are only publicly available for a short period of time, and thus this study could not have been expanded in scope without access to private information. Furthermore, while it is intentional to only explore the impacts of urban green spaces on property sale prices in the city of Boulder, this still limits the dataset of urban green space types to only active green spaces in the city — with only one or two data points for a few urban green space types, the model is not effective at predicting changes in property prices using distances to those spaces. Ultimately, distance to several urban green spaces (including community gardens and golf courses) were not significantly correlated with changes in housing sale prices in Boulder, despite there being evidence to the contrary in other settings (Nicholls, 2007).

This study provides new insight into the willingness-to-pay of homeowners in a physically active and self-identified nature-embracing community. It supports previous conclusions that urban green space valuation varies on type, while introducing how proximity to massive urban-adjacent green spaces impact the overall system of willingness-to-pay. This study contributes valuable content regarding the American Southwest and the Colorado Front Range region. It also provides a new analysis of how proximity to green spaces is related to housing prices within communities that prioritize engagement with natural spaces.

Background

According to Crompton's Proximate Principle, individuals exhibit a higher willingness-to-pay for property located close to environmental amenities (Crompton, 2004). This effect has been corroborated by multiple studies across the globe, utilizing a wide variety of approaches. However, there is a lack of literature exploring urban green spaces' perceived value in a highly physically active community. This study will focus primarily on Boulder, Colorado, a city in the American Southwest that has tied its identity strongly with its community health and 'outdoorsy' lifestyle. For this reason, it is necessary to create a definition for urban and urban-adjacent green spaces that encompasses the diversity of urban green spaces.

Literature Review

There is overwhelming empirical evidence that parks and open spaces contribute to increases in property values (Crompton, 2020). Previous studies have tended to focus on the impacts of one particular attribute of green space within a region. While this provides insight into the dynamic between housing prices and a specific urban green space, it fails to recognize the complex interplay of all forms of urban green spaces within a system. As green spaces become more critical in urban environments within the current cultural norm, interconnected park systems become even more vital to the health of the region (Dines, 2006). This transforms the lived environment into something greater than each individual open space. However, these initial studies are still essential in setting the baseline of research for which to construct this model upon.

It is established that urban open space size is important in the valuation of proximity. A study in Massachusetts (Neumann, 2009) found that a larger, homogeneous open space has a greater radius of influence (and a higher willingness-to-pay by property owners) than smaller open spaces, which is corroborated by an analysis in Oregon (Lutzenhiser, 2001) and in Poland (Laszkiewicz, 2019). Another study in Virginia (Poudyal, 2009) found that individuals place greater value on larger parks that are further away than smaller parks that are nearby.

The type of open space near a property was also found to have a significant impact on the property pricing of single-family homes (Bolitzer, 2000). Willingness-to-pay increases with proximity to woodlands (including shrubland and forest land) and non-developable open space (such as parks). Conversely, willingness to pay decreases with proximity to agricultural open space. A study in Canada (Hu, 2022) implied that individuals base a portion of their willingness-to-pay for housing on the scenic view and recreational uses of non-developable lands. Overall, green coverage had a significantly positive effect on the house's values, both directly and indirectly. While the structure of European cities is very different from North American cities, urban green spaces exhibited a similar result. A study in Poland (Laszkiewicz, 2019) explored marginal willingness-to-pay marginal willingness-to-pay for a collection of multi-dwelling apartments in the city center, splitting urban green spaces into categories (such as parks, forests, allotment gardens, and cemeteries). Using a baseline hedonic pricing model, it was found that general proximity to parks and forests affects apartment prices positively, while general proximity to cemeteries and allotment gardens is correlated with a negative impact on apartment prices. Neumann (2009) also found that proximity to a National

Wildlife Refuge, golf courses, and recreation parks is valued more than proximity to agricultural land, cemeteries, and conservation land.

Whether urban green spaces are perceived as a luxury good by property owners also impacts willingness-to-pay. The analysis of beachfront property in Florida (Kim, 2020) provides more insight into proximity-driven valuation of housing prices. Because the beachfront is considered a luxury good by many residents of Jacksonville Beach, the willingness-to-pay increased with adjacency to beach access points. This remains consistent with other studies of beach-proximity-driven property pricing in South Carolina (Pompe, 1994) and New Jersey (Major, 2004). Because of the unique nature of beaches as a dual-form recreation space (both terrestrial and aquatic) and societal perception of beaches as luxury spaces, the "coastal premium" (Conroy, 2009) of beaches provides a powerful case study for proximity-driven hedonic pricing. Similar to this, many residents of the city of Boulder prioritize an active lifestyle and their access to nature, whether in urban green spaces or parks outside of the city limits.

There is evidence to support the idea that access to a variety of urban green spaces in close proximity play an important role in willingness-to-pay. Many individuals do not use their nearest green space the most (Schipperijn, 2010). The Colorado Front Range provides an excellent case study: the collections of green spaces in suburban and urban regions are diverse in type and size, thus catering to a larger subset of individuals while providing variation in services. Furthermore, the proximity of major urban areas to federally designated open space and national forests allow for analysis of the effects of both inter-urban and ex-urban (urban-adjacent) green spaces on a single set of urban- and suburban residential properties. Having more parks in proximity may also be correlated

with higher levels of moderate-to-vigorous intensity physical activity (Poppe, 2022). Because a wider selection of parks may provide further incentive for individuals to engage in an active lifestyle, this is further evidence that proximity to urban open green spaces increases willingness-to-pay in regions where an active lifestyle is prioritized among the residents.

Not all individuals value green spaces equally. Individuals are willing to pay more for proximity to non-developable green open space and woodland-type regions (Hu, 2022). Park visitation rates also appear to prioritize convenience over park type (denoted by vegetation within the green spaces), with one notable exception. People with a greater orientation towards nature tend to travel further for more vegetated parks, indicating a preference for certain park types. (Shanahan, 2015). Thus, there are some similarities between nature-oriented individuals' preferences for housing and willingness to travel to parks.

It is important to recognize that green space value also varies by neighborhood. The value of proximity to open space is higher in neighborhoods that are dense, have higher income, or have a higher number of children per household (Anderson, 2006). Thus, any analysis performed must also control for the greater suburban and urban environmental context (Acharya, 2001) in which housing prices are sourced. While any open space may satisfy the requirement for the valuation, all urban green spaces provide the same open gap in developments, thus satisfying this preferred service in urban and suburban developments.

Defining Urban Green Space

This study will focus on urban green spaces and urban-adjacent green spaces. Previous literature evaluates a variety of open spaces, including urban green spaces and general green spaces. While urban open space is defined as regions within the built environment that have been reserved for parks and other recreational spaces (Kabisch, 2016), urban green spaces must include the natural "green" element — grasses, trees, and other plant life — in the region. Thus, they will not include recreation spaces with no outdoor components. For the purpose of this study, "blue spaces" — spaces including water features, such as Boulder Reservoir — will be considered part of the greater "green space" umbrella.

Because it has been found that green spaces are not uniform in their relative value, urban green spaces will be divided up into several categories: cemeteries, community gardens, golf courses, natural lands (within the city), city parks, recreational facilities, and undeveloped open space (as of 2019). These categories were not created for the sole purpose of the study; the city of Boulder has chosen to classify green spaces by these classifications. For the purposes of this study, urban-adjacent green spaces will be defined as green spaces outside of the city of Boulder (and thus not present in the previous dataset) but still close (while the radius of green spaces considered in this study is 18 miles from the city center, because only the space closest to any given property is translated into the dataset, data points that are too far away are expunged and thus do not pose any threat to the integrity of the data). This will be split into three primary categories: city-owned open space, county-owned open space, and forest-service owned land (such as Roosevelt National Forest).

Study Area

The role of green spaces in housing prices has remained relatively unsurveyed in the American Southwest, despite several interesting case studies available in the region. This study will focus on Boulder, Colorado. It is the largest city in Boulder County, with a population of 108,250 as of the 2020 US Census (US Census Bureau, 2020). The population density was 3,942.7 inhabitants per square mile and 43,479 housing units (at an average density of 1,760.3 units per square mile). (US Census Bureau, 2020). Boulder is located at the foot of the Rocky Mountains. In part due to being a college town, the city of Boulder has a population that is younger than the national average. With over 100,000 acres of open space (Boulder County Parks and Open Space, 2024), Boulder County has a published commitment to conservation and the provision of public spaces; roughly 60% of all open spaces in the county in 2016 were lands that are publicly owned, leased, or allows access to residents. (Boulder County Parks and Open Space, 2016).

Because there is a correlation between active individuals and their value of green spaces, this study will survey a region with a higher percentage of physically active residents. Colorado continues to rank within the top 10 most active states (CDCa, 2023) and boasts some of the healthiest counties in the United States of America, including Boulder County. Colorado also holds a high rate of physical activity in its residents, with over 83% reporting regular physical exercise (World Population Review, 2024), and Boulder is no different. However, Boulder also had the lowest percentage of any US city of residents who don't get any type of exercise in 2017 (Trimble, 2017) and places great pride on its identity as an "active" community. Not only is Boulder one of 5 Platinum-level bicycling communities in the US (League of American Bicyclists, 2018), but has

also been recognized as an “A-List” city by the CDP (CDP, 2023b), indicating they are a global leader in environmental action, ambition and transparency. This active lifestyle is further enforced by construction policy within the city of Boulder that both enables environmental conservation (such as being the first city to leverage a carbon tax in 2007) and access to green spaces (Hickox, 2007).

Data

To gain a more nuanced understanding of the impact that proximity to urban and urban-adjacent green spaces has on housing sale prices in Boulder, the study sourced quantitative and qualitative data from the Boulder County Assessor’s Office, the City of Boulder, and the Boulder County Parks and Recreation Department. While 6,252 property sales were collected and 1,052 urban green spaces (2 national forests, 437 county-owned open spaces, 501 city-owned open spaces, 3 undeveloped spaces, 9 recreational areas, 56 city parks, 11 natural lands, 1 golf course, 5 gardens, and 1 cemetery), were included in the study, roughly 3,700 property sales were analyzed in the final model. This study used ArcGIS Pro and Stata to process the data into geospatial content and perform analyses on the refined dataset.

Housing Data

All property sales were collected from the public Property Sales Database (Boulder County Assessor’s Office, 2020a), using the Base Period Sales. This includes 3, 824 sales from January 2014 to September 2020 of the 9 Market Areas within the city of Boulder for single-family residential properties (Market Areas 101-107) and townhome property sales (Market Areas 108 and 109). During this time, there does not appear to be many large shocks to the housing market, which allows for the impact of green space

proximity on housing prices to be more accurately evaluated. This dataset included unique registration numbers associated with parcel location and various data about each property sold, including square footage, address, quality, effective construction year, and year of sale. The effective construction year refers to the most recent year significant renovations or upgrades have occurred to the structure and thus will be used to calculate relative age of houses in this study. Table 1 shows the summary statistics of the dataset. The mean above ground square footage of houses was 1,822 square feet with a standard deviation of 843 square feet. The mean land square footage of the property itself was 7,860 square feet with a standard deviation of 5,987 square feet. The mean age of houses on properties sold was 30.77 years old, with a standard deviation of 14.21 years. The dataset also included the sale price of the parcel and a "time-adjusted" sale price, which standardized all sales to 2020 dollars (Boulder County Government, 2024). The mean sale price of the properties was $1,161,089, with a standard deviation of $728,289. Shapeform data of all ownership parcels in Boulder County were obtained from the ArcGIS Hub (Boulder Ownership Parcels, 2020b) and paired to the residential sales using the shared parcel registration number.

Table 1. Summary Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Time-Adjusted Property Sale Price	1161089	728389.3	279400	9148714
Distance to nearest Golf Course (miles)	2.577	1.058	0.000	5.106
Distance to nearest Garden (miles)	1.091	0.670	0.002	2.765
Distance to nearest County-Owned Open Space (miles)	1.923	0.779	0.084	3.397
Distance to nearest City-Owned Open Space (miles)	0.350	0.240	0.000	1.020
Distance to nearest City Park (miles)	0.177	0.118	0.000	0.741
Distance to nearest Recreational Green Space (miles)	1.308	1.069	0.001	3.968
Distance to nearest Undeveloped Green Space (miles)	1.182	0.486	0.021	2.372
Distance to nearest National Forest Land (miles)	4.336	0.961	2.025	6.419
Distance to nearest City-Designated Natural Land (miles)	1.211	0.635	0.009	2.818
Age of House (Effective Construction)	30.773	14.210	1	110
Estimated Land Square Footage	7859.571	5986.531	451	96081
Above Ground Square Footage of House	1821.704	843.239	480	7659

Green Space Data

Shapefile data for urban green spaces were collected from the Boulder County Open Data website (City of Boulder Parks and Recreation, 2019) for properties managed by the City of Boulder Department of Parks and Recreation. This data included green space size, departmental ownership, and open space type for all green spaces under the management of the city. Using the geospatial data provided by the dataset, green spaces were isolated by type and converted into independent layers.

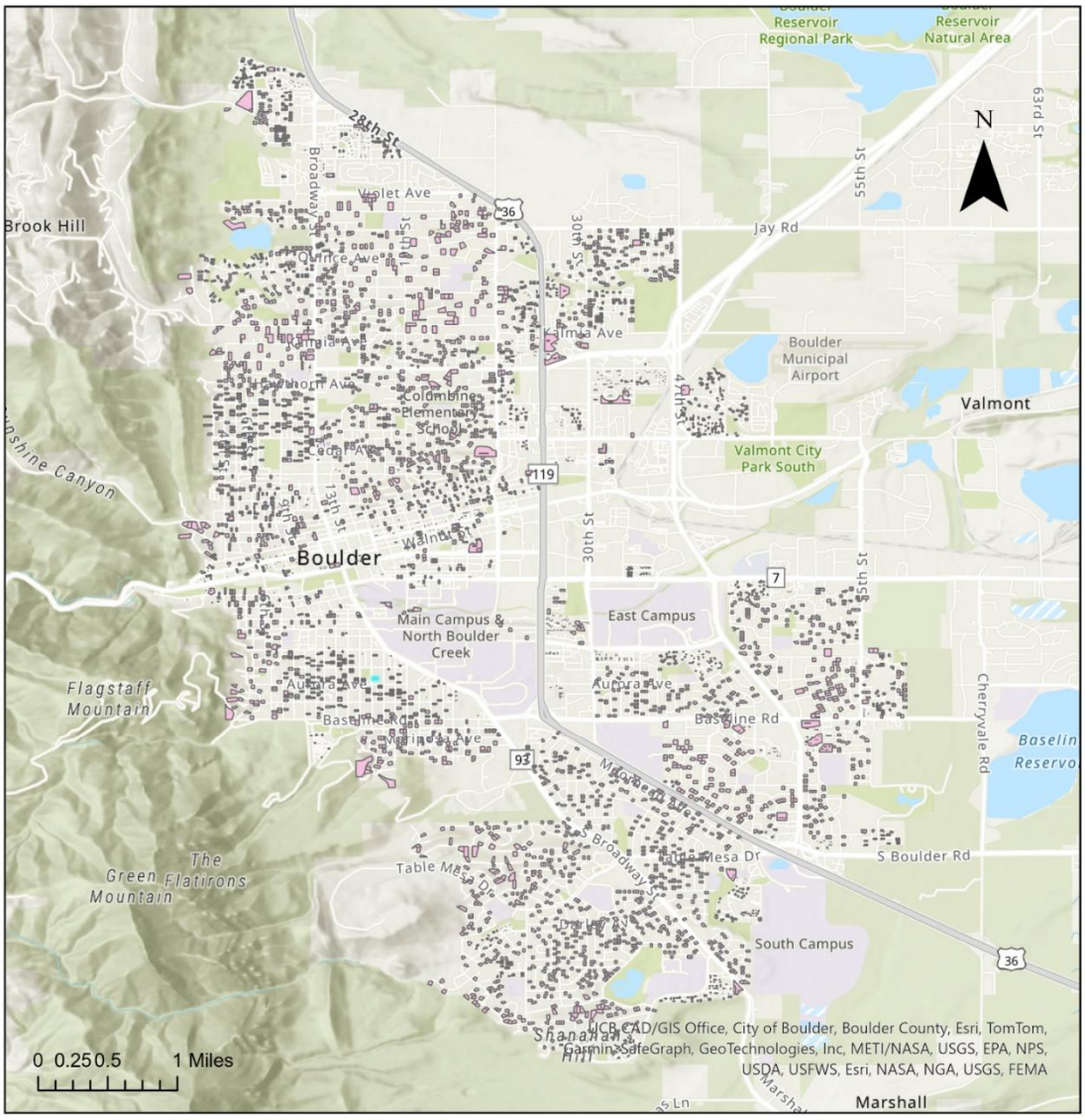
Data was also sourced from the Land Ownership database maintained within the USGS Protected Areas Database of the United States (PAD-US) for May 2023 (United States Geological Survey, 2023c) to provide additional data for county and federally managed green space regions. Three relevant layers were selected for this study: city-owned open space lands outside of the city itself, county-owned open space lands, and forest service-owned National Forest lands. All open spaces within an 18-mile radius of the geographic center of Boulder city were included within the study. Because the study primarily explores distances from each property to the nearest green space of each type, parks near the edge of the selected area will likely have no bearing on the model.

Merging Geographic and Spatial Data

Shapefiles were processed in ArcGIS Pro so each layer was geographically matched within the city of Boulder, Colorado. Properties were geographically positioned relative to urban green spaces (Map 1). Individual layers generated for each open space type (garden, golf course, cemetery, park, recreational, natural easements, and undeveloped open space) were superimposed on the property shapefiles (Map 2).

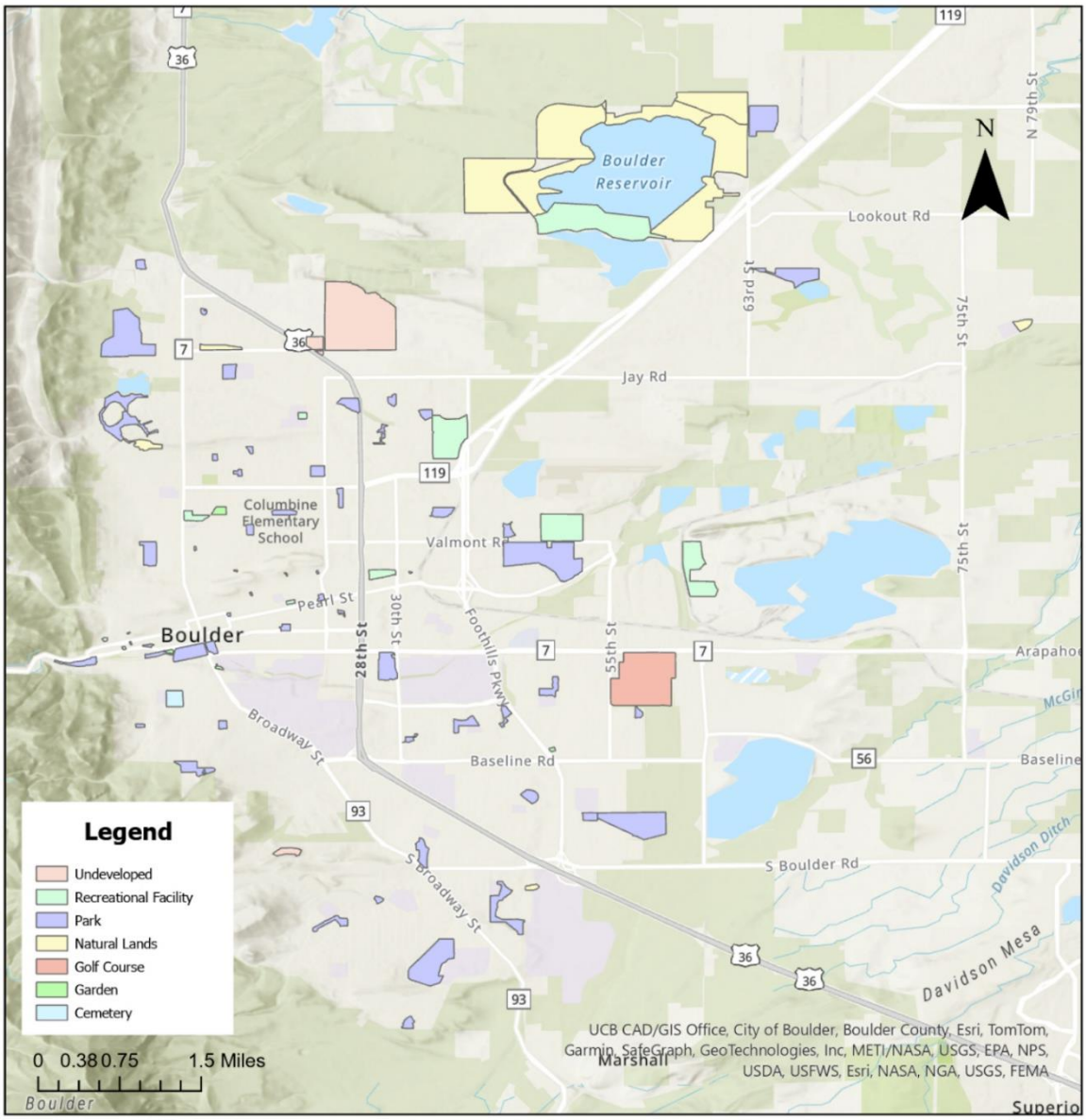
Similarly, the three layers for green spaces in the urban periphery (city-owned open space, county-owned open space, and national forest) were added to the map (Map 3).

Map 1. Property Sales in Boulder



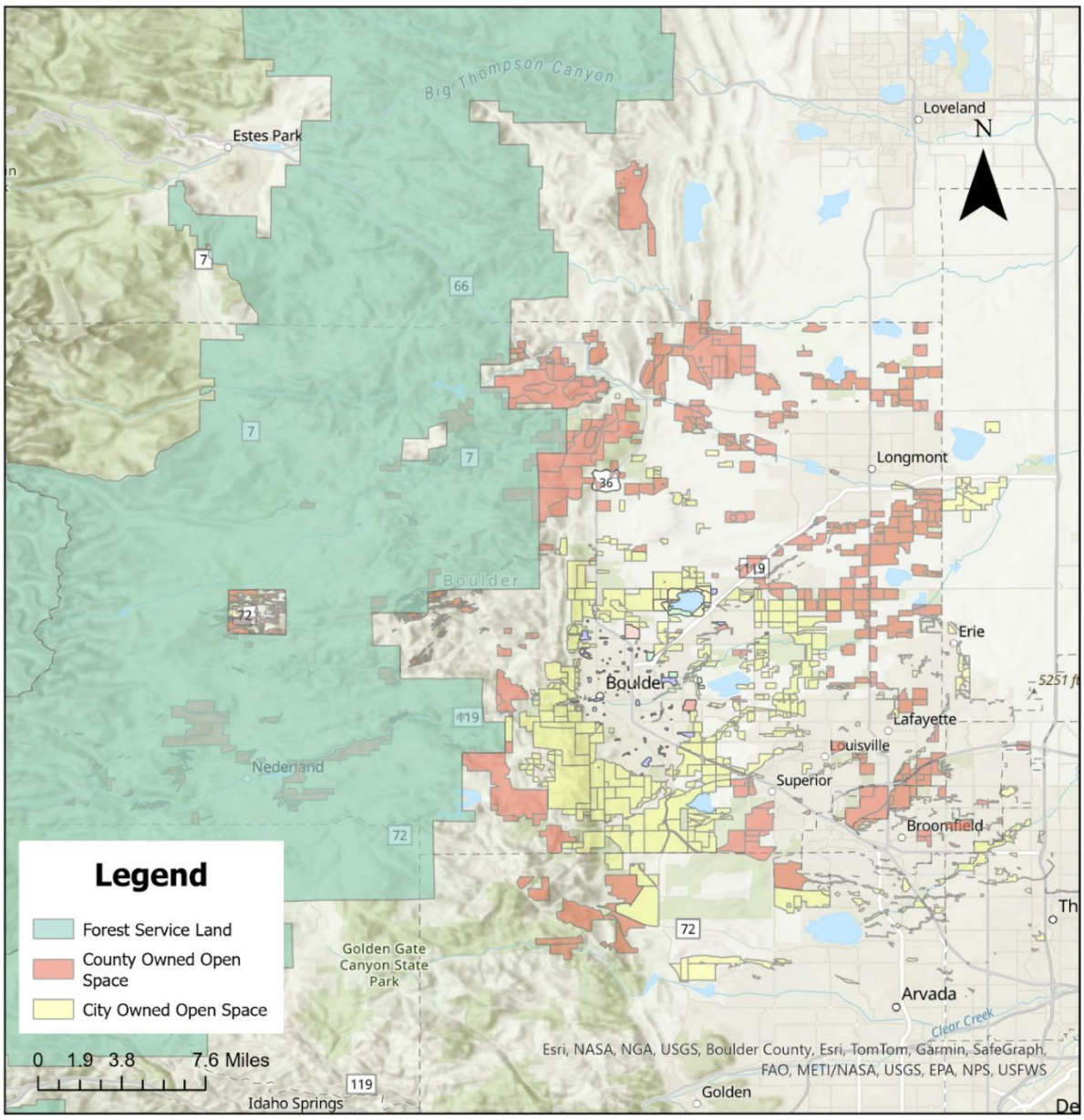
Map 1. Geographic locations of townhome and single-family home property sales in Boulder, Colorado from 2014 to 2020. Data sourced from the Boulder County Assessor's Office.

Map 2. Urban Green Spaces In Boulder, Colorado



Map 2. Geographic locations urban green spaces within the city of Boulder, Colorado. Shaded shapes indicate the type of green space and relative size of the regions. Data sourced from the Boulder County Parks and Recreation Department.

Map 3. Urban-Adjacent Green Spaces Near Boulder, Colorado



Map 3. Geographic locations of urban-adjacent green spaces near the city of Boulder, Colorado Shaded shapes indicate green space type and relative size of the plots. Data sourced from the United States Geological Survey.

Using the shapefile parcel dataset for property sales in the city of boulder and the shapefile layers of urban green spaces, a table was generated in ArcGIS of the distances

between each property parcel and the closest parcel of every individual open space type. Thus, every property is associated with its respective sale price, physical property details, and a matrix of the distances to each park type. Table 1 shows the summary statistics of all measured distances. The mean distance of properties to the nearest city-operated cemetery is 2.58 miles with a standard deviation of 1.06 miles. The mean distance to the nearest community garden is 1.09 miles, with a standard deviation of 0.67 miles. Distance to the nearest county-owned open space of sold properties has a mean of 1.92 miles and a standard deviation of 0.78 miles. The mean distance to the nearest city-owned open space is 0.35 miles, while the mean distance to the nearest city park is 0.18 miles, with standard deviations of 0.24 and 0.12 miles, respectively. The mean distance to the nearest recreational green space is 1.31 miles, with a standard deviation of 1.07 miles. Properties' distance to the nearest undeveloped green space has a mean of 1.18 miles and a standard deviation of 0.49 miles. The mean distance to the nearest city-designated natural land is 1.21 miles, with a standard deviation of 0.64 miles. Each distance measurement is also connected with other identifiers about the green space measured to, allowing for variables such as park size to also be connected and evaluated.

By restraining the scope of the study to the city of Boulder, Colorado, the study aims to remove impacts originating from regional differences. It is well-documented that house prices are affected by neighborhood characteristics, such as education level, urban density, or percentage of young or elderly people within a city. Boulder, Colorado is relatively uniform in population density, in part due to their stringent development laws preventing new development exceeding 55 feet tall outside of the downtown 29th Street

region. Thus, the variance of housing density is not as significant of a concern when the study only explores residential sales within the suburban and urban regions in the city of Boulder. Similarly, because Boulder is a college town, it has a higher percentage of younger individuals than the average US city. While this may have some small regional impact for property sales directly next to the university itself, this impact will likely be contained within the variations of sale location (designated by Market Area).

Methodology

To predict housing prices using these variables, we will create a multivariate regression of the form

$$\log(\text{Price}) = \beta_0 + \beta_1 \log(Cemetery) + \beta_2 \log(NationalForest) + \beta_3 \log(CountyOpenSpace) + \beta_4 \log(CityOpenSpace) + \beta_5 \log(Parks) + \beta_6 \log(Golf) + \beta_7 \log(Garden) + \beta_8 \log(Natural) + \beta_9 \log(Undeveloped) + \beta_{10} \log(Recreation) + \beta_{11} \log(AboveSQFT) + \beta_{12} \log(LandSQFT) + \beta_{13} Age + \beta_{14} MarketDummy1 + \beta_{15} MarketDummy2 + \beta_{16} MarketDummy3 + \beta_{17} MarketDummy4 + \beta_{18} MarketDummy5 + \beta_{19} MarketDummy6 + \beta_{20} MarketDummy7 + \beta_{21} MarketDummy8 + \varepsilon$$

Where time-adjusted housing price is a function of the above ground square footage of the house, the square footage of the property plot, the age of the house (since last significant remodel), the market region the house was sold under, and the distances to the nearest county open space, nearest public garden, nearest golf course, nearest cemetery, nearest national forest, nearest natural land, nearest city open space, nearest city park, nearest undeveloped open space, and the error term ε.

Dummy Variables

It is necessary to convert the categorical Market Areas variable into eight dummy variables for each region. The city of Boulder has 9 market regions for single family home sales, titled ‘Market1’ through ‘Market9.’ Sales in Market Area 101 are designated

as the baseline case for property sales, which is indicated by the absence of all other dummy market variables.

Linearity

Due to the nature of housing prices being nonlinear and skewed, it is necessary to transform the time-adjusted property sale prices into a log of the values. Scatterplots between the dependent and each independent variable were generated to ensure linearity across all variables. To best represent the relationship between the log of property sale prices and the square footage of the above ground structure on the property, the log of square footage was taken and used in place of the unmodified variable. The estimated total land area of each plot of property was treated with the same log function. Finally, a logarithmic transformation was applied to the measured distances to allow for a more appropriate interpretation of the results. By transforming the distance variables, the end model predicts percentage changes in property sale prices using the percentage changes in distances — this comparison-driven value is aligned with rhetoric of access and proximity, supporting the goal of this study. Thus, the model will be measuring the percentage impact on willingness-to-pay of homeowners in Boulder by percentage changes in distance, house size, and land size. It will also measure the percentage impact on willingness-to-pay of homebuyers in Boulder by housing age and market region.

Results

There is a strong correlation between increases in above-ground square footage and increases in the sale price of the property it sits on. Table 2 presents the main results of the multivariate regression. For every one percent increase in housing square footage, there is a predicted increase in sale price of 0.481%. This is not surprising. Similarly, for

every one percent increase in acreage of the property plot, there is a predicted increase in its sale price by 0.249%. Housing price is negatively correlated with age; for every additional year since a property's last major (effective) remodel, the price decreases by 0.008%. This also makes sense in the context of depreciation within a market for a standard good.

Table 2. Regression Coefficients

Variable	Time-Adjusted Property Sale Price	
logCemetery	-0.0502***	(-4.20)
logCityOpenSpace	-0.00945*	(-2.48)
logCountyOpenSpace	0.111***	-9.98
logCityParks	-0.00865*	(-2.36)
logGarden	0.00804	-0.89
logGolf	0.00105	-0.12
logNaturalLand	0.0162*	-2.45
logNtlForest	-0.0908**	(-3.17)
logRecreation	-0.0669***	(-9.45)
logUndeveloped	0.0992***	-8.61
logSQFT	0.481***	-40.6
logEstLand	0.249***	-26.97
Age	-0.00808***	(-25.11)
Market2	-0.145***	(-4.91)
Market3	-0.0623*	(-2.32)
Market4	-0.280***	(-11.01)
Market5	-0.376***	(-13.56)
Market6	-0.027	(-1.07)
Market7	-0.134***	(-4.88)
Market8	-0.245***	(-8.03)
Market9	-0.123***	(-4.27)
Constant	8.541***	-75.6
N	3712	

t statistics in parentheses

**** p<0.05*** ***** p<0.01*** ****** p<0.001***

Several urban green spaces exhibited a positive correlation between low distances from properties (i.e., access) and property sale prices. Proximity to a public cemetery is positively correlated to the sale price of properties within Boulder; for every 1 percent

further from the public cemetery, a given property's sale price will decrease by 0.050%. Property price is also negatively correlated with distance from city-operated open space and city parks: for every 1 percent increase in distance from city open space, property sale prices are predicted to decrease by 0.009%, while a 1 percent increase in distance from a city park is also associated with a predicted decrease of sale prices by 0.009%. Distances from both national forest land and recreation are also negatively correlated: a 1 percent increase in distance from national forest land is predicted to decrease property sale price by 0.091%, while the same percent increase in distance from recreation sites in the city is estimated to decrease sale price by 0.067%.

Conversely, some urban green spaces demonstrated a negative correlation between low distances to properties and the respective property sale prices. According to the model, proximity to county-owned open space is valued inversely; for every 1 percent increase in distance from county open space, property sale prices are expected to increase by 0.111%. Proximity to natural lands (in this study primarily located around Boulder Reservoir) exhibit a similar phenomenon: a 1 percent increase in distance from these regions has a predicted 0.016% increase in price. Distance from undeveloped lands is also positively correlated with price increases. A 1 percent increase in distance from undeveloped land is predicted to increase property sale price by 0.099%.

There is also a correlation between where the property is located within Boulder and the sale price. Property sale of a plot in Market Area 102 (single-family homes in Glenwood Grove, Moores, and Palo Parkway neighborhoods) is expected to be 0.145% less expensive than the sale price of a comparable sale in Market Area 101 (single-family

homes in Flagstaff, University Hill, and Lower Arapahoe neighborhoods). Property sales in Market Area 103 (single-family homes in Wonderland Hill and North Boulder Park neighborhoods) are predicted to be 0.062% less expensive than the sale of a similar house in Market Area 101. All else being equal, the sale price of a property in Market Area 104 (including single-family homes in Martin Acres and Majestic Heights neighborhoods) is expected to be 0.280% lower than in Market Area 101. Similarly, the model estimates that property sales in Market Area 105 (including single-family homes in Frasier Meadows, Arapahoe Ridge, and the Country Club/Gunbarrel region) will be 0.376% lower in price than a similar sale in Market Area 101. In Market Area 107 (single-family homes in Boulder Old Town and Whittier neighborhood), property sale prices are expected to be 0.133% lower than a comparable property in Market Area 101. In Market Area 108 (townhomes East of Broadway) and Market Area 109 (townhomes West of Broadway and in Downtown Boulder), property sales are anticipated to be 0.245% and 0.123% lower than sales of a single-family home sold in Market Area 101 with similar characteristics.

Under this model, the p-values for distance from golf courses and distance from community gardens are high, indicating that the coefficients for these variables are not statistically significant. Similarly, the high p-values for Market Area 106 (single-family homes in Highland Park, Table Mesa, and Devil's Thumb neighborhoods) indicate that the percent change between comparable property sales for this region and the baseline metric of single-family home sales in Market Area 101 may not be accurately reflected by this model.

Discussion

There is evidence to suggest that proximity to urban green space is correlated with higher property sale prices for key urban green space types, while select other urban green spaces have no correlation (or are negatively correlated) with property sale prices. Homeowners in Boulder are willing to pay more for proximity to public cemeteries, city parks, city-owned open space, recreational spaces, and national forest land. The green space type with the highest relative impact is National Forest, where a 1 percent increase in distance is estimated to decrease the property sale price by 0.091%. Conversely, homeowners are willing to pay more for increased distance from undeveloped lands, natural lands, and county-owned open space. The relationship between willingness to pay and proximity to city-operated community gardens and golf courses in Boulder was not statistically significant.

It is notable that the green space with the largest impact is National Forest lands, which is an urban-adjacent green space, located entirely outside of the city. The distance to National Forest is much greater than the distance to any urban green space for the vast majority of residential properties; this fact does not compromise the integrity of the model's prediction since it is based on percentage changes of both property sale price and distance from the nearest National Forest. National Forest is highly prioritized, perhaps due to the size of the nearby National Forest regions or the geographic association in the area with the nearby National Forest spaces and the scenic attractions of the area, namely the Flatirons. Boulder is well known for its location in the foothills of Colorado; houses closest to National Forest land may also have greater visibility of the rugged Colorado

landscape, while houses furthest from the National Forest may have their views obscured by other elements of Boulder.

Homeowners are unwilling to pay more for proximity to undeveloped urban green spaces. Undeveloped lands are categorized as urban green spaces that have not yet been developed and are not protected. One of the three such regions within Boulder is slated to become a Pocket Park — a small recreational space, including a playground — once the plot has been improved. Similarly, the other two properties (one staged for neighborhood development, the other undeveloped and not protected) are empty plots of urban or urban-adjacent green space. Unlike many other urban green space types, there is no guarantee of public access to these regions. This may explain the positive correlation between distance from undeveloped urban spaces and property sale prices. If individuals cannot engage with the space, this likely decreases willingness to pay for proximity to it.

Similarly, lower property sale prices were associated with decreased distance to "natural lands," urban green spaces designated as environmentally oriented and biodiverse parks. Over half of the regions in this category are directly connected to water features, with one park each for Maxwell Lake and Coot Lake and six properties for Boulder Reservoir (Coot Lake is directly next to Boulder Reservoir, so an argument can be made for the number of properties connected to the reservoir to be seven instead of six). The remaining three spaces, Tantra Environmental Park, Heatherwood Park, and Violet Park are distributed throughout the city but are relatively small regions with an emphasis on walking trails. Close proximity to Boulder Reservoir may be less desirable for Boulder residents, especially considering it is on the eastern side of the city (further

from valuable views of the mountains) and one of the furthest areas from the downtown and city center.

The magnitude of the effect that urban green spaces have on property sale prices may be diminished by the greater geographic surroundings of Boulder, Colorado. Because urban-adjacent green spaces (such as National Parks) remained the largest influencer of all green-space-proximity drivers, there is evidence to believe that green spaces outside of the city hold greater value to physically active homeowners than green spaces within the city. Boulder is close to many large green spaces (environments) not included in the scope of this study that may also hold sway over prospective homeowners.

Conclusion

Proximity to urban green spaces is correlated with both positive and negative changes in property sale price, depending on green space type. A hedonic pricing model was used to explore the relationship between distance from urban green spaces and property sale prices in Boulder, Colorado. This study found that there is a demonstrated preference of homeowners to be closer to certain types of urban and urban-adjacent green spaces, namely National Forests, city parks, recreational spaces, and city-owned open space, and further away from others, specifically county-owned open space, city-designated natural lands, and undeveloped land. The relationship between proximity to golf courses or community gardens and property price was insignificant in the model.

It is important to recognize that, due to the scope of the study, several of these urban and urban-adjacent spaces were limited to only a few key data points. In the data set used, there is only one listed public cemetery, a singular golf course, and the majority

of urban green spaces labeled as “natural lands” are clustered around Boulder Reservoir. Community gardens are also located in only two Market Areas, perhaps partially explaining the statistical insignificance of both golf courses and gardens in the localized dataset. Additionally, because the dataset was restricted to single-family and townhomes, many homes have their own backyards and thus have a decreased value for close urban green spaces that provide a similar service as their own yards. This may also contribute to the statistical insignificance of community gardens, as most individuals will have the ability to cultivate their own gardens from the comfort of their own property.

The multivariate linear model exhibits multicollinearity among several of the variables. Performing a variance inflation factor (vif) test on the regression reveals high values for the market dummy variables, indicating multicollinearity within the system. A vif value below 5 is indicative of low correlation of that predictor with other predictors. Apart from several of the dummy variables for market area, all variables lie below that threshold. Multicollinearity between the dummy variables is expected — because each dummy variable only holds true for a mutually exclusive subset of the property sales, there will be collinearity between them. Additionally, because of the nature of the sample size, certain green space types (such as Boulder city’s singular city-operated cemetery or the golf course) can only fall within a single market area and thus there may be overlap between property sales that have very low distances to these urban green space types and the market area they are located in. The estimated coefficients of the vast majority of the measured variables have very low p-values, indicating statistical significance.

There is motivation to be near many urban green spaces, perhaps due to their recreational value or health benefits. This demonstrated need of nature within the built

environment may be sufficient evidence for continued investment into the development of urban green spaces. Greater integration of nature into cities and urban environments not only increases the social health of the community as a whole and the physical health of individuals within the community, but also increases the value of properties in close proximity. Easy access to urban green spaces can be used as a selling point for urban spaces and cities as a whole, when the urban and urban-adjacent green spaces are implemented properly, as in Boulder's case.

Further research done in urban communities that self-identify as "outdoorsy" is needed to further explore the impact that proximity to urban green spaces have on willingness-to-pay in the built environment. It is not out of the question that Boulder, Colorado may be an outlier in itself, considering its high rate of physical activity among residents and commitment to the environment at both the social and governmental level. Thus, a study conducted across similar communities in the US and abroad could reinforce the conclusions drawn from Boulder.

Similarly, further studies could be conducted in the American Southwest, which has long remained unexplored in regard to urban green spaces and property values. While this would broaden the literature surrounding willingness-to-pay for proximity to green spaces, it may also shed light on how urban green space is valued in relation to general proximity to large protected ex-urban green spaces (i.e., National Parks, National Forest lands, and other pristine (but publicly accessible) natural spaces).

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