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The Relationship Between Housing Price and Proximity to Public Land in Denver, CO

by

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## **Abstract**

This study examines how proximity to public lands influences housing values. This will be done using a hedonic pricing strategy, which is useful when analyzing heterogeneous goods such as a house or apartment. The data for this study comes from the American Community Survey (ACS) of Denver, CO from 2010 and 2017. This study also includes four variables related to distance from large open public spaces: one each for the distance from the Rocky Mountain Arsenal National Wildlife Refuge, Rocky Flats National Wildlife Refuge, Cherry Creek State Park, and Chatfield State Park. Multiple linear regressions were used to analyze the effect of distance to these parks on median housing value. The results of this study reveal that consumers may value some of these large parks more than others.

## 1. Introduction

Debates surrounding the preservation of land and wildlife in the United States began in the 1900s. In the late 1990s concerns over urban sprawl and deforestation sparked new research by economists searching for a way to value these shrinking spaces (McConnell and Walls 2005).

This study examines how proximity to public lands influences housing values. This is done using a hedonic pricing strategy, which is useful when analyzing heterogeneous goods such as a house or apartment. Each housing unit is a bundle of characteristics. As McConnell and Walls (2005) point out in their survey of many existing studies, it is simplistic to focus on proximity when so many other variables influence both the price of real estate and the quality of a piece of land. The value of open space is dependent on what activities it can be used for.

This paper focusses on median housing prices of in Denver, Colorado. The distance from the Rocky Mountain Arsenal National Wildlife Refuge, Rocky Flats National Wildlife Refuge, Cherry Creek State Park, and Chatfield State Park are the primary variables of interest. Denver is unique among U.S. cities because these parks are adjacent to city limits. These areas are appropriate for recreational activities and contain diverse ecosystems of wildlife. The geographical units will be Census Block Groups obtained from American Community Survey data, and ArcGIS will be used to determine average distance to the State Parks and Wildlife Refuges. Based on my preliminary research and review of the literature, I hypothesize that proximity to these public lands on which recreation and wildlife are available will have a positive impact on the median housing price.

Land rights and land management issues are commonly raised in political discussions, especially at the local and state levels. The findings of this study could influence whether cities develop land on the perimeter versus converting these plots of land into nature reserves or recreational areas. If my hypothesis holds true, the creation of public open spaces will increase property values and raise tax revenues. Additionally, private real estate developers may utilize this study when planning a new development site. Leaving several plots untouched instead of building homes could increase the value of the developed plots enough to offset the loss of revenue. Environmental advocacy organizations could utilize the findings of this study to more effectively lobby for the preservation of land near cities.

## **2. Literature Review**

Lancaster (1966) introduced the hedonic pricing model. He theorizes that in the context of heterogeneous goods, it is the characteristics of these goods from which consumers reveal their preferences. He describes the model as common sense, stating that it is clear the traditional model of consumer behavior does not adequately incorporate what we see in the world.

Lancaster's model assigns variables to different attributes of a heterogeneous good. For example, an automobile would have variables representing paint color, year of production, interior material, etc. A regression coefficient is assigned to characteristic variables, showing the effect of a change in that variable on the price of the automobile.

Economists now had a framework which could be used to analyze other complex issues of consumer preferences, such as real estate valuation.

Ridker and Henning (1967) applied Lancaster's model to residential housing. Their study uses cross-sectional census data from St. Louis, MO gathered in 1960 to determine the effect of sulfur pollution on housing prices. The model considers 16 different variables as having an influence on the median property value in a Census Block Group. These variables are grouped into air quality, characteristics specific to the property, location characteristics, neighborhood characteristics, taxes, public services, and submarket variables (demographics).

This is one of the first studies to apply a hedonic model to residential housing valuation. However, the model did not account for the distance from a public open space. Despite the absence of this variable, Ridker and Henning's study provides a basic model that can be altered for other research into housing markets.

Smith, Poulos, and Kim (2002) utilized a hedonic model in Northern Wake County, North Carolina. This is a suburban region, located just north of Raleigh. The authors consider all vacant lands to be relevant to the value of real estate, not solely plots that were open to the public. For example, agricultural land is included, despite the fact that recreation would not be permitted by the landowner.

Data were collected from four subperiods from 1980-1998, a timespan in which Northern Wake County saw notable loss of open and accessible spaces due to a significant population increase. Smith et al. note that limiting the scope of the study to a small area allowed them to omit other variables, such as distance to employment centers and climate.

Thus, as the density of the area shifted and open space became increasingly scarce, they could more easily isolate the effect of distance to open space on real estate value. The authors found that, across all four subperiods, there was a statistically significant positive relationship between closeness to open space and real estate valuation. Furthermore, the study reveals that as the county's population density increased and open spaces became increasingly scarce, this effect became more pronounced. However, counter to the authors' hypothesis, houses located closer to public parks saw a negative relationship between closeness and property value. A home close to a public park in Northern Wake County was less desirable than a similar home farther from the park. This is likely due to negative externalities associated with small parks within city limits, such as increased traffic, noise, and lack of privacy. The findings suggest that there is a positive correlation between non-use values of nearby open land and real estate value. Homeowners value the knowledge that the land is there unoccupied, especially if it cannot be used by the masses for recreation.

The findings of this study may seem counterintuitive, but many other studies have uncovered the same result in urban and suburban environments. Kitchen and Hendon (1967) observed that in Lubbock, Texas, homes farther from the public parks generally had a higher real estate value. Although this study took place before hedonic pricing models were commonly utilized, and does not take into consideration many other factors that influence home prices, McConnell and Walls (2005) point out that many studies over the following decades produced similar findings in a number of different locations. Kitchen and Hendon go on to suggest that this could be explained by increased congestion in that

area as a result of the park. Essentially, almost all inhabitants of a town or city have equal access to the park regardless of proximity, but those who live adjacent to it must also deal with negative externalities of close proximity.

Later studies explain that the relationship between real estate value and public lands is not as simple as what we see in the urban park scenarios. Shultz and King (2001) examined Tucson, Arizona, using both census data and GIS data sources. They find similar results to other economists when analyzing real estate values near parks in the city; however, their results differ significantly when analyzing the proximity of homes to larger natural areas and wildlife habitat around the city. Tucson is located near a mountain range, and there was a positive relationship between housing prices and a closer proximity to these public spaces that are significantly larger and more “natural” than a city park. Not only do these areas allow for additional types of recreation beyond bike riding and jogging, they also allow for the viewing of dozens of wildlife species. These public lands do not produce the same negative externalities as a densely packed urban park, due to their size and greater distance from most neighborhoods.

Shultz and King’s study has implications for this research. The relationship between real estate value and urban parks is well established. It is more complex to measure the relationship between real estate value and these larger, more traditionally “wild” plots of public land.

Brander and Koetse (2011) conducted a meta-regression analysis of 52 hedonic pricing studies that have examined the valuation of open space in or near urban areas. The authors note that city parks are heavily considered in each of these models, while large



forested or open wilderness areas are often omitted. Thus, only 12 of the 52 studies were considered viable, 11 of which were studies from the United States.

Brander and Koetse showed a 0.1% increase in house value for every 10 meters closer to a large forested area. The authors also state that this effect compounded closer to the forested land. This study supports Schultz and King's (2001) findings. However, Smith, Poulos, and Kim (2002) showed that consumers value open spaces differently based on how much is available to them. Because of this, Brander and Koetse's results may not be applicable to areas unlike those used in the 12 selected studies. The change in housing price based on proximity to these large wild plots of land may be more or less in an individual city than when aggregated across several.

There are reasons to believe that public lands are valued differently for consumers depending on which state or city they reside in. The Bureau of Land Management releases a Public Land Statistics report each year. This document reveals the extreme variation in federally owned public lands in each state, ranging from zero acres in several states to over 70 million acres in Alaska. While these are the extremes, there is a spectrum of abundant public lands in some U.S. states, compared with none in others.

### **3. Data**

The data for this study comes from the American Community Survey (ACS) of Denver, CO from 2010 and 2017. The ACS provides data on demographics, housing prices, housing characteristics, neighborhood characteristics, and family structure for each of Denver's 481 Census Block Groups. Using two separate years of census data doubles the

size of the dataset. Instead of 481 observations, one for each CBG, there are now 962. This study will not analyze a change in home prices from 2010 to 2017, because although many of the baseline regression variables shift, the distance from a given CBG to one of the selected parks remains constant. If there is a change in home prices, it will not be due to the spatial factors which this paper examines. The mean Median Housing Value for a CBG in Denver is \$312,070, the median is \$265,600, and the standard deviation is \$168,865. Descriptive statistics of these data are in Appendix Fig. 1.

The GIS data required for this study comes from the U.S. Census Bureau, the Denver County and City Parks Service, Colorado Parks and Wildlife, and the U.S. Fish and Wildlife Service. ArcGIS allows GIS data from multiple different sources to be overlaid, seen in Appendix Fig. 2. A measuring tool within the program determines distance from edge to edge between each CBG and the aforementioned open spaces. These data will make up the remainder of the variables in the model.

#### **4. Econometric Method**

The hedonic model used in this study follows Ridker and Henning (1967). The study provides a strong core strategy for home valuation, but it lacks any variables related to distance from public open spaces. There are several other variables I believe should have been included in Ridker and Henning's model that are unrelated to public lands, but have been shown in other studies to have a statistically significant influence on home prices.

Median housing value is available for almost all 481 Census Block Groups (CBG) in Denver.\* Independent variables include demographic variables related to race and ethnicity. Education level is bucketed into High School Degree/GED, Undergraduate Degree, and Graduate Degree. Each of these three variables is the percentage of the CBG's population who have obtained that level of education, but not higher. Per capita income, the percentage of homes in a CBG which are occupied, and the percentage of single-family homes serve as proxies for the quality of the neighborhood. A dummy variable for the year the observation was recorded (2017 or not 2017) controls for variations in prices due to inflation over the seven year period.

This study includes four variables related to distance from large open public spaces; distance from the Rocky Mountain Arsenal National Wildlife Refuge, Rocky Flats National Wildlife Refuge, Cherry Creek State Park, and Chatfield State Park. There are additional influences related to distance from open spaces that must be accounted for. Smith et al. (2002) show that close proximity to small urban parks has a negative impact on housing value. Therefore, a variable to account for distance from the nearest urban park will be included. Many CBGs in Denver contain or are adjacent to at least one urban park, and only one single park is included in this variable for each observation.

A set of dummy variables is included to account for spatial fixed effects. These variables control for other factors that may influence housing price. Influences that fall

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\* The United States Census Bureau censors public releases which may compromise the privacy of individuals. If the Census Bureau determines that the population of a CBG is too small to maintain anonymity, data such as median home value or median household income may be omitted from publicly available records.

under these dummies could be unique neighborhood traits which cannot be observed through available data sources. These dummies are organized according to “Zip Tab.” This unit of measure can be compared to the zip code in a postal address; however, the zip code is a unit of measure used by the Postal Service, not the Census Bureau, and does not line up with the borders of CBGs. Zip Tabs group CBGs into one of 33 clusters in the city.

## 5. Models

Multiple linear regressions were used to analyze the effect of distance to these parks on median housing value. With this spatial data there are different ways to use distance to determine the effect of the distance from one of the four large parks on median housing value. A general equation for these models is shown below:

$$Y = \alpha + \beta_1 \text{PerCapInc} + \beta_2 \text{White} + \beta_3 \text{Hispanic} + \beta_4 \text{Occupied} + \beta_5 \text{HighSchool} + \beta_6 \text{Undergrad} + \beta_7 \text{Grad} + \beta_8 \text{Detach} + \beta_9 \text{Year} + \beta_{10} \text{ZipTab} + \beta_{11} \text{Local} + f(\text{Distance}) + \varepsilon$$

Each of the 962 observations is one Census Block Group. Y represents the median housing value. “PerCapInc” is the per capita income of the CBG. “White” is the percentage of the CBG population that identifies as white. Variables for all other races/ethnicities included in the census were omitted, making the racial/ethnic aspect of this model “white or non white.” “Hispanic” is the percentage of the CBGs population

that identifies as Hispanic.<sup>†</sup> “Occupied” is the percentage of housing units in a CBG that are occupied. “HighSchool,” “Undergrad,” and “Grad” are the percentage of the population of the CBG whose highest level of education is a high school degree/GED, undergraduate degree, or graduate degree, respectively. “Detach” is the percentage of housing units in the CBG that are detached from other housing units, meaning that they are single-family dwellings. “Year” is a dummy variable for the year the observation was recorded (2017 or not 2017). “ZipTab” is a dummy variable for which of the 33 ZipTabs the CBG is located within. “Local” is the distance from the CBG to the nearest urban public park.  $f(\text{Distance})$  is a function of distance to one or all of the four large parks selected for this study. The following models vary based on how “distance” to these parks is defined.

### **Model 1: Individual Locations**

This regression contains a variable for each of the four large parks, shown by the equation:

$$Y = \alpha + \beta_1 \text{PerCapInc} + \beta_2 \text{White} + \beta_3 \text{Hispanic} + \beta_4 \text{Occupied} + \beta_5 \text{HighSchool} + \beta_6 \text{Undergrad} + \beta_7 \text{Grad} + \beta_8 \text{Detach} + \beta_9 \text{Year} + \beta_{10} \text{ZipTab} + \beta_{11} \text{Local} + \beta_{12} \text{Chatfield} + \beta_{13} \text{CherryCreek} + \beta_{14} \text{RockyFlats} + \beta_{15} \text{RockyMountain} + \varepsilon$$

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<sup>†</sup> The Census Bureau treats Hispanic as a separate demographic from other ethnic/racial options, because an individual can identify as both white and Hispanic, black and Hispanic, etc.

Treating the distance from the CBG to each of these locations as its own variable allows differences in the desirability of each park to be isolated. However, there are potential issues with the analysis of this model that arise due to their position relative to the city. Each of the parks is located near one of the four corners of Denver, meaning that moving closer to one location moves one farther from another. In order to account for this, a second model was developed.

### **Model 2: Nearest Location**

This regression only includes the large park a CBG is closest to. This is identical to how local parks are treated in all three models, only considering the closest park to be relevant. This model is shown by the equation:

$$Y = \alpha + \beta_1 \text{PerCapInc} + \beta_2 \text{White} + \beta_3 \text{Hispanic} + \beta_4 \text{Occupied} + \beta_5 \text{HighSchool} + \beta_6 \text{Undergrad} + \beta_7 \text{Grad} + \beta_8 \text{Detach} + \beta_9 \text{Year} + \beta_{10} \text{ZipTab} + \beta_{11} \text{Local} + \beta_{12} \text{Nearest} + \varepsilon$$

The relationship between the median housing value and the nearest of the parks should eliminate the issues stated above. However, there are differences between the four parks which will not be accounted for in this model.

### **Model 3: Close vs. Not Close**

This regression differentiates between CBGs that are “close” to one of these parks and those that are not “close” to any of them, and is shown by the equation:

$$Y = \alpha + \beta_1 \text{PerCapInc} + \beta_2 \text{White} + \beta_3 \text{Hispanic} + \beta_4 \text{Occupied} + \beta_5 \text{HighSchool} + \beta_6 \text{Undergrad} + \beta_7 \text{Grad} + \beta_8 \text{Detach} + \beta_9 \text{Year} + \beta_{10} \text{ZipTab} + \beta_{11} \text{Local} + \beta_{12} \text{Close} + \varepsilon$$

“Close” is a dummy variable for whether a CBG is within 6400 meters of any of the four large parks. 6400m was selected because it is the first quartile of distance from any CBG to one of the parks, meaning that 25% of all 481 CBGs in Denver are within 6400m of a large park. This is similar to Model 2, but only seeks to determine whether people value being close to the parks. Perhaps the specific distance matters little.

## 6. Results

The significance of results varied across the three regressions. For a complete table of all coefficients, refer to Appendix Fig. 3. A negative coefficient on a distance variable means that a location farther from a park results in a lower median housing value. This means that moving closer to the park represented by that variable would have a positive effect on median housing price.

Across all three regressions the coefficients on Percentage White, Percentage Hispanic, Percentage Occupied, Percentage with Graduate Degree, and Percentage Single Family Homes were statistically significant. The magnitudes of these coefficients are in Appendix Fig. 3.

The coefficients for Percentage White and Percentage Occupied are negative, suggesting that an increase in these variables leads to a decrease in median housing value.

This goes against the literature. It is unclear why this is the case for Percentage White. For Percentage Occupied, one possible explanation is that CBGs with lower percentages have gone through a period of development over the past decade as the population of Denver has increased. This would lead to lower occupation rates. The development could be taking place because the neighborhood is desirable, resulting in higher prices. This result could also be a case of reverse causality. Occupation rates may be low because the housing units in that CBG are overvalued. The sign and magnitude of all other non-spatial independent variables align with the literature and theory.

### **Model 1: Individual Locations**

Including a variable for each of the four large parks showed significant results for three. Distance to Chatfield State Park has a coefficient of -11.58 with a standard error of 5.688, distance to Cherry Creek State Park has a coefficient of -10.96 with a standard error of 5.02, and distance to Rocky Flats National Wildlife Refuge has a coefficient of -11.15 with a standard error of 5.069. These coefficients are significant at  $\alpha=0.05$ . Both distance to Rocky Mountain Arsenal National Wildlife Refuge and the nearest local park returned insignificant results. Distance to Rocky Mountain has a coefficient of -3.124 with a standard error of 5.136, and distance to Local has a coefficient of 5.221 with a standard error of 21.72. The model returned an adjusted R squared of 0.7506.

The results for Chatfield, Cherry Creek and Rocky Flats indicate that consumers value living closer to large open spaces. The effects of both Rocky Mountain Arsenal and the local parks are negligible. This could be explained by differences in available activities.



Rocky Mountain Arsenal is primarily a wildlife sanctuary, with human recreational activities playing less of a role. In contrast, Cherry Creek and Chatfield State Parks exist primarily to serve as a place for outdoor recreation. Rocky Flats is managed in a similar way as Rocky Mountain Arsenal, but is located closer to the mountains and offers what consumers may see as a more enjoyable outdoor experience through hiking. Consumers may differentiate between these locations and prefer some over others.

An explanation for the insignificance of distance to local parks is their density in Denver. Most CBGs have a distance of 0 meters to the closest park. With access to these parks open to all residents, and the negative externalities of the parks experienced by nearly everyone, it makes sense that they would have little to no effect on median housing value.

While moving closer to one of the three significant large parks increases median housing value, this also means moving farther from a different park. The three significant coefficients have similar magnitudes. As a result, a spatial shift may have an inconsequential net effect on housing value. While these results may reveal that consumers do value closeness to these open spaces, the effect on median housing value is difficult to determine.

### **Model 2: Nearest Location**

The second regression only includes the large park nearest to the observed CBG. The coefficients on the Nearest Park and Local Park variables are insignificant. Distance to the nearest large park has a coefficient of 0.5755 with a standard error of 2.542, and

distance to nearest local park has a coefficient of -3.217 with a standard error of 21.73. The signs on both of these coefficients are opposite what was hypothesized, but due to their insignificance the magnitude is negligible. The model has an adjusted R squared of 0.7466.

Although this regression was designed to eliminate issues when moving toward one large park and away from another, it is possible that this effect is still interfering with the model's results. Model 1 shows that the magnitude of the distance to each large park was roughly the equivalent, so a net effect may be very small. When only including the closest location, we see this negligible effect.

Another explanation for these insignificant results is that for most CBGs, the closest large park is Rocky Mountain Arsenal National Wildlife Refuge. The coefficient on this variable in Model 1 is also insignificant. Consumers may not value proximity to this location.

### **Model 3: Close vs. Not Close**

The results for the third regression, which contains a dummy variable for whether the CBG is close (within 6400m) or not close to a large park, also returns insignificant results for spatial variables. The coefficient for Close is -24,180 with a standard error of 12,960, and the coefficient on the nearest local park is -4.429 with a standard error of 21.70. The adjusted R squared of this model is 0.7476.

The magnitude and sign of the coefficient on Close are in line with the hypothesized results, but the lack of significance means this relationship is also ambiguous. This could

once again be due to interference from other locations. As with Model 2, most CBGs that fall into the Close category are closest to Rocky Mountain Arsenal, which is insignificant in Model 1 and may contribute to the insignificance of these results as well.

## **7. Conclusion**

The relationship between housing value and proximity to farmland, golf courses and urban parks is well established in existing literature. However, few studies have considered large areas of public open space to be a separate and significant factor. Areas such as the Wildlife Refuges and State Parks considered in this study are distinct from other plots of open land in that they are larger, allow recreation, and also create a viable habitat for native plants and animals. The results of this study reveal that consumers may value some of these large parks more than others.

This study does not capture the existence value of these lands. Existence value is the benefit that consumers gain from knowing an environmental resource exists, even though they may never see or experience it. Thus, it is likely that the figures in this study undervalue the actual utility gained by consumers as a result of these parks' existence.

It is challenging to draw conclusions from these results, which are mostly insignificant. It appears from the results in Model 1 that consumers do not value all types of open space equally, preferring those more open to recreation such as hiking, biking and camping. Cherry Creek, Chatfield and Rocky Flats offer more opportunities for these activities than Rocky Mountain Arsenal. However, plans are in place for the development

of more trails throughout Rocky Mountain Arsenal. After this construction project is completed, the results of these models may shift.

Denver was chosen for this study due to the unique position of these four large parks close to the city. The prevalence of public land may reduce its value to consumers, who have access to one of the four parks regardless of location within Denver. More research is necessary on this subject in order for interest groups to make educated and efficient decisions about public land in the future.

## Appendix

Figure 1: Descriptive Statistics (N = 962)

	Mean	Median	SD
Median Housing Value	312,070	265,600	168,855.4
% White	79.39	84.76	18.06
% Hispanic	70.28	80.65	26.52
% Occupied	92.65	93.86	7.11
% High School/GED	28.15	27.50	16.65
% Undergraduate	30.97	31.85	14.78
% Graduate	16.91	14.41	13.40
% Detached	55.76	60.26	34.60
Distance Chatfield	19,318	19,534	5312.853
Distance Cherry Creek	12,399.7	13,215.8	4686.875
Distance Rocky Flats	24,093	23,867	4924.546
Distance Rocky Mountair	12,123	11,904	5132.808
Distance Local	72.577	0.444	145.9829
Distance Nearest	8692	9296	3839.551



# Denver County: ACS Units and Protected Lands

Fig. 2

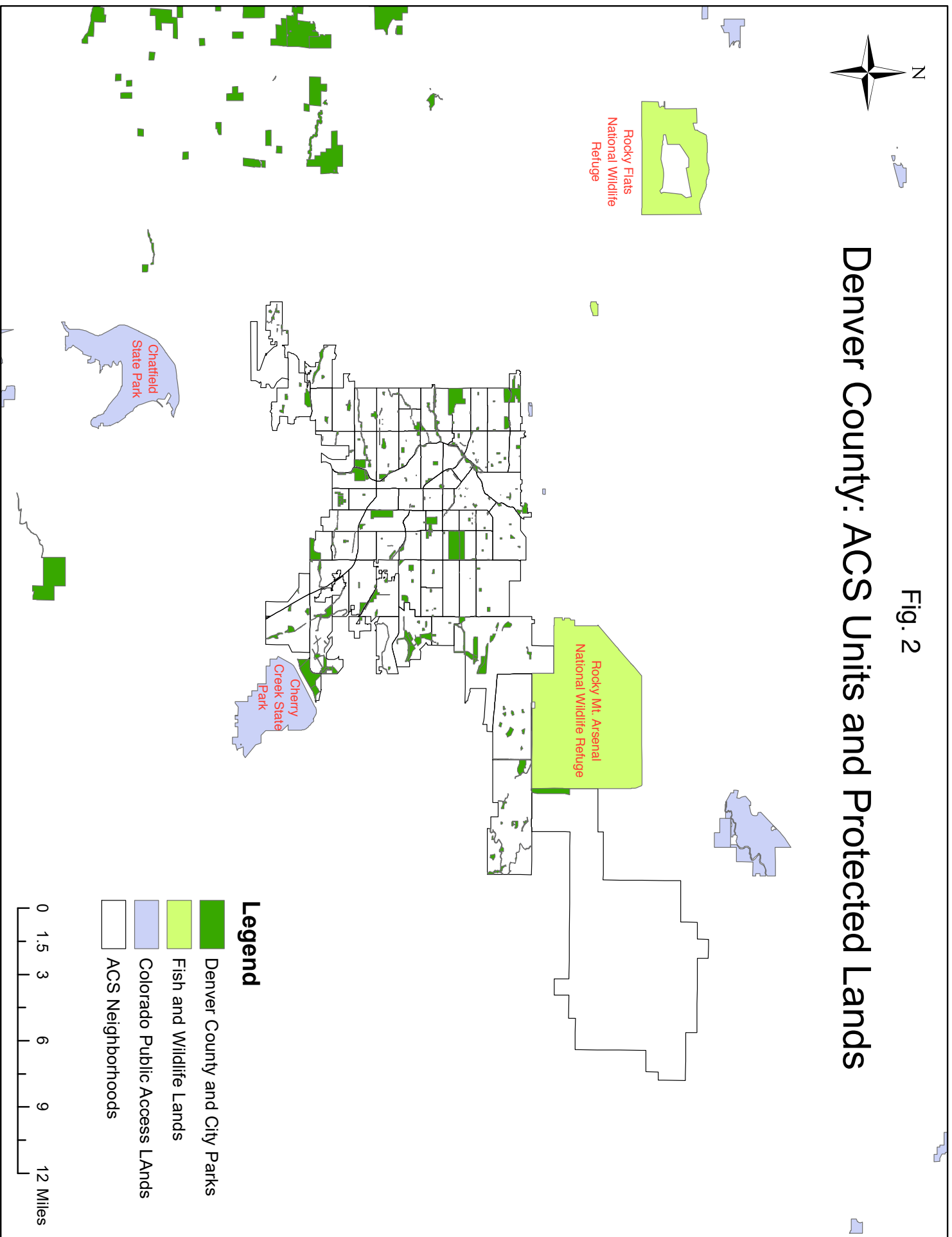


Figure 3: Hedonic Model Estimates

	Model 1 Individual Locations	Model 2 Nearest Location	Model 3 6400m
Per Capita Income	4.239*** (0.2267)	4.354*** (0.2257)	4.383*** (0.2257)
% White	-686.1** (240.5)	-693.6** (241.2)	-749.3** (242)
% Hispanic	-643.9* (255.5)	-556.6* (254.2)	-565.5* (253.3)
% Occupied	-1,300** (439.9)	-1,291** (443.6)	-1,302** (442.5)
% High School/GED	184 (392.4)	122.3 (393.4)	116.5 (392.2)
% Undergraduate	478 (416.5)	522.6 (419.2)	478 (418.7)
% Graduate	3,115*** (484.4)	3,273*** (487.6)	3,152*** (490)
% Detached	635.1*** (116.1)	584.3*** (116.5)	584.5*** (116)
Chatfield	-11.58* (5.688)		
Cherry Creek	-10.96* (5.02)		
Rocky Flats	-11.15* (5.069)		
Rocky Mountain	-3.124 (5.136)		
Local	5.221 (21.72)	-3.217 (21.73)	-4.429 (21.70)
Nearest		0.5755 (2.542)	
Close (6400m)			-24,180 (12,960)
R <sup>2</sup>	0.7506	0.7466	0.7476

Significance Codes: \* p < 0.05 \*\* p < 0.01 \*\*\* p < 0.001

Per Capita Income: coefficients represent \$1 increase

Variables beginning with %: coefficients represent 1 percentage point increase

Distance Variables: coefficients represent 1 meter increase in distance

Close (6400m): coefficient represents change if CBG is within 6400m

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