URBAN ENCROACHMENT ON THE WILDLAND-URBAN INTERFACE:
A COMPARISON OF HOME PRICES IN TWO CITIES
OF
SOUTHERN CALIFORNIA

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SIGNATURE PAGE

THESIS: URBAN ENCROACHMENT ON THE WILDLAND - URBAN INTERFACE: A COMPARISON OF HOME PRICES IN TWO CITIES OF SOUTHERN CALIFORNIA

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ABSTRACT

Encroachment at the wildland-urban interface (WUI) is a challenging issue in Southern California. The WUI is the geographic juncture at which the altered and natural environment meet. This connection is at the nexus of urban sprawl, where many issues arise. These issues include the introduction of exotic plants, subsidized species, and pressure on native food supplies. Nevertheless, people are attracted to homes where urban sprawl encroaches on the WUI. The model provides a means of investigation into the relationship between home prices and WUI proximity for the purpose of leveraging policy to combat sprawl. This study investigates whether homes that are closer to the WUI sell for a premium — causing the residential demand curve in the bid rent model to slope upwards at the edges of a metropolis. Specifically, the study areas of Topanga and Santa Clarita in Los Angeles County. A test for the hypothesis is created using a geographically weighted regression (GWR) coupled with hedonic analysis and travel time from trailhead parking lots to homes as a measure of WUI proximity. Results indicate that home prices are positively influenced by WUI proximity, although travel time is negatively influenced beyond a threshold of 17-minutes.
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CHAPTER 1: Introduction

Population increase has led to urban development, putting pressure on the natural environment. Human society relies on the environment for food, energy, and leisure amenities among other ecosystem services to sustain its population. However, the consistent increase of urbanization leads to urban sprawl which is encroaching on the natural environment. The encroachment is increasing pressure on provisions of environmental goods and services.

Los Angeles is the largest city within LA County. This city, and county, attract large numbers of people looking for opportunity (U.S. 2019). However, the natural environment in urbanized setting is scarce. In a review of 71-articles “the migration and regional economic studies suggest that migrants are attracted by amenities nearly as often as by low taxes” (Waltert & Schlapfer 2010). Fernandez and Scott (2018) find that “proximity to open space has a positive and statistically significant influence on increased value of residential real estate.” In order to provide that, a balance needs to be struck between urban development and natural conservation. Scholars have referred to this region of balance as the wildland urban interface (WUI), where the altered and natural environment meet (Radeloff et al. 2005; Alavalapati et al. 2005; Bar-Massada et al. 2014; Hjerpe et al. 2016).

Previous research has explored the relationship between urban development and natural space encroachment (Waltert & Schlapfer 2010). Indeed, this can be seen in the expansion of cities into natural areas. This study
will explore the relationship between WUI proximity and home prices. Moreover, this study specifically contributes to literature by examining the spatial influence of the variables included in this study on home prices via a geographically weighted regression (GWR).

People move from one location to another based on their decision-making processes. Therefore, one reason people move to the WUI is for the environmental amenities offered by the natural environment at that location (Walter 2010, p.141). Preference for environmental amities may drive up demand, density, and home prices within that area. These individuals may even be willing to move to be within an affordable, commutable distance to work or an area with a lower cost of living coupled with environmental amenities which can boost quality of life.

The goal of this research is to explain the effect of WUI proximity on home prices. My research is proposing that the Bid Rent Curve slopes upward at the end of the residential sector, in locations where homes encroach on the WUI creating a U-shaped Bid Rent Curve. These places are desirable because of optimal distance between natural and urban areas. I am predicting that as proximity to the WUI increases, home prices increase ceteris paribus due to consumers’ preference for natural amenities.
CHAPTER 2: Literature Review

The interdependent relationship between urban and natural areas has been studied from multiple perspectives. Relevant literature based on perspectives of environmental value, environmental influence, and environmental policy is presented here to provide a well-rounded interpretation of the results of my study. Literature informed both the selection of the modeling approach along with the data collection, and the discussion of the results for this study.

2.1 Environmental Value

Originally the United States was heavily populated in the East, but migration has since switched to the Western United States which has more natural outdoor areas due to the lack of development when compared with the East (Waltert, 2010 p. 141). More recently, the consistent migration within Western cities has caused an increase of home value in natural environments. An increase in population causes a shift of the demand curve which will cause an increase in both price and quantity of homes. Since there is scarce supply of homes at the WUI, relative to demand based on population growth, demand-pull inflation is the consequence. The inflation of home prices is driven by consumer preference. People will continue to migrate to take advantage of the services the WUI provides.

Consumers have preference for wilderness (Waltert, 2010 p. 147). There is a pattern which shows that larger patch sizes and denser forests which are normal goods sell for a premium in 2000 compared to 1990 (Cho, 2009 p. 2646). A home with a larger lot and denser forest provide more natural amenities. For
example, the forest offers a place to explore or hike while the increased lot size ensures that the property will suit a larger number of outdoor activities. The number of lots with dense forests that accommodate these activities might have decreased over the years and limited the supply. The limited supply allied with the strong demand for the private wilderness is a possible explanation for the WUI premium. Demand for private wilderness is suggestive of demand for public wilderness based on WUI proximity.

Home premiums vary based on the landscape type and legal conservation status. There is a positive relationship in-regards-to homes prices involving preserves, fairly-often with forests, and rarely with agricultural land (Waltert, 2010 p. 141). A preserve guarantees that the amenities provided by the ecosystem will always be there because the preserve cannot be developed. On the other hand, there is no guarantee that in the future a forest will not be developed. Forests that are developed will lose their natural amenities despite the quantity of amenities the forest contributes to a home’s value. These amenities provided by the forest is what gives homes near the forest their premium. Agriculture land provides some amenities, but fewer than a forest. Agriculture land is typically in rural areas which will ensure a nicer view, cleaner air, and fewer people. Forests provides wildlife, plants, cooling, and recreational opportunities such as fishing, hunting, camping, etc. Agriculture land is cleared of its native tree and plants which damages the habitat for wildlife. Diversity is lost, replaced with monoculture farming and domesticated livestock. Since there are fewer
amenities due to the altered state of the land, much of the value in agricultural land may lie in the views.

Consumers preferences for environmental amenities are also shaped by the regional geography. In Tucson, Arizona green neighborhoods had the greatest effect on homes prices (Bark, 2011 p. 412). Neighborhoods are considered green neighborhoods if homes within the area have an abundance of vegetation. The cost to cool homes in Arizona is high due to the extreme, year-round heat. Heat in Arizona is dry, not humid which means evapotranspiration from plants will cool the environment. Vegetation in riparian corridors positively influences home prices according to research (Bark, 2011 p.412). Plants also add to the neighborhood aesthetic. Homes buyers who preserve native plants may be able to sell for a premium (Bark, 2011 p. 412). Native plants in Arizona are succulents, which require less water to keep alive. Less water means a lower cost to maintain. Plant maintenance will become arduous with exotic species due to the arid weather conditions. The trifecta of low cost, low maintenance, and cooling have a role in increasing home premiums when these homes have abundant, native vegetation around them. Plants placed at correct locations will increase a home’s value when a local park location is unavailable.

Parks built in cities generally add value to homes, but the value is contingent upon safety. Parks closer to homes have positive influence on home prices as-long-as the crime rate is below a certain level, but if above a certain level, it has a negative influence (Troy, 2008 p. 233). In other words, the value added to a home is based on park location relative to crime. Home prices can
either increase or decrease depending on the park’s location. The variable which determines this increase or decrease in value is crime. As the crime rate moves further above or below a certain level the stronger the relational influence between distance and home prices (Troy, 2008 p. 233). A lower crime rate relative to an arbitrary threshold will exponentially increase a home’s value the closer it is to a park while the higher the crime rate relative to an arbitrary threshold exponentially decreases a home’s value. A home’s worth decreases the closer a park with a high crime rate is to it because safety is important to consumers, assuming they know the high crime rate. Crime rates are important to note because it is a factor which can alter the value of a home based on park proximity. Other outdoor areas may also act as a setting for illegal activity.

The WUIs value depends on consumer’s fire knowledge. The exponential growth in property loss from wildland fires that has occurred since 1990, could cause homes on the WUI to lose value (Firewise 2016). However, the removal of objects that add to a fires fuel load will increase property value for people who are knowledgeable about fire safety (Hjerpe, 2016 p. 66). Environmental amenities typically add to the value of a property, but the environment can provide dis-amenities as well. People typically pay a premium for proximity to the WUI, but the property must be maintained otherwise it becomes a fire risk. The fire risk must be reduced by striking a balance between the provided amenities and potential dis-amenities. Homes with dis-amenities are in hazardous locations. These hazardous locations include landslides, floods, and fire prone
areas. Homes built in these areas are done so for short-term gain, however, they can cause long-term loss.

2.2 Human-Environment Interaction

Human-environment interaction has considerable influence on the WUI. However, human influence on the WUI is usually not beneficial. Overwhelmingly, humans produce more negative externalities than positive externalities. The degradation of the environment that happens as a result of these negative externalities diminishes the value of homes located near or at the WUI.

Human activity often influences the environment in negative ways. Along with urban sprawl comes road construction as people commute from suburbs into the city center. Road construction causes many problems because it fragments the natural habitats and reduces biodiversity due to the many detrimental effects of fragmentation (Radeloff, 2019 p. 799). Natural habitats are typically large and continuous while roads divide the habitat, limiting the natural continuity of the ecosystem. Animals that attempt to cross the road for more habitat or prey run the risk of getting run over (Kreling et al. 2019). The addition of roads alters predator-prey and plant-herbivore dynamics contributing to specie endangerment or extinction. A system of waterways that is paved over will limit plant growth which has a cascading effect on herbivores, omnivores, and carnivores. Humans rely on watersheds to provide safe drinking water. However, reabsorption into the water shed is interrupted, which is a sign of encroachment.

At the WUI other activities can have cascading, far-reaching consequences on the ability of a natural habitat to deliver other ecosystem
Bar-Massada also discussed other ways human alteration around their homes can alter natural ecosystems, “biotic interactions including exotic plant introduction, wildlife subsidization, disease transfer, landcover conversion, and habitat loss” (2014 p.431) Advantages for invasive, exotic species at the WUI increase their reproduction rate which then out-compete native plants. Pressure on wildlife is then caused by limiting the native food supply for herbivores. Food supply for native plants will be limited in areas disturbed by humans their activities eroded soil which depletes nutrients. Limited nutrients in the soil promotes the use of fertilizers. Introduction of fertilizer damages the environment’s microbiota because it alters the natural balance among microbial species. Bar-Massada discussed, “biotic interactions including exotic plant introduction, wildlife subsidization, disease transfer, landcover conversion, and habitat loss” (2014 p. 430). Exotic animals tend to thrive in the human-altered environment. These animals include typical species such as cats, dogs, rats, feral dogs, starlings, and cow birds. The introduction of these species means there is more competition for the food sources that native animal populations rely on. As a result, more pressure is put on the food supply and fewer native animals will survive. Fewer native species coupled with disease transfer from subsidized wildlife is a potential lethal combination. Disease transfer has an extreme potential for harm because native animals have not developed immune system resistance that defends against these newly introduced diseases. These negative outcomes for ecosystems are all the results of human interference.
Human interference will jeopardize the future of our generations. Water, air pollution, and ecological goods and services are all detrimentally affected by the people who inhabit the forest and live along the WUI (Bark, 2005 p. 705). A faster rate of human occupation ensures more damage to the environment in less time. Where there are people, there is pollution. Pollution damages resources that are used in production of goods and services. Air is polluted due to vehicles, demand for electricity, and accidental fires. Chemicals from pesticides pollute waterways while trash and biohazardous material pollute as well. Plastics are non-consumable and non-biodegradable which cause problems for animals when ingested or wrapped around their body. Biohazardous material increases the chance of animals acquiring a disease such as cancer or a weakened immune system when they encounter the substance.

2.3 Environmental Policy

Environmental policy has the potential to add value to people’s homes while preserving the land. There are different policy strategies that can accomplish this: conservation policy, endangered species policy, density development policy, and land right purchase agreements. Conservation policy eliminates the ability to develop land. Endangered species policy prevents development in locations with the species habitat. Density policy can be used to promote density development while limiting sprawl. Cost-benefit analysis can be done to determine how much a landowner would make from the land which can them be paid to him or her for the rights to prevent the lands destruction. These
policies have potential to add value to properties while ensuring environmental amenities which may sway some homeowners in favor of these policies.

Conservation policy can increase home values by preserving the amenities offered by the environment that people value. Previous research shows that there is a premium in home prices due to proximity of conservation areas and conservation policy passed in Riverside County (Fernandez, 2018 p. 486). The importance of good environmental policy is shown by the value it adds to properties. Added value is a leverageable argument towards property owners in efforts to pass conservation policy in residential locations. Location is the most important characteristic that sells property. Property located near what consumers value will sell for a premium because of convenience. Property values guaranteed by good environmental policy is a win-win solution. The environment is preserved while boosting home values.

Policy ensures small, environmentally degraded property sells for a premium by freezing development. There are homes in 2000 with negative elasticities for patch density which reveals the value of developing policies to protect fragmented forest (Cho, 2009 p. 2656). Consumers do not have preferences for fragmented lots. Home prices will decrease the more fragmented the land is around their homes. A fragmented land lacks continuous habitat such that it makes the property undesirable due to decreased environmental amenities. However, it is easier to regrow fragmented lots than to enlarge the lot size. Environmental policy serves its purpose by allowing the land to naturally rejuvenate on its own. Therefore, homeowners will favor conservation policy
because it increases the value of their property simply by letting the forest regrow. Forest regrowth will alter dynamic markets which will adjust to fit a new efficient equilibrium.

An equilibrium must be struck between economic development and maintaining environmental amenities. Amenities had a positive and significant relationship to promoting development, which was comparable to the effects of low taxes on development (Waltert, 2010 p. 142). People migrate to seek new opportunities in efforts to better their life. A better life is achieved by increasing disposable income or equivalently by increasing access to nature. However, WUI proximity will encourage migration which promotes development through population growth. Increases in population puts pressure on the environment due to development. Therefore, economic development must be kept under control at the WUI via conservation policy.

Biodiversity must be protected via conservation policy. Endangered species policy in Riverside, CA, protects about 142 species and might be influencing the value of their habitat (Fernandez, 2018 p. 486). Land that has endangered species cannot be developed in this area, and it has indirectly led to a type of accidental conservation that increases home values because it guarantees homeowners environmental amenities in the long run. Obviously, people prefer to own land that is of greater value. Although, the value generated is based on policy that is meant to increase biodiversity. Since policy that increases biodiversity has been found to add value to property, this shows that
consumers have a willingness to pay for biodiversity. Riverside’s policy has simultaneously protected biodiversity while pleasing the market.

Policy can protect and increase the quality of natural amenities. Home buyers tend to know the quality of the lakes closest to the home and are willing to pay a premium for homes with better quality water (Tuttle, 2015 p. 13). Quality lake water determines the type of activities people can engage in. People enjoy fishing but poor water quality is not conducive to fishing. Fishermen will prefer to maintain the quality of the water because they like to fish. Effective policy is dependent upon the public support (Tuttle, 2013 p. 13). People can be persuaded to support policy based on what they enjoy. Without understanding what they enjoy or explaining the value added to their home policy will be difficult to pass.

Quantitative methodologies help explain how policy benefits consumers. Cost benefit analysis helps home buyers better understand the impact of negative externalities on their asset (Tuttle, 2013 p. 13). A consumer’s home is an asset which cannot be sold when there is too much damage done the environment. A prime example is Flint, Michigan. In Flint lead from old pipes seeped into the tap water, when highly corrosive river water was substituted for pre-treated Detroit as a cost-saving measure (Jurkiewicz 2016, p. 234). The resultant lead poisoning of children and adults then consequentially led to the devaluation of homes. The homes could not be sold since consumer’s perceived the water as a threat to their health. Environmental health is of the utmost importance and a main reason why cost-benefit analysis helps consumers
understand the value contributed to their home through good environmental policy and possible devaluation of homes brought about by greedy, short-sighted environmental policy.

Cost often prevents the adoption of sustainable methods. The cost to implement conservation easement (CE) decreases the greater the distance from cities (Mashour, 2005 p. 771). Therefore, it is important that compliance with conservation easement agreements must be enacted before land becomes heavily urbanized. These actions will yield more benefit to home buyers at the WUI, at a cheaper cost the further in advance they are implemented. The price to get owners to give up the right to log in wetlands and subdivide increases the cost of CE (Mashour, 2005 p. 771). The benefit from the payment must outweigh the benefits the owner receives from the natural resources of the area to get them to give up the rights. Rights are negotiated via policy.

Policies best used, will push for urban density as opposed to urban sprawl. People pay a premium for homes closer to urban areas (Mashour, 2005 p.779). What homebuyers are willing to pay for homes depends on personal preferences. Therefore, incentivizing people to build more homes near urban areas will help minimize damage done to the environment in rural areas. In other words, increasing density in an area that is already damaged in order to limit negative externalities.

2.4 Bid Rent Curve

A relevant conceptual mode that will be examined is the Bid Rent Curve (Shieh 1987, p. 71). The Bid Rent Curve gives substance to the thesis through
conceptual understanding and was first developed in the 1960s by William Alonso. Initially it was developed to analyze real estate prices within the city of Chicago, Illinois. Tobler's Law which states that “. . . near things are more important than things that are further away. . .” applies nicely to help explain the Bid Rent Curve.

The center of Chicago represents the central business district (CBD) where real estate is most expensive. The CBD is a city's downtown. This is where people are willing to pay higher rent for the optimal location to sell products to consumers. In the Bid Rent Curve, as distance increases from the CBD real estate prices drop. The next sector out is usually the industrial sector which has slightly cheaper real estate than the CBD. This sector lies in the middle between the CBD and the residential sector because it is in an optimal location to ship products easily to the CBD. The third sector is the residential sector where real estate for homes are located. Homes have an even cheaper rent than the industrial sector. At this distance people can get more for their money while commuting to the CBD for work. In other words, the beginning of urban sprawl and encroachment on the WUI.

The Bid Rent Curve merely serves as a hypothetical model to help understand and answer the hypothesis. As stated, “results presented wide variations in real bid-rent curves that a) overall deviated dramatically from the hypothetical distribution of rent, and b) spoke to the unique residential patterns in individual U.S. cities” (Bochnovic 2014, p. i). Cities throughout the United States cannot be simplified into a monocentric or a multicentric Bid Rent Curve model.
There are some pattern trends in cities, but each city is unique. There may be overlap or patch work between sectors.

The Bid Rent Curve was initially a unicentric model consisting of one CBD (Figure 1). The following is an example of the Monocentric Bid Rent Curve:

![Monocentric Bid Rent Curve](image)

*Figure 1. Monocentric Bid Rent Curve. Adapted from Bochnovic. (2014, p. 9)*

However, a multicentric model is more representative of current cities due to encroachment caused by urban sprawl (Figure 2) (Shieh 1987, p. 72). The original monocentric Bid Rent Curve worked best when development first began. However, development did not occur this predictably. A more likely scenario is that multiple cities were created apart from each other. Each with their own CBD. As these individual cities developed on their own, they grew, leading to urban sprawl and encroachment. Eventually these cities connected creating an almost continuous urban surface.

There is no single center, but there are some CBDs that are bigger than others. LA is the largest city in the area which contains the largest CBD. This is
the reason it is used as a control variable for home prices in the study. The reason is that the home prices at the end of the residential sector enjoy a premium due to the proximity of the WUI, and the scarcity of residential areas in the WUI. My version of the multicentric Bid Rent Curve is new in the sense that a U-shaped Bid Rent Curve is created that slopes upward at the edge of the residential sector with WUI proximity as the source of the home premiums. However, I predict these home prices do not reach the level of premiums that real estate located in the CBD does. The following is an example of the Multicentric Bid Rent Curve:

Figure 1. Multicentric Bid Rent Curve.
CHAPTER 3: Research Methodology

The interdependent relationship between urban and natural areas has been studied from multiple perspectives. Relevant literature based on perspectives of environmental value, environmental influence, and environmental policy is presented here to provide a well-rounded interpretation of the results of my study. Literature informed both the selection of the modeling approach along with the data collection, and the discussion of the results for this study.

3.1 Study Area

The study area encompasses the cities of Topanga and Santa Clarita City from the edge of a 50-mile buffer (Figure 1). These cities were chosen for several reasons. LA County as a whole, is not feasible due to scale. Topanga and Santa Clarita are on the edge of urban development or the WUI, making them ideal for the study. The following is the study area:
Figure 2. Study Area. The cities of Topanga and Santa Clarita are surrounded by 50-mile red buffers, the large green data point is LA City Hall, small green data points are WUI parking lots, blue data points are homes, and the black back lines represent city boundaries.

Homes must be located at the WUI to draw insight from the relationship with home prices. People who move to these locations will value what the land has to offer which will reflect in the implicit price of the home.

Santa Clarita is isolated which will give less biased results because the area will better capture the WUI proximity and home price relationship. Additionally, the city is surrounded by natural area, with enough home vector data for the potential to provide statistically significant results. Topanga is closer to the ocean, more developed, and is surrounded by far more trailhead parking
lots. The city is surrounded by natural area and is isolated from excessive
development. There is far more home data for the area which will yield better
results. Significant results are important to properly explain what happens to
home prices when encroachment on the WUI occurs.

The Euclidean distance from the central business district (CBD) is used as
a control variable in the four models of regression. The CBD is represented by a
bright green dot on the original map that was placed on LA City Hall.

Data is well concentrated within the city of Topanga followed by a break
due to natural area to the East, and then followed by a patch of densely clustered
home data in an urban area. In Santa Clarita, vector home data is fewer with
more dispersion but more isolated. In relation to LA, Santa Clarita and Topanga
will hopefully show a decrease in home prices as distance from the CBD
increases followed by an increase in home prices, as proximity to the WUI
increases. People are fewer in number when compared to LA decreasing
demand for real estate at these locations in comparison with real estate at the
CBD, but higher in comparison to other homes in the residential sector.

3.2 Conceptual Model

The study is conceived of home prices as a function of home attributes,
demographics data of the census block groups, and distance to the WUI
(represented by trailhead parking lots). For the purpose of this study it is
imperative to analyze home price variance, and ease of trailhead accessibility. I
will perform hotspot analysis, network analysis, and geographically weighted
regression (GWR) to understand the magnitude of the relationship between these variables.

A hotspot analysis helps determine where high and low home price clusters occur within the study area (McCord 2012, p.57). Hotspot analysis, as developed by Art Getis and Keith Ord, finds statistically significant clusters of high and low values in a sample of spatial data (Mitchell 2009, p. 175). Essentially the calculation method sums the value of features of the surrounding neighbors, divides by the total sum of all these values within the study area, and then multiples by 1 or 0 to determine if the value is a neighbor that should be included (Mitchell 2009, P. 176). In this case, the high and low values are the values of the home. Clusters of high value means that there are abnormally high home values surrounded by other homes of abnormally high value, and vice versa for low value clusters. Clusters of high valued hotspots near trailhead parking lots would be indicative of home prices increasing as proximity to the WUI increases. A visual perspective of the relationship shows where clusters of high home values exist in proximity to trailhead parking locations. However, hotspot analysis only tells one side of the story.

A network analysis allows for the calculation of distance by travel time. In this case, we are interested in the travel time to the nearest trail head parking lot. These calculations are made with a GIS road network that models real-world transportation networks. Basically, a program composed of lines that represent the roads and nodes to accurately portray the roads and intersections of the roads. Roads are broken up into types which are assigned speed limits based on
the type of road. This road network represents a more realistic depiction of the area of interest than hot spot analysis since driving time is taken into consideration. We are assuming the primary mode of transportation within this area are cars. As a result, the hotspot analysis can be overlaid on top of the network to determine if clusters of high valued homes are in fact located within a short travel time to trail head parking lots. This will allow the relationship to be observed visually.

The GWR model is based on the ordinary least square’s (OLS) regression. Therefore, the assumptions in the OLS model also applies to the GWR model. These assumptions are: 1) linearity, 2) error term has a 0 population mean, 3) variables and error term are uncorrelated, 4) no spatial autocorrelation, 5) homoscedasticity, and 6) no multicollinearity (Studenmund 2001, p. 85). However, spatial autocorrelation is indeed expected in the model because near things are more similar and important than things that are further away. Moran’s I will be run to test for spatial autocorrelation which, if significant, shows spatial autocorrelation (Osland 2010, p. 302). Both the OLS and GWR model will be tested. A geographically weighted regression (GWR) quantifies trailhead parking lot proximity. This is done by estimating an equation, with several independent variables as inputs, and total home value as the dependent variable or the output. Independent variables can be structural characteristics of the homes, demographics of the area, or distance to natural areas. In other words, a regression determines the increase of home value based on a one unit decrease from trail head proximity to parking lot locations. The GWR uses a
weight to represent proximity in the calculation of these determinations. Thus, more accurately representing proximity influence on the relationship. The magnitude of spatial influence on home prices vary. Due to this influence the weight acts as a mechanism against spatial bias, making the GWR the best method for the model. A fixed weight is chosen over adaptive weight because the data contains condominiums which means there are several data points within the same address. An adaptive weight would bias the model by minimizing the number of point selections due to a tradeoff.

Variables with the strongest explanatory power should be included in the regression to reflect the influence of distance from WUI parking lots most accurately. The general relationships can be viewed categorically: whether there is a positive, negative or no relationship.

A Euclidean distance vector or arc is calculated with a point located at City Hall to represent the distance from the central business district (CBD) to each home included in the dataset. This is used as a control variable because it is widely known that, in general, as homes gets further away from the CBD, home prices tend to decrease. Moreover, since other variables that explain price fluctuations are included in the regression, I expect that home prices will accurately reflect the relationship between WUI parking lots and home prices.

3.3 Empirical Model

The empirical work was performed using ArcGIS Desktop 10.7.1 and the hotspot analysis was performed with the Getis-Ord Gi* tool in this platform. The homes shapefile containing all the attributes was used and the input field was
total value in US dollars. A shapefile contains the geographic information of the attributes which can be represented as points, lines, or polygons. Conceptualization of spatial relationships was the fixed distance band and the distance method was Euclidean distance. There was no distance threshold.

The network for analyzing travel time was created with the network analyst toolbar. A street network and the shapefile with trailhead parking lot locations were required. The street network had speed limits that I assigned based on street type and undriveable roads were deleted. These steps required filtering and a definition query. A geodatabase and feature data sets were created. Travel time in minutes was calculated as:

\[
\text{Travel time} = \frac{\text{shape length}}{(\text{speed limit} \times 5280) / 60}.
\]

A mile contains 5,280 feet and 60 represents the number of minutes in an hour. The road network and trailhead parking lot locations were imported. At this point a new service area of polygons was created based on travel time from WUI parking lots as facilities to homes. Facilities were populated with the add locations tool for trailhead parking lot locations. Service area was the network analysis layer, sub field were facilities, locations were trailhead parking lots, and the tolerance was changed to feet. In the network, the snap to network option was used, minutes were set, along with breaks, and away from facility with no U-turns except at dead ends. At this point the model was solved for travel time from homes to the nearest trailhead parking lots.
Regression analysis was done with two tools: ordinary least squares (OLS), and geographically weighted regression (GWR). Homes shapefile was used for OLS and the unique ID field was FID_HomeVa which was simply a required field that did not play a role in the calculations. The dependent variable was total home value while the independent variables were home size, number of bedrooms, number of bathrooms, those with at least a bachelors’ degree, owner occupied, and Euclidean distance (ED) from the central business district (CBD). Educational attainment is relevant to home prices because those who are educated tend to make more which explains higher home price affordability.

Homes shapefile was used for the GWR. There were three GWR models: the benchmark (model II), Euclidean distance from trailhead parking lots (model III), and travel time from trailhead parking lots (model IV). All GWRs were run with a fixed kernel type and a bandwidth parameter of 40,000 feet because this was the minimum distance at which all the GWR models would run. Environmental processing extent was the 50-mile buffer around the cities of Topanga and Santa Clarita. The processing extent limits the area where the software processes the calculation to reduce time and resource use. Model I and model II regressions contain seven variables while model III and model IV contain 8 variables. Model I (OLS model) contains the same exact variables as model II. Model III contains the exact same variables as model I and model II, plus a variable measuring the Euclidean distance from trailhead parking lots. Model IV contains the same exact variables as model I and model II with an additional variable as well. However,
instead of the independent variable ED from trailhead parking lots, the variable is travel time from trailhead parking lots.

The GIS environment allowed parameters to be set in ArcMap for geographically weighted regression processing. This environment was set based on the processing extent of the city buffer which only allowed for the area within the buffer to be processed. NAD 1983 State Plane California V was the proper projected coordinate system (PCS) for LA County. Data was geocoded with the Los Angeles County CAMS Locator based on the property location (LA County CAMS Address Locator). When an address is geocoded, it is assigned an x and y-coordinate as a point on a map. The 50-mile buffer was used to clip the home point shapefile to ensure that only points within the buffer were included in the regression.

Demographic data provided the rest of the independent variables in the model. Demographic data at the household scale came from the U.S. Census between the years 2013 and 2017 (Explore Census Data). All independent variables were later joined to the clipped census block groups.

Euclidean distance measures distance using a straight line from one point to another. However, it is a simplification of reality. Nonetheless it does offer insight – LA County is famous for the omnipresence of automobiles. Parking lots were chosen because they are the actual access points to trailheads. Not the trailheads themselves. A shapefile containing all hiking information was filtered based on parking area locations at trailheads within the 50-mile buffer area (Countywide Multi-Use Trails).
There were many requirements to meet for the street network analysis to be complete. Trail roads were clipped from the same website as the trailhead data (Department of Parks and Recreation Trails). The street network was obtained from LA County G.I.S. Data Portal and clipped with the buffer (LA County Streets & Address File). All streets were given a speed limit based on the road type that was then used to calculate travel time. Railroads, planned roads, and walkways were removed from the street shapefile because cars cannot travel on these roads. A geodatabase along with feature data set classes were created before importing the street network and trailhead parking locations. The minute variable was used to calculate travel time in the new network dataset. A new service area was created with parking locations loaded as facilities in the network analyst window and impedance as minutes. Impedance is the unit of the calculation. Before the network was solved for travel time, default breaks were set from 3 to 24 in 3-minute intervals because no homes were outside the 24 minute travel time Fields values were set to-break and the color ramp was set to a red-green spectrum with 8 classes at equal intervals. In other words, a spectrum with dark green represents the distance a person can travel within the first three minutes, followed by a lighter green to represent the next three minutes, ending with red which represents the distance a person can travel between 21 and 24 minutes. U-turns were only allowed at dead-ends.

3.3.1 Data

Home data came from the Los Angeles County Open data portal and was provided by the LA County Assessor’s Office for years 2006 to 2019. Data for the
structural variables for the homes came from this source as well. A 50-mile buffer was drawn around the cities of Topanga and Santa Clarita with the place shapefile (U.S. Census Bureau). Home data was filtered based on the names of the cities within and on the edge of the 50-mile buffer. The buffer ensured that the results at the edges of the city were not biased by excluding points that would influence the calculations on the edges of the buffer.

The clipped home shapefile was exported to Excel for cleaning to delete excess variables and create dummy variables. This gave the data more functionality and utility. Dummy variables were created to categorize the variable influence of certain data characteristics. Structural variables that were included were: renovated dummy, square footage, number of bedrooms, number of bathrooms, condominium dummy, single family residence dummy, pool dummy, and age. Vacant lots, commercial, industrial, high-value residences, Mill's Property Act (historic homes), spa home’s, duplexes, doubles, three-unit combinations, four-unit combinations, residential income homes, pools, and miscellaneous were excluded due to low count.

Demographic variables were combined with structural variables in an excel sheet and the data was re-geocoded within ArcMap. The data was then joined to the census block groups with the variable geoid. Demographic data provides the rest of the independent variables in the model (Explore Census Data). This included information on the; number of Hispanics, number of Asians, number of whites, percent with high school diploma, percent with at least a bachelor's degree, percent of poverty, percent unemployment, percent men,
percent women, percent owner, percent renter, percent on food stamps, number of households with income below $60,000, number of households with income above $60,000, number of people age 18 to 29, number of people age 30 to 49, and number of people age 50 or higher.

The home shapefile that contained all structural variables was intersected with the census block group. Euclidean distance was calculated for the trailhead parking lots with an output cell size of 35 feet. A 35-foot output cell size ensures the accuracy since the calculations are done at a small scale. The extract value to points tool was used in combination with the previously intersected output and the Euclidean distance raster to create an output that contained demographic, and structural variables. Finally, this output was intersected with travel time polygons. Due to excessive counts from the overlapping polygons, a mean distance to break was calculated with the summary statistics tools as an output table. Ref ID was then used to join the combined output with this table. Data was exported to create a new shapefile with a count of 406. However, a control variable was needed.

A new shapefile was created for Los Angeles City Hall to mark the downtown area as the CBD. This was done with the editing tool and a new shapefile. Euclidean distance was then calculated away from LA City Hall with the newly created point feature and an output cell size of 35 feet, as was previously used. A base model was chosen with 6 variables as a benchmark. Gillard’s article (1981, p. 218) was used as a regression reference on home prices (Table 1). A visual representation of the variable relationships helped with
benchmark variable selection. Individual scatterplot graphs of each independent variable with the dependent variable provided the necessary visualization for this task. Four regressions were done for 2017 with total value as the dependent variable. The initial independent variables were home size, number of bedrooms, number of bathrooms, higher education, and Euclidean distance (ED) from the central business district (CBD). Model II, III and IV were run at a fixed distance of 40,000 feet (Cromley 2014, p.140). The GWRs originally did not run due to problems associated with three variables: Euclidean distance from the CBD, Euclidean distance from the parking lots, and travel time from the parking lots. These variables were several orders of magnitude higher than the other variables, therefore, the GWR could not process them correctly. Transformation was required in order to create values between 0 and 1. The transformation equation used:

\[
\text{Transformation} = (1 - \text{distance}/\text{max}).
\]

Transformed results were between 0 and 1 with those values nearer to 1 representing closer to the location and those values nearer to 0 representing a further distance from the location. A summary of the variables is presented in:
Table 1 Descriptive Statistics of Regression Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Max</th>
<th>Min</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Value</td>
<td>1245709.595</td>
<td>1473285.240</td>
<td>17955665</td>
<td>62693</td>
<td>406</td>
</tr>
<tr>
<td>Bedrooms (count)</td>
<td>2.847</td>
<td>1.196</td>
<td>8</td>
<td>0</td>
<td>406</td>
</tr>
<tr>
<td>Bathrooms (count)</td>
<td>2.894</td>
<td>1.411</td>
<td>11</td>
<td>0</td>
<td>406</td>
</tr>
<tr>
<td>Higher Education (%)</td>
<td>.609</td>
<td>.155</td>
<td>.887</td>
<td>.127</td>
<td>406</td>
</tr>
<tr>
<td>Owner (%)</td>
<td>.571</td>
<td>.269</td>
<td>.955</td>
<td>.019</td>
<td>406</td>
</tr>
<tr>
<td>ED from CBD</td>
<td>.531</td>
<td>.154</td>
<td>.750</td>
<td>0</td>
<td>406</td>
</tr>
<tr>
<td>ED from Parking Lots</td>
<td>.638</td>
<td>.262</td>
<td>.993</td>
<td>0</td>
<td>406</td>
</tr>
<tr>
<td>Travel time</td>
<td>.226</td>
<td>.078</td>
<td>.535</td>
<td>0</td>
<td>406</td>
</tr>
<tr>
<td>Size (sq. ft.)</td>
<td>2364.889</td>
<td>1583.430</td>
<td>11206</td>
<td>429</td>
<td>406</td>
</tr>
</tbody>
</table>

Note. From LAC. Open Data & Explore Census Data.
CHAPTER 4: Results

There are multiple ways to analyze relationships among the data used in the model and to understand the WUI proximity effect on home prices. Therefore, several methods are used: scatterplot of distance from City Hall (CBD), hotspot analysis, travel time network, travel time scatterplot from trailhead parking lots, Euclidean distance from trailhead parking lots, table for GWR model fit, benchmark OLS mode, benchmark GWR model, Euclidean distance from trailhead parking lot GWR model, and travel time GWR model. Multiple methods provide a well-rounded and in-depth understanding of the relationships involved in order to draft more efficient, effective policy.

The Bid Rent Curve initially displayed the relationship of home prices to the CBD. In the scatterplot graph of Euclidean distance from LA City Hall and home prices from within my study area (Figure 3), there is a noticeable gap between 0 and 50,000 feet because the home data is only within a 50-mile radius of Topanga and Santa Clarita and does not extend all the way to the CBD. However, as home values begin at the edge of a 50-mile buffer radius near City Hall, they start at a high peak of about $18.4 million but drop as distance from City Hall increases to about $1 million, and then appear to increase as they approach the WUI. In other words, a bimodal distribution that violates the linear assumption of the OLS and GWR. In this case, as a U-shaped curve between the independent and dependent variables. Additionally, the graph shows a slightly negative trend line as distance increases from City Hall. The scatterplot graph of Euclidean distance from City Hall is shown below:
4.1 Hotspot Analysis

A hotspot analysis was run on total home value to determine locations of high and low value clustering in relation to trail proximity. Additionally, hotspot analysis was done to test for spatial autocorrelation between the home prices. The results indicate the presence of hotspots in 19 homes out of a total quantity of 406 homes (Figure 4). Homes with statistically significant hotspots located near trailhead parking lots suggests an upward slope of the residential Bid Rent Curve as it approaches the WUI. Furthermore, there are no statistically significant cold spots which suggests that there is no downward slope of the Bid
Rent Curve as it approaches the WUI. A tradeoff potentially exists between the distance to urban areas, the WUI, and the ocean.

In Malibu city just West of Santa Monica, near Mountains National Recreation Area, there are two homes that are dark red which are three standard deviations above the mean and indicate a hot spot for total home value with a 99% confidence interval. This indicates a spatial clustering of high values that are less than 1% likely to be due to random chance.

Seven of these homes are dark red or three standard deviations above the mean indicating a 99% confidence interval, three homes are slightly red or two standard deviations above the mean indicating a 95% confidence interval, and another three homes are pink or one standard deviation above the mean which indicates a 90% confidence interval. Topanga contains one home which is slightly red or two standard deviations above the mean which indicates an abnormally high value with a 95% confidence interval.

In LA just North-West of Beverly Hills there are three homes that are dark red or three standard deviations above the mean which indicates a 99% confidence interval. They are located near the Santa Monica Mountains National Recreation Areas and other outdoor areas. Pacific Palisades has 13 homes that are red or two standard deviations above the mean, indicating high value clustering based on total price. There are three areas with clustered high value home prices for a total of 19 significant hotspots. The hotspot analysis results:
Despite finding no cold spots in the data there are clustered areas of high total value homes around other high total values (Figure 5). This suggests spatial autocorrelation, the reason for a GWR. The GWR model allows for adjustment based on correlation. The close-up of the hotspot analysis results shows statistically significant hotspots located within the cities of Pacific Palisades, Beverly Hills, Topanga, and Malibu:
4.2 Travel Time

An overview of the entire area of the travel time provides the bigger picture (Figure 6). However, the map is too large to interpret, therefore more detailed maps are provided. Travel time network analysis results:
There is a trade-off between three things: ocean distance, urban distance and WUI distance. These high clustered homes are situated in an optimal travel point which grants them access to this trifecta (Figure 7). This would explain the reason as to why so many high valued homes are clustered within the 15 to 18-minute travel distance. The close-up results for Beverly Hills:
However, in Topanga there is one high home value outlier that is within the 3-minute travel distance (Figure 8). Effects seem to diminish between the 18 to 21-minute travel time. The number of high home values within the orange area drops to 5 and then to 3 within the 21 to 24-minute travel time. Represented by the red area. The ocean is essentially a natural wildland area as well. A close-up of the results:
Figure 8. Close-Up of Travel Time Network Analysis & Hotspot Analysis. Colder colors indicate shorter travel time while warmer colors indicate longer travel time.

There is a trade-off at the wildland urban interface between urban and natural environments (Figure 9). When there is less urban area available and an abundance of natural area there is a surplus which decreases the cost for the amenities offered by the WUI. As you move further inland towards LA, there is a group of high value home clusters due to the proximity of the urban area. For a group of homes located near Santa Monica, the owners were willing to pay more for homes that were located closer to the beach, but further from the WUI. Another larger subgroup of homes located within the yellow area was willing to pay more for homes that were closer to the WUI. There is a tradeoff based on preferences. The results for Pacific Palisades:
Figure 9. Close-Up of Hotspot & Travel Time for Pacific Palisades. Colder colors indicate shorter travel time while warmer colors indicate longer travel time.

Two homes in Malibu with a 99% confidence are within the 18 to 21-minute range of a trailhead parking lot (Figure 10). These same homes are within a short distance of the ocean. The close-up results for Malibu:

Figure 10. Close-Up of Hotspot & Travel Time for Malibu.

Colder colors indicate shorter travel time while warmer colors indicate longer travel time.

People are willing to pay more for a home further away from trailhead parking lots until about 17 minutes (Figure 11). However, once their distance
exceeds the 17-minute threshold they want to pay less. Therefore, people prefer a balance between urban and natural areas. The optimal distance for the tradeoff based on this data appears to begin at 17 minutes. The closer people are to natural areas the further they are from the urban environment. However, the closer they are to urban areas, the further they are from natural areas. They still want to be within a decent distance of natural areas and urban life to be able to enjoy both. Travel time appears to be somewhat more linear than distance from the CBD. The scatterplot graph of travel time from trailhead parking lots:

![Travel Time Graph](image)

*Figure 11. Travel Time (in minutes) from Trailhead Parking Lots on Home Values (in million dollars).*

In Euclidean distance, homes that are closer to trailhead parking lots show more total value and as the distance increases away from parking lots total home
value decreases, but then begins to rise again (Figure 12). Most likely due to the higher demand for homes in denser urban areas.

The red trendline fit to the data is downward sloping indicating an inverse relationship between total home value and distance from trailhead parking lots. At about 3,000 feet there is a cluster of total home value between approximately $11 and $14 million. This trend continues until about 10,000 feet with a cluster of homes between ranges of approximately $15 to $19 million. Homes then decrease with the lowest peak of $1.9 million at approximately 21,000 feet. Total value then again begins to increase to a high peak of approximately $4 million. Here is a non-linear monotonic negative binomial distribution. The scatterplot graph of Euclidean distance from parking lots:
Figure 12. Euclidean Distance (in thousand feet) from Parking Lots on Home Values (in million dollars).

4.3 Regression Models

The relationship between home prices and the WUI have been demonstrated by the results of the scatterplot graphs, the hotspot analysis, and the travel time network analysis. To obtain more a detailed analysis, regressions must be performed. Regressions will allow for the quantification of each variable’s influence on home prices at the WUI and allow for comparisons between models to reach a deeper understanding. All these models are regressed on home prices as the dependent variable with a range of six to seven independent variables.

Bandwidth thresholds were determined by the shortest distance each model would run on. Thus, the minimum fixed distance the model would run on for model II, model III, and model IV was 40,000 feet. In a sense, these represent important cutoff thresholds where home value begins to have importance in the model because distances below 40,000 feet cannot be calculated. Model I is an OLS regression which does not require a bandwidth threshold.

Akaike information criterion (AICc) is a variable which represents a measure of model fit amongst the results for the GWRs which can be compared between models to determine model fit. Therefore, AICc must be reported since it shows which model has the best fit and the model which will have regressions run on it. Those models with lower AICcs are considered a better fit. The benchmark model II’s AICc is 731.67 while model III’s AICc is 246.634 (Table 2). Additionally, model II is compared to model IV’s AICc of 23.518 and shows that
model IV is indeed a better fit than model II. Because model IV incorporates travel time it demonstrates that it's an accurate measurement of WUI accessibility.

The $r^2$ is a measurement of variance explanation ranging from 0 to 1. Model I's $r^2$ is .571, Model II's $r^2$ is .981, model III's is .988, and model IV's is .961. Based on the $r^2$ of model I, only 57% of the variance in home prices is explained. Adjusted $r^2$ eliminates the bias. Again, the closer the number is to 1 for the model the better the explanation of variance. Adjusted $r^2$ for model I is .565 while adjusted $r^2$ for model II is .973, adjusted $r^2$ for model III is .989, and model IV is 1. Based on the adjusted $r^2$ model IV is 1 indicating a better explanation for variance, although the value of 1 can also indicate overfitting of the model because excessive variables push the adjusted $r$ squared higher, making it appear as if the model is a better fit.

All three models must be taken into consideration. AICc favors model IV, $r^2$ favors model III, and $r^2$ adjusted favors model IV. Since the $r^2$ adjusted is equal to 1 that means the model explains 100% of the variation in home prices. However, this can be an indication of model over fit. Therefore, the GWR was run on model IV.

Due to the presence of hotspots, the models were tested for the presence of spatial autocorrelation. Moran’s I is a tool to determine how spatially autocorrelated each model is. If Moran’s index is above 0 that means the model is clustered, if Moran’s index is below 0 that means the model is dispersed, and if Moran’s index is equal to 0 that means the model is random. Moran’s I for model
I is .102 with a p value of .009, model II is .108 with a p value of .006, model III is .144 with a p value of .000, and model IV is .092 with a p value of .020. Each p value is below .05 indicating significance. Moran’s I is closest to 0 in model IV indicating that model IV does the best job controlling for spatial autocorrelation.

AICc is lowest in model IV, while the adjusted $r^2$ for model IV is highest, and Moran’s I is closest to 0 in model IV. Therefore, Model IV is chosen as the best model fit due to these three reasons. The window of accessibility to the WUI this model represents, is indeed an important factor. The results for model fits:

Table 2 Models’ Goodness of Fit Statistics

<table>
<thead>
<tr>
<th>Statistics</th>
<th>OLS Benchmark (model I)</th>
<th>GWR Benchmark (Model II)</th>
<th>GWR ED from Trailhead Parking Lots (Model III)</th>
<th>GWR TT from Trailhead Parking Lots (Model IV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth</td>
<td>N/A</td>
<td>40,000 ft</td>
<td>40,000 ft</td>
<td>40,000 ft</td>
</tr>
<tr>
<td>Residual Squares</td>
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<td>7078755918.111</td>
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<tr>
<td>AICc</td>
<td>N/A</td>
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<td>23.518</td>
</tr>
<tr>
<td>$r^2$</td>
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<td>.565</td>
<td>.973</td>
<td>.989</td>
<td>1</td>
</tr>
<tr>
<td>Moran’s I</td>
<td>.102</td>
<td>.108</td>
<td>.144</td>
<td>.092</td>
</tr>
</tbody>
</table>

Note. From LAC. Open Data & Explore Census Data.

Model IV, travel time GWR has proven to be the model of best fit. The model can be biased when both cities are run with the same regression because they are at different locations, however, there is a tradeoff by splitting the model because it lowers the total count and risks loss of variable significance.

Furthermore, homes that are closer to the beach sell for a higher price.
Therefore, homes near Topanga are more likely to sell for a premium than homes in Santa Clarita. Additionally, a control variable for distance from the ocean is not included in the model. As a result, the same regression is broken up and done on each location individually (Figure 13). However, the bandwidth distance is changed to 50,000 feet because that is the minimum distance at which the split models would run. The results for travel time GWR predicted values in Santa Clarita:

![Figure 13. Predicted Values of Home Prices for Travel Time GWR in Santa Clarita.](image)

A clearer view of Santa Clarita (SC) provides the predicted higher values of home prices in relation to proximity of trailhead parking lots (Figure 14).
Ideally, the higher the home price or the more homes above the mean, and the closer to parking areas the better, since it is indicative of an upward sloping Bid Rent Curve. There are three predicted low home prices to the North-West that are far away from parking lots and three predicted low home prices to the South-East that are far away from parking lots. Near the center of Santa Clarita, the number of predicted low and high home prices near trailhead parking lots are approximately equal. The results for travel time GWR predicted values in Santa Clarita:

*Figure 14. Close-Up of Predicted Values for Travel Time GWR in Santa Clarita.*
A close-up of the group of predicted high price homes to the South-West of Canyon Country reveal a group of 17 homes, with 16 of those 17 homes having values above the mean. Nine of those 17 are two standard deviations above the mean while eight are one standard deviation above the mean.

A closer look at the homes to the East of Santa Clarita, reveals a group of 10 predicted home prices. Six of which are one standard deviation below the mean, and four of which are approximately equal to the mean.

Residuals are the difference between predicted and observed values. They represent how well the regression explains the variance in the dependent variable. Therefore, it is a measurement of error. Ideally, the closer residuals are to the mean, the better the regression does at explaining the variance. However, the residuals are not visible enough in this figure. Therefore, the color symbology is helpful, with warmer colors representing above average residuals and colder colors representing below average residuals (Figure 15).

The results for travel time GWR residual values in Santa Clarita:
Figure 15. Residual Values for Travel Time GWR in Santa Clarita.

A close-up provides a better view of the residuals in the regression (Figure 16). The variance tends to be on extremes of the spectrum. About half of the residuals are within one standard deviation above or below of the mean. The group of homes near Canyon Country and Santa Clarita requires a closer look.

The results for travel time GWR residual values in Santa Clarita:
Figure 16. Close-Up of Residuals Values for Travel Time GWR in Santa Clarita.

Nine of these residuals are within one standard deviation of the mean. That is half of the 18 points in this group of homes. This is consistent with the larger view of the residuals. Moreover, another group of homes near Santa Clarita needs attention.

All homes are within one standard deviation of the mean residual. Four are within the range of the mean, with three within one standard deviation above the mean, and three within one standard deviation below the mean.

Residuals are important to report because they represent the validity of the model. Since there is no clustering of over or underestimates that means the
model does a good job specifying the model. In other words, there is no major variable left out of the model.

Topanga has a larger quantity of home price data points which takes time to interpret (Figure 17). A general look at the pattern of high and low predicted home prices can be seen, but a closer look is required. The results for travel time GWR predicted values in Topanga:

![Figure 17. Predicted Values for Travel Time GWR in Topanga.](image)

There are 265 out of 359 predicted low home prices clustered around the parking lot locations (Figure 18). However, 49 out of the 359 predicted high home prices are clustered around trailhead parking locations as well. Where the high values do exist, they tend to be clustered closer to parking lot locations than
predicted low home prices. Those that are not close to the parking locations tend to be closer to the beach which explains why the predicted home prices are higher. The results for travel time GWR predicted values in Topanga:

![Map of Topanga showing predicted values for travel time GWR](image)

*Figure 18. Close-Up of Predicted Values for Travel Time GWR in Topanga.*

Residuals of the home prices must be inspected to determine how well the regression explains the variance of the dependent value (Figure 19). A closer look is required. The results for TD GWR residual values in Topanga:
Figure 19. Residual Values for Travel Time GWR in Topanga.

In the area of Topanga city, many residuals are within the mean range (Figure 20). Pacific Palisades has variation in high and low residuals, but more than half are within one standard deviation of the mean of residuals. Slightly South-East of Santa Monica is another cluster of residuals that are approximately equal to the mean.

Where high and low predicted home prices meet, the model does a decent job explaining the variation in the dependent variable. This is important because these are locations where predicted high home prices are located. Although, Pacific Palisades is not as well explained as other home clusters in the model. The results for travel time GWR residuals values in Topanga:
Figure 20. Close-Up of Residuals Values for Travel Time GWR in Topanga.

The GWR exhibits a negative relationship between higher education and number of bedrooms, on home prices (Table 3). A negative relationship suggests that as the number of bedrooms increases, home prices decrease which is the opposite of what would be expected. The reason for the negative relationship can be explained by the multicollinearity between the number of bedrooms, the number of bathrooms, and the size of the home. Additionally, those who are more educated typically earn more which means they can afford a more expensive home.

A positive relationship is exhibited by the number of bathrooms, owner percent, ED from CBD, and travel time. Renters may bring down the value of homes around them due to poor maintenance which explains why a higher percentage of owners increases home prices. Bathrooms add size and
convenience which increases home prices. Euclidean distance to the CBD increases home prices. In other words, as homes gets closer to the CBD the home price increases. This is indeed supporting part of my hypothesis on the proposed behavior of the Bid Rent Curve. Size increases home prices because people tend to prefer larger homes. As travel time from trailhead parking lots decrease, home prices increase which confirms the hypothesis. The following is the estimated coefficients for Santa Clarita:

Table 3 Santa Clarita GWR Coefficients

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Max</th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bathrooms (count)</td>
<td>18190.719</td>
<td>12286.789</td>
<td>31403.667</td>
<td>-20842.719</td>
</tr>
<tr>
<td>Bedrooms (count)</td>
<td>-79025.161</td>
<td>9686.521</td>
<td>-45959.139</td>
<td>-87813.817</td>
</tr>
<tr>
<td>Higher Education (%)</td>
<td>-20697.182</td>
<td>17794.161</td>
<td>19231.927</td>
<td>-65315.088</td>
</tr>
<tr>
<td>Owner (%)</td>
<td>450984.050</td>
<td>20957.657</td>
<td>526413.284</td>
<td>433499.470</td>
</tr>
<tr>
<td>ED from CBD</td>
<td>472770.514</td>
<td>65743.551</td>
<td>580382.123</td>
<td>265936.819</td>
</tr>
<tr>
<td>Travel Time</td>
<td>405902.083</td>
<td>19077397.883</td>
<td>495501.521</td>
<td>368074.665</td>
</tr>
<tr>
<td>Size (sq. ft.)</td>
<td>211.739</td>
<td>2.506</td>
<td>217.852</td>
<td>206.696</td>
</tr>
</tbody>
</table>

Topanga’s GWR exhibits a negative relationship between the dependent variable home prices number of bedrooms, percent educated, and the number of bathrooms. An increase in bathrooms or bedrooms is associated with a decline in home price. This is a surprise as more bathrooms or bedrooms on the market typically increase the value of a home. These issues may arise due to exclusion of a variable for distance to the ocean. However, these may be explained by the multicollinearity that arises due between the number of bedrooms and the number of bathrooms. Additionally, the negative correlation between home prices
an education may be due to rising student debt. These issues may arise due to exclusion of a variable for distance to the ocean.

Additionally, percent owner, ED from CBD, size, and travel time all have a positive relationship with home prices (Table 4). An increase in any individual variable represents an increase in home prices, ceteris paribus. Since travel time is positive it confirms the hypothesis because the closer a home is to a trailhead parking lot, represented the closer the transformed travel time value is to 1, the higher the home price. Additionally, the transformed ED from CBD value is correlated with a higher home price the closer the home is to the CBD. The following are the estimated coefficients for Topanga:

Table 4 Topanga GWR Coefficients

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Max</th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bathrooms (count)</td>
<td>-31426.174</td>
<td>74727.179</td>
<td>104233.896</td>
<td>-271603.936</td>
</tr>
<tr>
<td>Bedrooms (count)</td>
<td>-75147.104</td>
<td>20975.782</td>
<td>-30759.988</td>
<td>-111944.328</td>
</tr>
<tr>
<td>Higher Education (%)</td>
<td>-108687.679</td>
<td>295588.504</td>
<td>1682829.593</td>
<td>-593836.700</td>
</tr>
<tr>
<td>Owner (%)</td>
<td>372920.667</td>
<td>233479.862</td>
<td>966694.888</td>
<td>-411355.007</td>
</tr>
<tr>
<td>ED from CBD</td>
<td>1685923.665</td>
<td>582885.634</td>
<td>2765547.004</td>
<td>-2122847.652</td>
</tr>
<tr>
<td>Travel Time</td>
<td>1946580.319</td>
<td>200939.578</td>
<td>2335732.894</td>
<td>413997.114</td>
</tr>
<tr>
<td>Size (sq. ft.)</td>
<td>767.689</td>
<td>137.741</td>
<td>1148.630</td>
<td>495.097</td>
</tr>
</tbody>
</table>

The compositions of the city’s neighborhood matter in the GWR. Predicted variables in Topanga have little variation while predicted variables in Santa Clarita have strong variation. Topanga is closer to the ocean which may be the reason for little variation because there is no variable which captures the higher value of homes near the ocean.
CHAPTER 5: Discussion and Conclusion

The GWR can be used to predict the value of homes at any distance from the CBD or travel time from the home to the trailhead parking lot. The scatterplot suggests that there may be no reason to make predictions above the 17 minutes travel time because below this threshold value is added to the home while above it value is taken away from the home. This is due to excessive development increasing travel time beyond the optimal point. The reduction in home value by additional development can be estimated based on the increased travel time from natural areas. However, travel time suggests that there is an optimal range for travel time between 15 to 18 minutes. These results can inform policy to help ensure that sprawl will not expand continuously leading to more encroachment on the WUI.

“For good land management, policy makers need information on the value people attach to environmental amenities” (Gillard 1981, p. 1). As a general estimation of the implicit price that people are willing to pay for environmental amenities, this study, as opposed to Gillard’s, investigates in many ways the impact proximity to the WUI has on home prices. Hotspot analysis shows locations where home prices are spatially autocorrelated, network analyst estimates travel time, scatterplots show the distance threshold of 17 minutes while the GWR quantifies travel time. Gillard “demonstrated here that the economic evaluation of such an intangible residential environmental amenity as a view is both possible and useful” (Gillard 1981, p.1). However, a view is one of many alternative variables to quantify in terms of environmental amenities.
Environmental amenities matter when determining the value of a home. Travel time to parking lots at the WUI offer a different representation of the value people place on these amenities. Environmental amenities are usually represented by Euclidean or straight-line distance, whereas travel time quantifies the trip with the car as the primary mode of transport because within LA County cars would be used to get access to the WUI. Furthermore, the GWR quantifies access to the WUI based on travel time while controlling for spatial autocorrelation for more robust estimates.

Previous studies have used the distance from CBD as an independent variable on homes. In Hui’s study he is, “. . . using a more appropriate parameter i.e. the shortest time to CBD” (Hui 2007, p. 2341). Travel time to trailhead parking lots coupled with distance to CBD complements Hui’s study. Distance to the CBD is a robust variable to include since it represents the tradeoff between urban and natural areas. In other words, there is an optimal location based on the consumer’s preference. Consumers that prefer a more urban location can purchase homes closer to the CBD while those who prefer more natural settings can purchase homes closer to the WUI. Consumers who have equal preference can purchase a home in the middle between urban areas and the WUI. Additionally, this paper includes both condominiums and single-family residences. Since different types of living situations are considered, the implicit home price will be more accurately represented. When home prices are taken into consideration, they are usually represented by single family homes.
However, many people who cannot afford single family homes live in condominiums. Therefore, the inclusion of condominiums is imperative.

As was stated, “...emphasis was placed on the role that geographic variations in discount rates, can have on cost-benefit analyses” (Hanink 1995, p. 383). This study uses travel time as a measure of the role location plays in environmental solutions. Hanink said, “Location, it seems, matters in analysis and solution of many environmental issues” (Hanink 1995, p. 383). The contribution from this article is one of locational influence of WUI proximity on home prices i.e. closer WUI proximity has a positive impact on home prices. The closer the home is to trailhead parking lots the more value added to the home. Therefore, relevantly using location within the environmental context. Further research into the potential tradeoffs in this article would add to the relational understanding and help to develop more informed policy.

High standard errors in relation to the coefficients for each variable are indicative of less efficient estimators and may exemplify multicollinearity. The variables home size, number of bedrooms, and number of bathrooms are all potential sources of multicollinearity because they all have to do with the size of the home. However, these three variables used in the model are important factors in determining the price of a home. Therefore, they had to be kept in the model. Dummy variables coded as 0 or 1 were excluded from the GWR because the regression model cannot handle many zeros.

There are extreme values in the data which show that there is an issue with model misspecification. A key variable which can be included in further
research is distance from the ocean. Homes within proximity to the ocean or on
the ocean, sell for a premium. These abnormally high values are skewing the
model. However, the ocean variable was excluded because Santa Clarita was
too far from the ocean. The model for that area would have been biased if the
variable included. The model shows this because the values within the Santa
Clarita area are close to the mean range in the GWR. Therefore, the variable
would have been included only for the Topanga area.

The hotpot shows statistically significant high home prices are clustered
around trail head parking lots with no statistically significant low clustered home
prices. More specifically, Topanga has a statistically significant high home price
while Santa Clarita does not.

The scatterplot shows that the premium on homes peaks at about the 17-
minute travel time which is consistent with the 15 to 18-minute range shown by
the travel time analysis. Another scatterplot graph represents Euclidean distance
from the CBD and has a U-shaped Bid Rent Curve as hypothesized.

The GWRs show a positive relationship between travel time to trailhead
parking lots, distance to the CBD, and home prices. This confirms that WUI
proximity is associated with a higher home price the closer the home is to either
a trailhead parking lot or the CBD.

Multiple methods help uncover what is happening to get a better picture
and truly understand the relationship between WUI proximity and home prices.
Based on the regression, building new trailheads parking lots closer to homes will
increase the price of existing homes. Additionally, building homes closer to
trailhead parking lots will increase home value. The relationship between homes and natural area does indeed incentivize encroachment which confirms the upward sloping Bid Rent Curve as it approaches the WUI. This research can inform policy makers about the existing positive returns of building closer to the WUI, and if the intention is to preserve the WUI, ways must be found to remove these returns.
REFERENCES


