Gentrification and Environmental Amenities: Evidence of Feedback Loops from Texas

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Abstract

Gentrification is commonly perceived as an influx of newly educated, wealthy white individuals into a previously minority, lower income neighborhood. Economic literature disagrees on what exactly are the "pulling" forces that attract this demographic change. Environmental amenities are almost invaluable to community welfare and growth even if residents do not perceive the benefits as being direct, so I propose that existing or endogenous environmental amenities such as parks, riverside walks, and lakes, may be a contributor to the attraction of new neighborhood residents. However, anecdotal evidence suggests that gentrification's enaction–including the construction of luxury apartments and the influx of new higher-end businesses–may actually be destructive to the amenities that attract demand in the first place. My work investigates the feedback interactions between environmental amenities and gentrification of neighborhoods (census tracts) in three cities in Texas: Austin, El Paso, and San Antonio.

Keywords: Gentrification, Environmental Amenities, Urban Studies

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1 Introduction

"A process in which a poor area (as of a city) experiences an influx of middle-class or wealthy people who renovate and rebuild homes and businesses and which often results in an increase in property values and the displacement of earlier, usually poorer residents" -Merriam Webster

This paper will focus on the relationship between a neighborhood's gentrification status and its environmental amenities. Key questions include:

- Do environmental amenities increase the likelihood of a neighborhood to gentrify?
- Does the act of gentrification reduce or obstruct environmental assets?
- How does the ecology of urban environmental amenities interact with the man-made action of gentrification?

Using data from the Census Bureau, the City of Austin, City of El Paso, City of San Antonio, and the Richmond Mapping Inequality Project, I evaluate these questions in a subset of Texas cities that represent a diverse set of urban, geographic, and demographic characteristics.

One important element of a community's identity is the environment it inhabits and interacts with. In environmental health literature, we refer to the environment as an inclusive term for physical, chemical, and biological factors external to a person and their behaviors that might affect them in a physical, chemical, biological, or behavioral way. In this paper, I will refer to the environmental amenities of a community which include trees, parks, blue, and green spaces. Although natural, these amenities are a part of the built environment—the human made surroundings—which can contribute to health, economic well-being, and other important outcomes. The interactions between people and their built and natural environments is of particular interest to a number of important stakeholders, like elected officials, city planners, those interested in sustainable development, and those looking for

the best place to live and work. People come and go from cities for all sorts of reasons; this migration can be due to a changing labor market, furthering education, expanding family, or a constriction of budgets. There are characteristics about cities that pull people in, and those which push people out; Gentrification does both of these actions simultaneously.

In this paper, I investigate the role of environmental amenities as a "pull" factor, and the potential for resultant elimination of these amenities themselves. A framework of feedback loops borrowed from environmental studies research methods elucidates the complexities of these intertwined urban attributes.

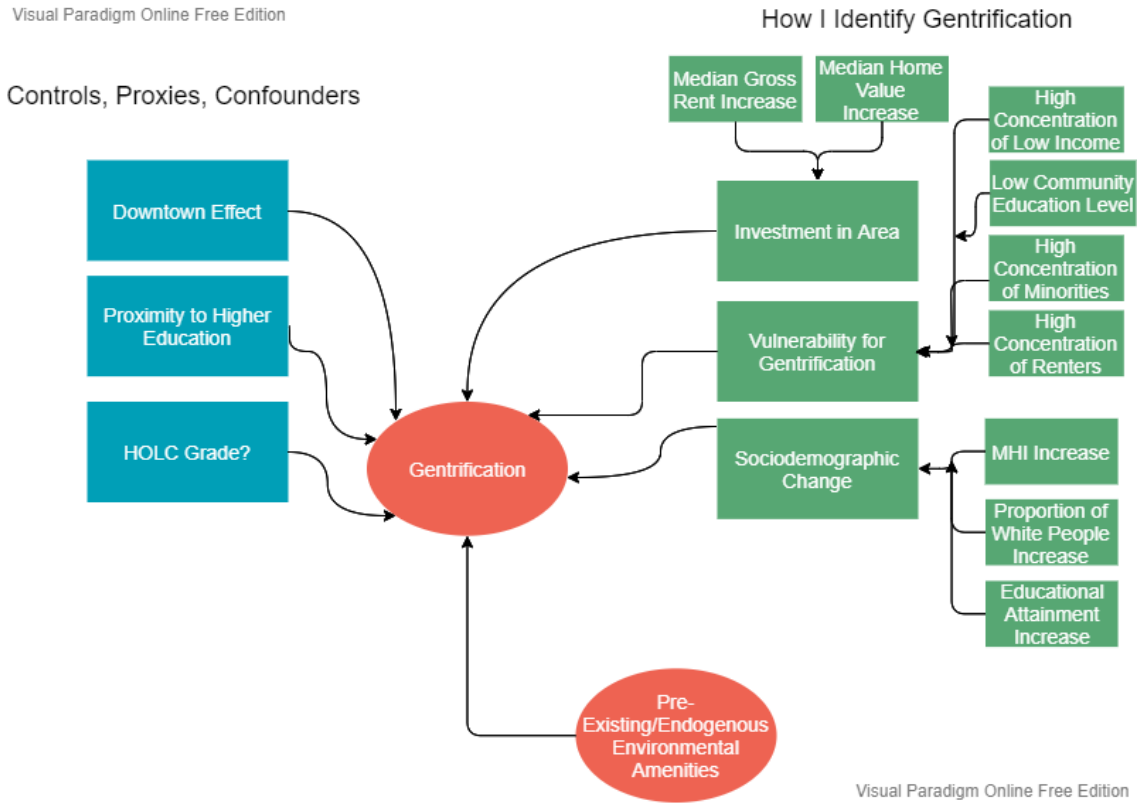


Figure 1: Flowchart of Factors Contributing to Gentrification

1.1 How is Gentrification Defined?

Although the migration mechanism gets a lot of press coverage, academic research fails to agree on what *is* gentrification, let alone what causes it. However, most studies' def-

initions would broadly fit into this sentiment: gentrification is when lower-income, less-educated neighborhoods (usually majority non-white) change in demographics to become higher-income, higher-educated (and usually more white), and higher value.

Economically speaking, gentrification can be described using an industrial organization framework: a market entry problem. Neighborhoods with established communities, typically lower-income and minority dominated, are faced with new entrants who are willing to invest in capital (housing, in this case) and grow its value through upgrades, renovations, and sometimes new development. The entrant developers compete, and consumers are not always better off because of it.

Considering a more traditional microeconomic framework: once a neighborhood hits a certain tipping point, demand for property in the area rises as the prices rise; a counter-intuitive upwards-sloping demand curve emerges. Looking at the raw economics, this may seem improbable but consider pricing as a signal of value–as prices rise in a neighborhood, it can act as an implication that the neighborhood in question is where buyers should want to be.

Outside of academia, gentrification's reputation is primarily focused on outcomes and what changes in a neighborhood when gentrification happens. In media and anecdotal evidence, gentrification can bring in a lot of resources and opportunity to an area. For example, a neighborhood experiencing gentrification may visually "clean up," hold more upscale businesses, and show lower crime rates. However, a gentrifying neighborhood may also experience displacement and out-migration of pre-existing residents due to rising rent and/or home value in the area. This displacement is where many of the arguments against gentrification arise.

1.2 What Causes Gentrification?

Knowledge on the causes of gentrification is still sparse, despite heavy media reporting and local activism in hundreds of cities. Many economists and researchers still refer to gentrification as endogenous, or just something that "naturally" happens. However, recent research

using case studies suggests that there may be a multicausal pathway that is more attainable than previously thought. Hwang and Lin reviewed the literature in a systematic review and listed some potential reasons why urban neighborhoods transition through gentrification: job access, amenities, public policy, new technologies, race/ethnicity diversity, family structure, housing finance and housing supply (Hwang and Lin, 2016.) I focuses on amenities on the supply-side of a neighborhood rather than some of the other shocks that Hwang and Lin describe.

Some other researchers claim that predictors of gentrification are much more limited, and do not hold beyond the city-center-effect and the effect of an older housing stock. Other studies rely on proxy variables such as coffee-shop introduction (the "Starbucks Effect") to explain what spurs in-migration to these downtown urban neighborhoods. However, this defines amenities narrowly, potentially excluding value brought about by other neighborhood features.

To my knowledge, supply of environmental amenities has never been evaluated as a potential causal factor in gentrification.

On the effect of amenities on gentrification, Hwang and Lin question whether neighborhood amenities are a symptom of gentrification or a cause (Hwang and Lin, 2016). I pose that both are possible with the integration of feedback loops.

In the field of ecological economics, feedback loops have been examined with regard to environmental amenity driven migration . Using one amenity, lake ecosystems, Chen et al. explores how environmental amenities can be attractive to consumers, but then as development increases, they can become damaged (Chen et al., 2009). If their findings hold with other amenities, we might expect to see environmental amenities attract wealthy educated residents, and then expect to see those amenities might degrade after initial gentrification.

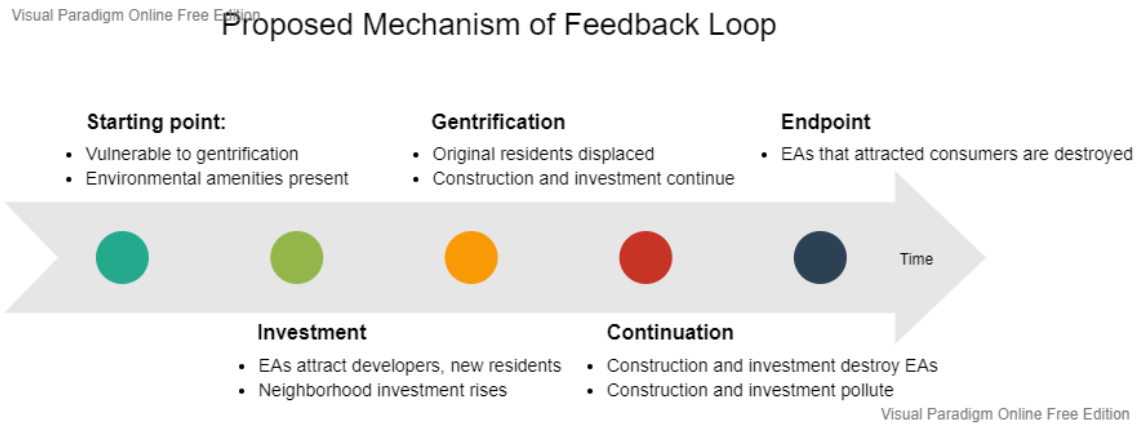


Figure 2: Timeline of Environmental Assets and Gentrification

1.3 Why are Environmental Amenities Valuable?

I argue that the value of environmental amenities supplied by a neighborhood act as a pull factor for gentrifiers to demand high value new development in a neighborhood. If these are to act as an attraction, it is important to understand their value to communities and consumers alike.

The mechanism that makes urban forests and urban greenery amenities is as much biological and ecological as it is economic. This mechanism inspired my exploration of gentrification in relation to the environment, and can be best understood through a series of examples and sectors' stories. I also reference the socio-ecological model, a commonly used public health framework, to tease out exactly how environmental amenities affect a neighborhood, a consumer's willingness to pay, and a developer's cost-benefit analysis.

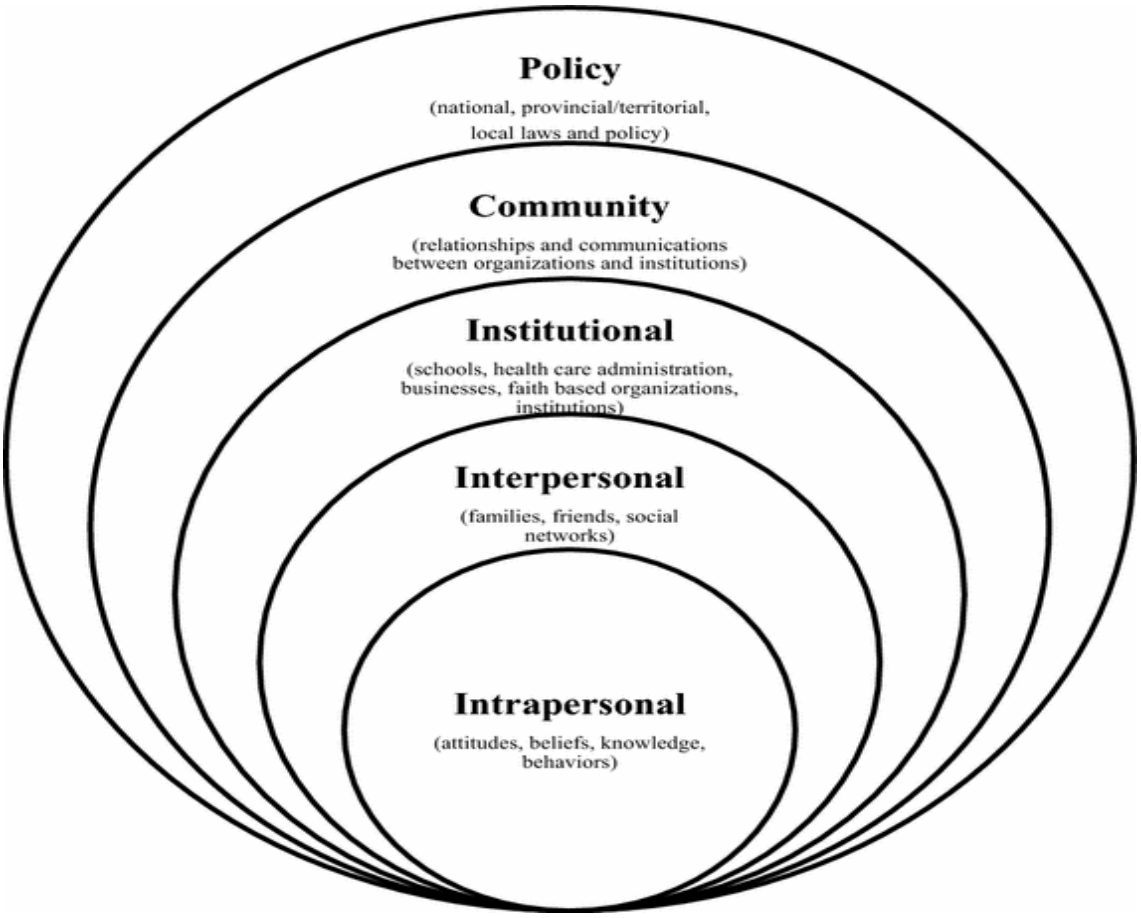


Figure 3: Socio-Ecological Model source:CDC

Trees naturally remove and store carbon dioxide from the atmosphere, helping to mitigate climate change. Historically, 25% of the world's carbon emissions have been captured through forests, farms, and grasslands, but expanding urban tree planting by 7-11% (or 8 million acres) could capture up to 2.27 million metric tons of carbon dioxide equivalent per year that would have otherwise remained in the atmosphere. It's unlikely that your average consumer or developer will pay attention to this particular impact, but it underpins a number of the practical values environmental amenities hold, like lowering energy costs, lowering health costs, etc.

Urban forests and increased tree cover are a key strategy for cities and towns to protect against the adverse impacts of the Urban Heat Island (UHI) effect, especially those associated with extreme heat and heat waves. The UHI effect results from the fact that urban areas

have more human-made structures and impervious surfaces–such as roofs, sidewalks, roads, buildings, and parking lots–and less natural vegetation and green-space compared to the geography they inhabit. Urban design and building materials (often concrete and asphalt) change the way that cities reflect, absorb, and re-emit solar energy, and their patterns of airflow and water evaporation that provide natural cooling. Collectively, this results in daytime urban temperatures that are on average about 1-7 degrees Fahrenheit higher than outlying areas. As a consumer, the UHI is noticeable upon walking down the street, and could aesthetically make a neighborhood appear unappealing.

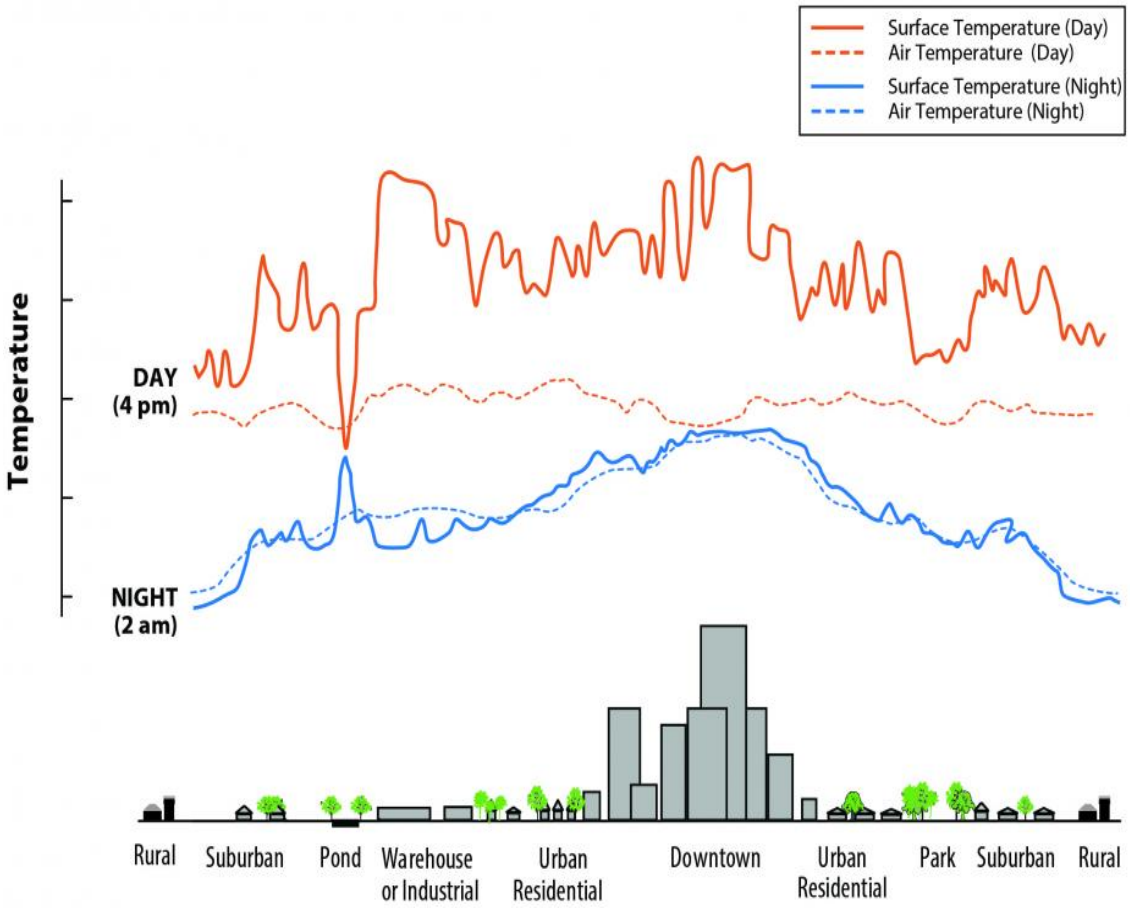


Figure 4: Source: https://www.epa.gov/heatislands/learn-about-heat-islands

Looking at the community level, the UHI effect is very damaging to population health, especially in the summer when it is at its most intense. Increased temperature exposes city-dwellers to more heat stress, and puts them at a higher risk of heat-related illness

than non-city dwellers in similar climates. Researchers expect that in the coming years, with increasing urban density and development, the UHI effect's intensity will only increase, leading to more frequent and severe heat waves. Strategies to reduce the UHI effect include the expansion of green roofs, planting vegetation, and turning vacant lots and underutilized spaces into green spaces. Again, although consumers and developers may not be aware of the impact of the UHI effect, they are still able to perceive disamenity on a street that is concrete and asphalt as far as the eye can see.

Tree cover is a natural coolant and creates shade for buildings, but the right composition of urban tree species can also improve local air quality and help reduce community exposure to non-carbon air pollutants, such as ozone, particulate matter, nitrogen dioxide, and sulfur dioxide. These pollutants have harmful health effects that include respiratory and cardiovascular illnesses (e.g., asthma, bronchitis, heart attacks) and increased hospitalizations and mortality. The U.S. Forest Service's Urban Forests Effect Model calculates that in 2020 dollars, the average annual dollar value of pollution removal per hectare is upwards of $750 and that air quality improves as the percentage of tree cover in urban areas rises.

Trees and parks can also benefit community health by reducing traffic noise. Urban noise pollution is linked to a variety of adverse health effects, such as sleep disturbance, deteriorated cardiovascular health, and cognitive impairment in children. Field tests show that strategically planted wide belts of dense trees can reduce the volume of city sound by 50% or more. Additionally, for narrow areas (less than 10 feet wide), noise can be reduced by 3-5 decibels by planting a row of trees with dense shrubbery bases.

Many cities and towns use urban vegetation to better manage stormwater and associated water pollution runoff. Trees help by catching and storing rainfall in their canopy, creating healthy soil conditions to promote the infiltration of rainwater into the soil, and slowing down runoff by taking up nutrients and other pollutants from soils and water through their roots.

Often overlooked, other co-benefits of urban tree planting are increased community pride

and collectively improved mental health. Greenspace in an urban area can encourage people to spend more active time outdoors, boosting both physical and mental health. Interacting with nature has been shown to reduce stress, a major risk factor for heart disease. Incorporating nature into urban living also strengthens the ties between those who live there. One study finds that areas with more urban vegetation have higher rates of intrapersonal social interaction, which builds community, and that greener cities promote positive youth and early childhood development.

In addition to improved community health and resilience, urban forests have direct economic benefits. The presence of trees near a home or building increases the property's value, increasing the city's property tax base. This economic effect can promote development and the desirability of an area, it is worth noting that this could contribute to the pricing out of lower-income residents who could greatly benefit from the community wellness effects of these policies.

Another economic benefit provided by urban tree planting is the avoidance of costs incurred by natural events, such as storms. Trees and urban greenery create a natural infrastructure that dampens the intensity of major weather events by creating in-place stormwater infiltration. Areas previously plagued by flooding can avoid costly renovations and water removal services with strategic tree planting. Avoiding harmful erosion and stormwater damage using trees as natural infrastructure is especially appealing for coastal or low-altitude cities where intense storms are becoming more and more frequent. On an individual level, residents in areas with greater tree cover can expect to save money on cooling bills, compared to those with fewer trees.

These impacts of urban trees and urban greenery contribute to what I reference in this paper as an environmental amenity. These amenities are more than just an appearance boost to a street; they contribute valuable disease-preventing, cost-reducing, and community building outcomes to those who live with them. I propose that these amenities contribute to a pull effect for higher income individuals looking to move to a new city, but might also

be subject to the will of developers looking to satisfy the increased market demand. These amenities hold value, and are worth evaluating when we discuss decisions about where to move, live, and work.

1.4 History of Gentrification in Austin

Of the three cities in this study, concerns about Austin ring the loudest. Key findings from a UT report show that the "Eastern Crescent" of Austin, which has been home to some of Austin's most vulnerable residents, has seen a steep increase in housing costs from 1990 to today, the Guadalupe neighborhood has sought to fight gentrification related displacement through the creation of affordable housing through a community land trust, and that the Holly neighborhood has faced gentrification which many attribute to its environmental amenities (Way et al., 2018). In this section I will outline a qualitative and historical assessment of gentrification in Austin, informed by research of primary and secondary sources which include news articles, UT reports, and other nonpartisan agencies' contributions to the literature.

To discuss gentrification, displacement, and migration in Austin, the history enacted through the "1928 Master Plan" must be illuminated. In 1928 at the tail end of the roaring twenties, the city adopted a policy designed to segregate the city in a way that was federally legal. That is, they could not explicitly zone areas as "black neighborhoods" or "white neighborhoods". The intention of the 1928 plan was to incentivize Black residents to move to the East side of the city, eliminating the need for the city to duplicate black and white schools, parks, and other civil services (Phillips, 2012.) The master plan led to the shutdown of all Black schools outside East Austin. By 1932, nearly the entire Black population of the city had moved to East Austin, what the plan called the "Negro District" in search of schooling and services for themselves and their families (Phillips, 2012.) The former "Negro District" of East Austin was designated the "African American Cultural Heritage District" by the Texas Commission on the Arts in 2012 (Phillips, 2012.) That said, East Austin is an

area many are concerned about today with regard to gentrification and displacement.

Later on, in the mid 20th century, the city's Hispanic population also found solace in East Austin when the City's language on public amenities shifted from "No people of African descent" to "Caucasian people only", further segregating the city (Way et al., 2018.) Then in the wake of the Great Depression, redlining and the impact of the Home Owner's Loan Corporation set in, solidifying these policy-driven segregation tactics for decades to come, only so that when all of these policies died off, long term residents could no longer afford to stay in the neighborhoods they had been historically pushed to live in.

From 1990 to today, Austin went from being one of America's most affordable cities to one of its least affordable, and its proportion of minority residents is on the decline (Way et al., 2018.) East Austin has been marked by a few studies as susceptible to gentrification, but one neighborhood in particular is experiencing the accelerated and late stages of it. Past the 35, a highway which segments the city, East Austin is changing.

The Holly Neighborhood was recently ranked the 24th "coolest neighborhood in the world" by TimeOut Magazine, calling it "laid back, earthy, and cool" singing praises of its proximity to the Colorado River, Beach, and the riverfront park ("The 40 coolest neighbourhoods in the world", n.d.) Although Holly has attracted positive attention for being a "cultural hub on the rise" since Big Tech companies established headquarters nearby, value of houses increased along with property taxes, pricing some residents out and making room for old houses to be replaced with high-income luxury apartments (Way et al., 2018.) Interestingly, Holly is a city designated "Grow Zone", meaning that some areas of grasses and wildflowers are left unmanicured and unmowed to keep the area wild and the urban ecosystem healthy (Way et al., 2018.)

The qualitative assessment of gentrification in the Holly neighborhood leaves me with questions about why it has gentrified. There has clearly been a shock to the labor market with the influx of trendy tech workers and companies, but returning to the economic literature we can conclude that this may not be the spark. Hwang and Lin note that high-skilled jobs

and employers requiring further degrees follow household movements, making positive labor shocks a symptom of gentrification, rather than a cause (Hwang and Lin, 2016.) This leaves us with the environmental attraction as a potential driver. This history and qualitative deep-dive informs the creation of the categories I use to define gentrification. By learning more about the city, I hope that my classification is less likely to present false-positive or false-negative results for a gentrifying neighborhood.

1.5 History of Gentrification in El Paso

In El Paso, the history of gentrification is shorter than in Austin, but no less important. Since El Paso is the hottest (climate-wise) city in my study, the relationship between environmental amenities and city residents are crucial to the city's development. This said, over the past four years, a conglomeration of the City and local developers have made efforts to demolish and redevelop the city's historic southern side to add amenities near the downtown center.

The southern side of the city, containing the Duranguito, Chihuahuaita, and Segundo Barrio neighborhoods running along the US/Mexico Border, is the location local news outlets express concern over gentrification (Hooks, 2019). Plans to develop Duranguito and nearby neighborhoods have been underway since the early 2000s, but only since 2016 has the City supported efforts to demolish existing buildings through eminent domain[1] to create a multipurpose sports, arts, and entertainment center. A citywide vote in 2012 approved the plan, although residents were not given a specific location and El Paso holds the 7th largest proportion of non-citizen residents in the US at 25.7% who presumably were not included in this vote (Paso et al., 2019, Valdez, n.d.). The stadium's construction, intended to be a positive force in El Paso's economy, has brought the city under fire. In particular, the use of eminent domain, and the demolition of buildings in Duranguito against a court order, and the lack of a plan to prevent displacement of current residents has caught locals'

[1]"Eminent domain is the legal right to acquire property by force rather than by voluntary exchange...In the US, the use of eminent domain is constrained by the constitutional provisions at the federal and state level which typically require that private property only be taken for "public use" and only after payment of "just compensation" (**munch˙economic˙1976)**

attention and sparked questions about corruption among development and government in the city (Paso et al., 2019).

As with many stories of gentrification, those at risk of being displaced by projects like the stadium are low income people of color. In El Paso, these communities tend to be those with Mexican heritage (Hooks, 2019). With the proximity of the southern side to Mexico, these neighborhoods have become a home for Mexican immigrants, and hold a long history from the Mexican Revolution to today.

Gentrification is a young concern in El Paso, but as the Sun City grows approaching Austin in population, the City will need to address the growing unrest regarding the building of the stadium. El Paso's trendy music festivals, hub of fortune 500 employers, and outdoorsy nature won't go un-noticed by highly educated, high income, young people, and as its housing markets adjust, displacement of Mexican and Mexican-Americans will certainly take center stage (Ramirez, n.d.).

1.6 History of Gentrification in San Antonio

San Antonio is also a hub of recent gentrification activity and concerns. Taking a different approach from Austin and El Paso, San Antonio saw a housing shock in the form of the Pearl Complex, a luxury condo complex which gave the city a taste of what an influx of high income residents could do. The Pearl Complex became the poster child against gentrification as pre-existing residents despised the manner in which the complex went up.

In the wake of the Pearl drama, concerns of impending gentrification rose primarily from the West Side, a predominantly Hispanic area of the city. With the median household income rising by 39% in 15 years, it's no wonder residents were concerned about the cost of living. San Antonio did not lean into gentrification the way that El Paso did; rather, they created new zoning (c. 2019) that restricts the kinds of expensive town-homes that gentrification thrives on, and increased access to historical designation which would make it harder for developers to continue down that road. This raises the question of supply: is it better to

restrict supply by banning these town-homes, or to allow supply to increase in a way that existing residents may not be able to afford?

San Antonio's answer to this comes in the development of mixed income housing intended to become a home to new wealthier residents as well as existing families and communities. However, this is not intended to open until 2023. For the purposes of this study, we can consider these concerns about San Antonio to prove vulnerability to gentrification, although policy-wise they seem to be at a standstill.

2 Data

2.1 Austin Environmental Asset Data

The city of Austin has an immense amount of environmental data availible. For this analysis, I chose to include parks, lakes and rivers, and "urban trails" as environmental amenities to a neighborhood. In the spirit of this analysis being relevant to policy-makers rather than citizen, I focus on amenities that are owned or maintained by the city, rather than by individuals. An analysis of all environmental amenities would need to rely on LiDAR data, which uses satellite imaging to quantify tree-cover and green spaces.

Austin's parks come in many shapes and sizes. From small "button" parks (n = 2) to massive golf-courses and greenbelt areas, the 316 parks provide a range of environmental benefits to the neighborhoods they share. The most common type of park is "neighborhood parks" (n = 100), followed by greenbelt parks (n = 51).The table below describes the City of Austin's parks.

Park Type	n	median area (square meters)
Button	2	786
Cemetery	5	120,300
District	14	206,048
Golf Course	5	822,022
Greenbelt	51	124,319
Metropolitain	26	158,054
Nature Preserve	15	198,726
Planting Strips	10	1,769
Pocket	28	3,504
School	23	22,320
Special	37	15,879

The lakes and rivers of Austin are contained in a polygon layer delineating the area covered by major lakes and rivers within Travis County, Texas. This includes the Colorado River, Lake Walter E. Long, and Lake Travis. The Colorado River functions as a natural boundary and cuts through the center of the city. Lake Walter E. Long is a power plant cooling reservoir since 1967, and Lake Travis is a hydroelectric flood-control reservoir known for its party boats and high water levels.

As for the "urban trails," they represent pedestrian and bicycle infrastructure that is off-street, 12ft wide, space to accommodate many residents' physical activity. This is an in-progress program from the city, but currently 45 segments of urban trails exist. They are not explicitly greenspaces, but are included in this analysis as an environmental amenity since many of them are offset by sidewalk trees and local greenery.

All three of these types of amenities are equally weighted in my analysis since parks, rivers, lakes, and trails are all similarly valuable to a neighborhood. The total number of environmental amenities included in analyses for the City of Austin is 366.

I find that there are 433 instances of a park, 46 instances of a lake or river, and 64 instances of a trail intersecting with a census tract in Austin, TX for a total of 543 environmental amenities in the 218 census tracts of the city.

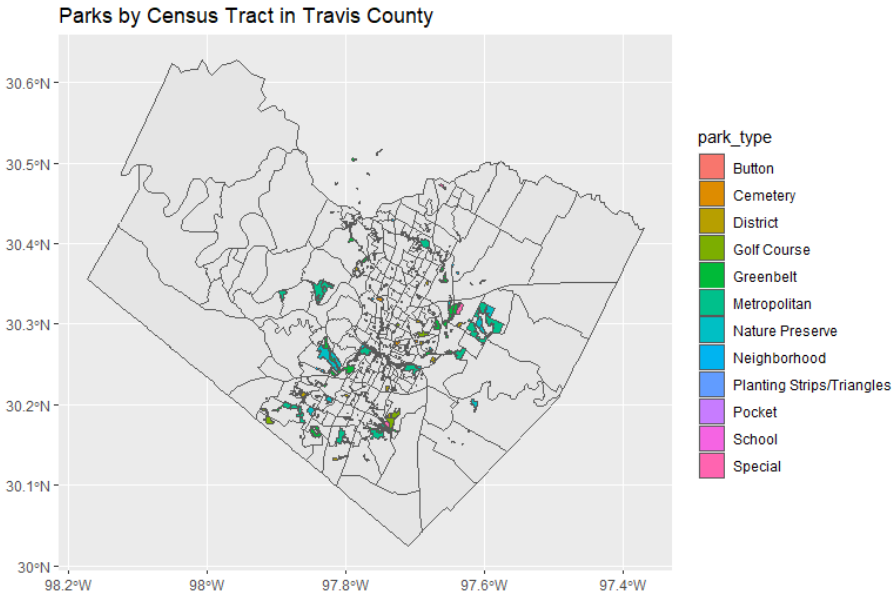


Figure 5: Austin Parks

2.2 El Paso Environmental Asset Data

El Paso's parks database contains a total of 299 parks after removing any park categorized as proposed, under construction, a parking lot, or a turf median. Parks are described in frequency and size in the table below by category:

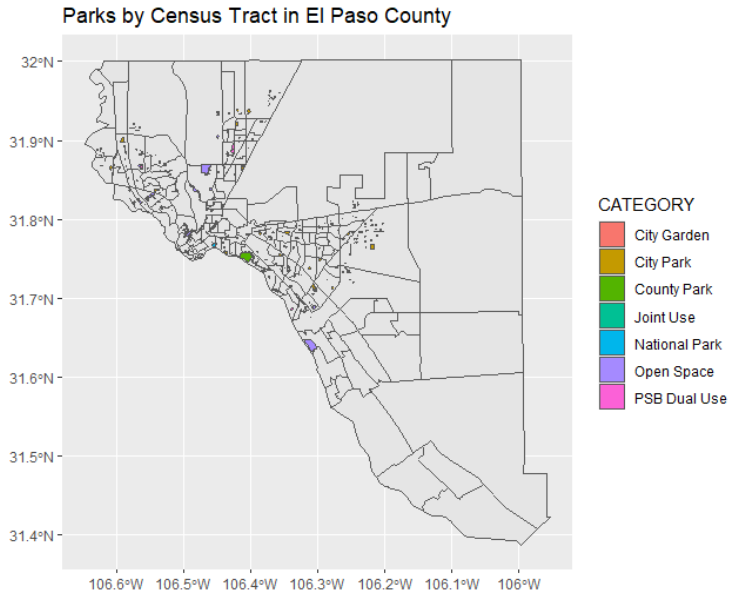


Figure 6: El Paso Parks

Park Type	n	median area (square meters)
City Garden	1	5,710
City Park	246	10,579
County Park	1	1,644,995
Joint Use	11	7,476
National Park	1	230,197
Open Space	18	110,019
PSB Dual Use	21	20,773

2.3 San Antonio Environmental Asset Data

San Antonio's environmental asset data is comprised of park boundaries, trailhead points, trails, and the river-improvement-overlay (RIO) boundaries. Each city's unique reporting of amenities brings opportunity for endogenous differences to emerge; my selection of environmental amenities is meant to reduce this endogeneity by sticking to parks, trails, and river-related amenities.

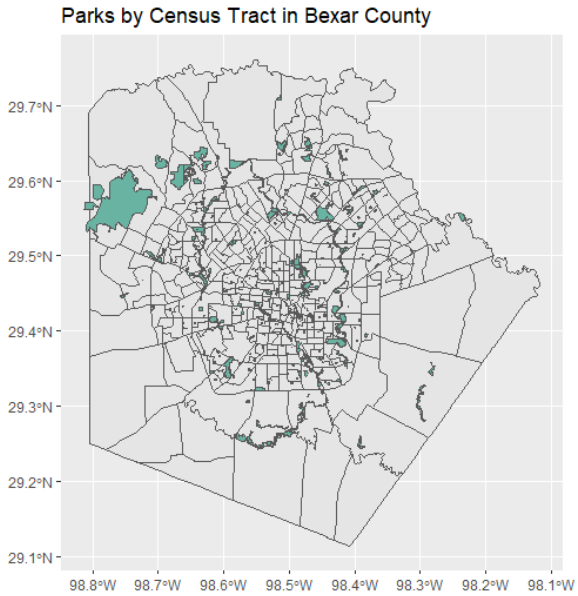


Figure 7: San Antonio Parks

San Antonio reports 354 parks and 78 trailheads which include entry points to the greenways of the city. However, when superimposed onto census tract boundaries, we see a total of 220 out of the 336 tracts of San Antonio have at least one amenity.

2.4 Gentrification Classification

For my identification of gentrification, I to a method outlined by a Rice University publication where neighborhoods, defined by census tracts, are compared to their county-level demographics over time to classify them as gentrified, gentrifying, at risk of gentrification, and not at risk. This framework was intended to create categorizations for the City of Houston, which presents with a unique issue of having no zoning laws. The framework used by Kinder, n.d. is used as a jumping off-point, and then category cutoffs are adjusted such that all tracts in Austin, El Paso, and San Antonio fit into a definition.

I supplement this measure with qualitative exploration using news-articles and google street-view to calibrate the identification of gentrification.

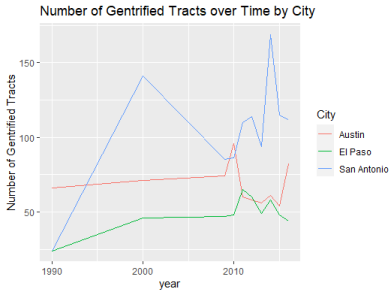
To determine whether or not a tract is gentrified, a panel analysis of tracts over time was conducted. The following criteria were evaluated based on Kinder, n.d.'s work on Harris County, TX:

Table 1: Vulnerability Criteria

Gentrification Identification Tools
Vulnerability (3 of 4)
Prop low income households > county median
Prop pop. aged 25 + without Bachelor's degree > county median
Prop non-white > county median
Prop renters > county median
Sociodemographic Change
Change in prop pop. 45 + with bachelor's degree > county change OR
Change in MHI > county change
Change in prop non-hispanic white population > county change
Investment Change
Change in median monthly gross rent > county change OR
Change in median home value > county change

Data to construct these conditions comes from the 1990, 2000, and 2010 Decennial census, the 1989, 1993, and 1995-2016 Small Area Income and Poverty Estimates (SAIPE), and the 2009-2016 American Community Survey 5- year estimates.

Figures 5-10 show the variance in gentrification, investment, and vulnerability over time as raw counts and as proportions.



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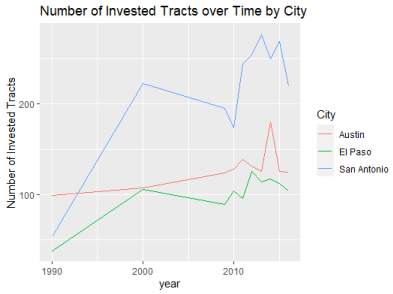

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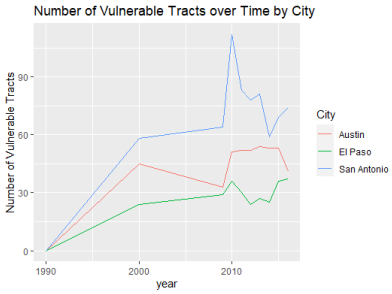

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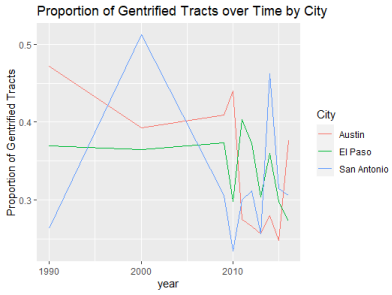

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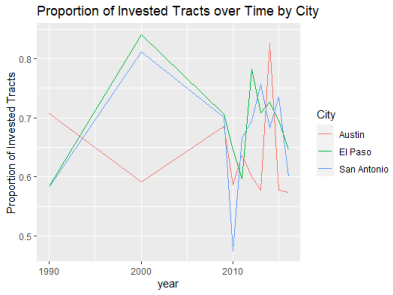

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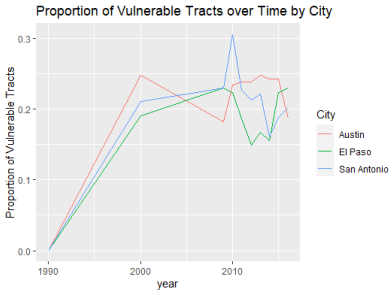

Figure 13

Using the timeseries data of these three characteristics: gentrified, invested, and vulnerable, I create a typology that reflects the history of each by census tract. Neighborhoods in 2016 are characterized as established, gentrified, gentrifying, continual, not gentrified, and not vulnerable. Again , Kinder, n.d.'s framework for classification is adapted.

2.5 Other Data

Since many traditional covariates were used in the creation of the gentrification metric, proxies are estimated to avoid collider bias and autocorrelation in the final model.

To control for another confounder, the "Downtown Effect", I identify all city tracts as "downtown" if their census tract population density is higher than the median population density for all tracts in the city. For El Paso, all tracts with a population density of over 0.00152 people per square meter are downtown. For San Antonio, all tracts with population

Table 2: Classification for 2016 based on Panel Analysis

Time Period	Definition	Number of Tracts
	Gentrifying	
2016	Vulnerable in 2000 or 2010, gentrified anytime between 2000 and 2016, but did not gentrify from 1990 to 2000	165
	Continual	
2016	Vulnerable in 1990, 2000, or 2010, gentrified from 1990 to 2000, 2000 to 2010, and 2010 to 2016	50
	Not Gentrifying or Vulnerable	
2016	Vulnerable at any time but did not gentrify anytime between 1990 to 2016 or was never vulnerable	530
Total tracts		745

density over 0.00166 are downtown, and for Austin, all tracts with population density over 0.00155 are downtown. I use cutoffs for population density by city to account for the fact that some cities are more dense than others, and that comparing them to an aggregated value may miss some downtown locales. Studies have found that gentrification often happens in "downtown" areas, and in order to avoid this entangling with our environmental variables, I control for it in the model.

I also measure historical segregation and ethnic enclaves by referring to each tract's historic HOLC grade. Again, this is intended to proxy for a traditional confounder such as median income or race. It has been fount that HOLC grading of census tracts continue have lasting effects on neighborhood wealth, health, and demographics (Badger, 2017).

2.6 Data Appendix

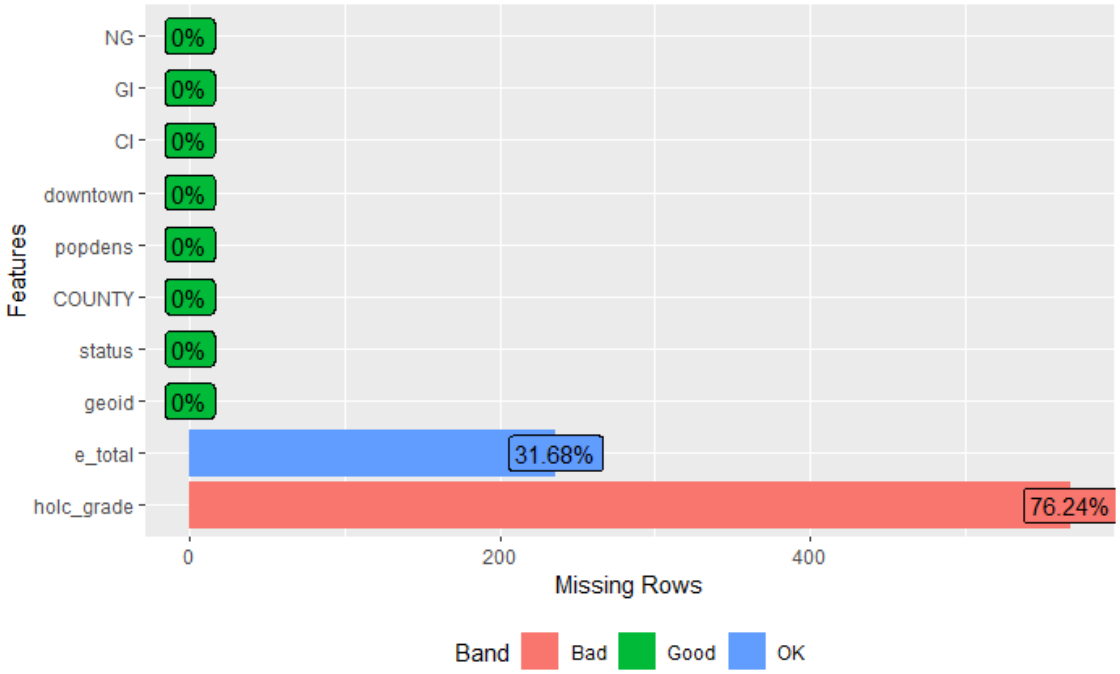

Figure 14: Missing Value Analysis

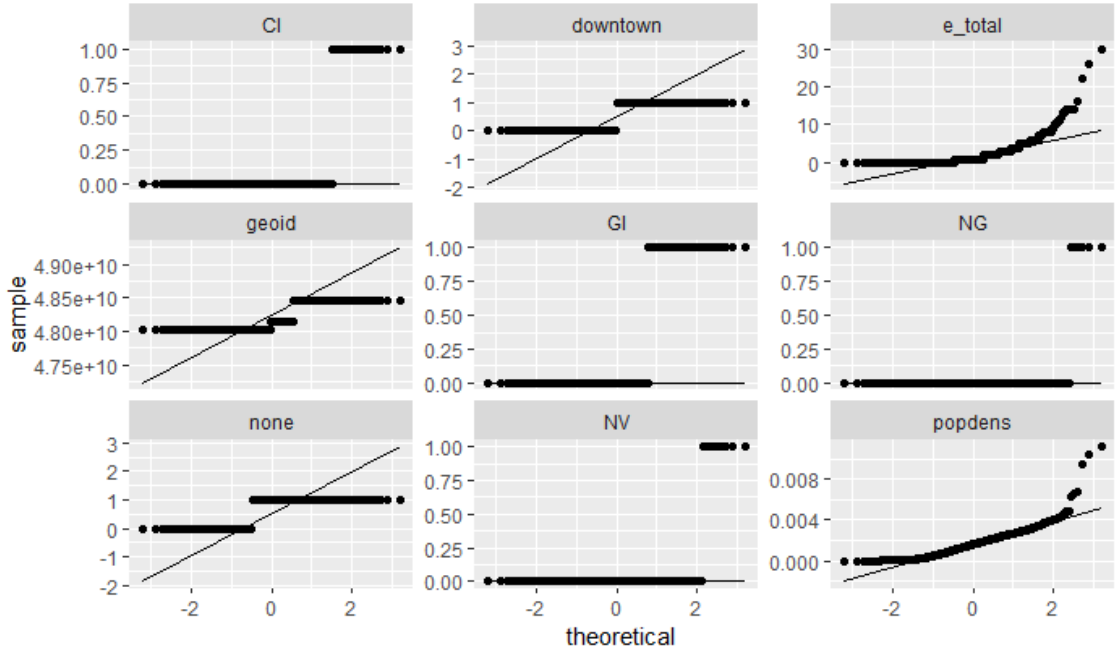

Figure 15: QQ Plots

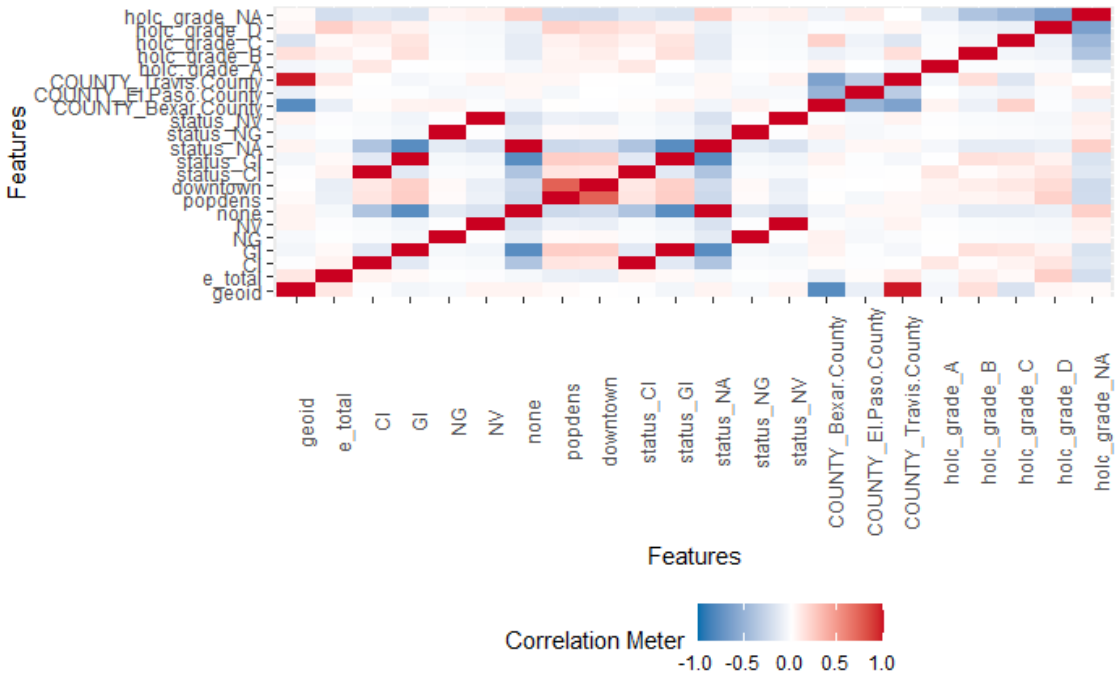

Figure 16: Correlation Matrix

3 Methods

To show the multifactorial and two-sided nature of my question, I use a combination of a forwards and backwards looking model. To look backwards and estimate how gentrification might affect the environmental amenities, I estimate an ordinary least squares (OLS) regression where I estimate the effect of gentrification categorization on the expected number of environmental amenities per census tract. Then I estimate the main model which is in line with my original proposition that environmental amenities can affect a tracts likelihood of being gentrified. For this, I use a series of multiple logistic regression models where the outcome variable is the log odds of a census tract being categorized according to my classification matrix.

Ideally, to truly estimate this potential feedback loop, an event-study design would need to be undertaken to show how tracts environmental amenities change over time as its gentrification status changes. However, since the environmental data available is mostly cross-sectional, that is beyond the scope of this paper. The estimations of my models are not

a robust causal inference design, but can point stakeholders such as city officials and local activists towards associations of interest that could inform their decisions regarding gentrification in their cities.

3.1 Backwards-Looking Model

My main model is an ordinary least squares (OLS) regression examining the effects of gentrification in a census tract on its environmental amenities. Since the distribution of environmental amenities has a long right tail, the outcome is evaluated in log form.

Controls are included for some SES factors, but since the gentrification metric was created of these variables, some are rendered redundant and are not included. Controls for historical redlining status, the "downtown effect" and proximity to higher education hubs are also included along with a city fixed effect.

$$log(y) = \beta_0 + \beta_1 x_1 + \phi x_2 + \epsilon$$

The model includes x_1 a set of (k-1 = 4) categorical dummy variables defining gentrification status, with "NA" values as the reference group. x_2 represents control variables; The model was fitted to include the downtown effect, an educational proximity estimator, and historic segregation.

3.2 Forwards-Looking Model

The forwards looking model an ordered logistic regression such that:

$$log\frac{p}{1-p} = \beta_0 + \beta_1 x_1 + \phi x_2 + \epsilon$$

Where the left hand side is the log odds of p, a particular gentrification categorization, β_0 is the intercept, β_1 is the estimated coefficient of x_1 which is a variable representing the number of environmental amenities in a census tract, ϕ is the estimated coefficient of x_2,

a set of covariates which could affect the odds of gentrification, but that are not related to environmental amenities such as being in a downtown zone and being poorly graded by HOLC standards in the 1940s.

Run one regression with other categories as dummies. Run it as an ols–try to interpret it. Then run an ordered logit.

Throw in some characteristic of a zip code.

3.3 City-by-City Evaluation

Since each city has unique policies, populations, and peculiarities, looking at results city-by-city is necessary to get a full picture of what is happening. Precision will be lowered by this evaluation, but examining the direction of trends may still be helpful to understanding gentrification's relationship to environmental amenities. Therefore, each regression is also run with a city-level fixed effect.

4 Results

Table 3 shows a contingency table of the breakdown of tract classifications by city with margins to show total values.

Table 3: Classification by City

City	Continual Tracts	Gentrifying Tracts	Not Gentrifying Tracts	Total
Austin	14	41	163	218
El Paso	10	34	117	161
San Antonio	26	90	250	366
Total	50	165	530	745

Table 4 shows the results of an the backwards looking model, an OLS regression where the left hand variable is the log of the count of environmental amenities in a census tract. The primary, secondary, and tertiary models show the change in estimates and errors as

controls are introduced to the model. The constants in each model represent the unconditional expected mean of the log of the number of environmental amenities. Therefore, the exponentiated value of these constants represents the unconditional geometric mean number of environmental amenities per census tract.

I observe that a census tract that is gentrifying compared to one that is not, holding all else constant, shows increased log number of environmental amenities. Looking at table 5, we observe the exponentiated coefficients and standard error, for ease of interpretation and conceptualization. It is important to note that table 5's coefficients represent the expected geometric (not arithmatic) mean for each variable. We observe that the downtown effect is a strong negative predictor of environmental amenities, showing how increased population density influences the number of parks, trails, and lakes in a census tract.

This model suggests that gentrification predicts increased environmental amenities, which is contrary to my original hypothesis, but could be due to a number of reasons. Gentrification is an event which happens over time; likewise environmental amenities change over time. To truly evaluate if gentrification causes increased amentites, an event study like DID or TWFE would be necessary. It is possible, also, that we are not looking forward enough, and that between 2016 and 2020, the degradation of amenities by gentrification hypothesized has not occurred in full force yet.

The ordered logit model results for the backwards facing model show that for each one unit increase in log(Number of EAs), the odds of being gentrifying opposed to not gentrifying, or continual opposed to gentrifying are multiplied by 1.546, a 54.6% increase (Not gentrifying ¡ gentrifying ¡ continual). Likewise, for tracts that are downtown compared to those that are not downtown the odds of being gentrifying opposed to not gentrifying, or continual opposed to gentrifying are multiplied by 2.845, a 184.5% increase.

Table 4: Backwards Looking Model

	Dependent variable:		
	log(Number of EAs)		
	Primary	Secondary	Tertiary
Continuing	0.232**	0.242	0.242
	(0.104)	(0.181)	(0.181)
Gentrifying	0.127**	0.366***	0.366***
	(0.064)	(0.138)	(0.138)
Not Gentrifying	*REF*	*REF*	*REF*
downtown	−0.197***	−0.450***	−0.450***
	(0.053)	(0.132)	(0.132)
El Paso	0.130**	0.320*	0.320*
	(0.066)	(0.181)	(0.181)
Austin	0.246***	0.533***	0.533***
	(0.060)	(0.159)	(0.159)
HOLC grade B		0.199	0.199
		(0.383)	(0.383)
HOLC grade C		0.317	0.317
		(0.363)	(0.363)
HOLC grade D		0.537	0.537
		(0.359)	(0.359)
Constant	0.452***	0.346	0.346
	(0.046)	(0.369)	(0.369)
Observations	745	177	177
R^2	0.043	0.172	0.172
Adjusted R^2	0.037	0.132	0.132
Residual Std. Error	0.697 (df = 739)	0.767 (df = 168)	0.767 (df = 168)
F Statistic	6.690*** (df = 5; 739)	4.356*** (df = 8; 168)	4.356*** (df = 8; 168)
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 5: Backwards Looking Model: Exponentiated Coefficients and SE

	Dependent variable:		
	Backtransformed of EAs		
	(1)	(2)	(3)
Continuing	1.261	1.273	1.273
	(1.110)	(1.198)	(1.198)
Gentrifying	1.135	1.443	1.443
	(1.066)	(1.147)	(1.147)
Not Gentrifying	*REF*	*REF*	*REF*
Downtown	0.822	0.637	0.637
	(1.054)	(1.142)	(1.142)
El Paso	1.139	1.376	1.376
	(1.068)	(1.198)	(1.198)
Austin	1.279	1.704	1.704
	(1.062)	(1.172)	(1.172)
HOLC grade B		1.221	1.221
		(1.467)	(1.467)
HOLC grade C		1.373	1.373
		(1.438)	(1.438)
HOLC grade D		1.711	1.711
		(1.432)	(1.432)
Constant	1.571	1.414	1.414
	(1.047)	(1.446)	(1.446)
Observations	745	177	177
R^2	0.043	0.172	0.172
Adjusted R^2	0.037	0.132	0.132
Residual Std. Error	0.697 (df = 739)	0.767 (df = 168)	0.767 (df = 168)
F Statistic	6.690*** (df = 5; 739)	4.356*** (df = 8; 168)	4.356*** (df = 8; 168)
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 6: Ordered Logit Results

	Dependent variable:
	statusnum
log(EAs)	1.546**
	(0.199)
Downtown	2.846***
	(0.377)
HOLC grade B	0.790
	(0.980)
HOLC grade C	0.319
	(0.949)
HOLC grade D	0.373
	(0.938)
El Paso	0.425*
	(0.485)
Austin	0.203***
	(0.425)
Observations	177
Note:	*p<0.1; **p<0.05; ***p<0.01

5 Conclusion

To conclude, I return to the key questions of the paper.

- Do environmental amenities increase the likelihood of a neighborhood to gentrify?
- Does the act of gentrification reduce or obstruct environmental assets?
- How does the ecology of urban environmental amenities interact with the man-made action of gentrification?

Through an ordered logit regression we see that the odds of a neighborhood gentrifying increase multiplicatively as the number of environmental amenities increases in Austin, El Paso, and San Antonio. This is in accordance with the hypothesis stated at the beginning of this research, and although it is not a causal link, this result is statistically significant, and warrants a more thorough investigation through an event study.

On the other hand, we see that gentrification seems to increase the predicted number of environmental amenities in a tract. This differs from the original feedback loop proposed. If true, this could mean that the feedback loop is reinforcing, meaning that as neighborhoods gentrify, they will become multiplicatively greener and greener. However, it is also possible that the cross-sectional nature of this study obfuscated any temporal effect between gentrification and green-space. After all, development moves slower than people.

Throughout this research we see how the ecology of urban environmental amenities interacts or does not interact with man-made gentrification. Above all, the associations described in this paper show that considering environmental amenities as a cause of gentrification is warranted, and potentially impactful.

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