CLIMATE GENTRIFICATION:
THE IMPACT OF STORM SURGE FLOODING ON HOME VALUES IN FLORIDA

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ABSTRACT

Climate Gentrification is the theory that links climate change with population movement. Inland areas that are less exposed to climate-related threats such as storm surge and sea level rise become more attractive to wealthy homeowners who traditionally chose to live in areas near the coast. In Florida this concept is salient, given the vast coastal areas and fast-growing population. In fact,

This study tracks storm surge flooding from tropical storms and hurricanes between 2000 and 2019 and measures the rate of home value appreciation or depreciation during that same period at a county level. My hypothesis is that counties with more storm surge events will experience slower appreciation than those with fewer events. By using an Ordinary Least Squares model, I will measure the rate of home value appreciation during this period as a function of number of events, controlling for economic factors including population and income.

My findings suggest that with each additional event, the average home value in the affected counties increased by about $5,243. While my findings did not validate my hypothesis, I believe there are major policy implications for Climate Gentrification that will result from further research on the topic.

The research and writing of this thesis is dedicated to
Stipica Mudrazija for his unrelenting patience as my advisor,
my parents for their regular reminders of the due date,
James Bay for providing the soundtrack, and
everyone else who helped along the way.

Thank you,
Kevin Washam

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INTRODUCTION

“Location, location, location” is a popular mantra in real estate. Historically, homeowners have considered the idyllic area for a new house to be near good schools, public parks, grocery stores, and in the case of Florida, the beach. But what if the ideal location changes over time due to climate change?

Growing up on the east coast of Florida, I understood the risk associated with living near the water. I saw first-hand the impact that hurricanes and tropical storm flooding had on the region, and I recognized the impending threat of sea level rise (SLR) on coastal zones. I also knew that the tradeoff of living near the water was having a smaller home; my family could afford a much larger house farther inland. In fact, our property was worth about twice as much as the house that was built on it. However, the reality was that might change some day if our house was exposed to long-term damage from storms and SLR.

Florida’s population is growing quickly, and new residents are moving in droves to areas that have been and will continue to be impacted by flooding from these storms. Florida is at especially high risk for flooding due to its low elevation and proclivity to tropical storm events. Sea levels in parts of Florida have risen over 8 inches since 1950 and have been rising exponentially in recent years, according to the National Oceanic and Atmospheric Administration (NOAA). It’s difficult to tie climate change with an increase in major storms, but the development and population growth on the coasts puts more and more homeowners in Florida at risk of flooding and wind damage from the storms.

Climate gentrification is a relatively new concept linking climate change, manifested as sea level rise, with changes in real estate markets that lead to displacement of residents. As SLR impacts homes near the coast, homeowners are more likely to move inland where the threat of flooding is lesser. This leads to higher home prices in inland areas, driving out existing low-income residents. The theory of climate gentrification follows a typical gentrification life cycle, in which investment in traditionally underserved areas forces existing residents to relocate to undeveloped areas. The question is whether I can demonstrate that this phenomenon is connected with a county's predisposition to and history of storm surge events.

For the purpose of this thesis, I am analyzing average home values from a sample of counties in Florida. Florida is a state that for six months out of the year is synonymous with hurricanes, and as an immediate impact of hurricanes and tropical systems; storm surge flooding. I will examine the relationship between a county's 20-year history of storm surge events and its market value over the same period. Storm surge events will serve as an indicator of a county's susceptibility to nuisance flooding and eventually, sea level rise. Home values are correlated with current economic conditions in the local region as well as a homeowner's presentiment for future economic outcomes are exogenous conditions such as flooding and sea level rise.

Within this scope, there are two effects that may demonstrate the presence of climate gentrification. First, wealthier residents who historically have sought out waterfront property are now looking to relocate to less flood-prone areas. This causes home values in higher elevation areas to increase and begins a period of development in lower-income areas. Second, residents regardless of wealth who live in lower-elevation areas are subject to flooding are facing the harsh reality of hurricanes, increased insurance rates, and are being quickly priced out of inland properties due to the aforementioned gentrification. This process is modeled in my conceptual framework.

My study may help to predict long-term trends in real estate and economic development. My findings may lead to better urban planning in flood-prone areas and mitigate the inevitable impact of climate gentrification. It is important to note that the effects of climate gentrification may spread throughout the entire country, impacting cities far from the coast. Low income residents displaced by increased home prices in higher-elevation areas may be forced to relocate to an urban area outside the region. They may lose their jobs because of changes in industry composition.

LITERATURE REVIEW

This thesis builds on previous research at the intersection of climate change and gentrification. Climate gentrification is a new concept and the state of research is limited. The research that exists is concentrated in coastal metro areas, such as Miami-Dade County and New York City, where homeowners are experiencing the most severe effects of SLR. In order to better understand the topic, it is necessary to examine the research branching out from both climate change and economic development separately. I divided my research into two categories: climate gentrification studies that directly influence my topic, and storm surge and sea level rise studies that inform my methodology or contribute to my thesis substantively. Most of the literature contributes substantively, since much of the work in this field is new.

Home values are central to my thesis. While there are many factors that influence home values, they typically go hand in hand with the economy. Nothaft (2007) describes home value growth as a strong economic indicator. Rising home values stimulate consumption expenditures, resulting in increased GDP. Home value is driven by local economic conditions; strong local economies will drive appreciation, while weak economies drive down home values. Climate change and sea level rise can also impact home values directly.

Sea level rise is one of the most definitive and also imperceptible impacts of climate change. As opposed to a more tangible impact such as flooding, understanding sea level rise requires analyzing historical data and making bold projections for the future. Hauer (2016) forecasts that a 0.9 m increase in sea level will put 4.2 million people at risk of flooding in the United States by 2100. This prediction is on the low end. The worst-case scenario, a 1.8-meter

SLR, endangers over 13 million people, most of whom live on the east coast in cities including Miami.

Tying together the two concepts in the most relevant study to inform my research, Keenan et al. (2018) examines home values in Miami-Dade County, considered one of the metro areas most-threatened by SLR. The article discusses two distinct hypotheses: one that states the rate of price appreciation of single-family homes is correlated with higher elevation, and one that states that homes in lower elevation areas have appreciated slower than those in higher elevation. These findings align with my hypotheses, citing changing consumer preference as a result of impending or existing threats from climate change.

Anzilotti (2018) describes the situation unfolding on the ground in Miami. The lower-income inland areas of Little Haiti have already seen new development as a result of a string of hurricanes hitting the coast. If this trend continues, the local populations will have no choice but to relocate to more vulnerable areas or out of the region entirely. The solution? Invest in sustainable, equitable housing away from the coast without impacting the local population. Rather than contributing to the gentrification cycle by eyeing existing neighborhoods to develop for wealthy residents, investors should seek to increase density in climate-resilient areas.

Coastal homes have already been shown to have experienced tangible financial loss as a result of SLR. The First Street Foundation, a non-profit that examines flood risk nationwide, calculated the total home value lost across 18 states along the east coast of the United States from 2005 to 2017. The study found homeowners had lost $15.9 billion from flooding, exacerbated by sea level rise and continuing to accelerate. Florida comprised more than one third of the value lost, at $5.42 billion across 384,548 properties. Unsurprisingly, most of the value loss was concentrated near the urban areas of Miami, Tampa, and Jacksonville.

Research done by First Street Foundation researchers McAlpine and Porter (2018) estimates the impact that sea level rise has on real estate value in Miami-Dade County specifically. They analyzed SLR projections and elevation data to determine the total amount of real estate value loss per square foot and in the entire market. Their findings concluded a total loss of over $465 million between 2005 and 2016 in the Miami-Dade area. Looking at a trend in a vacuum can only suggest that climate change is a problem in that one area; studying multiple areas would do a better job of contributing to the national discussion.

My proposed methodology has the significant distinction of analyzing a large sample of coastal and inland counties in Florida. Conducting my research beyond Miami-Dade County will serve two purposes: it will validate or discredit the conclusions found in the original study and will lead to more questions about trends beyond Florida. Research is also being conducted in other states and countries, where climate gentrification may be a reality even sooner than Florida.

Understanding the gentrification process is also an important consideration throughout my analysis; how the changing home values will impact residents of different income levels. Oppenheimer et al. (2018) mentions gentrification as a motivator to relocate prior to flooding, but there is no discussion on gentrification as an effect of flood events. Keenan et al. (2018) suggests more of a presentiment that sea level rise exists, and how homeowners react, based on elevation above sea level.

Finally, it is necessary to understand how local communities might adapt to the impact of storms. According to Census estimates from 2018, Florida has 9,547,305 homes. The Insurance Information Institute (2019) estimates Florida alone has 358,902 homes that would be impacted by a Category 1 hurricane, or about 3.5 percent. That number nearly triples to over one million, or 11 percent when considering a Category 2 storm. The total continues to increase to 2,830,210 homes impacted by a Category 5 storm; almost one third of the total homes in Florida. All of these communities must learn to adapt to future storms as well as the threat of more storms and (in the case of homes along the coast) sea level rise.

Craig (2010) has one of the first recommendations for adapting to sea level rise as it happens. This article informed my approach with background on climate change adaptation. In the decade since this research was published, scientists have learned that SLR has significant public health risks and should be treated as a national emergency. In the same vein, the article by Oppenheimer et al. (2018) details the steps a community has taken to adapt to coastal flood risk. Mitigation strategies must start early and be focused and intentional in order to be effective.

I built my conceptual framework around the concepts presented by Hauer (2017). His research argues that gentrification may be caused by climate-related forces. This hypothetical model combined with Keenan et al. (2018), who cover the topic empirically, serve to lay the foundation for future climate gentrification studies.

According to the 2015 report from the Intergovernmental Panel on Climate Change (IPCC), both urban and rural areas near the coast will be impacted by climate change, specifically storm surge, for years to come. Borrowing from the he Union of Concerned Scientists (2019) report explains that Climate change has been linked to an increase in storm intensity in the Atlantic Ocean. Because of the number of factors that contribute to hurricane formation, it is difficult to determine if climate change causes more storms, as the sheer number of storms has stayed relatively consistent over the past 40 years. However, there has been an increase in the strength of storms over the same period due to the ocean warming. Warmer water and air contribute to the strength of existing hurricanes; as the ocean warms, storms are more likely to grow. This effect, combined with the melting ice caps causing sea level rise, is likely to lead to more intense storm surge along the coasts of Florida.

Even for inland populations, extreme weather events such as droughts and heavy rains threaten to displace residents and contribute to climate gentrification. These occurrences are shown to be exacerbated by climate change, according to the Center for Climate and Energy Solutions (2020). Droughts can be triggered by warmer weather, accelerating evaporation and leading to wildfires and crop shortages. Florida is a major citrus and sugar producer, and farms throughout the state may suffer as a result of dry conditions. In turn, farmers and low-income workers may be displaced, leading to a nationwide food shortage. On the other extreme, heavy rains from storms can cause floods in low-elevation areas throughout the state, forcing low-income residents to abandon their homes. The solution, according to the article, is building more infrastructure for stormwater management to improve climate resilience.

CONCEPTUAL FRAMEWORK

Climate gentrification is the fundamental concept that serves as an explanation for the phenomenon described within this study. With sea level rise comes increased risk, leading to wealthy homeowners choosing to relocate. The lower-income areas are subjected to a higher cost of living. They are then forced to relocate elsewhere, either to a higher-risk area or out of the region entirely.

As shown in Figure 1, there are two primary pathways that we will see as a result of sea level rise. The first is through reallocation of financial resources and population increase. As homeowners near the coasts begin to feel the pressure to move inland, wealthy investors will inject capital to areas with a lower risk profile. This will cause home values in these areas to increase and create jobs (both temporary and permanent). In the areas impacted by storm surge flooding, I expect to see the opposite effect, where home values decrease relative to the mean and jobs are lost due to decreased demand and population loss. The second is the shift in population that will follow the increased home values. Many of the traditionally low-income residents of these areas will be priced out of their homes, subjected to increased cost of living, and eventually forced to relocate. They may settle into the higher-risk areas where wealthy residents formerly resided, or they may leave the city, state, or region in search of a lower risk profile.

I came to choose this framework from previous research done on the topic, specifically Keenan et al. (2018). The study details how homeowners are impacted by sea level rise in two different ways: resistance to nuisance flooding and a desire for higher elevation in the long term. As a result of storms and sea level rise, I came to my hypothesis. Storm surge events and, eventually, a homeowner's presentiment to seek a home farther from the coast, will lead to a flow of capital from the coast to inland areas. The difference between my framework and Keenan et al. is that mine comprises the entire state, whereas Kennan et al. focus on Miami-Dade County.

For the purpose of this thesis, I am connecting the changes in county-level home values with a long-term impact that may lead to widespread gentrification. Climate Gentrification is manifested as home value appreciation in inland areas, which will drive low-income residents out of the area. If home values in inland areas increase by a larger margin than in coastal areas, we may conclude that this may be one distinct way in which climate change will have a direct impact on the regions near the coast and contributed to migration patterns.

Hypothesis

My hypothesis tests whether homes in inland areas are increasing in value faster relative to homes in coastal areas across a 20-year period. As home values increase in certain areas, we will likely see the presence of financial and social capital increase in turn. As a result, we may see lower-income residents displaced in these areas. If this trend continues, this form of gentrification could affect millions of people throughout the country.

DATA, VARIABLES, AND METHODS

Data

County-level data is the basis for my study. The U.S. Census Bureau publishes population estimates for every county in Florida based on the 2010 Census. I used population estimates for 2018 to control for population growth that might have skewed the sample on either end. I didn't want to include a city that might have lost a significant portion of their population over the last eight years. The data is concentrated on cities near the coast, since that is naturally where most of the population resides, but there is sufficient data inland to analyze appreciation in these areas.

I measured rural vs urban counties according to the Office of Management and Budget metrics based on population from the 2000 census. All counties that are not designated as parts of Metropolitan Areas by the Office of Management and Budget (OMB) are considered non-metro, or rural. OMB (2013) describes Metropolitan Areas as meeting the two following criteria:

1. "Central counties with one or more urbanized areas; urbanized areas (described in the next section) are densely-settled urban entities with 50,000 or more people."
2. "Outlying counties that are economically tied to the core counties as measured by labor-force commuting. Outlying counties are included if 25 percent of workers living in the county commute to the central counties, or if 25 percent of the employment in the county consists of workers coming out from the central counties—the so-called "reverse" commuting pattern."

I used storm surge data from the National Oceanic and Atmospheric Administration to indicate how susceptible a county is to storm surge flooding. NOAA compiles an updated list of weather events at different levels, including county and state. Storm surge is just one measure of impact from tropical storms and hurricanes. Storm surge is defined by NOAA as "an abnormal rise of water generated by a storm, over and above the predicted astronomical tide." In the context of Florida, storm surge is most likely caused by hurricanes and tropical storms. Storm surge is measured as feet above normal tide.

Storm surge is caused by high winds in the eye of the storm, but it is not always correlated to the strength of the storm at landfall. For example, Hurricane Katrina (only a category 3 at landfall) produced a devastating 28-foot storm surge but minimal wind damage. Hurricane Charley made landfall as a category 4 storm with winds up to 150 mph, but only produced a storm surge of 6-8 feet.

I found home value data on Zillow.com via the Zillow Home Value Index (HVI). The HVI is an estimation of home values based on what Zillow calls a Zestimate. The formula is based on a number of factors, including economic conditions and consumer preference. The output contains the average home value for every county in Florida by month and is the most comprehensive dataset that separates values by county. The HVI dataset contains complete data for 55 of the 67 total counties in Florida.

Sample

Florida has 67 counties. For the purposes of this thesis, I will be looking at 55 counties. 12 counties were removed because they had insufficient data from the year 2000; Baker, Calhoun, Gadsden, Holmes, Jackson, Jefferson, Liberty, Monroe, Suwannee, Taylor, Union, and Washington county. Monroe County has had the most hurricanes make landfall of any county in Florida, while the others did not have significant events.

Florida has 35 coastal counties, 32 of which are included in my sample. Coastal is defined as a county having any incorporated land with a coastline. Inland counties have no part of the county touching water and are very unlikely to experience storm surge. In fact, storm surge in this sample is a direct indicator of a coastal county. All coastal counties in the sample experienced at least one storm surge event, and no inland counties experienced any storm surge.

I examined home values in Florida counties in two distinct years; 2000 and 2019. I isolated the values from January of each year because January is outside of hurricane season and therefore typically unaffected by storm surge, keeping the home values controlled for the treatment variable. In addition, most flooding in Florida occurs during the fall season due to high tides from the gravitational pull of the sun and moon (NOAA, 2017).

I created a dataset with population and demographic information for each city to use as control variables for my sample. This data was pulled from the American Community Survey, an annual survey of socioeconomic conditions in every community in the United States. It is the most accurate measure of demographic information to be used in this context.

To measure storm surge events in my sample, I used NOAA data for all counties in Florida from January 1, 2000 to January 31, 2019. Storm surge is recorded as a binary result, in which one flood in one part of the county would register as an event for the entire county.

Variables

Table 1 presents the variables used in this study, including economic controls across the 55 counties in my sample. *Events* is the total number of storm events in a given county during the 20-year period. This is the primary treatment variable. I also created categorical variables *eventscat1*, *eventscat2*, and *eventscat3* to measure impact across different risk groups. *Damage* is a measure of the financial loss as a result of all storm surge events in a county.

I included population and income in my model to serve as economic controls. Because the final outcome is home value change, I included economic variables that measure change across the 20-year period; *pop_change* and *income_change* as well as the percentage equivalents *pop_percent* and *income_percent.* The variables *pop2000*, *pop2018*, *income2000*, and *income2018* are the bases for the change variables.

Finally, I created location variables to control for where the county is in relation to storm surge events. *Location* is a binary variable indicating if a county is *coastal* (any areas touching the Atlantic Ocean or Gulf of Mexico) or *inland*. *Density* is a binary variable indicating whether a county is *urban* or *rural*, according to the OMB definition. Finally, *coast* indicates if the county is located along a coast with the indicator variables *eastcoast*, *westcoast*, and *nocoast*.

Methods

My approach is to measure home value appreciation between 2000 and 2019 relative to storm surge in each of the 55 counties in my sample. The outcome variable is home value change, measured in absolute change and percentage change. The predictor variables are listed in Table 1.

I recognize that homeowners might not understand the difference between a county that has had 12 storm surge events and one that has only had 10. To measure how homeowner preference might be affected in areas with drastically different flood risk, I sorted number of events into groups. I created a categorical variable to understand how home values in "high risk" counties compare to those in “low risk” and “no risk” counties. The categories for the variable *eventscat* are sorted by counties with 0 events, 1-5 events, and 6 or more events.

I calculated the percentage increase in home values between the two years and totaled storm surge flood events in all 20 years. For my analysis, I used Ordinary Least Squares (OLS) to estimate linear regression models controlling for various conditions at the county level including income, population, density, and location.

I used two OLS predictor models, shown below, to demonstrate home value change based on the variables described above:

Absolute Home Value Change = α + β1 (Number of Events) + β2 (Storm Damage) + β3 (Income Change) + β4 (Income Level) + β5 (Population Change) + β6 (Population Level) + β7 (Density) + β8 (Coast) + … + u

Percent Home Value Change = α + β1 (Number of Events) + β2 (Storm Damage) + β3 (Income Change) + β4 (Income Level) + β5 (Population Change) + β6 (Population Level) + β7 (Density) + β8 (Coast) + … + u

RESULTS

Descriptive Statistics

Counties

As shown in the map (Figure 2), the most densely populated areas in Florida are located near the coasts. Most of the east coast and the southern half of the west coast contains dense areas. Overall, homes are much safer from storm surge on the east coast than the west coast. The average number of events in the 12 east coast counties is four, with an average cost of damage of about $5.4 million. In the 20 west coast counties, the average number of events is eight, and the average cost is almost $68 million.

Economic Factors

The total population across the sample increased from 15,648,926 in 2000 to 20,939,301 in 2018; a difference of 5,290,375, or about 37 percent. In coastal counties, the population increased by an average of 116,164 residents. In inland counties, the population only increased by 68,396 per county. Average income also increased across the time period. In 2000 the average income was $36,160, and in 2018 it was $52,008, an increase of $15,848, or 44 percent.

Storm Surge Events

Between 2000 and 2019, Florida counties experienced 231 storm surge events taking place on 55 days, including 29 of those days with property damage recorded. Of the 55 counties in the sample, 32 counties experienced one or more days with storm surge, while 23 counties experienced no events during this period (Figure 4).

From Table 3, The most frequently seen number of events per county was four. Nine counties had four events over the 19 years, while seven counties experienced five events. This was due to multiple hurricanes impacting the same area multiple times during this period. If an area is susceptible to storm surge, it will be hit multiple times. This explains the uptick after one and two events.

Taking a look at the total number of events in Florida by year (Table 4), 2004 and 2005 had the most events; 35 and 52, respectively. This was a result of a string of major hurricanes that hit Florida directly or indirectly, including Charley, Katrina, and Wilma. Major hurricanes are defined as a Category 3 (111 mph winds) or higher when they make landfall (Insurance Information Institute, 2019). 13 of the 19 years had fewer than ten events, while six years had more than ten events. Only two years with more than 10 storm surge events had zero major hurricanes.

Figure 6 shows the risk of specific areas to experience storm surge damage. According to NOAA ("Introduction to Storm Surge") storm surge in the gulf is likely to be stronger because of the low-sloping continental shelf. As demonstrated in Figure 5, the ocean floor on the east coast drops off quickly, while the gulf deepens gradually. Southeast Florida, where many storms have made landfall and caused significant wind damage, have not experienced storm surge at the same level as the west coast, according to the data from NOAA.

As shown in Figure 7, Florida has a significantly higher population at risk of storm surge flooding than any other state in the U.S. Out of approximately 24 million residents at risk from flooding, Florida has about 8 million who would be impacted by a category 5 hurricane.

Home Values

Table 5 contains descriptive statistics for home values. Examining values across all counties in the sample for the year 2000, we see an overall average home value of a little over $102,000. The minimum value was $36,933 in rural Dixie County, and the highest was $238,116 in Gulf Coast vacation destination Walton County. In 2019, the highest value remains in Walton County at $389,116. The lowest average home values of 2019 are in Hamilton County, while Dixie County is the second lowest.

For counties in the control group, we see that the average home value is much lower, at $82,435 in the year 2000 and $165,321 in 2019. These are inland counties that also have a lower average population. The population change for these counties is slightly lower, at 34 percent, than counties that experienced storms, at 39.5 percent.

Transposing home values with events in Figure 3, we see no apparent definitive correlation across the state. Of course, there are certain economic conditions that impact home values exogenous of storm surge events. The effect is more likely concentrated in certain counties that are highly impacted by flooding in the years immediately following large storms.

Inferential Statistics

In Table 2, I model the absolute change in home value for each predictor variable in four groups; all counties, counties with no events, counties with some events, and counties with many events. Table 3 shows the same analysis in terms of percentage change in home value.

After running a multiple OLS models with events as the main predictor and various economic controls, we see that a higher number of storm surge events does in fact increase the average home value appreciation in Florida counties.

Across all counties in Florida, the number of storm surge events is a strong indicator for an increase in home value. For each additional event (all else held constant), the average change home value increased $5,242.76, or about 4.52 percent, above the base of $50,027.55. Total cost of damage is not a significant indicator, but it is generally correlated with storm surge events.

Unsurprisingly, income is also tied very closely to home value change. For each dollar that income increases, home value change increases about $2.52. This effect is slightly stronger in counties with no storm events. Not surprisingly, being in a higher income bracket has an effect on home values. Being in the wealthier half of the sample was correlated with an increase in home value change of about $17,457.

Population growth has a positive correlation with home value change. For each additional resident that moved to the county between 2000 and 2018, the change in home value increased by $0.08, or $808.59 per 10,000 people. Interestingly, although not significant, high population (190,000 or more) counties saw a decrease in home value change of about $6436, while the low population counties saw an increase.

Population change is an important variable to consider because it may be the most telling indicator of a market's average home value. Demand for homes drives the price up, while slower population growth may lead to slower appreciation, regardless of storm events. In a state that is growing as quickly as Florida, it's no surprise that population change is positively correlated with home value change.

The correlation between number of events and home value appreciation is positive, so I am unable to validate my hypothesis. The impact of damage is negative, but insignificant, leading to a very weak conclusion that the presence of stronger storms may cause more of an impact on home values than the sheer number of storms. Because of the small sample size of the “some events” and “many events” groups, it is difficult to establish conclusions based on the results from those categories.

CONCLUSIONS AND DISCUSSION

While my hypothesis was ambitious in predicting the impacts of climate change on home values, there is still much research to be done on the topic. I'm confident within the next decade we will see this research area of study increase exponentially. The long-term effects are still yet to be tested and seen.

One possible explanation for the results is that the counties with the highest home value growth and storm surge events also had the most room for home value growth. In the same way that high-value homes depreciated more during the recession and appreciated more after the recession, these areas may respond more strongly to external changes than areas with low-value homes. The best way to test this is on a county-by-county basis.

This thesis led me to many ideas for future areas of study. First of all, further research should be done outside of Florida, in states including Texas, Louisiana, North Carolina, and Virginia. By adding additional regions, we are able to increase our sample size and gain a better understanding of the problem. I would have, given more available data, included more control variables.

Cost of damage would also be an interesting variable to study more in-depth. For the purpose of my research, it was not used as a major indicator due to the small sample size. I would suggest collecting more substantial data on the strength and relative impact of storm surge and how it affects home values rather than simply counting the number of storms.

There are many economic impacts that cannot be controlled for, including localized market influences. For example, a county may be experiencing political issues that cause residents to flee. A county may face a streak of devastating hailstorms that lower home value.

Examining home values for each county in each year and the subsequent reaction in the housing market the following year would be useful for determining the impact of each hurricane season. Finally, it's important to consider to what extent climate change affects price directly, and how much of the change in price is due to change in population.

Climate change has become more than an environmental discussion; it is now an issue of economics and real estate. While my thesis did not validate my initial hypothesis, the framework presented is in motion in certain isolated areas of the country, including Miami-Dade County. Fortunately, many local policymakers are taking action to mitigate the effects of climate change in areas where the impact is significant. Unfortunately, more research measuring the direct impact of climate change on our national economy will be necessary for legislators at the federal level to enact any kind of large-scale change. Policies are often driven by "shocks" to the system, and in the case of climate change a shock is not possible. Climate change, in this case sea level rise, is slow and steady; almost immeasurable. It will continue to cause slow damage to our nation's coastal areas until enough homeowners decide to move and set off a pattern of relocation. Only after that occurs will we begin to see the process of climate gentrification take hold.

APPENDIX A: FIGURES

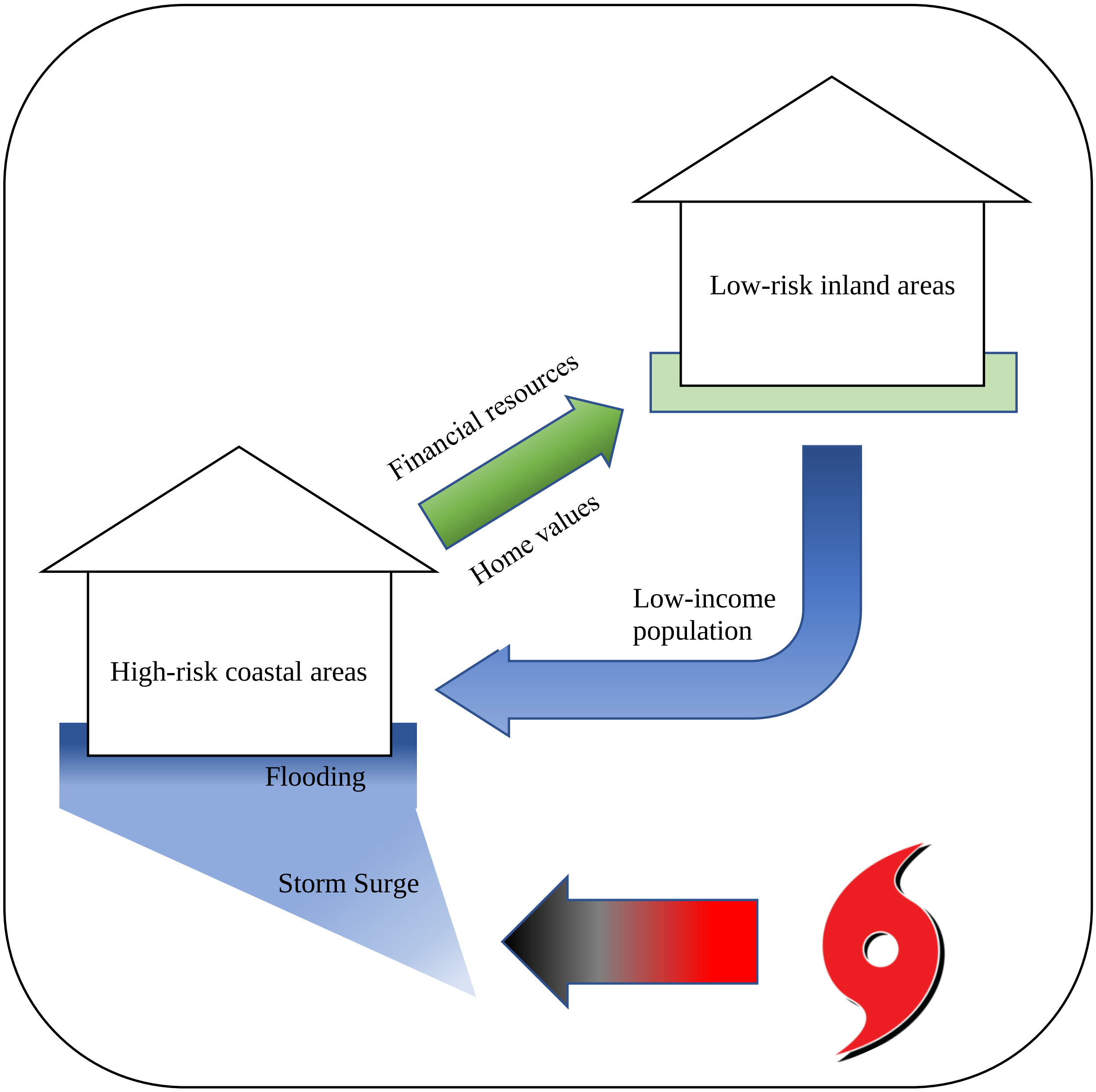


Figure 1: Conceptual Framework

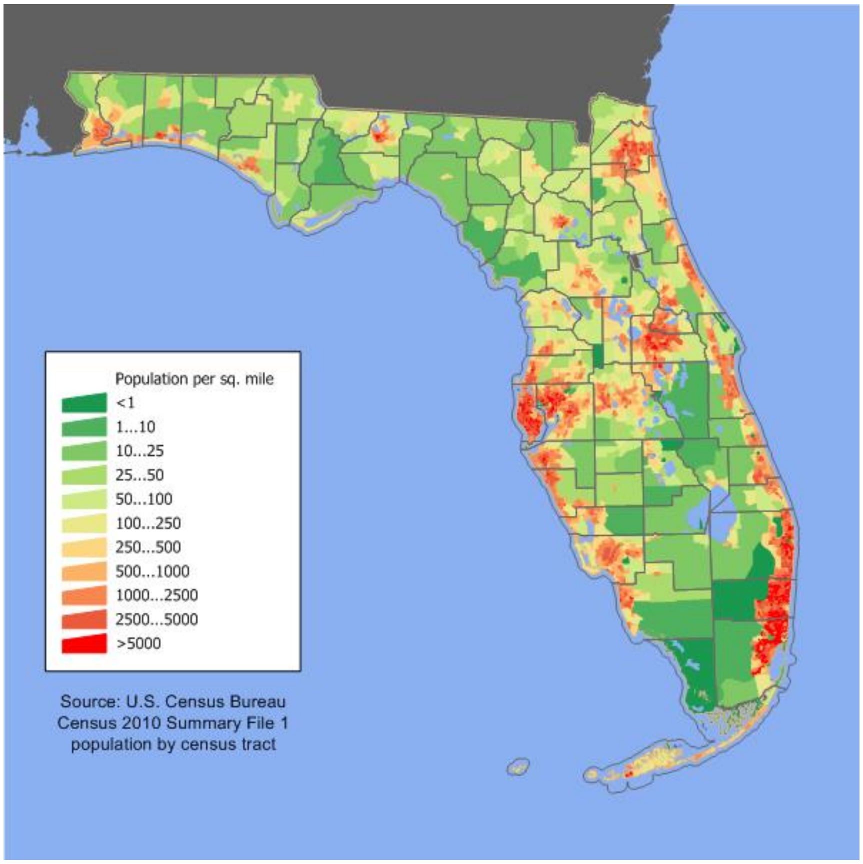


Figure 2: Population Density

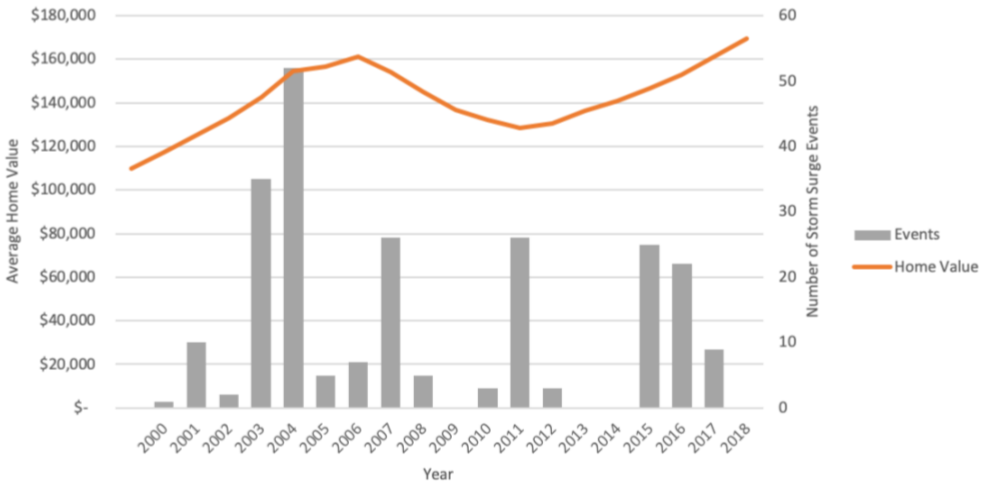


Figure 3: Home Values and Events

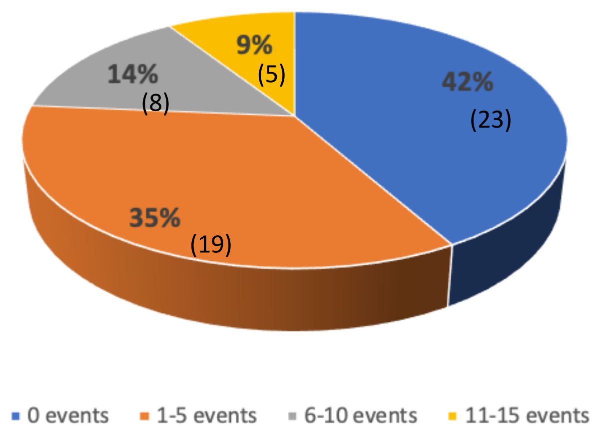
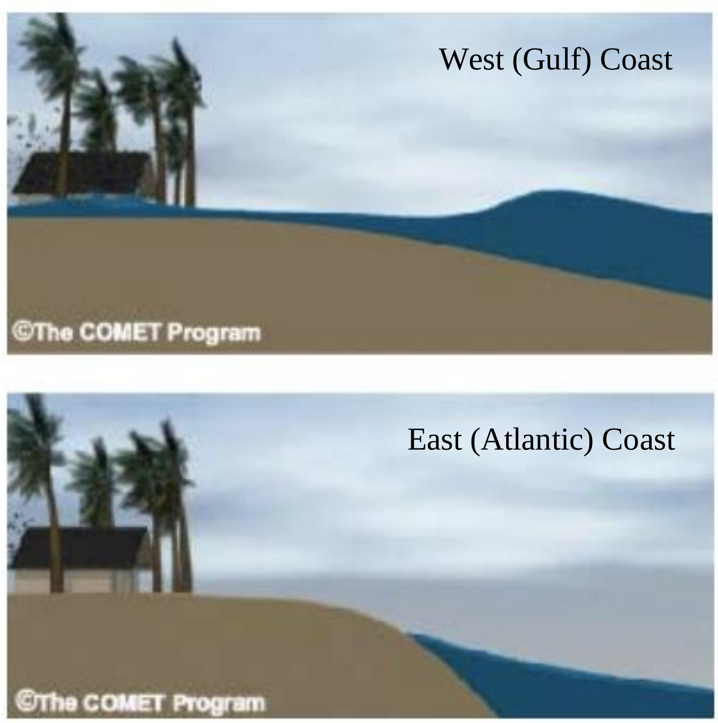


Figure 4: Events per County



(from NOAA)

Figure 5: East vs West Coast Continental Shelf

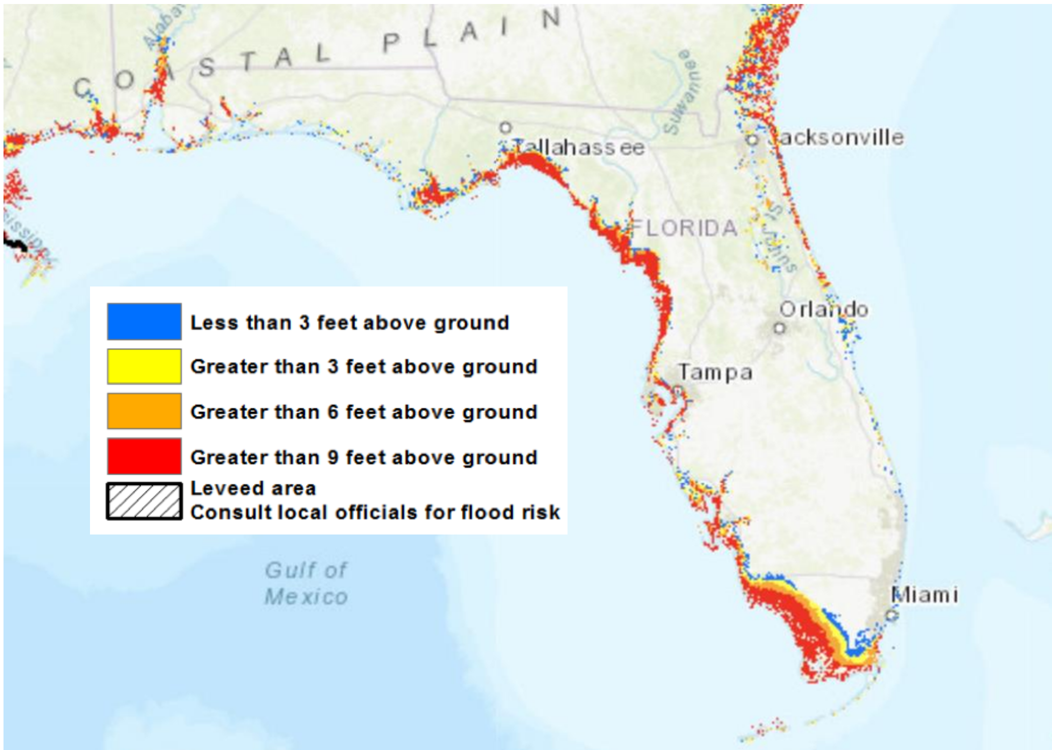


Figure 6: Storm Surge Risk

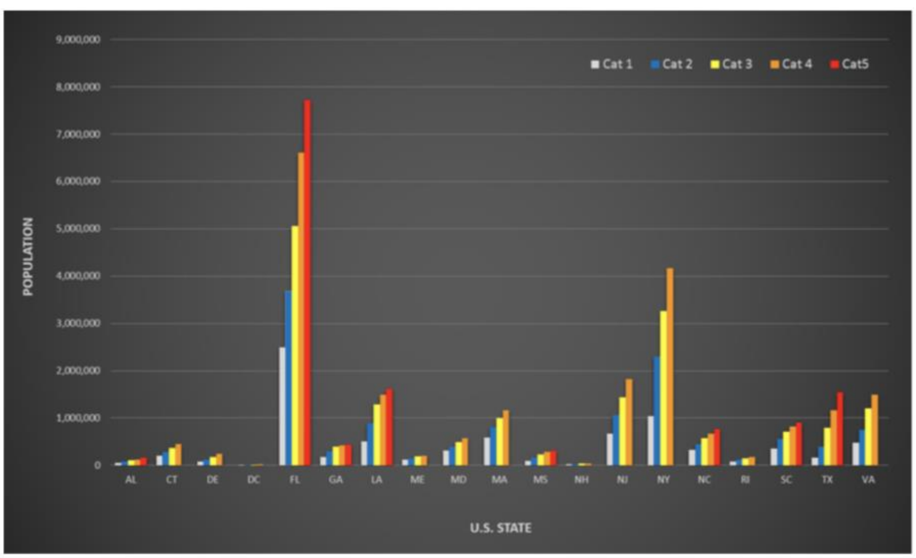


Figure 7: Population at Risk

APPENDIX B: TABLES

Table 1: Variables

VARIABLE	NAME	SAMPLE	MEAN	MINIMUM	MAXIMUM	STD. DEV.
County name	county	55	N/A	N/A	N/A	N/A
Number of unique storm surge events in a county	events	55	3.73	0	15	4.20
No events in the county	eventscat1	23	N/A	N/A	N/A	N/A
Some (1-5) events in the county	eventscat2	19	N/A	N/A	N/A	N/A
Many (6+) events in the county	eventscat3	13	N/A	N/A	N/A	N/A
Financial cost of damage from events (USD)	damage	55	$25,800,000	0	713,000,000	$1,000,000
ECONOMIC INDICATORS						
County population in 2000	pop2000	55	284,526	7,019	2,253,793	424,372
County population in 2018	pop2018	55	380,715	8,732	2,761,581	534,098
Absolute change in population from 2000 to 2018	pop_change	55	96,189	-191	507,788	125,495
Percentage change in population from 2000 to 2018	pop_percent	55	37%	-1%	141%	30%
Average per capita income in 2000	income2000	55	$36,160	$26,032	$52,244	$6,431
Average per capita income in 2018	income2018	55	$52,008	$36,299	$81,925	$10,054
Absolute income change from 2000 to 2018	income_change	55	$15,848	$7,283	$29,681	$4,825
Percentage income change from 2000 to 2018	income_percent	55	44%	24%	88%	11%
LOCATION INDICATORS						
Coastal or Inland Counties	location	55	N/A	N/A	N/A	N/A
Rural or Urban Counties	density	55	N/A	N/A	N/A	N/A
Coast of County	coast	55	N/A	N/A	N/A	N/A
Rural Counties	rural	13	N/A	N/A	N/A	N/A
Urban Counties	urban	42	N/A	N/A	N/A	N/A
Coastal Counties	coastal	32	N/A	N/A	N/A	N/A
Inland Counties	inland	23	N/A	N/A	N/A	N/A
East Coast Counties	eastcoast	12	N/A	N/A	N/A	N/A
Neither Coast Counties	nocoast	23	N/A	N/A	N/A	N/A
West Coast Counties	westcoast	20	N/A	N/A	N/A	N/A

Table 2: Absolute Home Value Change

Variable	Absolute Home Value Change ($)			
	All Counties	Counties with no events	Some (1-5) events	Many (6+) events
events	5242.758*** [1386.54]	N/A	1778.196 [7103.191]	4270.891 [4435.738]
damage	-.0000221 [.0000334]	N/A	.0000614 [.0003806]	-.0000352 [.0000727]
income change	2.573762*** [.8520917]	3.090681*** [.8497974]	2.675121 [2.061304]	2.743354 [3.286231]
low income ($0-$51,999)	-17457.01* [9122.683]	-23054.38*** [7277.013]	-12717.35 [25918.56]	3752.38 [45298.32]
population change	.0808589*** [.0298115]	.0800177** [.0284389]	.1037574 [.0939184]	-.0040865 [.1100081]
low population (0-189,999)	6436.184 [7851.115]	14254.14* [7259.829]	8672.322 [20257.59]	-18464.54 [31874.84]
urban	6383.248 [9161.724]	8953.684 [6729.558]	N/A	14668.98 [40174.57]
East coast	-4946.736 [10225.02]	N/A	28676.42 [17228.66]	65377.4 [49893.77]
West coast	-36663.7*** [12942.57]	N/A	N/A	N/A
Constant	50027.55** [18872.42]	41533.00** [16015.37]	27186.34 [65267.68]	29817.13 [76111.91]

Significance levels: * < 10% ** < 5% *** < 1%.
Standard errors in parentheses
N/A indicates omitted for collinearity

Table 3: Home Value Percent Change

Variable	**Home Value Percent Change (%)**			
	All Counties	Counties with no events	Some (1-5) events	Many (6+) events
events	4.5217** [1.67866]	N/A	1.66479 [4.07011]	1.62898 [4.43953]
damage	-7.07e-08* [4.04e-08]	N/A	-2.29e-08 [2.18e-07]	-9.75e-08 [7.28e-08]
income change	-0.0012 [0.00103]	9.86e-04 [0.00171]	-4.39e-06 [0.00118]	-0.00698 [0.00329]
low income ($0-$51,999)	-5.87053 [11.04464]	1.56724 [14.62251]	-7.34297 [14.85126]	-5.78832 [45.33708]
population change	6.47e-05* [3.61e-05]	7.09e-05 [5.71e-05]	7.71e-05 [5.38e-05]	-2.33e-05 [1.10e-04]
low population (0-189,999)	29.19481*** [9.50518]	56.48058*** [14.58798]	10.28839 [11.60754]	32.01104 [31.90212]
urban	-6.84005 [11.09191]	3.95592 [13.52245]	N/A	49.70913 [40.20895]
East coast	-8.13713 [12.37922]	N/A	.242353** [9.87197]	.5069753 49.93647]
West coast	-30.27695* [15.6693]	N/A	N/A	N/A
Constant	109.7107*** [22.84844]	52.33316 [32.18145]	70.74788* [37.39819]	175.1871* [76.17705]

Significance levels: * < 10% ** < 5% *** < 1%.
Standard errors in parentheses
N/A indicates omitted for collinearity

Table 4: Events per County

Events per County	**Frequency**	**Percentage of Total**
0	23	41.82
1	1	1.82
2	2	3.64
4	9	16.36
5	7	12.73
6	1	1.82
7	3	5.45
8	1	1.82
9	2	3.64
10	1	1.82
12	2	3.64
13	1	1.82
14	1	1.82
15	1	1.82
Totals	**55**	**100.00**

Table 5: Events per Year

Year	Number of Events	Major Hurricane(s)
2000	0	
2001	1	
2002	10	
2003	2	
2004	35	Charley, Frances, Ivan, Jeanne
2005	52	Dennis, Katrina, Rita, Wilma
2006	6	
2007	7	
2008	26	
2009	5	
2010	0	
2011	3	
2012	26	
2013	3	
2014	0	
2015	0	
2016	25	Hermine, Matthew
2017	22	Irma
2018	9	Michael

Table 6: Home Values

HOME VALUES	SAMPLE	MEAN	MINIMUM	MAXIMUM	STD. DEV.
2000 – all counties	55	$102,226	$36,933	$238,116	$37,586
2000 – non-impacted counties	23	$82,435	$39,478	$126,495	$31,706
2000 – impacted counties	32	$116,450	$36,933	$238,116	$35,326
2019 – all counties	55	$204,958	$96,039	$389,116	$66,598
2019 – non-impacted counties	23	$165,321	$96,039	$271,932	$52,809
2019 – impacted counties	32	$233,447	$101,725	$389,116	$61,183
Change from 2000 to 2019 – all counties	55	$102,732	$59,106	$151,000	$29,012
Change from 2000 to 2019 – non-impacted	23	$82,886	$56,561	$145,437	$21,103
Change from 2000 to 2019 – impacted	32	$116,997	$64,792	$151,000	$25,857
Percent change – all counties	55	100%	160%	63%	77%
Percent change – non-impacted	23	101%	143%	115%	67%
Percent change – impacted	32	100%	175%	63%	73%

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