FIRST STREET FOUNDATION

Climate Abandonment Areas

Natural disasters are increasing in frequency across the US.

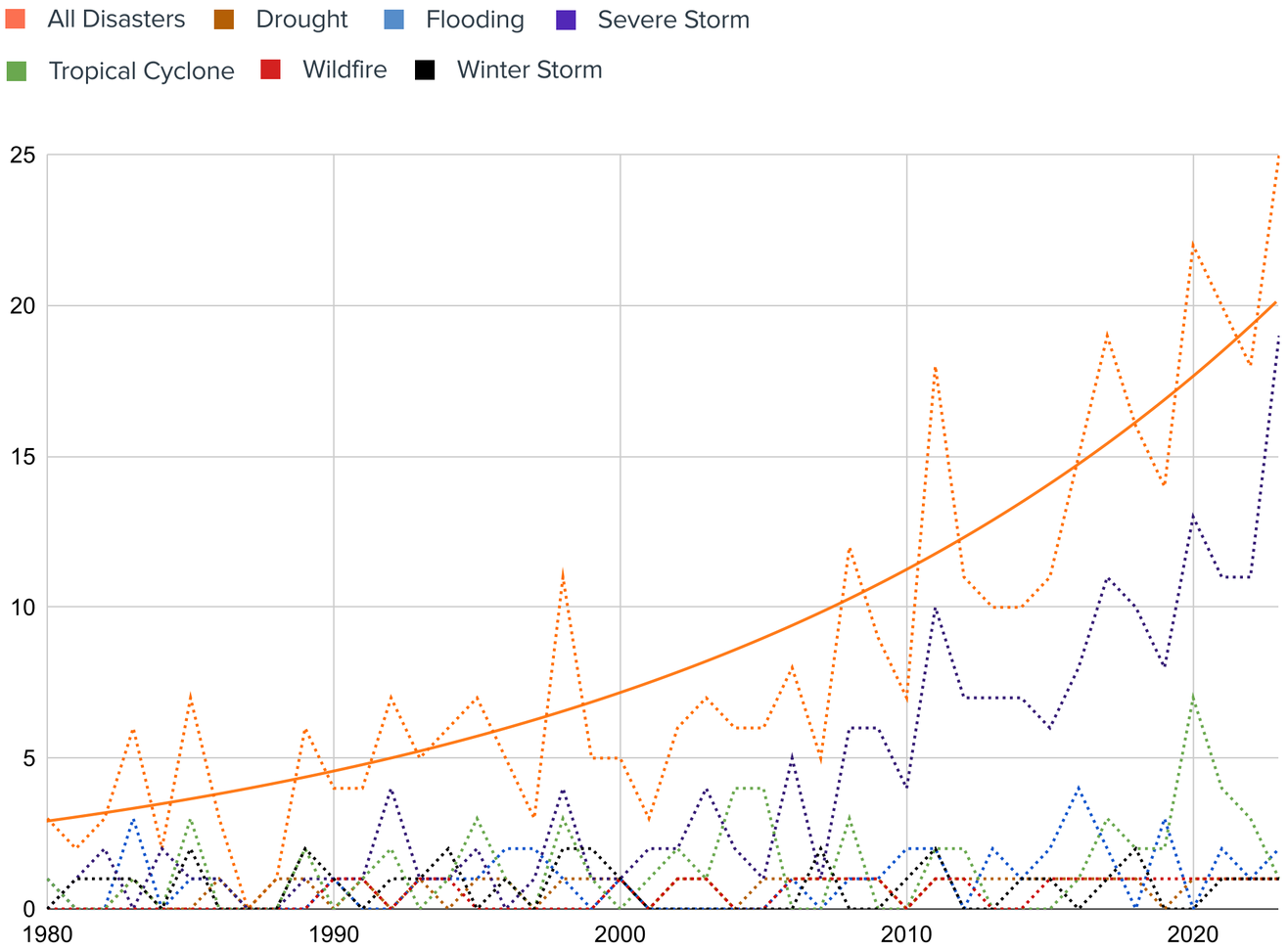
Individual and property exposure to climate disasters has increased significantly over the past few decades. Perhaps the most compelling evidence of these increases is the rise in inflation-adjusted Billion Dollar Disasters as tracked by NOAA. Since 1980. The frequency of Billion Dollar Disasters from flood, wildfire, drought, severe storm, tropical cyclones, and winter storms (as tracked by NOAA) has increased dramatically, growing from 3 per year in 1980 to 25 a year in 2023.

Tracking the frequency of events over this time period (orange solid line), it is apparent that there has been a relatively consistent, and exponential, growth in these events, underscoring the fact that more events are occurring in places where people and infrastructure can be impacted.

The underlying raw data indicates that the increase in risk has accelerated considerably since 2010. The largest increases can be seen in severe storms, including heavy precipitation, which have nearly quadrupled from around 5 per year in 2010, to around 20 annually in 2023. Tropical cyclones have also increased to 7 Billion Dollar Disasters in 2020. However, the frequency of wildfire, flood, drought, and winter storms remains relatively constant over the time period.

Overall, the increased occurrence of these phenomena across the United States has been attributed to climate change, with an expectation that the frequency of these events will continue to climb as the climate continues to change.

Frequency of Billion Dollar Climate Disasters Across the US



No part of the country is safe from climate disasters.

There has been an estimated $2.65 trillion in damage from Billion Dollar Disasters alone since 1980. However, different regions of the country face different climate hazards.

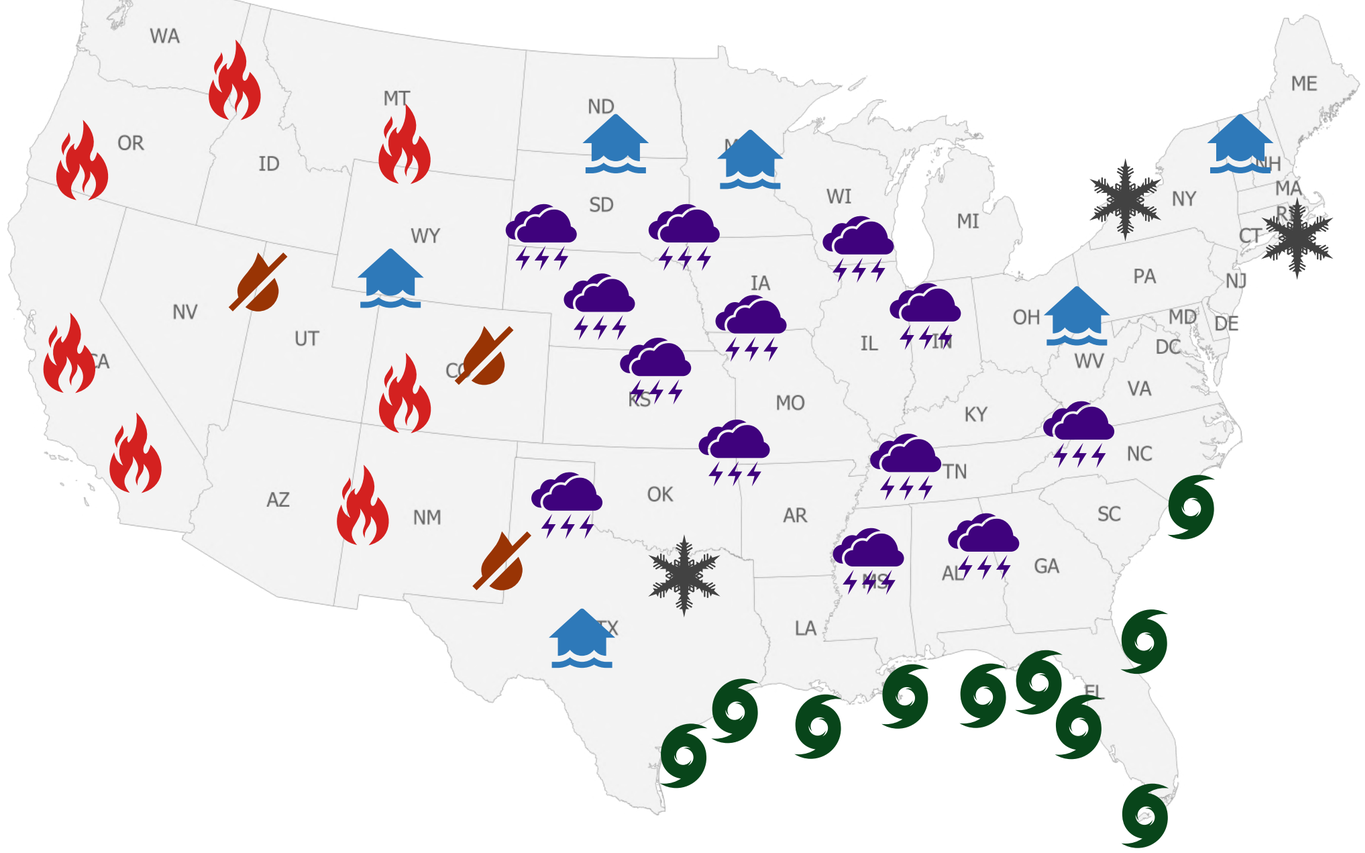
Wildfire predominantly impacts the Western US with over $97 billion in damages accumulated just in the state of California, with two other western states, Colorado and Oregon, following ($7 billion and $5.7 billion, respectively).

Flood damages, on the other hand, are spread across the country. The largest losses historically have been in the state of Iowa, which has accumulated nearly $24 billion in losses since 1980. Louisiana follows closely at $21 billion.

By far the costliest climate hazard, tropical cyclone damage is concentrated along the Gulf and Atlantic Coasts, with the largest damages recorded in Florida ($362 billion), Louisiana ($263 billion), and Texas ($236 billion).

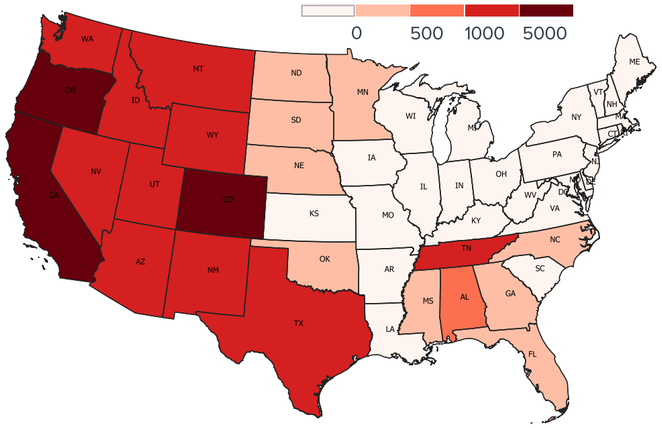
The most widespread damages in NOAA's database are due to drought, with the recorded damages of over $345 billion stretched over half of CONUS. Texas has the largest losses at over $40 billion in drought damages since 1980. Similarly, Texas leads the way in Severe Storm damages with nearly $82 billion and is also the most impacted state in regard to costs associated with Winter Storms, experiencing damages ($25 billion) over three and a half times more than the next closest state (New York).

There has been an estimated $2.65 trillion in damage from Billion Dollar Disasters alone since 1980.

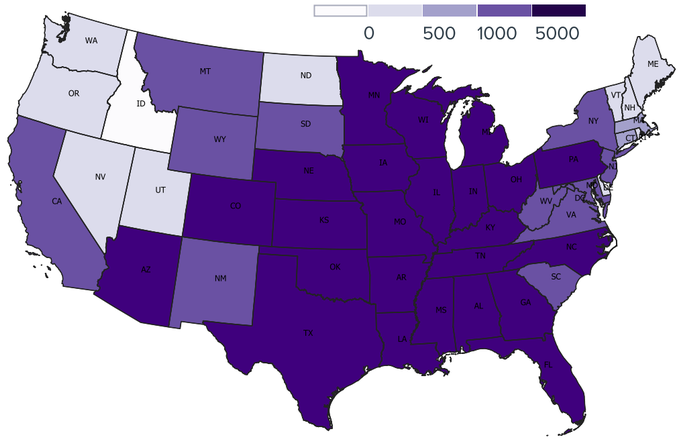


Billion Dollar Disasters by Peril Since 1980.

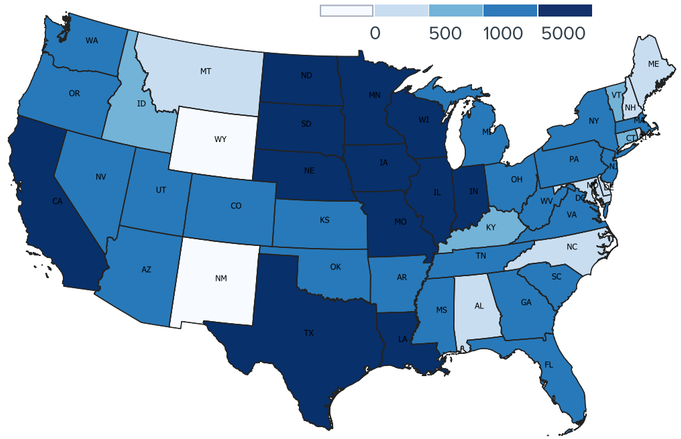
Wildfire Damage Since 1980
($Millions)



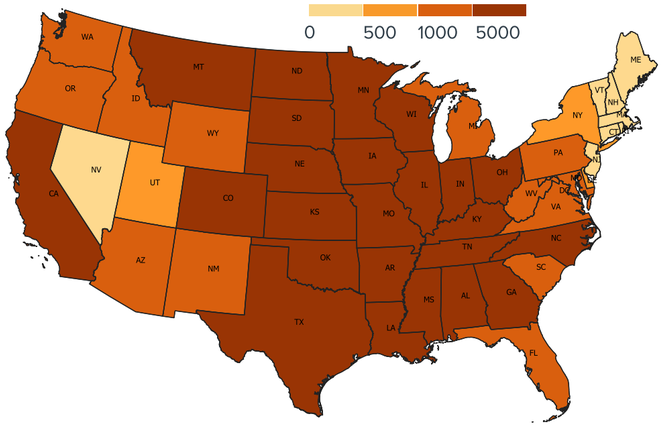
Severe Storm Damage Since 1980
($Millions)



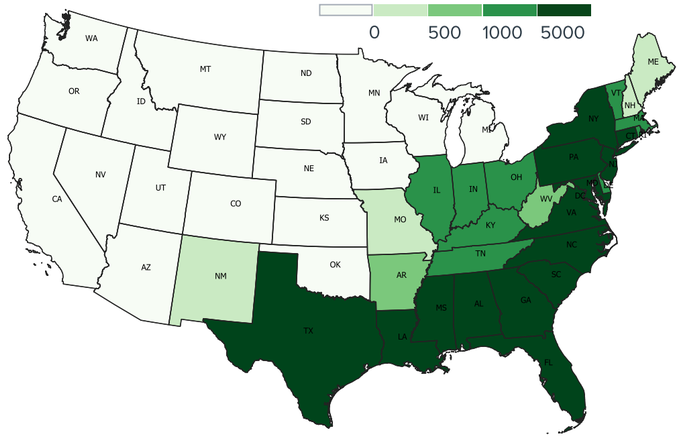
Flooding Damage Since 1980
($Millions)



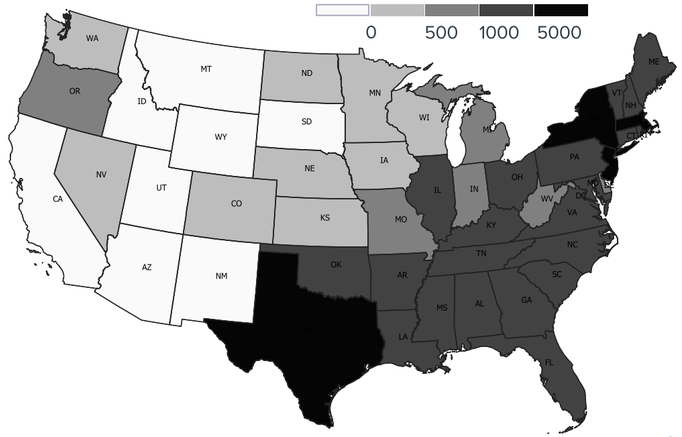
Drought Damage Since 1980
($Millions)



Tropical Storm Damage Since 1980
($Millions)



Winter Storm Damage Since 1980
($Millions)



Climate-related damages are also growing because they are occurring in places that have experienced large population booms over the last half century.

The largest increases in damages tend to be located in states with dense populations and high levels of development at risk. In many cases, this combination has been exacerbated by uneven out-migration from the Midwest and Northeast, to the growing South and Western parts of the country.

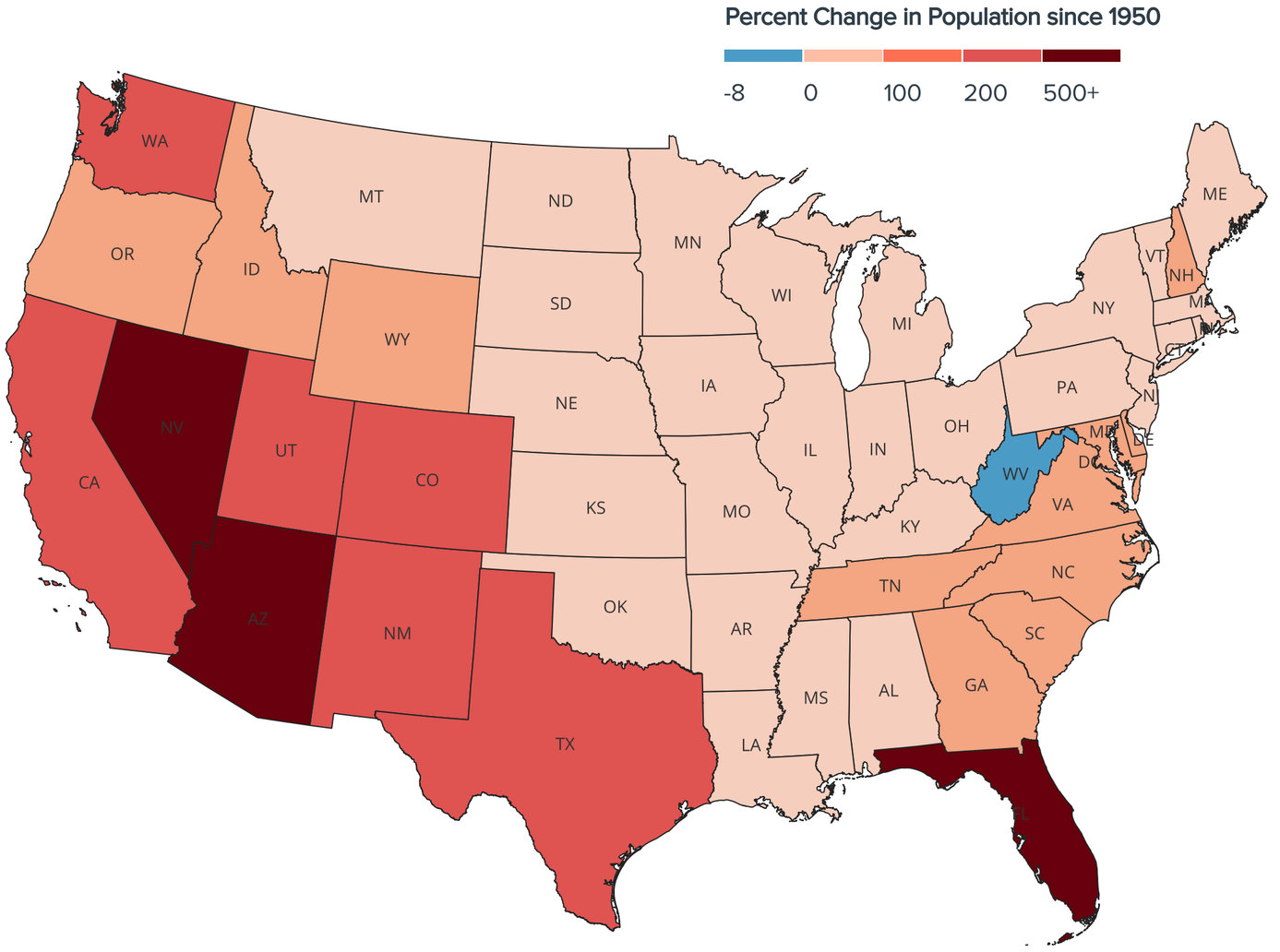
While climate risk exists across the country, the fastest-growing areas are parts of the country with uniquely high levels of risk to some of the costliest climate disasters.

Source: US Census Bureau

Since the 1950s, the population has doubled in many of these states, with the largest increases occurring in Florida (+643%), Arizona (+824%), and Nevada (+1,736%).

This macro-level migration trend indicates that people are moving towards climate-risky areas, putting themselves in the way of tropical cyclone, wildfire, flood, drought, and extreme heat risk.

Along with a growing population, the increased development leads to more physical structures, economic systems, and other financial systems at risk of damage from climate exposure and increasing the cost of these events when they happen.



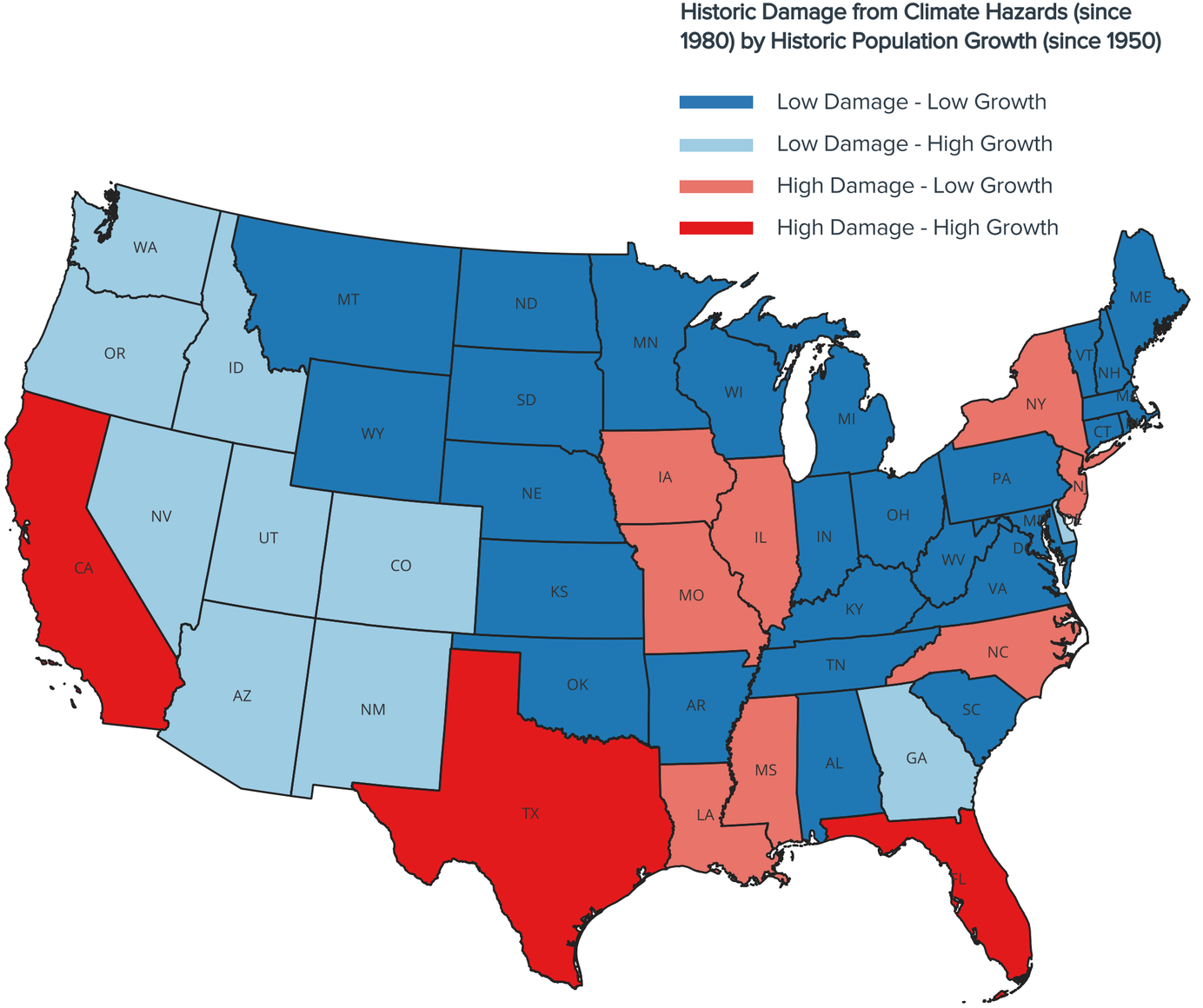
The fast-growing states of Florida, California, and Texas are among those most at risk.

The migration movements of the US population towards the Sun Belt has resulted in particularly large population growth in the states of Florida, California, and Texas. Today, those three states account for over one-quarter of all population in the US, with over 90.5 million residents.

At the same time, these states (along with Louisiana) top the list of recorded damages from NOAA's Billion $ Disasters since 1980. Combined, the states of Texas, California, and Florida account for over 35% of all damages due to climate risk. With Louisiana, these four states have seen over $1.24 trillion in damages in just over three decades.

This combination of population growth and the increasing frequency of climate disasters has led to increases in damages that are far outpacing the increase in frequency of climate hazards overall.

This large scale trend is not likely to reverse anytime soon, as there is a strong sense of attachment to place for many individuals to the areas in which they live, with most people staying within a few hundred miles of their hometowns. Driving that attachment are connections to family, property, jobs, and overall familiarity. These make up many of the factors that draw people into new communities (pull-factors) or push them out (push-factors).



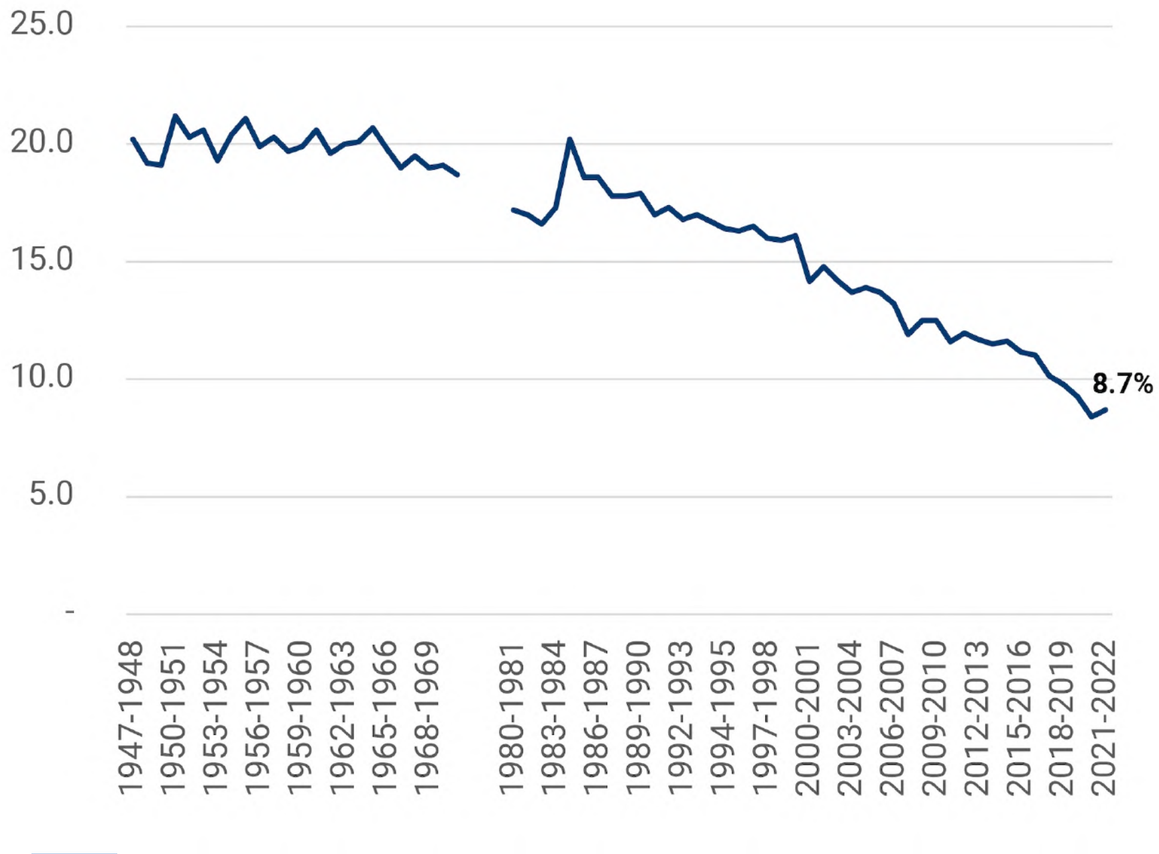
Americans are moving less often and are increasingly taking climate into account.

Attachment to place has grown over time, as today American's are less likely to move than at almost anytime in the last century. Said differently, Americans are staying in place longer and are more likely to reside in the same residence for longer than at anytime in the recent past.

When examining those trends, we can see that around 1950 the annual migration rate of Americans was about 20%, which held constant through the middle of the 1960s. Between the late 1960s and early 1980s there was a slight and consistent decrease in mobility rates. However, since about the mid-1980s there has been a relatively continuous drop in the rate in which Americans move on an annualized basis.

Surprisingly, this shift towards an inclination to remain in place includes the perceived shifts in large-scale migration during the pandemic, which was only a slight increase to 8.7% of the overall population, relative to the previous year at 8.4%. This equates to the rate of migration that we saw from the middle of the last decade (~2015). In the larger context, that bump in in the rate of moving from 2020-2022 represented a very small increase, and an overall low rate when viewed historically.

In spite of the lower levels of population movement, in a recent survey nearly a third (30%) of Americans said climate change was a reason to move (Forbes).



Annual Migration Rates, 1947 to 2022

Source: William H. Frey analysis of U.S. Census Bureau Current Population Survey

Note: Data are not available for 1972-1975 or 1977-1980

Brookings Metro

When confronted with information about climate risk, potential homebuyers are making informed decisions to minimize that risk.

In understanding these larger migration trends in the face of growing climate risk, it is important to note that there is clear evidence that when confronted with risk, homeowners/buyers are making decisions which lower their risk.

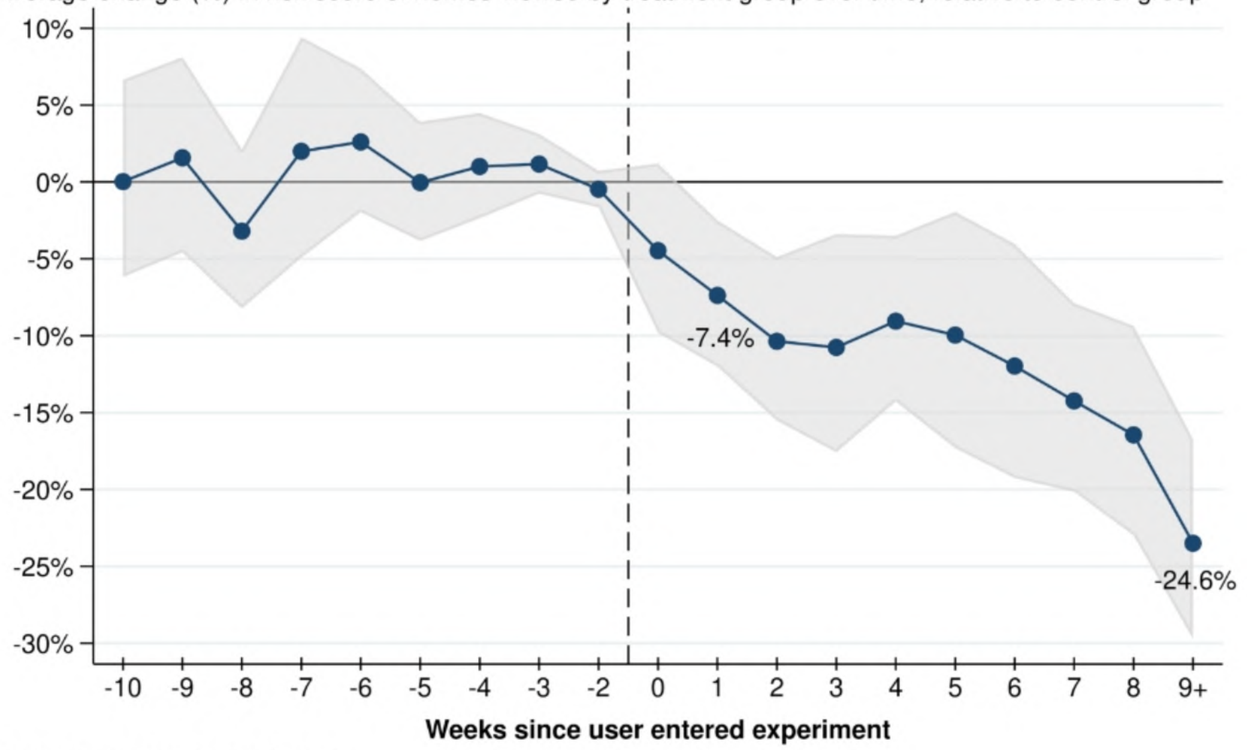
Such evidence indicates that as individuals decide to relocate, they are likely to take into account information on how to avoid climate risk. The real estate portal Zillow recently found that more than 80% of home shoppers consider climate risks when looking for a new home.

In a research collaboration between the University of Southern California, Massachusetts Institute of Technology, and Redfin, researchers found in a randomized control-treatment study that by exposing potential home buyers to First Street Foundation's FloodFactor risk ratings, homebuyers systematically searched for homes at lower risk.

Following exposure to the Flood Factor information, the decrease in risk among the homes being searched was persistent, and over 9 weeks grew to a 25% reduction in that risk. Additionally, without this exposure to the risk information (either prior to exposure, or by the control group), there was no reduction in risk for the homes that study participants chose to observe. When presented with this information, people will actively attempt to avoid homes with high risk.

House Hunters Viewed Homes With 25% Less Flood Risk After 9 Weeks in Experiment

Average change (%) in risk score of homes viewed by treatment group over time, relative to control group



Source: Redfin user trial; Flood Factor
Note: Includes only registered users who on average viewed homes with extreme risk prior to study. Blue dots represent coefficients. Grayed-out areas represent 95% confidence intervals.

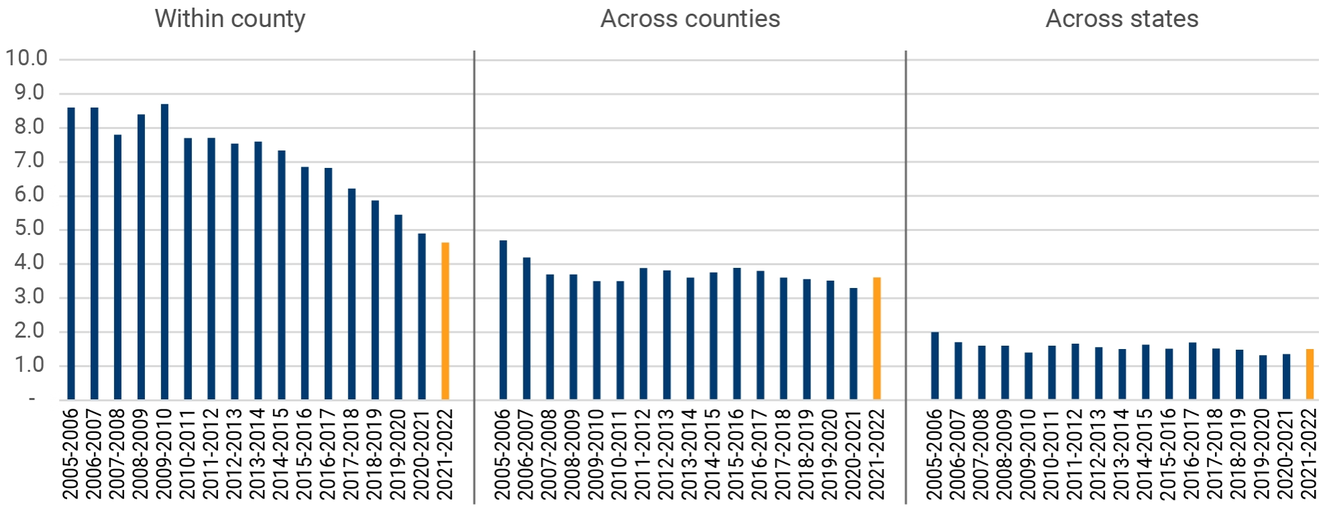
Residential mobility trends show that when people do move, they don't move far.

Additionally, when people decide to move, they tend to move locally rather than across large distances. The overall migration rate has decreased dramatically over the last century, and the rate of within-county moves has decreased at about the same rate as the overall rate of moving. The rate has decreased by half, from around 9% of the population making within-county moves nearly 20 years ago (2005), with just over 4.5% of Americans moving within-county as of 2022.

However, while the rate of local moves has decreased, it is still the most likely type of move when compared with moving across counties (within-state) or across states.

This localized movement is generally driven by individual preferences to remain close to their families, support networks, local labor market, and familiarity with the local housing market. It is important to note that moves across counties and across states have stayed relatively constant (albeit lower than local moves), but within-county moves are still the most common forms of mobility.

This indicates that higher level migration projections may be missing the majority of American moves each year.



Migration rates by type of move, 2005 to 2022

Source: William H. Frey analysis of U.S. Census Bureau Current Population Survey

Brookings Metro

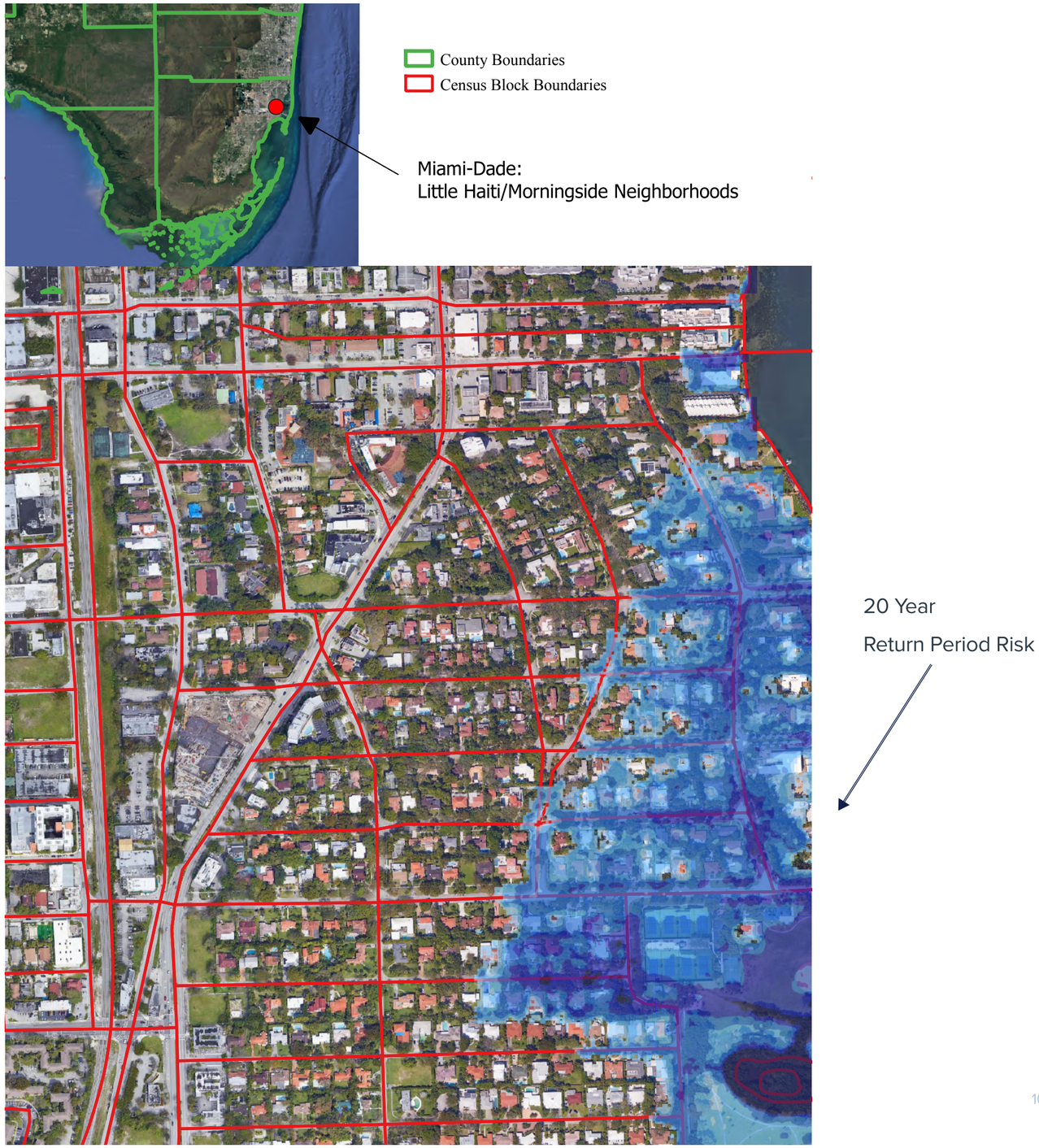
Climate risk is a house-by-house issue, not a state-by-state issue.

With much of the national narrative focusing on long-standing migration trends to the South and Western parts of the country (across-state moves), and the climate hazards that are increasing in those areas, there has been a disproportionate amount of attention paid to a relatively small part of the story around the relationship between state level population change and climate risk. The question should be, what is the effect of highly granular climate risk and localized moves (the most likely type of mobility)?

For example, flood risk is highly localized, and past research has shown that as awareness increases in an area about where that risk exists, residents respond by moving to high ground and protecting their property investments (Keenan et al, 2018).

Another study found that as awareness of flood risk increased, so did the uneven property value growth across neighborhoods (McAlpine and Porter, 2018), with high flood risk areas' value growing more slowly.

This raises the question that this research aims to answer—what is the relationship between high resolution flood risk and the associated population change in the historic record? Given the research above, one might expect that as an area reaches a critical point of flood risk, residents will respond with their decisions to relocate to less risky areas, but within the same communities given the high likelihood of within-county moves.



In order to test for the impact of local flood risk on population change, the First Street Foundation - Climate Migration Model (FSF-CMM) was developed.

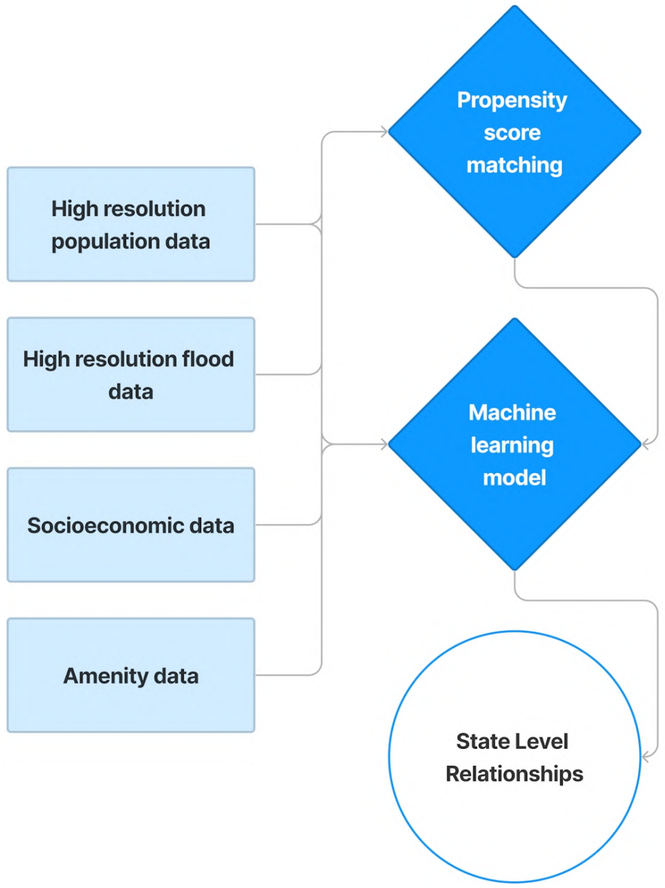
In order to test for relationships between flood exposure and historic population change, a model was built focused on historic block population estimates from the US Census Bureau, across the time period spanning from 2000 - 2020.

To understand the impact of flood risk, exposure data were included from multiple sources. First, risk information was incorporated from the First Street Foundation - Flood Model. Next, geo-located information on actual flood events was compiled using a Natural Language Processing (NLP) approach and coupled with other administrative data on historic flood risk from NOAA.

In order to isolate the relationship between flood risk and population change, additional information on the social, political, and economic characteristics of areas were included in the analysis to control for the well-known push and pull factors associated with general migration activity.

Finally, to set up a suitable comparison for the analysis, a synthetically created comparable treatment and control group using propensity score matching was used, which can isolate the effect of historic flood exposure on population change over the time period through state-level econometric models optimized to produce the best model fit.

Modeling of the Effect of Flood Risk on Observed Population Change



When examining the relationships at a higher resolution, "tipping points" of flood risk appear.

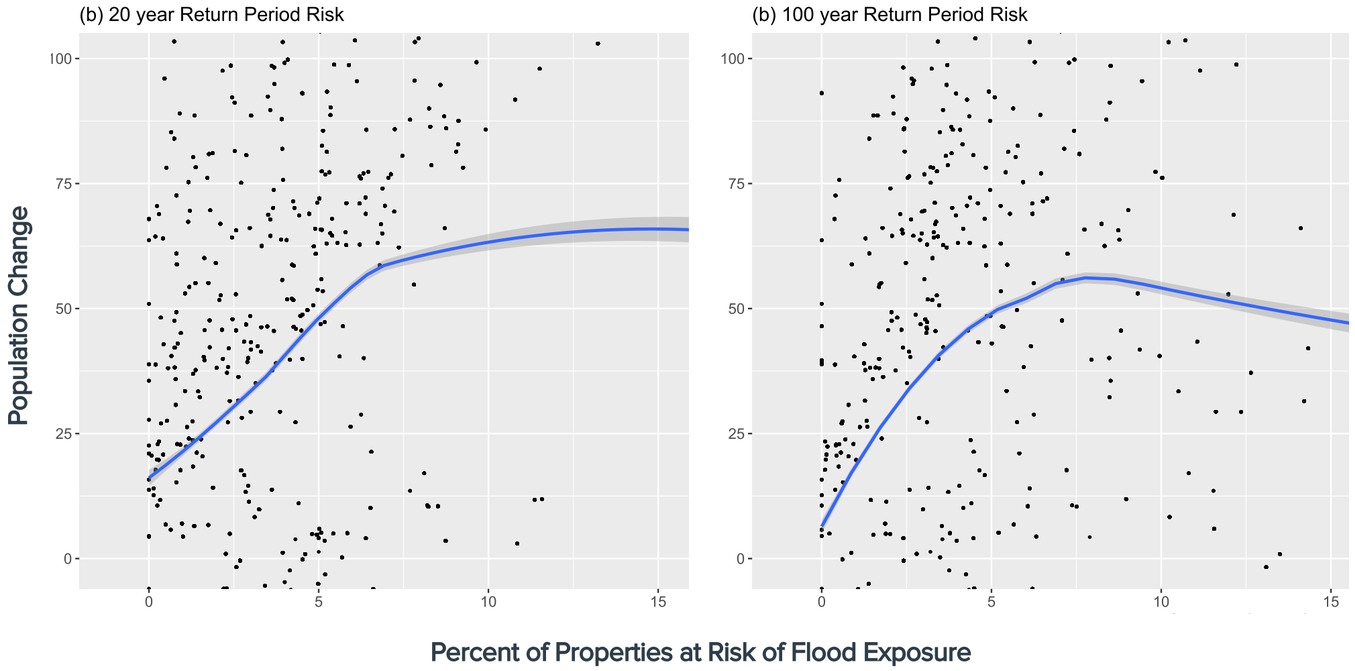
At the Census block resolution, the research finds that when between 5-10% of properties are at risk of being impacted by flooding, people may begin to move away from risky areas. These patterns are derived from historical analysis and indicate that, at a hyperlocal level, individuals are responding to flood risk. Moreover, this seems to indicate a threshold of risk at which awareness rises to the point of impacting relocation decisions.

While water amenities (such as proximity to the coast) traditionally may attract people to areas with flood risk, at a certain point that flood risk begins to outweigh the other benefits that come with those resources. After this point, you can see a consistent reversal of population trends across all risk probabilities (i.e. return periods).

This pattern appears in all of the return periods (5, 20, 100, and 500-year) even though the exact shape and magnitude of the relationships vary by state and flood risk levels. However, the patterns are all consistent when you isolate the impact of flood, characterized by a non-linear relationship in which "tipping points" appear and reflect that level of risk at which population growth slows, or even declines.

The example on the right shows this relationship across two return periods and indicates that while population growth slows in the 20 year scenario, it actually begins to decline in the 100 year scenario.

Population Projections and Climate Corrections for Census Blocks with Negative Consequences Due to Flood Risk

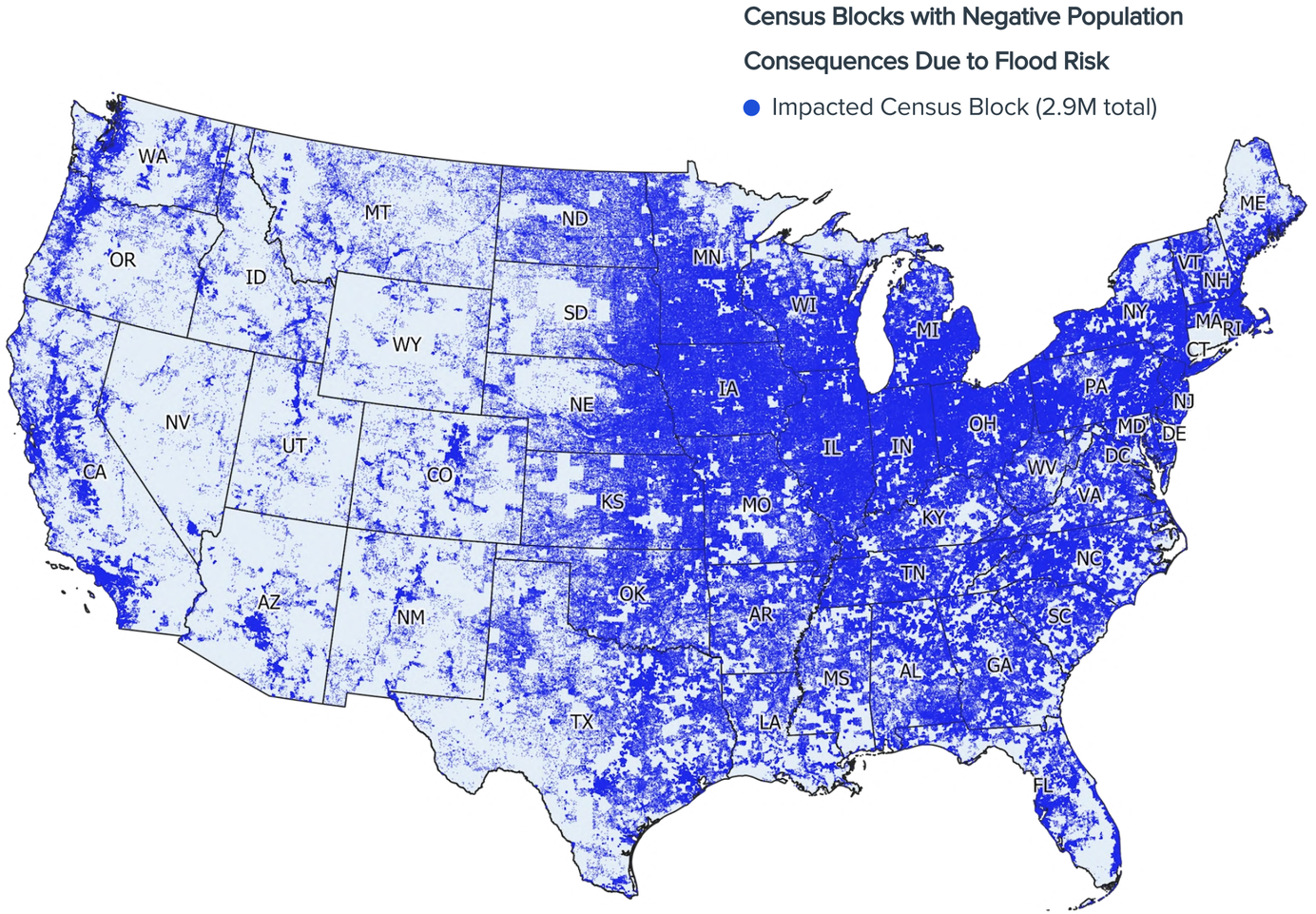


34.5% of the population lives in census blocks that have already been impacted.

In total, there are over 2.9 million Census Blocks across the US that have flood risk levels above the tipping point where population growth is impacted. In some areas, this contributes to overall population decline. In many other parts of the country, the population loss associated with flooding is not enough to offset in-migration from other pull factors. In these areas, the amenities tied to location choice, job markets, and other location factors are pulling more people into the area than are leaving. However, it is important to note that these places would have even more growth if the same level of flood risk didn't exist.

These already-impacted areas represent 34.5% of the total US population (totaling over 113.6 million people) and 41.9% of all housing stock (with over 50.4 million properties).

The map to the right shows the Census Blocks that are already seeing population decline or slowed growth due to high levels of flood risk. The map indicates that all areas of the country are seeing some impact from this phenomena. In particular, areas in the Midwest (Indiana, Ohio, Michigan) pop out as having high levels of risk. These areas have historically seen declining populations, but these results indicate that many of those trends are exacerbated due to flood risk.



A subset of impacted blocks make up Climate Abandonment Areas.

Nationally, the results of the analysis yielded two distinct categories into which the impacted areas could fit, given their historic rates of population growth and levels of flood risk.

Risky Growth Areas
Among areas with high levels of flood risk, some have seen continued growth in their populations. These areas, "Risky Growth Areas", saw a population increase of about 17.6 million which represents about 30% of the country.

Climate Abandonment Areas
Nearly 818,000 Census blocks in the United States, accounting for 7.4% of the total number of blocks, have already passed the localized tipping points defined by historical models and have experienced an overall population decline.

These blocks have experienced a total population decrease of over 9 million from 2000 to 2020, with over 3.2 million (35.5%) of that decline being directly attributed to flood risk. The cumulative count of the populations living in these declining blocks is almost 16.4 million individuals, making up 5.0% of the entire population.

Climate Abandonment Areas

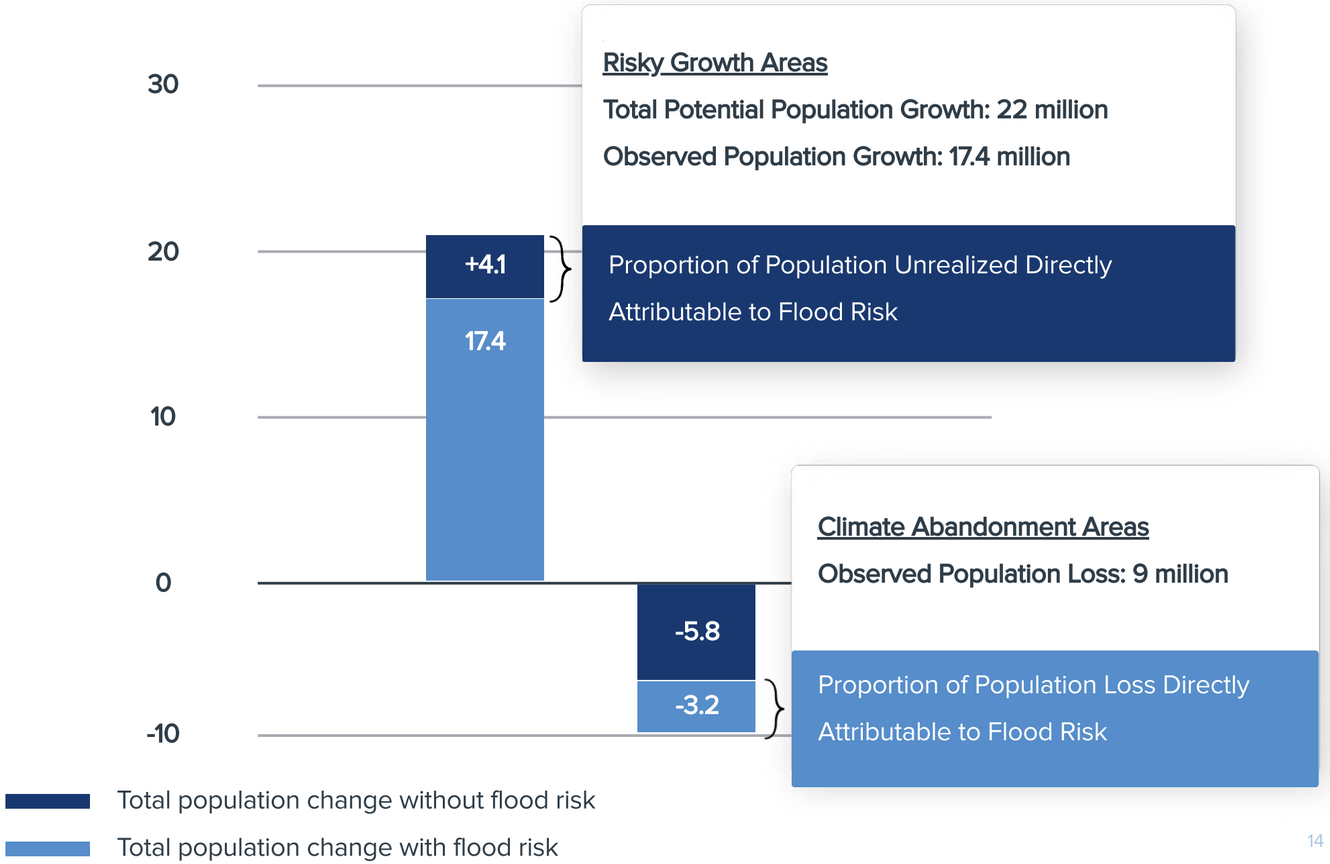
Blocks	Properties	Population
818K	**9.4M**	**16.4M**
(7.4%)	**(7.8%)**	**(5%)**

Population loss due to flood: 3.2 million

Risky Growth Areas

Blocks	Properties	Population
2.1M	**41M**	**97.2M**
(19.4%)	**(34%)**	**(29.5%)**

Unrealized Population Growth: 4.1 million



When people abandon an area, the economic and demographic makeup changes.

The implications of becoming a Climate Abandonment Area are significant and can have direct impacts on who remains in a community and on the overall desirability of the area. When the population in an area grows, it can lead to an increase in demand for goods and services, which can stimulate economic activity and lead to job creation, higher property values, and an increase in the overall desirability of an area.

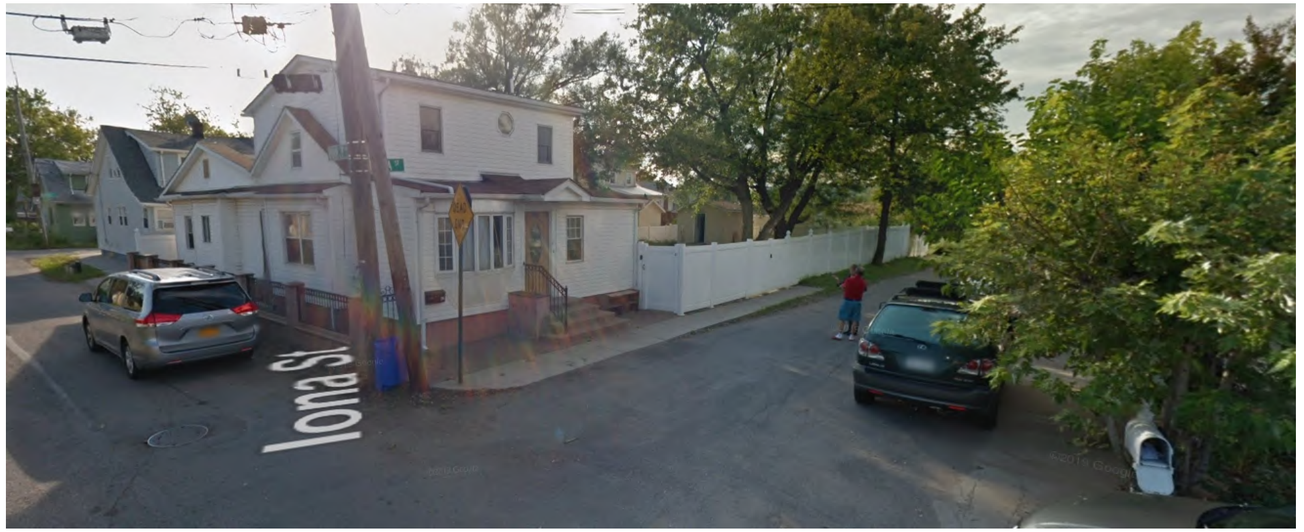
On the other hand, a decrease in the population can have the opposite effect. If an area is unable to attract and retain residents, it may struggle to support businesses and provide essential services, resulting in potentially negative consequences for the local economy and quality of life.

A slowing population and increased flood risk can lead to declining property values (McAlpine & Porter, 2018). For example, in Miami-Dade County, properties lost as much as $3.99/sqft due to flood exposure between the years of 2005 and 2017. Additionally, declining property values can affect the city's tax base, with some municipalities being particularly impacted given the disproportionate amount of risk associated with revenue from property taxes, lowering their ability to fund important services (Gourevitch et al., 2023).

Additionally, as populations move to avoid risk, the population left behind in these Climate Abandonment Areas is often older and socioeconomically more vulnerable (Hauer et al., 2022).

Staten Island, Midland Beach Neighborhood

2000 Population: 93 | 2020 Population: 31 | Properties With 100 Year flood risk: 100%



2008

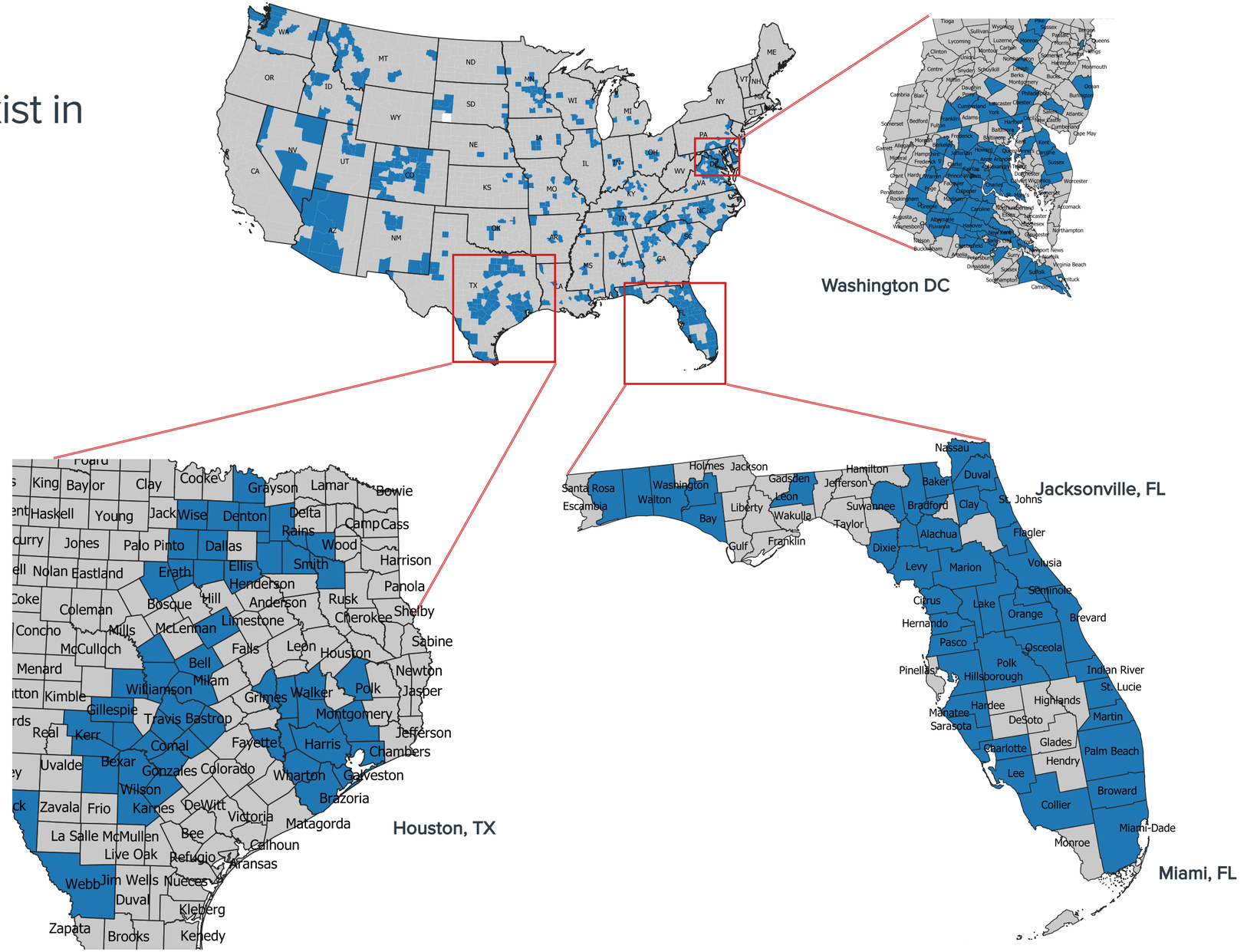
2013

Climate Abandonment Areas exist in major metros across the US

In isolating the unique impact of flood on population change, the research finds that Climate Abandonment Areas surprisingly exist even in some of our fastest-growing metropolitan areas.

There are a total of 513 counties, about 17% of all counties across the CONUS, which grew at a faster rate than the national average of 18% between 2000 and 2020, but contained blocks which met the two conditions of losing population over this time period and had high risk of flooding above the "tipping point" identified in the historic model.

While the counties are spread across the country, there are concentrations in Gulf Coast areas of Texas (specifically the Houston area), the Mid-Atlantic region between Washington DC and New Jersey, and most of coastal Florida.



There is a disproportionate number of Climate Abandonment Areas in some fast-growing metropolitan counties.

Considering counties within CONUS that are growing in population at a higher than average rate, the research finds a number of counties that have a high concentration of blocks within them above that are defined as Climate Abandonment Areas. These blocks are declining in population, even though they are within a county of growing population.

In Bexar County, TX, 17.1% of all blocks are declining in population and have high flood risk above the "tipping point", making them Climate Abandonment Areas even though the county as a whole has grown significantly between 2000 - 2020 (+%). This is followed by Will County, IL (~17.0%); El Paso County, TX (~12.7%); Fairfax County, VA (~10.0%); and Tarrant County, TX (~9.8%) to round out the top five.

Notably, some of these counties represent some of the largest cities in the country. For instance, El Paso County, TX, home to the City of El Paso, has about 12.7% of the blocks in the county beyond the threshold observed in the historic models to drive population change, and has been losing population during the 20 year period. Also in Texas, Harris County, right in the middle of Houston, already has surpassed the tipping point associated with flood risk, and has a declining population in about 9% of Census Blocks within the county.

Ocean County, NJ (9%) is the lone Northeastern county represented on this top 10 list, but is indicative of the widespread reach associated with the risk to communities across the country.

Top 10 Counties with Most Climate Abandonment Areas Despite Having Above Average Population Growth

State	County	County Change in Population, 2000 - 2020	County Percent Change in Population, 2000 - 2020	Percent of Blocks that are Climate Abandonment Areas
TX	Bexar	+616,393	+44.3	17.1%
IL	Will	+194,078	+38.6	17.0%
TX	El Paso	+186,035	+27.4	12.7%
VA	Fairfax	+180,644	+18.6	10.0%
TX	Tarrant	+662,291	+45.8	9.8%
AZ	Pima	+199,691	+23.7	9.7%
AZ	Maricopa	+1,348,418	+43.9	9.5%
NM	Bernalillo	+120,457	+21.7	9.1%
NJ	Ocean	+126,337	+24.7	9.0%
TX	Harris	+1,331,955	+39.2	9.0%

What's going on in Bexar County?

Wetmore (Existing Residential, High Risk)

Total Census Blocks	Identified Climate Abandonment Areas		Average Population Change	
476	104	22%	118 to 112	-6 residents

Alamo Ranch (Existing Residential, High Risk)

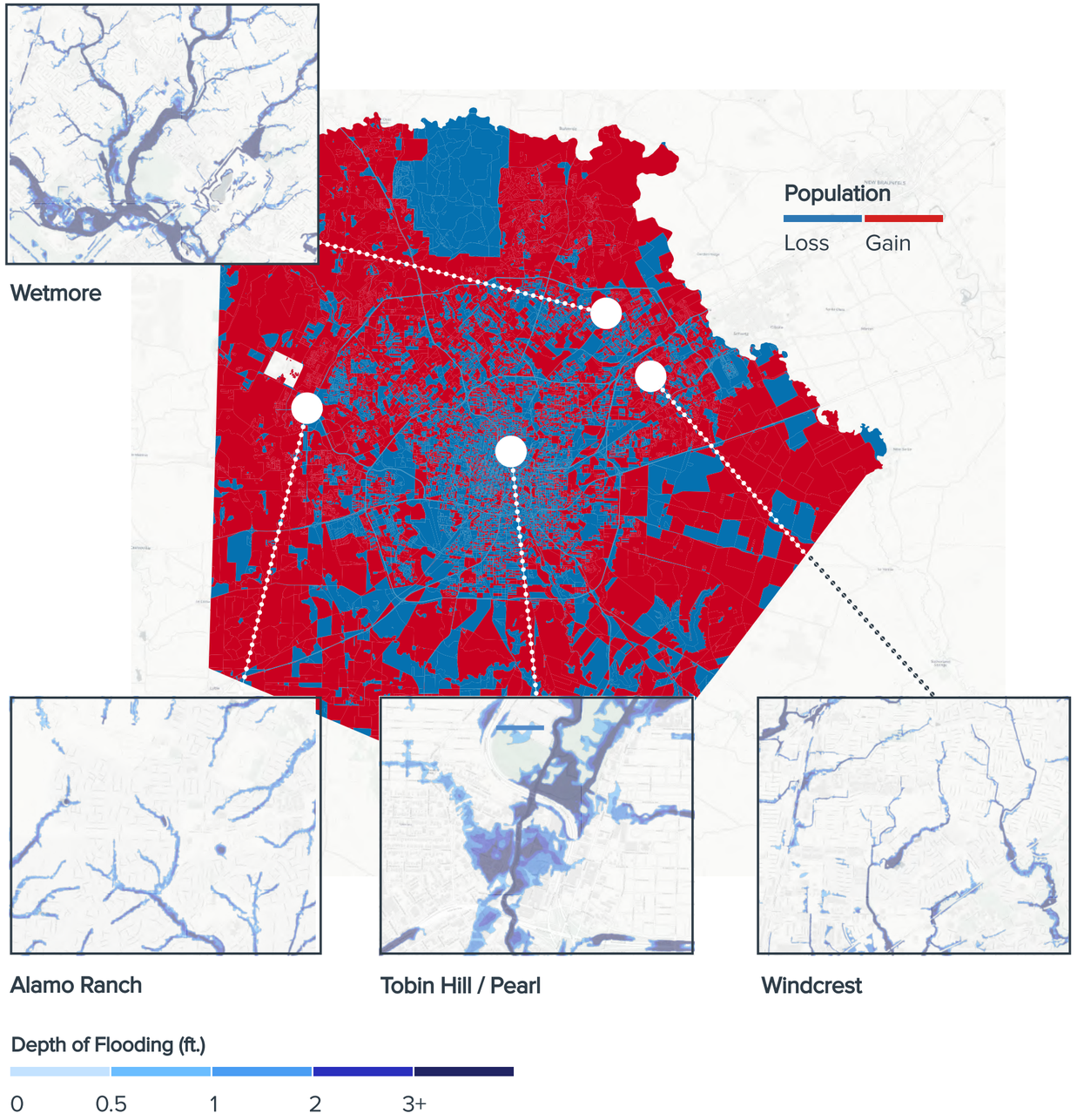
Total Census Blocks	Identified Climate Abandonment Areas		Average Population Change	
235	5	2%	8 to 61	+53 residents

Tobin Hill / Pearl (Existing Residential, High Risk)

Total Census Blocks	Identified Climate Abandonment Areas		Average Population Change	
376	147	39.1%	42 to 33	-9 residents

Windcrest (Existing Residential, High Risk)

Total Census Blocks	Identified Climate Abandonment Areas		Average Population Change	
197	26	13%	71 to 123	+52 residents



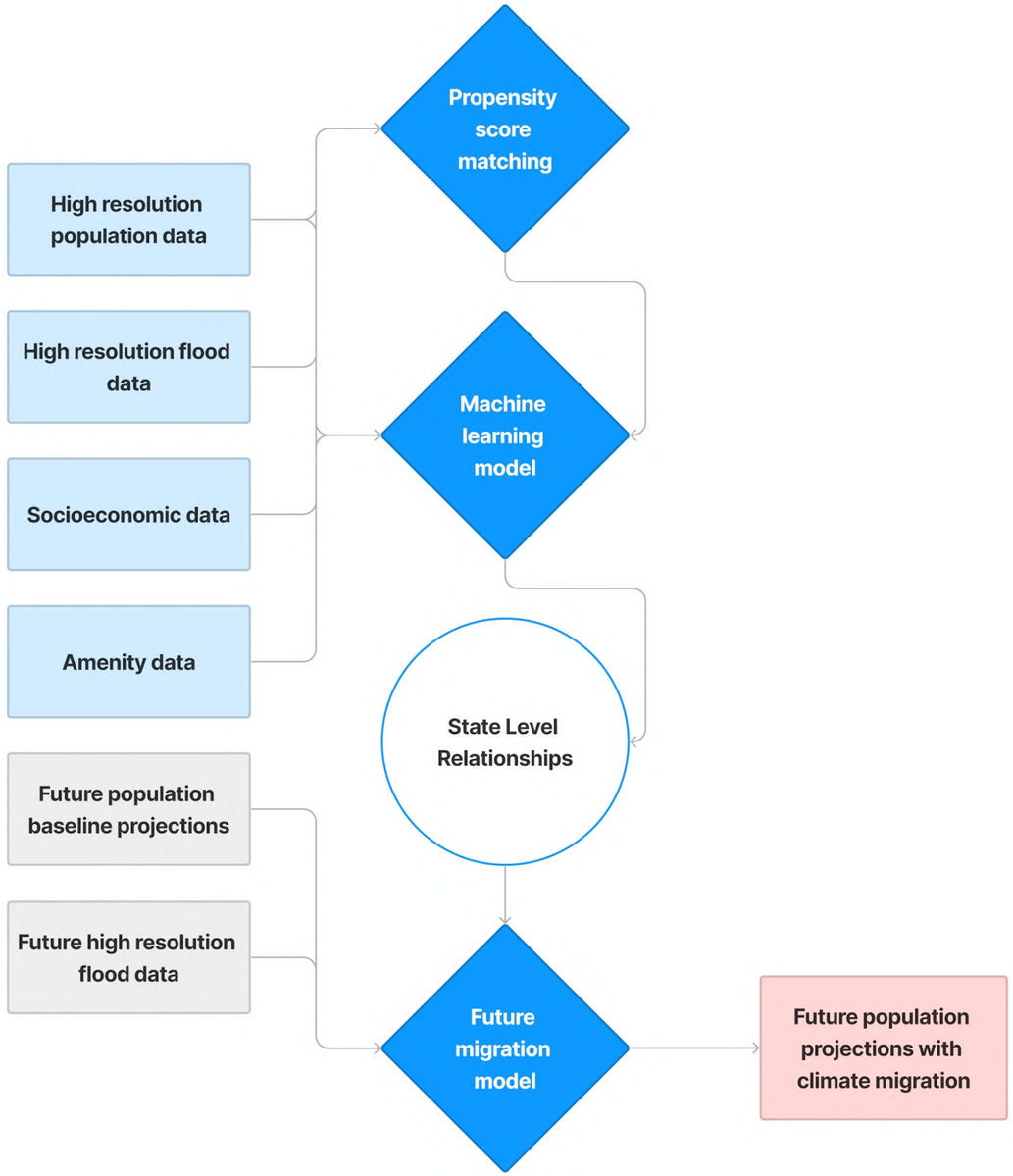
By combining the results of the FSF-CMM with future climate risk and baseline population projections, First Street can forecast population levels into the future.

Through the historic modeling process, relationships were identified between localized levels of flood risk and observed population change when controlling for other known migration push and pull factors. These relationships can be thought of as "climate consequences" in a changing environment. In the previous example of Galveston County, for instance, these consequences are clearly identified among the areas of high and low flood risk.

Coupling those consequences with the future flood risk from the First Street Foundation - Flood Model (FSF-FM) and baseline future population projections, the research is able to estimate climate-adjusted population change out to 2053.

By integrating the historically-derived "climate consequence" into the future projections, this approach adds significant information to past approaches aimed at projecting population levels into the future. Also, the model relies explicitly on the underlying demographics of the community as a core component of population change in the future, and adds future economic, social, and political conditions of the larger community as components to the forecast, as defined by the Shared Socioeconomic Pathways (SSPs) from the Intergovernmental Panel on Climate Change (IPCC). Specifically, this research relies on the conservative "middle of the road" Pathway, SSP245, which assumes some coordinated global efforts to curb carbon emissions.

Full Model Projecting Population Change based on Flood Risk



Baseline future population projections are based on a combination of regional growth expectations and demographics.

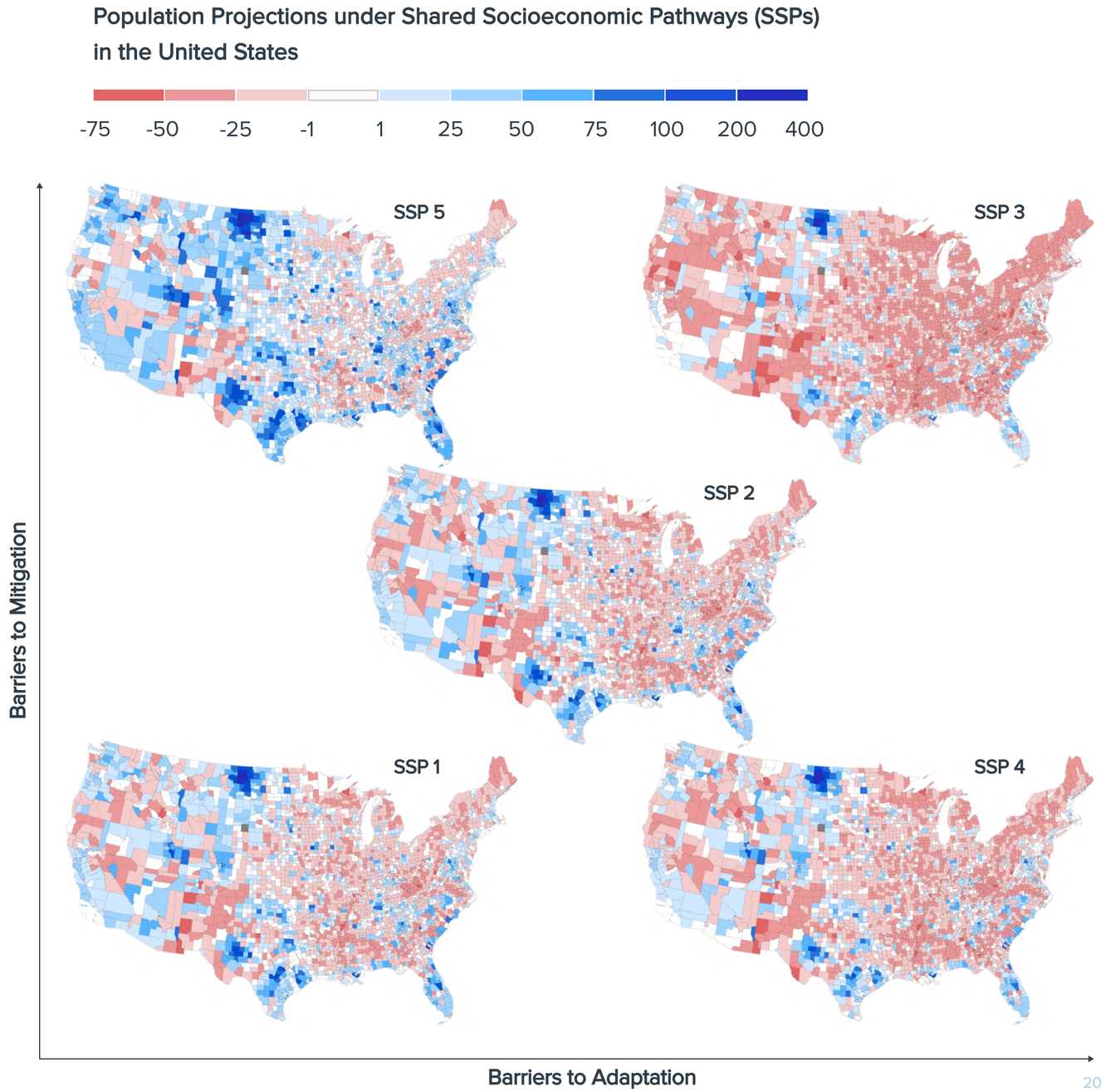
The baseline population projections to which the "climate consequence" is applied were created using data from Hauer and colleagues (2021) as part of NASA's Socioeconomic Data and Applications Center (SEDAC) data offerings.

These population projections are the first sub-national projections to be built on the IPCC's SSP trajectories, which are alternative pathways associated with population growth, industrial trends, the adoption of environmentally clean technologies, and the social, economic, and political conditions of the area.

For the purpose of this research, the SSP245 pathway was chosen as it is the climate trajectory over the next 30 years.

The data provided by SEDAC have already been downscaled from the national level based on the demographically-informed Cohort Change Ratio (CCR) approach, which take into account the age, race, and gender composition of the existing population, along with expectations around in-migration, to project future population levels and composition.

In order to further downscale those projections to the block level, a statistical approach was applied in which the block's proportion of county population was used as a weight for redistribution.



Climate Abandonment Areas will continue to grow.

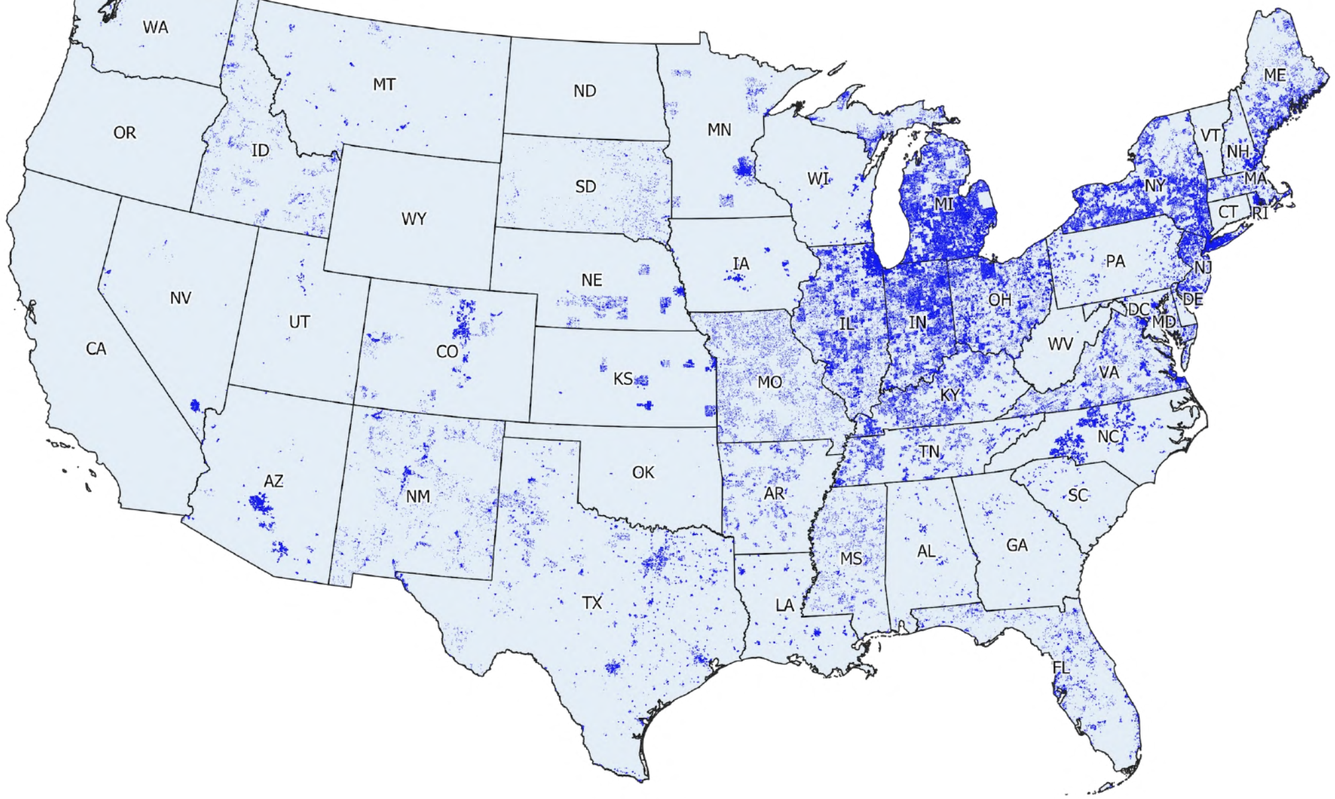
With increasing flood risk due to climate change over the next 30 years, areas which have historically grown despite some flood risk will likely pass a tipping point where that flood risk grows large enough that populations are expected to decline and become Climate Abandonment Areas. There are expected to be over 443,000 blocks that will become Climate Abandonment Areas.

These new Climate Abandonment Areas are scattered across the country, and are especially focused in the Midwest and Northeast regions. In particular, many blocks are expected to become Climate Abandonment Areas in the states of Illinois, Indiana, Michigan, and Ohio.

While many areas in these states are projected to decline in population with high flood risk, other areas of the state may see growth as populations redistribute to avoid risk. Additionally, while many areas are expected to emerge as new Climate Abandonment Areas, many of those which have already seen declining populations will continue to decline.

New Climate Abandonment Areas forecast to transition from areas of population growth to population loss due to flood risk

● Impacted Census Block (443k total)



Current Climate Abandonment Areas will continue to lose population into the future as new ones emerge.

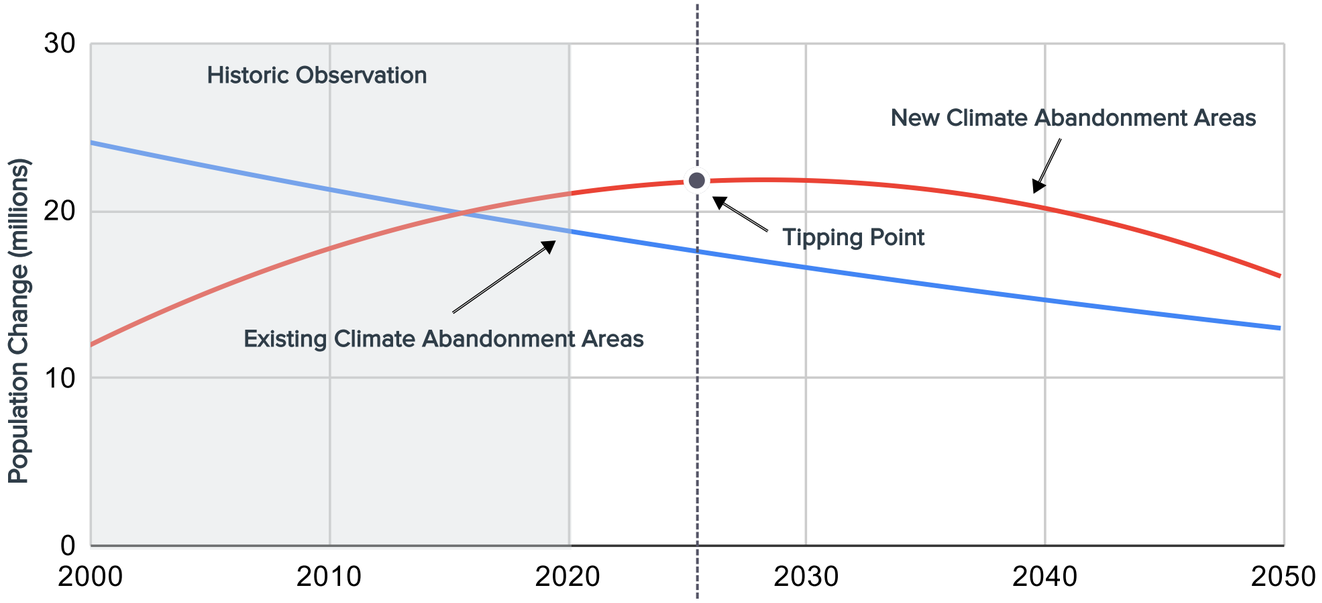
As mentioned earlier, most of the Climate Abandonment Areas which have developed over the last 30 years, will continue to see losses in population totaling an additional 2.5 million in loss when projected out to 2053 using the SSP245. In these areas, the loss of population remains persistent over the next 30 years, due to the growing flood risk, slowing natural population growth, and a lack of pull-factors associated with the attraction of new in-migration into the area.

These patterns are represented by the persistent blue trend line on the graph, which also captures the rate at which the decline slows as the decreases in these areas and the demographic characteristics of those that remain are taken into account.

On the other hand, the orange line represents areas that historically have seen population growth in high flood risk areas. These areas are projected to hit a "tipping point" as a group around the year 2025. These emerging Climate Abandonment Areas have increased from over 12.0 million people in 2000, to above 21.0 million people just 20 years later. However, the increasingly high flood risk in those areas are forecast to result in a loss of almost 5.0 million people from those areas over the next 30 years, leading to a population projection of about 16.0 million people.

In summary, these trends indicate that most Climate Abandonment Areas will continue to lose population into the future, while many of the areas that are growing today with high flood risk will see those trends reverse.

Population trends in existing and future climate abandonment areas



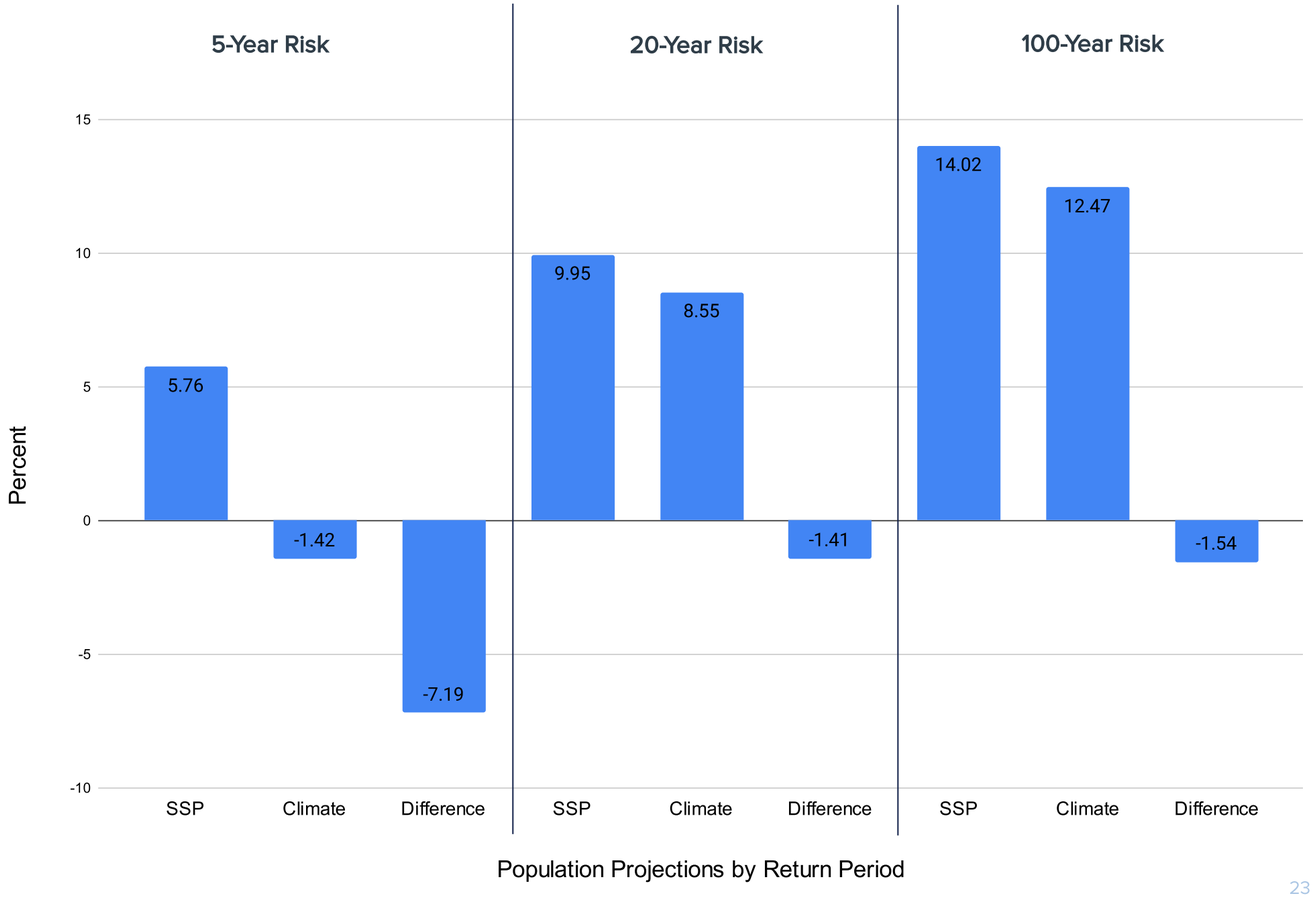
Population change in Climate Abandonment Areas is primarily driven by high frequency flood risk.

While Climate Abandonment Areas are expected to increase in both the current number of properties and population at risk, future projections show that the areas most at risk of becoming areas of negative population growth are those blocks with the highest percent of their properties at risk of frequent flood events. In particular, the integration of the "climate consequence" into the baseline SSP245 projections results in decreases in expected population growth into the future, but predicts actual decreases in the highest risk areas.

Specifically, blocks with relatively high exposure in the 5-year RP report a negative 7 percentage point difference in the rate of growth in the baseline projections (5.7% cumulative growth) versus those corrected by the integration of the climate consequences (1.5% cumulative loss).

Similarly, results show that communities with high risk in the 20-year RP will grow at slower rates than the baseline population projections, with a 1.4 point loss on the cumulative rate of growth in the baseline projections (10%) versus the cumulative growth in the climate adjusted projections (8.6%). Finally, the 100-year RP difference in baseline and corrected projections is negative with about a 2% difference in the cumulative rate of growth in the baseline population projections (~14%) versus the cumulative growth in those areas following the integration of the climate consequence (~12%).

Population Projections and Climate Corrections for Blocks with Negative Consequences Due to Flood Risk



Some of the most populated areas in the country are forecasted to have growing Climate Abandonment Areas.

When looking at the counties which will see the largest increase in Climate Abandonment Areas over time, there are a large number in highly populated metro areas. These include counties in Minneapolis (Hennepin and Ramsey), Indianapolis (Marion), Milwaukee (Milwaukee), Alexandria (Fairfax), and Las Vegas (Clark).

Among the top 10 counties, Hennepin County tops the list and is expected to see the number of blocks defined as Climate Abandonment Areas increase from about 23.0% today to 56.9% in by 2053. This amounts to an absolute increase of approximately 33.9%. Ramsey County, part of Minneapolis, reports the 2nd largest increase with an absolute increase of 29.1%, bringing the Climate Abandonment Areas to 54.3% of all blocks.

Milwaukee County (the center of the city of Milwaukee), is projected to have a slightly smaller increase over the next 30 years (+19.8%), but has the highest level of Climate Abandonment Areas (25.7%) today among the counties in the top 10.

Other notable areas on the list include Marion County, Indiana, (part of Indianapolis) which is projected to see an increase in Climate Abandonment Areas from 15.3% to 39.0% of all blocks in the county. Providence County, in Rhode Island, is expected to see an absolute increase of 17.6% over this time period from 12.2% in the current year.

Top 10 Counties with largest increase of Climate Abandonment Areas 2023 to 2053

State	County	Metro Region	% of county in Climate Abandonment Areas 2023	% of county in Climate Abandonment Areas 2053	Absolute Increase in Climate Abandonment Areas 2023 - 2053
MN	Hennepin	Minneapolis	23.0%	56.9%	33.9%
MN	Ramsey	Minneapolis	25.2%	54.3%	29.1%
IN	Marion	Indianapolis	15.3%	39.0%	23.7%
WI	Milwaukee	Milwaukee	25.7%	45.5%	19.8%
RI	Providence	Providence	12.2%	29.8%	17.6%
NV	Clark	Las Vegas	4.4%	19.6%	15.2%
VA	Fairfax	Alexandria	10.0%	24.8%	14.7%
NE	Douglas	Omaha	9.2%	23.2%	13.9%
KS	Sedgwick	Wichita	21.7%	32.9%	11.2%
NC	Guilford	Greensboro	8.0%	18.1%	10.1%

- Defined by the % of blocks past tipping points and with overall decreasing populations

Case Study: Projecting population estimates in Miami-Dade County, FL

One area that is commonly discussed as a climate-risky destination spot is Miami-Dade County, FL. Today, nearly 3 million people live there, with about half (1.49 million) living in areas at significant risk of flooding.

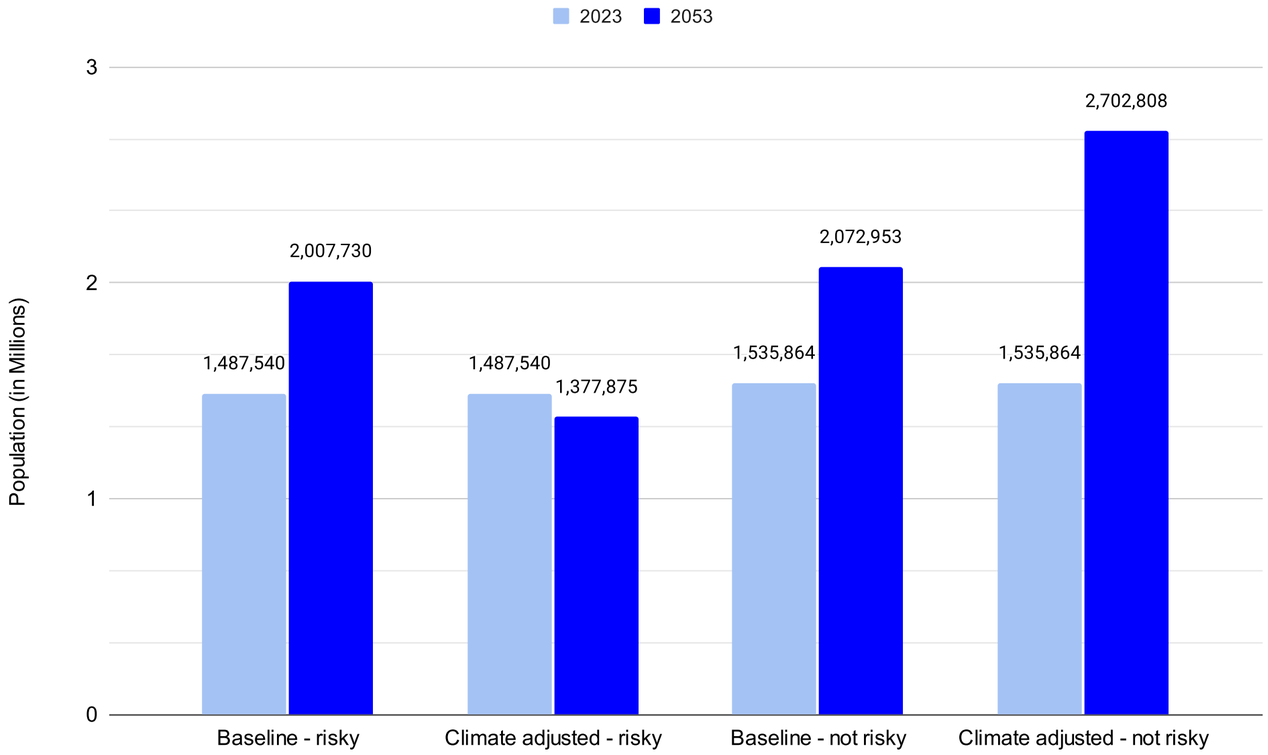
When projecting population forecasts to 30 years into the future based solely on the SSP245 trajectory, the population is expected to increase consistently across the county while growing to over 4 million residents evenly split across the risky (2 million) and non-risky (2.1 million) areas. These projections have been made without accounting for future population responses to increasing climate risk and the growth in flood exposure.

On the other hand, if the observed historic relationship between flood risk and population change is taken into account, the growth across the county is much more uneven with rapid growth taking place in the less risky parts of the county at the expense of growth in the most risky parts.

Specifically, the less risky areas of the county are expected to grow from about 1.54 million to over 2.7 million, representing an 80% increase in population over this time period.

Over that same 30 year period, risky areas with significant and increasing flood risk are actually projected to lose population, falling from 1.49 million to 1.38 million (-8%). Thus, the climate migration model based on historic patterns indicate that the future population growth in Miami-Dade County will be focused in less risky areas.

Impact of Climate Corrections on Future Population Projections by Flood Risk Level in Miami-Dade County, 2023 - 2053



Case Study: Projecting population estimates in Miami-Dade County, FL

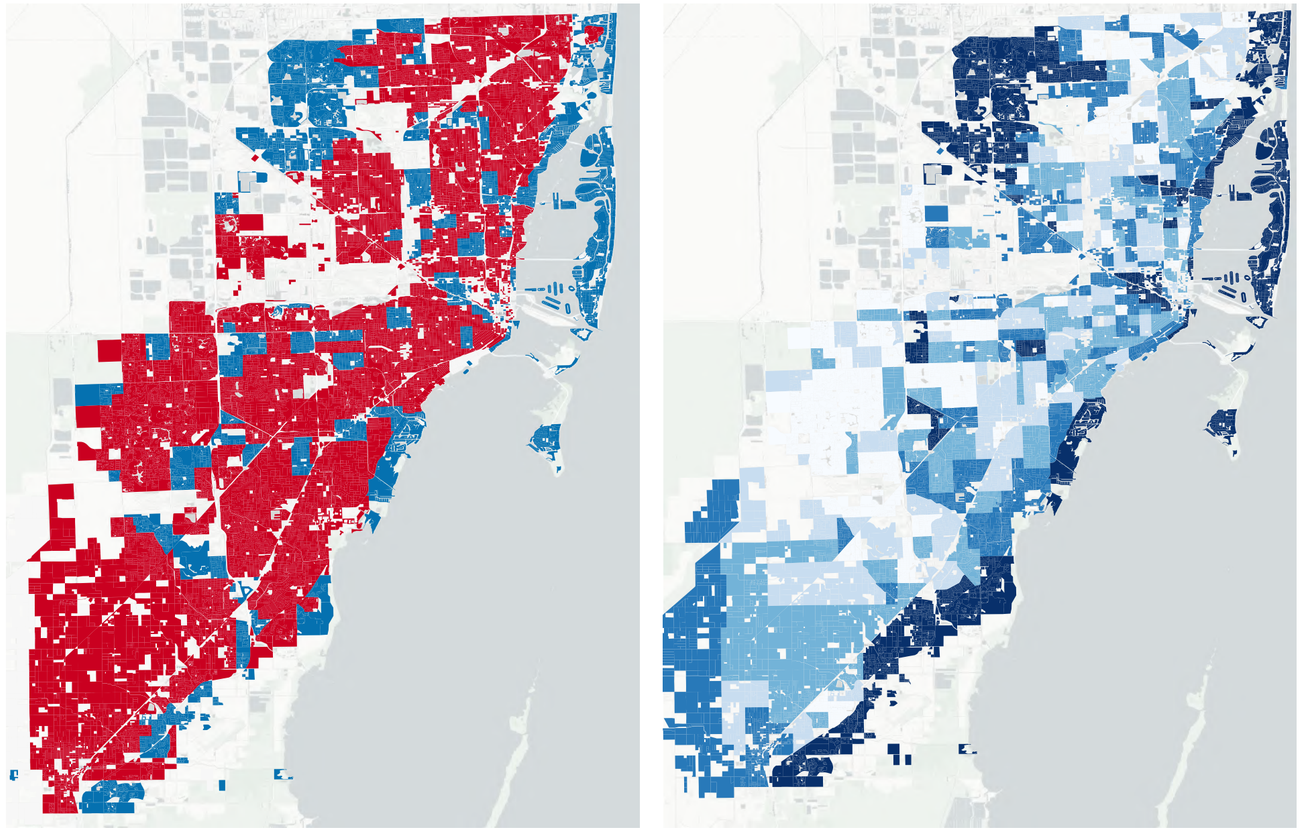
Carrying forward the example of, Miami-Dade County, FL we would expect to see positive population growth overall into the future. However, that growth is not expected to be uniform based on observed historic patterns in the county where we have already seen declining population in blocks in the Climate Abandonment Areas — despite the significant uptick in county-wide population since 2000.

When examining the spatial locations of where population loss and gains are likely to occur, there is a clear relationship with flood risk by block. The historically-derived "climate consequence" may be used to modify future baseline population levels, based on demographically-driven cohort change ratios.

After introducing the climate corrections, the impact of flood risk will be felt most directly in Miami Beach and other low-lying areas of the county. Specifically, those areas which are projected to lose populations are the same areas which have the most flood exposure in the 100 year return period.

On the other hand, areas with lower risk of flooding are likely to benefit from the redistribution of population within the larger housing market, leading to increased desirability. Being able to identify those areas likely to be negatively or positively impacted by differential levels of flood risk allows for informed planning based on a future-facing understanding of potential downstream climate implications.

Comparison of Future Population Projections by Future Projections of the Percent of Properties at 100-Year Flood Risk, 2053



Population Projection

Less Stable Gain

Percent Change in Flood Exposure

15 30 45 60+

Some US areas will benefit from the emerging patterns of climate migration.

On the other side of decreased demand due to high flood risk, there will also be areas in the US that will grow due to their relatively low levels of flood risk, which serves to attract people who are looking to move away from that risk.

In some counties, a large percentage of blocks are expected to experience additional growth due to relatively lower flood risk compared to higher risk across other parts of the county. In Jefferson County, KY (Louisville), as much as 61.5% of blocks may experience increased population growth. In that county, baseline projections indicate that 84% of the county population are projected to live in those 62.5% of blocks. However, under the climate-adjusted future projections from the FSF-CMM, almost 87% of the county population is projected to reside in those blocks.

Jefferson County, KY is followed by Macomb County, MI (Detroit), where 53.9% of blocks may have higher than expected growth, increasing the population residing there from 72.8% (baseline expectations) to 85.6% (climate adjusted projections). Passaic County, NJ (Newark) and Oakland, MI (Detroit) also make the top 10 list of counties ranked by the highest percentage of blocks with higher-than-expected growth.

Other counties on the list make up the metro regions of various big cities, such as San Francisco and Sacramento, CA; Denver and Boulder, CO; and Chicago, IL. In addition to the lower levels of flood risk, the projected growth in these areas can generally be tied to economic opportunity as well.

Top 10 Counties with largest positive impact to population growth

State	County	Metro Region	Current pop	Future pop	% of blocks growing due to low climate risk	% of population in initial forecasts	% of population including climate effect
KY	Jefferson	Louisville	809,546	943,908	61.5%	84.1%	86.6%
MI	Macomb	Detroit	911,986	1,017,016	53.9%	72.8%	85.6%
NJ	Passaic	Newark	522,401	557,230	53.7%	75.9%	83.9%
MI	Oakland	Detroit	1,314,046	1,475,826	53.4%	70.7%	83.4%
CA	San Mateo	San Francisco	840,268	1,087,444	51.9%	65.7%	72.4%
CO	Denver	Denver	833,759	1,458,299	51.1%	67.9%	85.2%
CO	Arapahoe	Boulder	726,383	1,080,920	48.3%	71.2%	90.4%
CA	Sacramento	Sacramento	1,623,024	1,958,269	45.6%	60.4%	81.3%
IL	Kane	Chicago	553,354	556,819	45.3%	54.4%	65.7%
CA	Stanislaus	Modesto	569,603	664,932	44.5%	59.6%	66.0%

- Defined by the percent of blocks with higher than expected growth, due to relatively lower flood risk serving as an amenity

The emergence of future Climate Abandonment Areas will lead to more widespread economic and demographic impacts.

Decreased population is directly tied to decreases in market demand for housing, putting home values at risk.

Additionally, as the cost of moving is high, the most vulnerable are left behind in the most risky areas. Not only will the population of coastal areas be significantly older within the next few years, but they will accelerate in aging more quickly over time.

With high flood risk and people moving out of areas, the cost to governments will also be increasingly high as home buyout programs help people relocate from risky areas. This ensures that areas with unmitigated high flood risk do not continue putting people in harm's way.

With decreased populations, lower property values, and potentially a smaller labor force due to an aging population, tax revenues are also likely to decrease. This results in fewer expenditures on education, investments in infrastructure, and social welfare programs.

While many of these impacts are beginning to be felt, their magnitude will increase significantly with climate change and the associated movement of people away from increasingly risky areas. By understanding the relationship between flood exposure and population growth, and projecting those impacts into the future, communities and governments can work towards ensuring a resilient, sustainable, and equitable future.

Home Values Declines

Vulnerable Left Behind

Decreased Tax Revenue

Cost of Buyout Programs

ibrahim.almufti@arup.com

FIRST STREET FOUNDATION

RISK FACTOR™

Thank you.