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Snow Belt to Sun Belt Migration: End of an Era?*

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Abstract

Internal migration has been cited as a key channel by which societies will adapt to climate change. We show in this paper that this process has already been happening in the United States. Over the course of the past 50 years, the tendency of Americans to move from the coldest places ("Snow Belt"), which have become warmer, to the hottest places ("Sun Belt"), which have become hotter, has steadily declined. In the latest full decade, 2010-2020, both county population growth and county net migration rates were essentially uncorrelated with the historical means of either extreme heat days or extreme cold days. The decline in these correlations over the past 50 years is true across counties, across commuting zones, and across states. It holds for urban and suburban counties; for rural counties the correlations have even reversed. It holds for all educational groups, with the sharpest decline in correlations for those with four or more years of college. Among age groups, the pattern is strongest for age groups 20-29 and 60-69, suggestive of climate being an especially important factor for those in life stages involving long-term location choices. Given climate change projections for coming decades of increasing extreme heat in the hottest U.S. counties and decreasing extreme cold in the coldest counties, our findings suggest the "pivoting" in the U.S. climate-migration correlation over the past 50 years is likely to continue, leading to a reversal of the 20th century Snow Belt to Sun Belt migration pattern.

*We thank Cindy Zhao for excellent research assistance. The views expressed in this paper are solely those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of San Francisco or the Board of Governors of the Federal Reserve System.

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1 Introduction

The risks and impacts associated with climate change in the United States and elsewhere will depend on adaptation and mitigation ([1]). One important adaptation channel is internal migration ([2], [3], [4]), as people move away from places with worsening climates toward relatively better ones.

Yet, American migration over the 20th century strongly favored hotter climates, with the U.S. population shifting from the Snow Belt of the Northeast and Midwest to the Sun Belt of the South and Southwest.[1] This pattern accelerated considerably after the 1960s, likely due to the widespread adoption of air conditioning (AC) in the 1960s and 1970s.[2] Over the same period, the climates of these regions have also gradually changed, with extreme cold in the historically colder areas of the country becoming less common and extreme heat in the historically hotter areas increasing in frequency and severity (see Figure 1).

In this paper, we take a deeper look at the relationship between internal migration and climate in the United States and how it has changed over time. Using detailed county-level temperature data from the National Oceanic and Atmospheric Administration (NOAA), we document that, over the past several decades, the positive relationship across counties between net migration and historical exposure to extreme heat highlighted in the literature (e.g., [6], [7]) has steadily weakened and, by some measures, has vanished or even reversed. We also document the opposite pattern occurring for the negative relationship between net migration and historical exposure to extreme cold. The weakening Snow Belt to Sun Belt migration pattern is broad and holds across counties, commuting zones, and states, as well as for both rural and urban areas. In some cases, the direction of migration has even reversed. For instance, among rural counties, hotter places actually lost population over the latest decade of data relative to colder places.

To our knowledge, this study is the first to document these shifting patterns. An important aspect of the analysis is its simplicity, relying on raw data and simple bivariate ordinary least squares regressions, ensuring that the results are not driven by methodological choices.[3] Given climate change projections of increasing heat in hotter counties and less extreme cold in colder counties ([8],[10],[11],[12],[13]), the emerging patterns documented in this paper are likely to continue, reversing the Snow Belt to Sun Belt migration pattern of the previous century. These new migration trends should help mitigate the effects of climate change, as fewer people would be directly exposed to the negative impacts of hotter and more frequent extreme heat days.

[1] See https://www.census.gov/dataviz/visualizations/050/.

[2] See [5] for evidence on the adoption of air conditioning and its effect of reducing heat-related mortality since 1960.

[3] See [8] for a comprehensive cross-sectional empirical analysis to trace out the short- and long-run impacts of climate change on counties' population growth, employment, wages, and house prices. See also [9].

2 Data

We used county-level data on average daily temperatures from January 1, 1951, to December 31, 2020, from the National Oceanic and Atmospheric Administration's (NOAA) nClimDiv data set ([14]). From these daily data, we measured the number of extreme heat and extreme cold days in each county for each year from 1951 to 2020. We defined an extreme-heat day as one for which the average 24-hour temperature was above 80 degrees Fahrenheit, while an extreme-cold day was defined as one with an average 24-hour temperature below 20 degrees Fahrenheit. Given our focus on internal migration, we exclude counties in Alaska and Hawaii, focusing on the contiguous 48 states.

County-level population and net migration data were obtained from multiple sources. Though we provide some results for decades back to 1900, we focus on the period 1970 to 2020 due to the availability for this period of both net migration data and population counts disaggregated by age and education. Population by age were obtained from the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program.[4] Population by education data came from the U.S. Census Bureau. Net migration data for 1980 to 2020 came from the Census Bureau's "Components of Change" data; net migration data from 1970 to 1980 were obtained from the University of Michigan's Inter-university Consortium for Political and Social Research (ICPSR). To distinguish between urban, suburban, and rural counties, we use the 2013 urbanicity classification from the National Center for Health Statistics (NCHS). For the purposes of aggregating county data to commuting zones (CZs), we use the 2000 CZ classifications from the U.S. Department of Agriculture.[5] Lastly, to compare the population results for 1970 to 2020 to earlier decades, we use county-level population data for decades from 1900 through 1970 from the National Bureau of Economic Research (NBER).[6]

3 Results

3.1 The Warming of Historically Hot and Historically Cold Counties

To start the analysis, Figure 1 documents that, while most counties in the contiguous United States have seen an increase in the number of extreme heat days (panel (a)), the increase has tended to be larger for historically hotter counties – those with a higher average number of extreme heat days per year over 1951 to 2020. Similarly, while the vast majority of counties have experienced a decline in the frequency of extreme cold days over the past 70 years, the decline has been greatest in those counties most historically accustomed to extreme cold. These relationships are highly statistically significant as indicated by the large t-statistics associated with the estimated slopes of

[4]`https://seer.cancer.gov/popdata/download.html`

[5]`https://www.ers.usda.gov/webdocs/DataFiles/48457/cz00_eqv_v1.xls?v=8473.6`.

[6]`https://www.nber.org/research/data/census-us-decennial-county-population-data-1900-1990`.

a linear regression of the 1951-2020 change in the number of annual extreme heat (cold) days on the 1951-2020 mean number of annual extreme heat (cold) days. These patterns are in line with the general warming patterns documented in the U.S. Global Change Research Program ([15],[13]).

3.2 Changing Patterns of County Population Growth

In the not-so-distant past, Americans generally moved toward warmer climates. Panels (a) and (b) in Figure 2 highlight that, during the 1970s, hotter counties, measured by average annual extreme heat days over 1951-2020, tended to experience faster population growth than other counties, while colder counties tended to see slower or even negative population growth. A simple ordinary least squares (OLS) regression of decadal population growth from 1970 to 1980 on the historical (1951-2020) mean number of extreme heat days per year yields a positive slope coefficient that is statistically significant below the 1 percent significance level (t-statistic of 7.17). In contrast, the slope coefficient estimate obtained by regressing counties' 1970s population growth on their average number of extreme cold days is strongly negative. These patterns reflect the general and well-known 20th century pattern of population reallocation from the Snow Belt to the Sun Belt.

Yet, as shown in panels (c)-(j), these relationships moderated substantially over the subsequent four decades.[7] To see this moderation more clearly, panel (a) of Figure 3 reports the extreme heat and extreme cold slope coefficient estimates from Figure 2, along with their 95 percent confidence intervals, for each decade from 1970-1980 to 2010-2020. The chart shows a clear downward trend in the slope coefficients for extreme heat days and a rising trend in those for extreme cold days. By the 2010s, county population growth was largely uncorrelated with the number of extreme heat days or extreme cold days, a significant change from 50 years prior.

Importantly, these trends are nearly identical using county net migration rates instead of population growth as the dependent variable, as documented in panels (a) and (b) of Figure 4, demonstrating that the patterns we find for population growth are driven nearly entirely by net migration rather than births and deaths.[8] There is a similar, though somewhat more muted, decline in the relationships between extreme temperature days and either population growth or net migration when weighting each county observation by its beginning-of-decade population, as shown in panels (c) and (d) of Figure 4.

To examine how robust the pattern in Figure 2 and panel (a) of Figure 3 are to the size of the geographical area, we report estimates for these relationships after aggregating the data to either commuting zones or states. Specifically, we regress CZ- or state-level population growth on the number of extreme heat days per year over 1951-2020 averaged over all counties within that CZ or state. We estimate the analogous regression for extreme cold days. The weakening relationship

[7] In Extended Data Figure 1, we present a geographical representation of county-level population growth since the 1970s by decade.

[8] The literature on fertility and mortality effects of extreme temperatures suggests the effects on these margins are much more short-run than the effects on migration. See [16], [17], and [5].

between population growth and extreme temperature days over the decades from the 1970s to 2010s across counties is also true across CZs and across states (panels (c) and (e) of Figure 3).

In addition, we explore the relationships by level of county urbanization. While our results are comparable for urban and suburban counties to those across all counties, the trends are more pronounced for rural ones (panels (b), (d), and (f) of Figure 3). In fact, over the last full decade, rural counties historically most exposed to extreme heat days saw significantly lower population growth than historically cooler counties, while rural counties historically most exposed to extreme cold days have seen their populations grow faster on average than historically less exposed counties.[9]

3.3 Heterogeneity Across Household Characteristics

It is also useful to investigate these climate-population growth patterns for population subgroups, given data availability. We focus on education and age. Figure 5 reports the decadal relationships between extreme temperature and population growth separately by educational attainment: less than a high school degree, high school degree or equivalent, some college, and four-year college degree or more.

The general patterns of a downward trend over time in the estimated slope coefficient on extreme heat and an upward trend in the estimated slope coefficient on extreme cold holds for the lower three educational groups, similar to the pattern for overall county population in panel (a) of Figure 3. For those with a four-year college degree or more, these trends hold from the 1980s onward, but not from the 1970s to the 1980s. Interestingly, for the highest education group, the correlation (as measured by the slope coefficient) between population growth and historical extreme heat exposure turned negative, though statistically insignificantly different from zero, in the 1990s and 2000s, and became negative and statistically significant (at the 5 percent level) during the latest full decade. As such, this recent negative relationship for those with college degrees may foreshadow similar ones for other, less educated, residents if the declining pattern for these groups continues.

In addition to a breakdown by education, we also examine whether age is a factor impacting the link between extreme temperature and population growth. Age groups differ substantially by their mobility rates, with people between 20 and 40 years old being typically the most mobile. While the relationships between extreme temperature and population growth is more volatile for many age groups given the smaller sample sizes, Extended Data Figure 4 shows a clearer moderating pattern for these more mobile residents, particularly since the 1980s and 1990s. There has also been a pronounced shift in the climate-population growth patterns for individuals in their 60s, the group around traditional retirement age, which is a natural point in the life cycle for making long-term relocation decisions. For this group, the relationship between population growth and historical extreme heat exposure turned negative and statistically significant in the 2000-2010 decade and became even more strongly negative in the 2010-2020 decade. Conversely, the relationship with

[9] Extended Data Figure 2 contrasts the results by urbanicity when weighting observations by population or not and shows that weighting yields qualitatively similar results.

historical extreme cold days flipped to strongly positive and significant during the latest decade. These results indicate that individuals around retirement age have been moving on average away from relatively hotter counties toward relatively cooler counties over past 10 to 20 years.

3.4 Full 20th Century Patterns

Since county population data are available for a longer period, we contrast the recent trends between population growth and extreme temperature to the period between the 1930s and the 1970s. We continue to classify counties based on their average number of extreme heat days and extreme cold days per year between 1951 and 2020, since daily county weather data are not available prior to 1951. Thus, we are assuming that the relative positions of counties in terms of extreme heat days and extreme cold days was similar back at least to the 1930s.

The two panels in Figure 6 report coefficient estimates of the cross-country relationship between population growth and extreme temperatures when observations are either equally weighted or weighted by beginning-of-decade county population. In either case, we find that the recent decline in the sensitivity of population growth to extreme heat returns this sensitivity to levels more in line with those experienced before the 1970s. This aligns well with the diffusion of residential AC across the South ([5]). For instance, in the Southeast, only about 10 percent of households had AC in 1960, but this jumped to 71 percent by 1980. Similar patterns occurred in other southern areas. In part, AC raised the quality of life in the South by making it less dangerous and less unpleasant to live and work in counties more exposed to extreme heat. Barreca, et al. ([5]) find that the diffusion of AC over time largely accounts for the steep decline in extreme-heat induced mortality after 1960. Nevertheless, our results indicate that, despite the availability of AC, the mobility-heat relationship has by now abated to levels similar to the pre-AC period.

4 Discussion

Our findings have important implications for the impact of climate change on the geography of population and economic activity in the United States over the decades to come. While there is growing evidence of climate-induced internal and international migration for middle-income and developing countries, where agriculture plays a large role ([18]), our results indicate that internal climate migration is also occurring in the United States, an advanced economy with little economic reliance on agriculture. The U.S. population is starting to migrate away from areas increasingly exposed to extreme heat days toward historically colder areas, which are becoming more attractive as extreme cold days become increasingly rare.[10] Indeed, to the extent that projections of relatively hotter areas of the country experiencing increasingly frequent and severe extreme heat days, and

[10]See evidence from [19], based on hedonic house price regressions, that Americans have high willingness-to-pay to avoid both extreme heat and extreme cold.

historically cold areas experiencing fewer and less severe extreme cold days (e.g., [10] and [11]) are realized, our results suggest the pivoting in these correlations is likely to continue, with U.S. migration reversing the Snow Belt to Sun Belt pattern of the past half-century. Though migration is not without financial and welfare costs, this migration could help mitigate the negative effects from hotter and more frequent extreme heat days, including from associated risks such as wildfires and droughts, with fewer people directly exposed to them.

Our results also have important distributional implications. As highlighted by Carleton and Hsiang ([2]), climate change generates two offsetting effects with distributional consequences for migration. On the one hand, the decline in the attractiveness and economic viability of a local area incentivizes migration. However, since it also reduces income for many groups ([20],[21]), climate change impedes the ability to migrate, particularly for those already lacking a financial buffer to help cover migration costs. Such dependence on financial resources aligns with our finding that the declining positive correlation of county population growth with extreme heat (and declining negative correlation with extreme cold) has been sharper for individuals with higher educational attainment, who tend to have higher income, than for those with lower levels of education. In particular, between 2010 and 2020, hotter counties have tended to see their population of highly educated residents, those with a four-year college degree or more, decline (Figure 5, panel (d)). As a result, climate change may have a more adverse impact on less-educated residents, who are less mobile and thus more likely to remain in hotter counties. In addition, our results that the changing patterns between population growth and historically colder and hotter counties are most evident for younger individuals and those around retirement age suggests migration responses to climate changes have been and will be driven most by individuals at stages of life in which long-term relocation decisions are common.

Overall, the welfare consequences of climate change in the United States will depend on how the geography of the population distribution overlaps with the geography of local climate changes and the extent to which people move in response to those climate changes. Given climate change projections of increasing heat in hotter counties and less extreme cold in colder counties, the emerging patterns documented in this paper should continue. As such, the previous century's migration pattern from the Snow Belt to the Sun Belt is likely to ultimately be reversed. This should help mitigate the effects of climate change, as a smaller fraction of the U.S. population would be directly exposed to the impact of hotter and more frequent extreme heat days.

Many factors, including government policy, may facilitate or impede the relocation away from adversely affected areas. For instance, to the extent that local extreme heat is associated with damaging events such as wildfires, market signals from higher premiums to insure commercial and residential real estate in riskier areas provide some incentives to relocate ([22]). However, government subsidies in the insurance market, which are becoming more common across states, may mute these signals. Government subsidies for development and rebuilding in disaster-stricken areas can also reduce market-based migration incentives.[11]. In addition, the uncertainty and imperfect information about how different regions are impacted by climate change may increase inertia and reduce migration.

Finally, adaptation may also take other forms, for instance through investment in more climate resilient infrastructure, that may also mute migration toward colder areas. Thus, the historical trends documented in this paper are by no means structural and could change with private actions or government policies.

[11]See [23] for a discussion of climate-related government relocation policies

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Additional Information

Authors report no competing interests.

Authors contributed equally to the paper.

Supplementary information is available for this paper: Extended Data Figures S1-S4.

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Figures

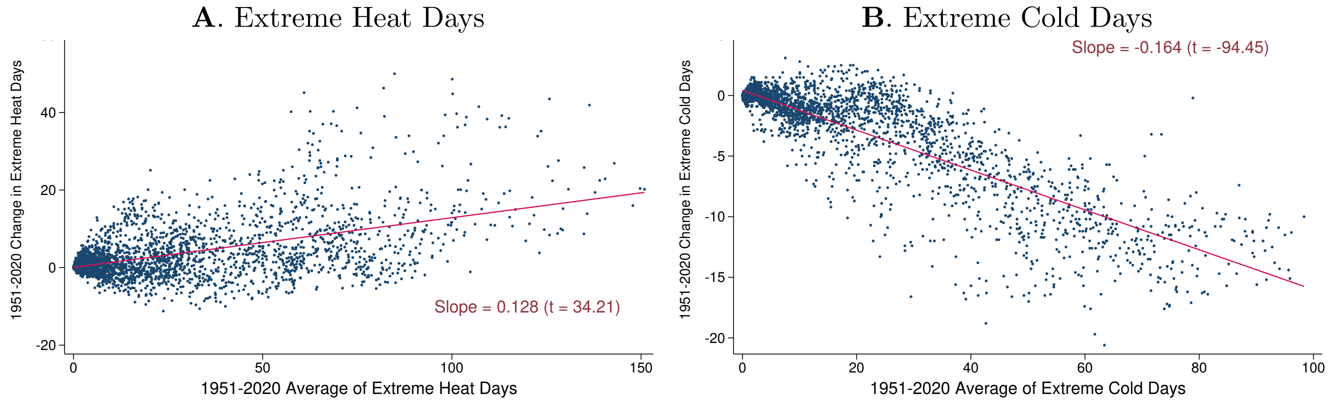

Figure 1: **Cross-County Relationship between Mean and Change in Extreme Temperature Days, 1951 to 2020**

Each panel displays a scatter plot, where each dot represents a single county. The lines in each panel are linear OLS regression fit lines, where counties are equally weighted. The estimated slope coefficients and their t-statistics are displayed. (**A**) The x-axis shows the average number of extreme heat days per year in the county over 1951 to 2020. The y-axis shows the change in the number of extreme heat days per year over 1951 to 2020, where the change is measured as the 2011-2020 mean minus the 1951-1960 mean. Extreme heat days are defined as days for which the average 24-hour temperature is above 80° Fahrenheit. (**B**) The x-axis shows the average number of extreme cold days per year in the county over 1951 to 2020. The y-axis shows the change in the number of extreme cold days per year over 1951 to 2020, where the change is measured as the 2011-2020 mean minus the 1951-1960 mean. Extreme cold days are defined as days for which the average 24-hour temperature is below 20° Fahrenheit.

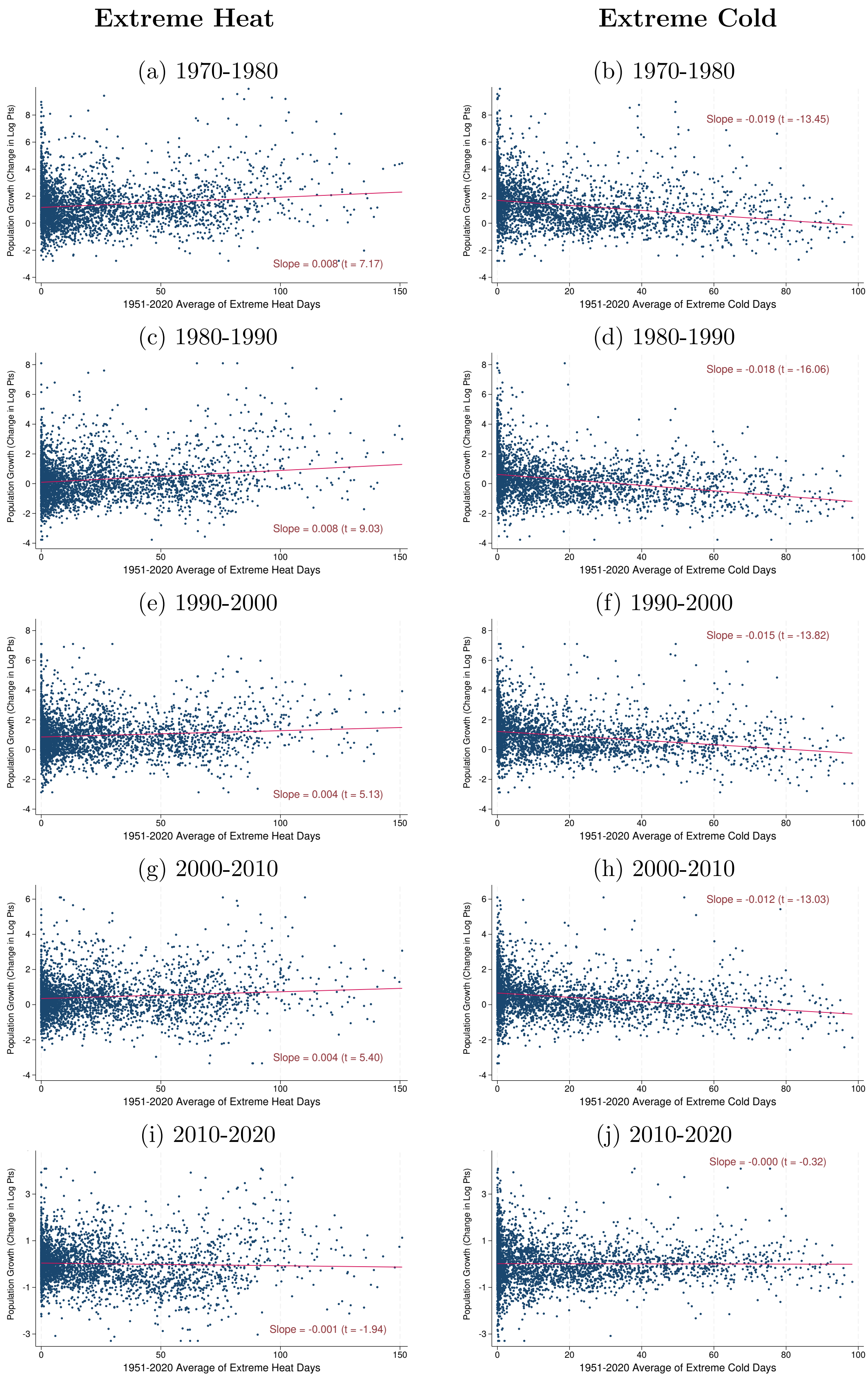

Figure 2: **Cross-County Relationship between Population Growth and Extreme Temperatures**

Each panel displays a scatter plot, where each dot represents a single county. The y-axis shows the county's population growth (measured by change in log points) over a given decade: (a-b) 1970-1980, (c-d) 1980-1990, (e-f) 1990-2000, (g-h) 2000-2010, (i-j) 2010-2020. The lines in each panel are linear OLS regression fit lines, where counties are equally weighted. The estimated slope coefficients and their t-statistics are displayed. The x-axis in (a,c,e,g,i) shows the average number of extreme heat days per year in the county over 1951 to 2020. Extreme heat days are defined as days for which the average 24-hour temperature is above 80° Fahrenheit. The x-axis in (b,d,f,h,j) shows the average number of extreme cold days per year in the county over 1951 to 2020. Extreme cold days are defined as days for which the average 24-hour temperature is below 20° Fahrenheit.

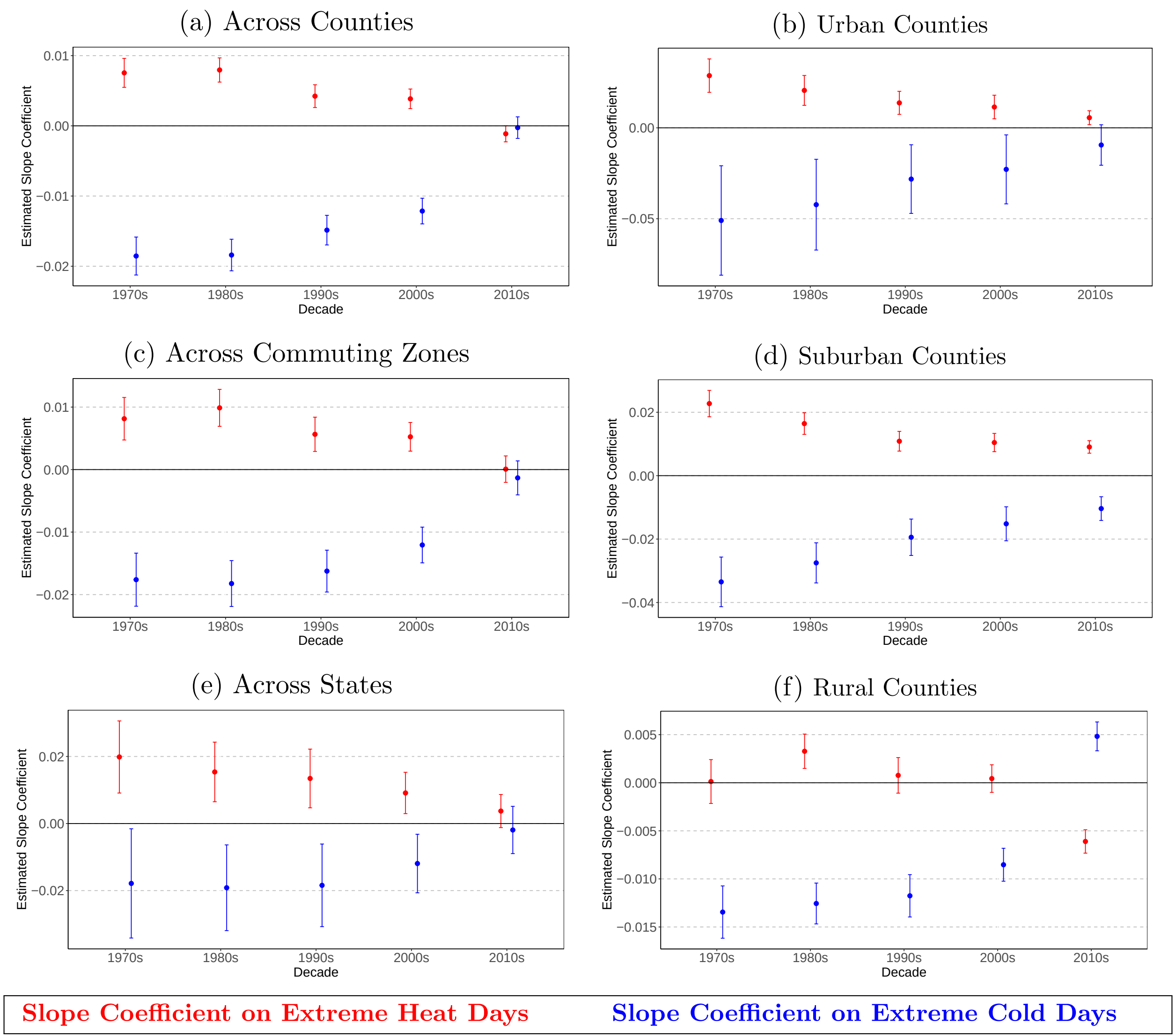

Figure 3: **Cross-Geographic Relationship between Population Growth and Extreme Temperatures, by Decade**

Each panel plots, on the y-axis, the estimated slope coefficients and 95 percent confidence intervals from separate cross-geographical regressions of decadal population growth on either the average number of extreme heat days (red) or extreme cold days (blue) per year over 1951-2020. The x-axis indicates the decade of population growth used in the regression. Geographic units are equally weighted in the regressions. (a) Sample is all counties in the contiguous U.S. (b) Sample is urban counties. (c) Sample is all commuting zones in the contiguous U.S. (d) Sample is surburban counties. (e) Sample is all states in the contiguous U.S. (f) Sample is rural counties.

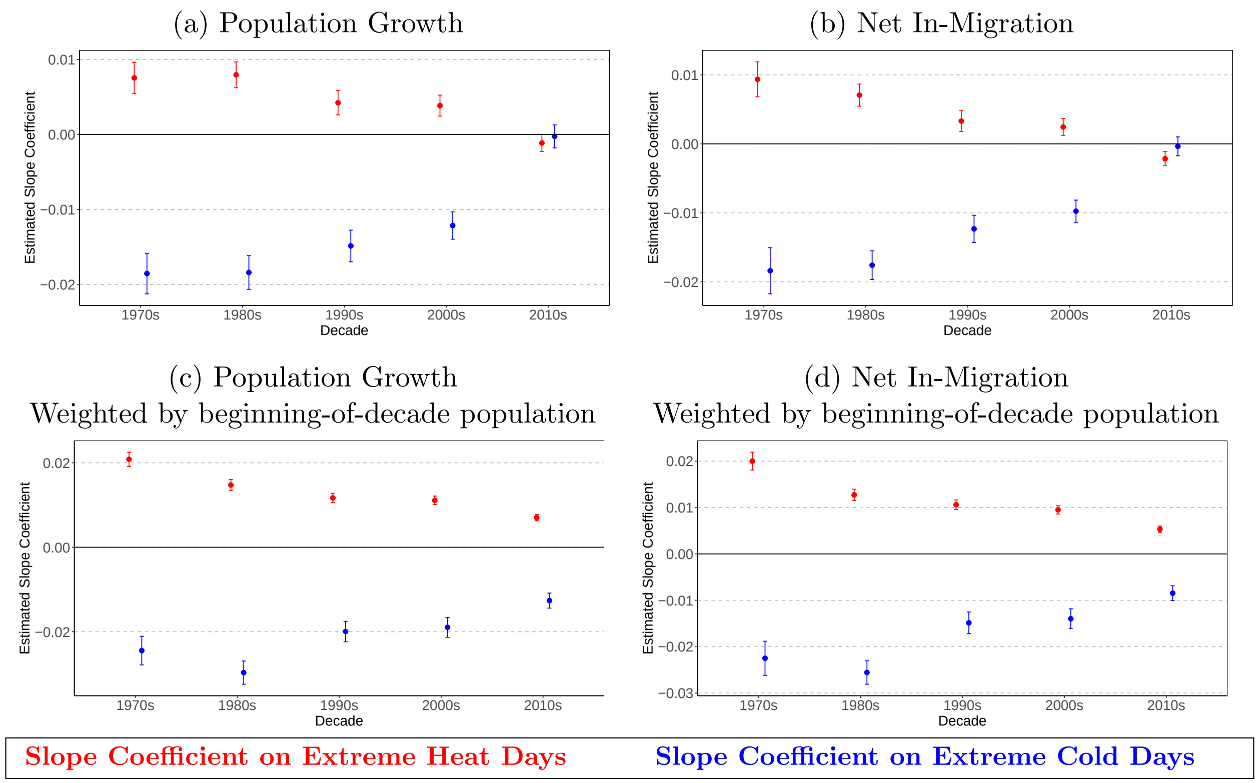

Figure 4: **Cross-County Relationship between Population Growth and Extreme Temperatures, by Decade**

Each panel plots, on the y-axis, the estimated slope coefficients and 95 percent confidence intervals from separate cross-county regressions of either decadal population growth or decadal net in-migration on either the average number of extreme heat days (red) or extreme cold days (blue) per year over 1951-2020. The x-axis indicates the decade of population growth or net in-migration used in the regression. (a) Dependent variable is decadal population growth and counties are equally weighted. (b) Dependent variable is net in-migration and counties are equally weighted. (c) Dependent variable is decadal population growth and counties are weighted by their beginning-of-decade population. (d) Dependent variable is decadal net in-migration and counties are weighted by their beginning-of-decade population.

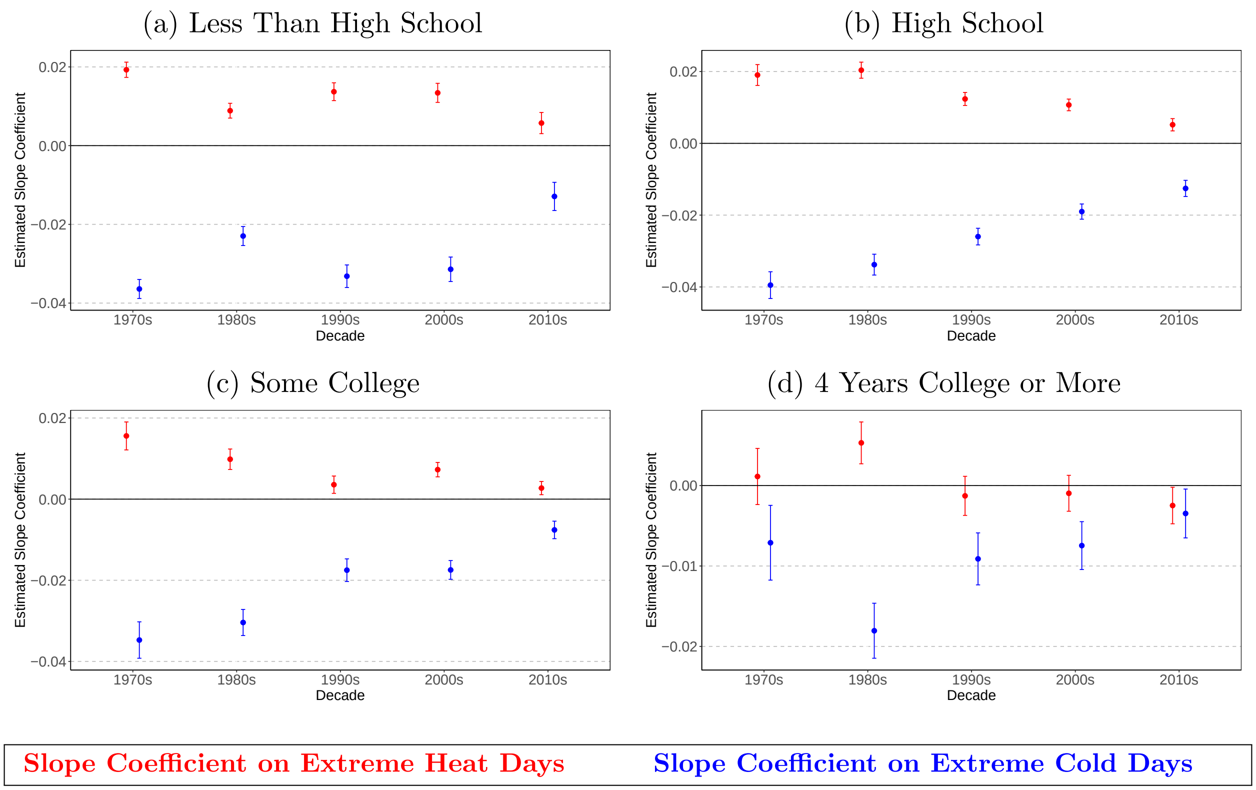

Figure 5: **Cross-County Relationship between Population Growth and Extreme Temperatures, by Decade**

Each panel plots, on the y-axis, the estimated slope coefficients and 95 percent confidence intervals from separate cross-county regressions of decadal population growth for selected educational groups on either the average number of extreme heat days (red) or extreme cold days (blue) per year over 1951-2020. The x-axis indicates the decade of population growth used in the regression. Counties are equally weighted in the regressions. In the panels, population growth is for persons with (a) less than high school education, (b) high school education, some college education, and (d) four years of college or more education.

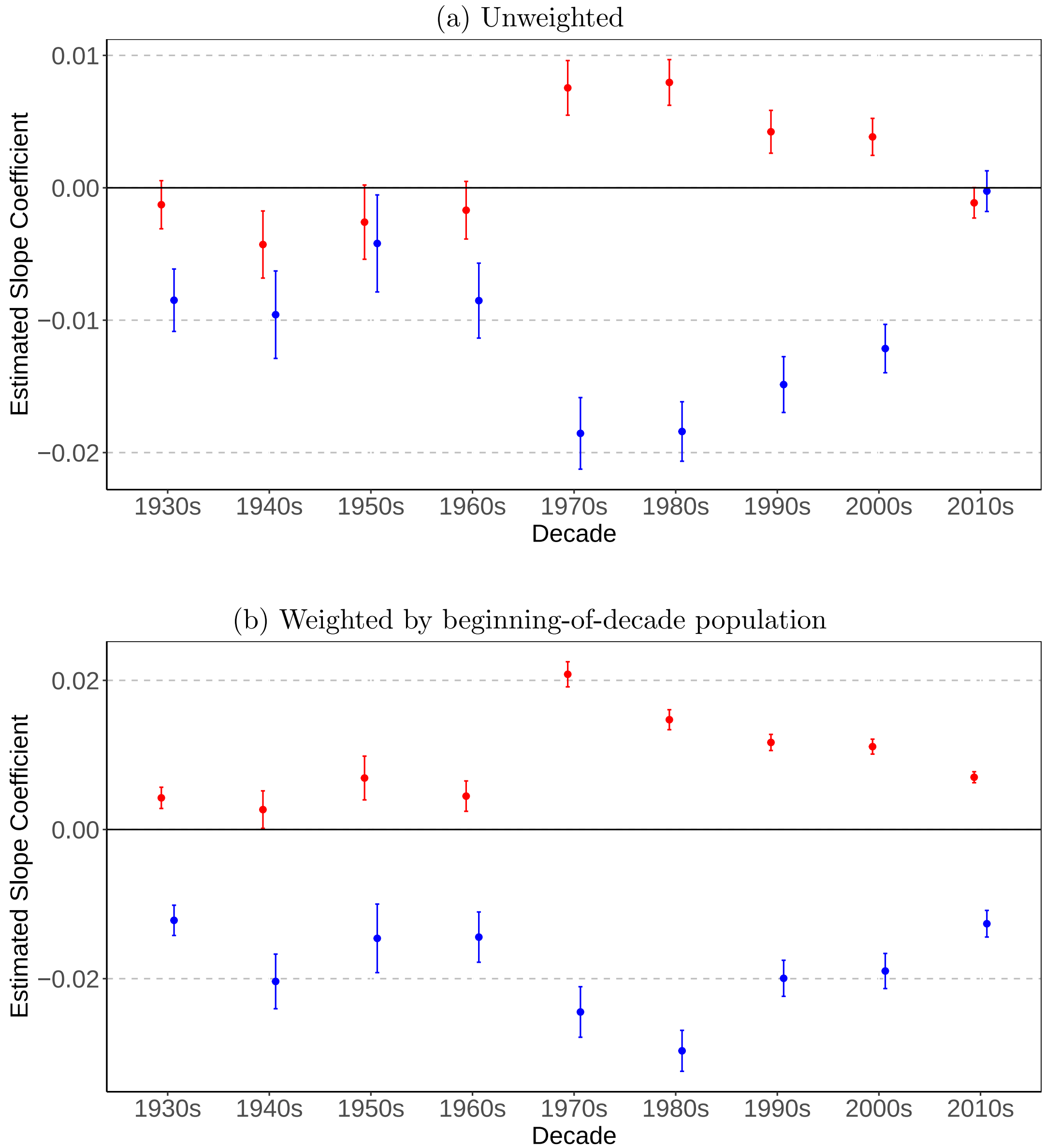

Figure 6: **Cross-County Relationship between Population Growth and Extreme Temperatures, by Decade Back to 1930**

Each panel plots, on the y-axis, the estimated slope coefficients and 95 percent confidence intervals from separate cross-county regressions of decadal population growth on either the average number of extreme heat days (red) or extreme cold days (blue) per year over 1951-2020. The x-axis indicates the decade of population growth used in the regression. (a) Counties are equally weighted in the regressions. (b) Counties are weighted by their beginning-of-decade population.

Extended Data Figures
for "Snow Belt to Sun Belt Migration: End of an Era?"
by Sylvain Leduc and Daniel Wilson

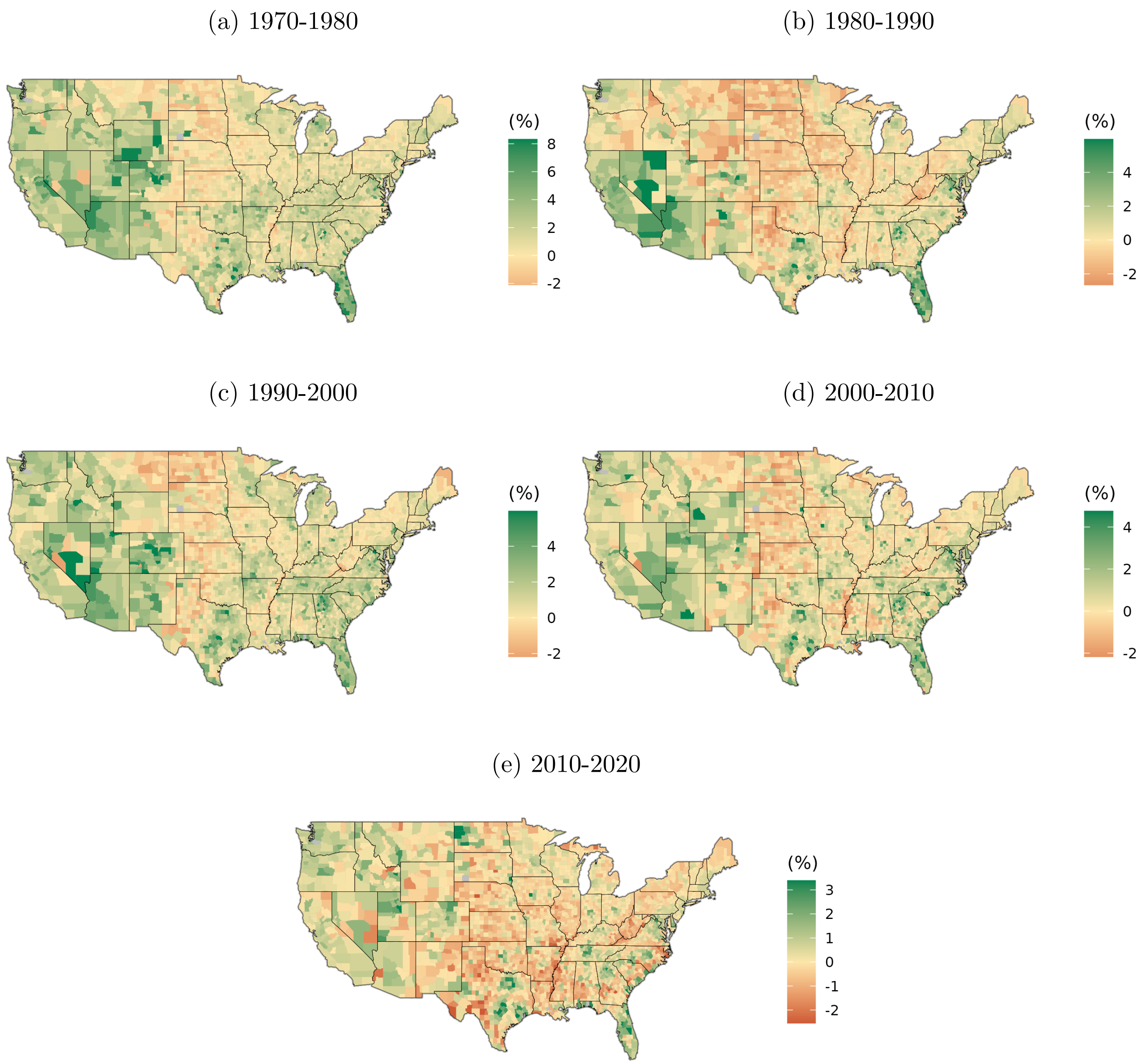

Figure 1: **Decadal Population Growth by County**

Each panel shows a map indicating each county's population growth over the indicated decade: (a) 1970-1980 (b) 1980-1990, (c) 1990-2000, (d) 2000-2010, and (e) 2010-2020. To ease visualization, population growth is winsorized at the 0.5th and 99.5th percentiles separately for each decade.

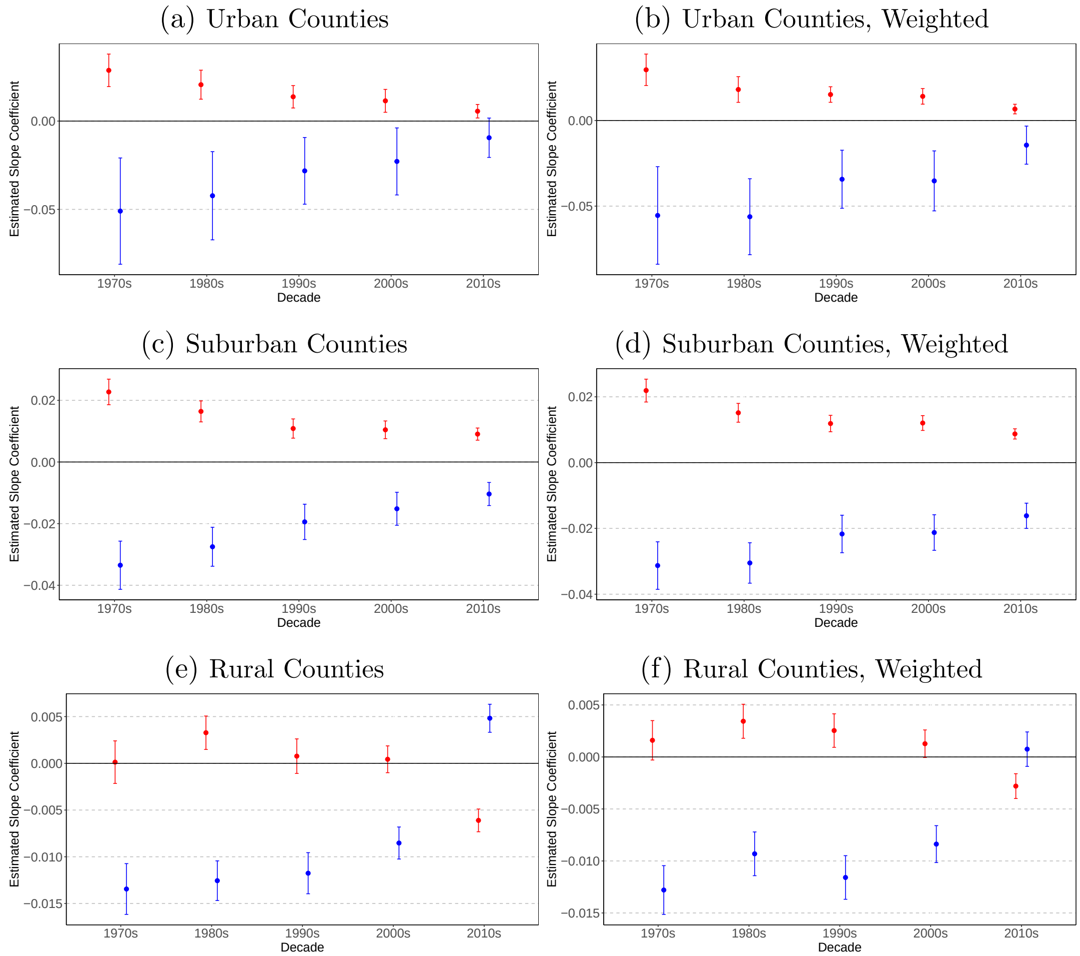

Figure 2: **Cross-County Relationship between Population Growth and Extreme Temperatures, by Decade, Unweighted vs. Weighted**

Each panel plots, on the y-axis, the estimated slope coefficients and 95 percent confidence intervals from separate cross-county regressions of decadal population growth on either the average number of extreme heat days (red) or extreme cold days (blue) per year over 1951-2020. The x-axis indicates the decade of population growth used in the regression. Counties are equally weighted in the regressions for panels (a,c,e). Counties are weighted by beginning-of-decade population in panels (b,d,f). (a-b) Sample is all urban counties in the contiguous U.S (c-d) Sample is suburban counties. (e-f) Sample is rural counties.

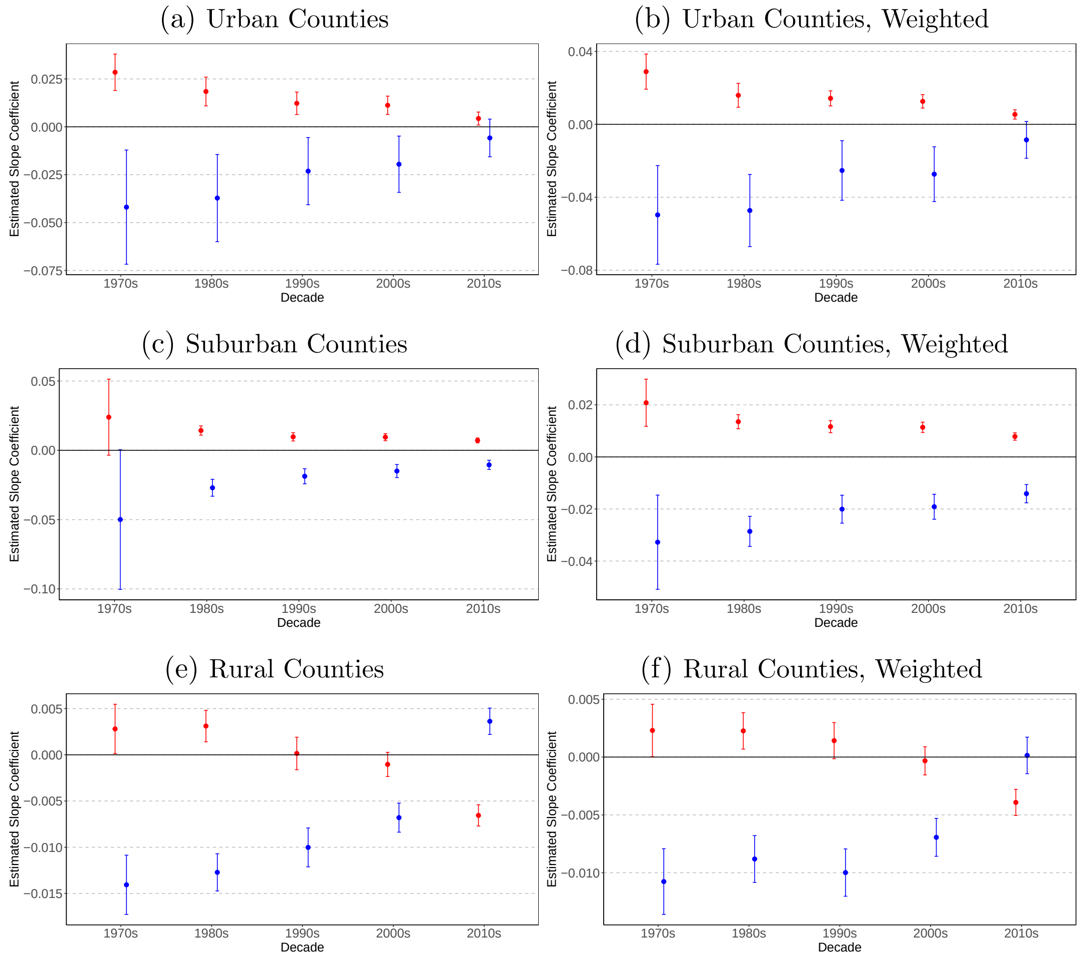

Figure 3: **Cross-County Relationship between Net In-Migration and Extreme Temperatures, by Decade, Unweighted vs. Weighted**

Each panel plots, on the y-axis, the estimated slope coefficients and 95 percent confidence intervals from separate cross-county regressions of decadal net migration rates on either the average number of extreme heat days (red) or extreme cold days (blue) per year over 1951-2020. The x-axis indicates the decade of net migration rates used in the regression. Counties are equally weighted in the regressions for panels (a,c,e). Counties are weighted by beginning-of-decade population in panels (b,d,f). (a-b) Sample is all urban counties in the contiguous U.S (c-d) Sample is suburban counties. (e-f) Sample is rural counties.

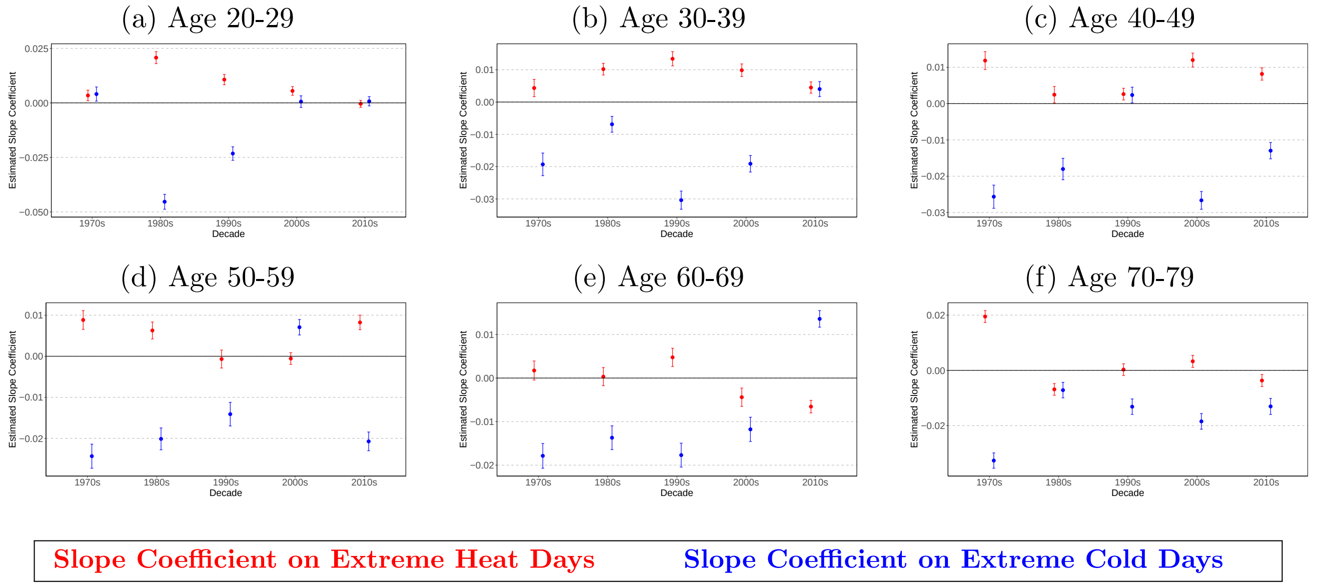

Figure 4: **Cross-County Relationship between Population Growth and Extreme Temperatures, by Decade, for Selected Age Groups**

Each panel plots, on the y-axis, the estimated slope coefficients and 95 percent confidence intervals from separate cross-county regressions of decadal population growth for selected age groups on either the average number of extreme heat days (red) or extreme cold days (blue) per year over 1951-2020. The x-axis indicates the decade of population growth used in the regression. Counties are equally weighted in the regressions. Population growth is for age groups (a) 20-29, (b) 30-39, (b) 40-49, (d) 50-59, (e) 60-69, and (f) 70-79 years old.