Migrant Selection and Sorting during the Great American Drought

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America's worst drought induced mass environmental migration during the 1930s. This paper studies heterogeneity in the migration response to the drought by relating migration decisions recorded in the 1940 census to county drought conditions. Drought increased migration primarily for individuals with a 12th grade education or higher because this segment of the population was less often financially constrained. In terms of destinations, drought migrants were *less* likely to relocate to cities compared to similar non-drought migrants. These findings document the importance of human capital for individual-level adaptation and challenge the perception that rural-to-urban is the dominant environmental-migrant channel.

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I. Introduction

Droughts—climatic events defined by lack of moisture and excess heat—are destructive for people and property, and may lead to migration from the affected area.¹ But migration is costly, complicated, and risky. Not everyone who wants to move has the resources to move and not all moves successfully improve circumstances. Individual characteristics such as human capital and wealth are key because these variables relate to people’s ability to move and returns to migration.²

Environmental-migration decisions are further complicated as shocks heterogeneously impact people based on economic circumstances. Shocks may induce more or less migration in aggregate depending on the average wealth of the impacted area.³ But we know less about who actually moves or where these migrants go (Gray and Mueller 2012; Sedova and Kalkuhl 2020; Hornbeck 2020). I expand on previous research by estimating the impact of drought on individual migration propensities and destination choices by education.

The worst drought in U.S. history stretched from 1930 to 1939 (Seager et al. 2008; Cook et al. 2010). One area, the Dust Bowl, became central to both popular culture and scholarship on the 1930s. The Dust Bowl (categorized by dust storms, wind erosion, and drought) was undeniably important, but was only a fraction of the drought-affected region as shown in Figure 1.⁴ Despite the magnitude of the broader drought, little is known about its economic influence. My research distinguishes itself by examining the migration implications for the totality of 1930s drought.

Specifically, I study individual-level migration for 65 million adults in the U.S. during the late 1930s with respect to drought and education. Prior climate-migration research (both in the 1930s and

¹Droughts influence standard of living, morbidity, and mortality by increasing crop failures and reducing agricultural output (Deschênes and Greenstone 2007; Libecap and Steckel 2011; Hornbeck and Keskin 2014; Bleakley and Hong 2017). Abnormally high temperatures, closely related to droughts, have large economic and health effects outside of their impact on the agricultural sector (Barnett and Adger 2007; Jacob, Lefgren, and Moretti 2007; Deschênes and Moretti 2009; Hsiang 2010; Dell, Jones, Olken 2012; Barreca et al. 2016).

² See Sjaastad (1962) and Borjas (1987). I focus on people’s ability to move in this paper and I study returns to migration in Sichko (2021a).

³ See Beine and Parsons (2014); Kleemans (2015); Mastroiello et al. (2016); Cattaneo and Peri (2016); Bazzi (2017); Beine and Parsons (2017); Gröschl and Steinwachs (2017); and Benonnier, Millock, and Taraz (2019).

⁴ Moreover, the Dust Bowl was a unique phenomenon to a subset of the 1930s U.S. and was partially endogenous to farming practices (Hansen and Libecap 2004). Droughts, by contrast, are among the most ubiquitous and damaging climate shocks.

beyond) focuses on migration either at a more aggregate level (county, state, or country) or at the individual-level but for some subset of the population (men or rural individuals, for example). The ability to study complete and individual-level migration in the wake of such a large climate shock is unique.

I match full-count U.S. census data with county-level drought data to document who moved and study destination characteristics. The 1940 census includes individuals' locations in 1935 and 1940, and extensive demographic variables (education, occupation, age, race, etc.) (Minnesota Population Center 2017; Ruggles et al. 2019). To study the impact of drought, I created a dataset of yearly county-level drought conditions by geospatially linking the Living Blended Drought Atlas (LBDA) with the 1930 U.S. county map (Cook et al. 2010; Manson et al. 2019).⁵ This new dataset enables the examination of migration from drought at the individual-level for the whole country.

I find that exposure to additional drought years led to more migration (where migrants are defined as anyone living in a different county in 1940 compared to 1935). However, increased migration was driven by higher migration rates among relatively well-educated individuals. High school educated people (roughly the top one-fourth of the education distribution) were 6.1 percentage points more likely to leave counties with three or more drought years, compared to a baseline migration rate of 16 percent for this education category. This increased propensity to migrate among highly educated people was present for women and men, and from rural and city origins. Drought was associated with a smaller increase in migration for individuals with an 8th to an 11th grade education, and no additional migration for individuals with less than an 8th grade education—43 percent of the adult population.

My results show that drought led to intermediate and positive selection into migration. Highly educated people moved from drought, whereas people with less education disproportionately stayed. In this way, drought-induced migration was a story of unequal opportunity in which individuals with less human capital persisted and faced the negative implications of drought. My findings expand on previous climate-migrant research, which primarily studies selection based on the average wealth of geographic areas. This

⁵ I also match county-level covariates, including variables measuring the intensity of the Great Depression, the New Deal spending response, and soil erosion (Fishback, Horrace, and Kantor 2005; Hornbeck 2012).

higher-level perspective introduces ambiguity: whether migration responsiveness is driven by local amenities or movement among affluent individuals in particular. My results clarify this ambiguity by showing that affluent people moved more when facing drought whereas less affluent people did not.

The typical explanation for why climate migration occurs from relatively wealthy communities is that migration is costly (Chiquar and Hanson 2005; Angelucci 2015; Cattaneo and Peri 2016; Bazzi 2017; Benonnier, Millock, and Taraz 2019). This explanation is consistent with qualitative evidence of individual migration choices during the 1930s. In a survey of persisters, the most common response to the question “Why did you stay?” was a lack of the resources to pay for migration. As one respondent stated, “We didn’t have money to go anywhere so we just existed” (Riney-Kehrberg 1994). Furthermore, I document that Great Depression severity, which made credit and cash harder to come by, further amplified positive selection into migration from drought.

In terms of where migrants went, previous environmental-migration research emphasizes rural-to-urban migration (Cohen 2016; Cattaneo and Peri 2016; Peri and Sasahara 2019). But taking the complete migration history of the 1930s, I find that migrants from drought counties were *more* likely to relocate to rural destinations (compared to observationally similar migrants from non-drought counties in the same state and controlling for the distance to the nearest city).⁶ Considering this result, focusing on rural-to-urban migration from climate shocks may obscure the experience and outcomes of typical migrants, as during the 1930s.

Analyzing the influence of America’s worst drought at the individual-level enables the study of climate-migrant selection and sorting on an outstanding geographic and population scale. This paper builds a more comprehensive view of how an environmental catastrophe influenced migration and, thereby, altered the labor distribution of the United States. These details, concerning mass migration resulting from drought, are among the most salient data we have to anticipate the repercussions of current and future shocks.

⁶ Cities are defined as urban areas with more than 20 thousand residents in 1940. This follows the Integrated Public Use Microdata Series (IPUMS) definition of *cities* and are different than the IPUMS definition of *urban* which include smaller urban areas of 2,500 residents or more.

II. Environmental degradation and migration during the 1930s

Local climate conditions are central to geographic settlement patterns, development, and migration. In the U.S., the aridity and climatic volatility of the Great Plains led to an initial reluctance of European-Americans to settle the region (Webb 1959). This reluctance gave way to opportunism and speculation in the late 19th and early 20th century, which coincided with a wet period on the Plains and population growth for the U.S. as a whole (Libecap and Hansen 2002). Economic expansion on the Plains faltered beginning in the 1920s, given declining crop prices after World War I, and then collapsed as drought gripped the region in the 1930s (Alston 1983).

The Dust Bowl has long been recognized as a pivotal environmental episode. But much of the previous research fails to recognize the Dust Bowl as a subset of a larger environmental disaster. During the 1930s, the Soil Conservation Service (SCS) of the U.S. Department of Agriculture (USDA) designated 20 southern Great Plains counties as the most adversely impacted by wind erosion and dust storms (Joel 1937).⁷ These 20 counties became the epicenter of environmental degradation research. We know that the drought, dust storms, and wind erosion had profound and long-lasting impacts on the economic development of the southern Great Plains (Hurt 1981; Worster 2004; Hansen and Libecap 2004; Cunfer 2005; Cutler, Miller, and Norton 2007; Hornbeck 2012; Arthi 2018). Yet, as we expand from the 20 counties at the core of the Dust Bowl, we know less and less of the impact of drought.⁸

Migration has likely been the most studied consequence of the Dust Bowl (Hurt 1981; Gregory 1991; Riney-Kehrberg 1994; Worster 2004; Hornbeck 2012; Long and Siu 2018; Hornbeck 2020). For the 20 core Dust Bowl counties, migration rates were high during the 1930s, but migration was also high during the 1920s (Long and Siu 2018). The net decline in population for these 20 counties was largely due to a decrease in in-migration rather than an increase in out-migration. More broadly, eroded counties throughout the Plains saw large population declines during the 1930s and through the 1950s (Hornbeck 2012). In terms of who moved, the average migrant from more-eroded counties had more years of education compared to

⁷ Later, SCS defined a larger set of roughly 100 counties severely impacted by wind erosion (Natural Resource Conservation Service 2012). These are the counties outlined in Figure 1 and the 20 original counties are a subset of these 100 counties.

⁸ For a more complete discussion of how the Dust Bowl related to the wider drought see Sichko (2021b).

non-migrants, but less years of education compared to other migrants from the Great Plains (Hornbeck 2020).⁹

Outside the bounds of the Dust Bowl, even by its broadest definition, we know that people left hot and dry areas throughout the western U.S. in the late 1930s (Gutmann et al. 2016). In the realm of widespread drought, I expand on previous research by studying who moved and where migrants went (selection and sorting) distinguishing by individual education attainment. Migrant selection and sorting are central topics to climate-induced migration because individual characteristics, specifically human capital, are key to determining whether someone moves as discussed in the next subsection.

Because drought coincided with the largest economic downturn in modern history, my analysis is in the context of the Great Depression. Investment, consumption, production, employment, and the stock market all fell precipitously during the early 1930s (Eichengreen 1992; Romer 1993; Bernanke 2000).¹⁰ The Depression's severity and the associated New Deal relief spending impacted migration trends and the composition of migrants (Fishback, Horrace, and Kantor 2005; Molloy, Smith, and Wozniak 2011; Saks and Wozniak 2011; Feigenbaum 2015). As discussed below, my empirical estimates incorporate the impact of the Great Depression in measuring drought's impact on migration.

Migration from climate shocks and selection

Conceptually, people move if the expected benefits of residing in another location exceed the benefits of staying in their current location (net of the cost of moving and conditional on having enough money to pay for migration). But because the costs and benefits of migration vary by individual characteristics, migrants are not randomly selected from their origin population (Abramitzky, Boustan, and

⁹ The results of Hornbeck (2020) might appear contradictory to my results. However, there are a few factors to consider when comparing my results to Hornbeck (2020). First, erosion and drought were related but not equivalent environmental shocks. The worst drought was northwest of the worst erosion on the Great Plains. Moreover, while the drought of the 1930s ebbed and flowed for a decade, when the rains returned in 1940 the lasting impact of the drought likely receded quickly apart from the erosion damage, which became a long-term problem. Finally, Hornbeck (2020) studies whether the average migrant was positively or negatively selected whereas I study whether drought increased the propensity of individuals to migrate differential by human capital. These topics are discussed more in the Section VII and Appendix.

¹⁰ Sichko (2021b) studies the relationship between drought and Depression severity in detail.

Eriksson 2012; Collins and Wanamaker 2014). Human capital, or skill, is a key variable in the decision to migrate because skill relates to variables that enable migration (such as income, wealth, and liquidity) and to the expected returns of migration (Sjaastad 1962; Borjas 1987; Chiquiar and Hanson 2005; Armstrong and Lewis 2012).

When a climate shock impacts particular areas, it creates new incentives to relocate. Most directly, climate shocks increase the push factors of migration by negatively affecting local living conditions. Not surprisingly, a number of studies find that weather and climate shocks induce migration out of the impacted area.¹¹ Yet some studies find little, no, and even negative effects of climate and weather shocks on out-migration for large segments of populations. An explanation for why climate shocks sometimes result in little migration, or reduce migration, is that shocks negatively impact cash on hand, which is needed pay for migration (that is, there are binding liquidity constraints).¹²

Empirical evidence is largely consistent with the hypothesis that liquidity constraints impede climate migration, as most often we observe higher out-migration in high income areas and less out-migration from lower income areas (Kleemans 2015; Cattaneo and Peri 2016; Bazzi 2017). But most previous research, given data constraints, analyzes climate migration at data aggregation levels above the household or individual level. Therefore, we do not know whether the higher out-migration from wealthier areas is driven by migration among affluent people, in particular, or for the population as a whole (given better access to transportation infrastructure or other amenities). My research is among the first to study the individual-level migration response to a climate shock heterogeneously by human capital. This provides a direct analysis of who, out of the impacted population, moves from climate shocks.

Models of migrant selection provide the framework to anticipate the impact of drought on individual-level selection. McKenzie and Rapoport (2010), for example, build on Roy (1951) and Borjas (1987) to show that large migrant networks lower the cost of migration by providing information, housing services, and relaxing credit constraints. Therefore, large networks tend to reduce the amount of positive

¹¹ See Reuveny and Moore (2009); Boustan, Kahn, and Rhode (2012); Hornbeck (2012); Bohra-Mishra, Oppenheimer, and Hsiang (2014); Hornbeck and Naidu (2014); and Kleemans and Magruder (2018).

¹² See Bryan (2014); Angelucci (2015); Nawrotzki and DeWaard (2018); Beine and Parsons (2017); and Cattaneo et al. (2019).

selection into migration. This result has two implications for studying selection from drought during the Great Depression. First, drought and Depression severity are expected to work in the opposite direction as large migrant networks. Drought should constrain credit and liquidity and thereby induce more positive selection into migration. Additionally, if drought is increasing positive selection through liquidity constraints, positive selection should increase even more in drought areas that were more adversely impacted by the Great Depression. These predictions are tested and analyzed in Section VI.

III. Data construction

The overlap between the 1940 census and 1930s drought creates an opportunity to analyze how a monumental environmental shock impacted migration by individual characteristics. The primary data are first the full-count 1940 census and second drought conditions from 1935 to 1939 (Cook et al. 2010; Manson et al. 2018; Ruggles et al. 2019). These datasets allow me to match all adults, aged 20 to 65 in 1935, to drought conditions at the county level based on their self-reported 1935 location.¹³

The 1940 census forms the foundation of analysis. This was the first census to record place of residence five years prior and, as such, it captures internal migration from 1935 to 1940 for the entire population. Furthermore, the 1940 census recorded the highest grade achieved for each person, which provides a measure of 1935 human capital for the adult population.¹⁴

To study the impact of drought, I match the census records with county-level drought conditions. The U.S. National Atmospheric and Oceanic Administration (NOAA) provides publicly available historical drought data in the Living Blended Drought Atlas (LBDA) (Cook et al. 2010). The LBDA estimates yearly drought conditions based on instrument records of heat, rain, wind, soil, runoff, and evaporation for a grid of 11 thousand points across North America (Cook et al. 2010). But the LBDA does not contain any variables that allow for direct linkage to the census data. Therefore, I interpolate between the data points

¹³ The full count 1940 census data is publicly available from the IPUMS (Ruggles et al. 2019). The Living Blended Drought Atlas (LBDA) is publicly available from NOAA (Cook et al. 2010).

¹⁴ Anyone in school in 1940 is excluded from the analysis.

and match the LBDA to the 1930s county map (Manson et al. 2018) in Global Information System (GIS) software to calculate the average drought by year and county.

I use the number of *moderate or worse* drought years each county experienced from 1935 to 1939 as the independent variable of interest in this paper. Details on the construction of drought variables, including an alternate measure of drought, are discussed in Sichko (2021b). All results in this paper are robust to an alternate measure of drought as documented in the Appendix.

I supplement census and drought data with a number of other datasets. These datasets include county-level measures of Great Depression severity and New Deal spending, and soil erosion (Fishback, Horrace, and Kantor 2005; and Hornbeck 2012). These variables allow me to control for important events, trends, and other variables.

IV. Summary statistics

Multiple drought years spanned the Great Plains and the northern Mountain West as seen in Figure 1. Comparing drought to county-level out-migration in Figure 2, indicates that drought roughly corresponded to the region with the highest county-level out-migration across education categories.¹⁵ Figure 2 also shows that out-migration was more common for individuals with higher education. Nonetheless, from Figures 1 and 2 it is not clear that drought impacted migration and whether drought induced positive selection as discussed below.

Bringing drought, out-migration, and education together, Figure 3 displays the fraction of individuals who migrated, differentiating between drought years and individual education attainment. Again, we see that migration became more common as education increased for both non-drought and drought counties. Furthermore, migration increased for all education categories as drought years increased. The increase in migration related to drought was most pronounced among individuals with a 12th grade education or higher, with 30 percent of these people leaving counties with three or more drought years.

¹⁵ The most notable exception is the southwest, where there was little drought and high out-migration. This is discussed in more detail below.

Figures 1 through 3 suggest a correlation between drought and migration, but drought was not randomly distributed. Instead, drought centered on a geographically and demographically distinct region. Therefore, drought and migration should be considering in the context of the covariates in Table 1. There are three main points to take from Table 1. First, the drought region was rural compared to the rest of the United States.¹⁶ Second, people living in the drought region were relatively geographically mobile, or at least were more likely to be living in a state other than their birth state. Finally, New Deal spending, especially the Agricultural Adjustment Act (AAA), was allocated to drought counties.¹⁷ In light of the differences between drought and non-drought counties, it is possible that underlying migration rates among people with different backgrounds led to descriptive differences in migration rates rather than drought. This motivates the formal estimation of the relationship between drought and migration in the next section.

In terms where migrants went, Figure 4 shows county-level in-migration as a fraction of each county's 1935 population in each education category. Most in-migration was to western counties. By comparing in-migration patterns with the out-migration patterns (Figure 2), an attribute of migration for the drought region becomes clear. In the drought region, counties with high out-migration largely did not have high in-migration because migrants from drought counties often moved out of the drought region and few migrants from other parts of the country moved into the drought region to replace those who left. These factors resulted in a net decline in total population for the drought region.¹⁸

Finally, with regard to rural and city distinctions, Figure 5 displays the fraction of migrants, by origin and destination type. The majority of migrants, regardless of drought exposure, made rural-to-rural moves. Nearly 75 percent of migrants who started in rural locations moved to other rural locations, almost regardless of drought at the origin. In terms of descriptive statistics, there does not appear to have been a higher propensity for individuals from drought counties to move to cities. Moreover, of migrants who

¹⁶ This relationship is seen by comparing the fraction of people living in cities and on farms as drought years increased and is expected given the geographic distribution of drought to the Great Plains, which was a relatively rural region.

¹⁷ This is expected as AAA spending was designated to help drought and wind eroded counties.

¹⁸ The same pattern of low in-migration for counties with high out-migration does not hold outside of the drought region. Specifically, while much of the Southwest, and parts of the Pacific Coast, had high out-migration, counties in these regions also had high in-migration. This is a key difference in migration patterns in the drought region versus other high out-migration areas: in the drought region few migrants moved in to replace those who left. This finding is consistent with the pattern Long and Siu (2018) document for the 20 Dust Bowl counties.

started in city locations, nearly half relocated to rural destinations (where rural includes smaller towns with less than 20 thousand residents and unincorporated areas). These statistics are important in the context of previous climate-migration research, which focuses on the rural-to-urban channel. The migration dynamics between the rural and city sectors are studied more in Section VI.

V. Empirical framework

I estimate the probability of migration for individuals in counties with more years of drought relative to that of observationally similar individuals in counties with fewer years of drought within the same state. Equation 1 is written in vector notation for compactness here and is written out fully in the following footnote.¹⁹

$$(1) M_i = \alpha + \beta_1 E_i + \beta_2 D_c + \beta_3 (D_c \times E_i) + \theta_1 X_{i1935} + \theta_2 X_{c1935} + \gamma_{s1935} + \gamma_a + \varepsilon_i$$

The outcome M_i is a binary variable that takes a value of one if individual i was in a different county from their 1935 county in 1940 and a value of zero otherwise. Migration status is regressed on a vector of indicator variables for the number of drought years at individual i 's origin county (D_c), a vector of indicator variables for individual i 's education attainment (E_i), a vector of interaction terms between drought years and education attainment ($D_c \times E_i$), state fixed effects (γ_{s1935}), age fixed effects γ_a , a vector of 1935 individual characteristics (X_{i1935}), a vector 1935 county characteristics (X_{c1935}), and an error term (ε_i).

The vector of indicator variables for number of drought years (D_c) contains an indicator variable for whether a county experienced two drought years and an indicator for whether a county experienced three or more drought years. The omitted category are counties that experienced zero or one drought year.²⁰ The vector of indicator variables for educational attainment (E_i) contains an indicator variable for whether

¹⁹ $M_i = \alpha + \beta_{11}(8th\ to\ 11th\ grade)_i + \beta_{12}(12th\ grade\ or\ higher)_i + \beta_{21}(2\ drought\ years)_c + \beta_{22}(3\ or\ more\ drought\ years)_c + \beta_{31}(8th\ to\ 11th\ grade)_i(2\ drought\ years)_c + \beta_{32}(8th\ to\ 11th\ grade)_i \times (3\ or\ more\ drought\ years)_c + \beta_{33}(12th\ grade\ or\ higher)_i \times (2\ drought\ years)_c + \beta_{34}(12th\ grade\ or\ higher)_i \times (3\ or\ more\ drought\ years)_c + \gamma_{s1935} + \gamma_a + \theta_1 X_i + \theta_2 X_c + \varepsilon_i$

²⁰ I include counties with one drought year in the excluded group because most U.S. counties experienced at least one moderate or worse drought year from 1935 to 1939. One moderate or worse drought year is typically for a county over a five-year time interval given normal climatic fluctuations. All results are robust to separating zero and one year of drought into two different categories.

an individual had an 8th to 11th grade education and an indicator variable for whether an individual had a 12th grade education or higher. The omitted category are individuals with less than an 8th grade education. The vector of drought years is interacted with the vector of education attainment ($D_c \times E_i$). The omitted category is individuals with less than an 8th grade education and from a county with zero or one year of drought. The vector of 1935 individual controls (X_{i1935}) includes: number of children, and indicator variables for whether the person was male, white, foreign born, in a city, and in their birth state. The vector of 1935 county controls (X_{c1935}) includes: average age, fraction male, fraction white, fraction in a city, fraction in birth state, average education in years, fraction foreign born, population, number of moderate or worse drought years from 1930 to 1934, and log change in per capita retail sales from 1929 to 1933.

The coefficients on the vector of education indicators (β_1) estimate whether individuals with higher levels of education were more likely to migrate for the omitted drought group (counties with zero or one year of drought). Positive β_1 values indicate that there was intermediate selection (in the case where the coefficient for 8th to 11th grade education (β_{11}) is positive) and positive selection (in the case where the coefficient for 12th grade education or higher (β_{12}) is positive) for individuals from non-drought counties. The coefficients on the vector of drought indicators (β_2) estimate how drought years impacted migration decisions for the omitted education group (individuals with less than an 8th grade education). Positive β_2 values indicate that the migration propensity for individuals with less than an 8th grade education increased with exposure to drought. The coefficients on the interaction term (β_3) of drought years and education attainment estimate the difference in migration propensity between individuals with higher levels of education in drought counties relative to the omitted group (individuals with less than an 8th grade education in non-drought counties). Positive β_3 values indicate that the gap in migration propensity between more highly educated people and less educated people was larger in drought counties compared to non-drought counties and therefore indicates that drought induced selection into migration.

There are a number of ways in which drought could induce more selection into migration as measured by β_3 . For example, drought could lower migration propensities for individuals with less than an 8th grade education but not impact the migration propensities for individuals with higher education ($\beta_2 <$

0 and $\beta_3 > 0$). Alternatively, drought could have a neutral impact on migration for individuals with less than an 8th grade education but increase the migration propensities for more highly educated individuals ($\beta_2 = 0$ and $\beta_3 > 0$). In both cases, the estimated β_3 values might be the same, but how drought is impacting migration is different.

To understand how drought impacted migration within education categories, a β_3 coefficient should be considered in the context of relevant β_2 coefficient. The summation the relevant coefficients (from each vector) estimates whether drought induced more or less migration for a particular education category.²¹ As such, I supplement the regression output tables with coefficient plots that display how migration for each education category differed by drought years at the origin county relative to the same education category in non-drought counties.

VI. Results

Additional drought years increased migration. Table 2 and Figure 6 contain the baseline results. Table 2 column 1 displays the impact of additional drought years on migration. Being exposed to drought years increased the likelihood that an adult would migrate by 1.6 (two drought years) and 2.2 (three or more drought years) percentage points relative to observational similar people in non-drought counties within the same state. These are sizable increases in migration as the base inter-county migration rate for the five-year period was 11 percent. However, increased migration overall was driven by higher migration among highly educated individuals specifically as discussed in the following subsection.

Selection

The out-migration response to additional drought years occurred among individuals with relatively high education as shown in column 2 of Table 2. High school educated individuals in counties that

²¹ That is, the impact of three or more drought years on migration for individuals with a 12th grade education is β_{22} plus β_{34} . In long form: the impact of three or more drought years on migration for individuals with a 12th grade education is equal to the sum of the indicator variable coefficient for three or more drought years (β_{22} in the β_2 vector) and the coefficient for three or more drought years interacted with the indicator for a 12th grade education of higher (β_{34} in the β_3 vector).

subsequently experienced two years of drought were an additional 3.7 percentage points more likely to have moved compared to individuals with less than an 8th grade education. The magnitude of the coefficient increases to 6.5 percentage points for high school educated individuals from counties with three or more years of drought, as seen in the last row of column 2.²² By contrast, additional drought years had a neutral effect for individuals with less than an 8th grade education.

Higher migration rates among highly educated individuals from drought counties in the context of a neutral migration response among individuals with less than an 8th grade education means that highly educated individuals from drought counties were moving more than individuals in their *same* education category from non-drought counties. To illustrate this point, Figure 6 plots the sum of the coefficients for the impact of drought years for the omitted category (an individual with less than an 8th grade education) and the relevant interaction term between drought years and education category.²³ For example, individuals with a high school education and from a county that experienced three or more drought years were 6.1 percentage points more likely to move compared to high school educated individuals from non-drought counties.

I disaggregate my results along a number of dimensions: women and men, and rural and city origins. The pattern of higher intermediate and positive selection from drought holds for both women and men (Table 2 columns 3 and 4 and Figure 6.b. and 6.c.). In fact, women and men migrated away from drought at similar rates. The majority of people in this age range (76 percent) were married by 1940. Among married individuals the migration response to drought was virtually identical between women and men, suggesting that couple or families were moving together. Couples and families migrating as a unit is indicative of permanent moves, and is an interesting finding in light of research showing that migrations from some negative weather shocks are largely composed of temporary moves by one household member

²² This additional propensity is in relation to the underlying migration propensity gap of 5.8 percentage points between individuals with a 12th grade education or higher versus individuals with less than an 8th grade education as seen in the second row.

²³ This is the sum of the coefficient in the fourth row (3+ Drought Years) and the last row (3+ Drought Years)×(> 11th) in Table 2.

(Kleemans 2015). Likely, the length and severity of the shock plays a role in whether moves are temporary or permanent.

The pattern of higher intermediate and positive selection from drought holds when disaggregating the sample between non-city non-farm, farm, and city origins (Table 2 columns 5, 6, and 7, and Figure 6.d., 6.e., and 6.f.). The result that people moved away from cities in drought is novel because research on climate-induced migration focuses on the rural sector. Nonetheless, given previous research showing that climate shocks have widespread impacts outside of the agricultural sector (Hsiang 2010; Dell, Jones, and Olken 2012; Barreca et al. 2016) and the extent that cities in the drought region depended on agricultural output during the 1930s, it is not surprising that people migrated from both rural and city origins.

Selection mechanism

Why, when faced with severe and persistent drought, did individuals with less human capital not move more frequently? A number of papers posit that individuals with low human capital or wealth are more often constrained in their migration decisions because they do not have the required liquidity (or cash on hand) to pay the up-front cost of migration (McKenzie and Rapoport 2010; Cattaneo and Peri 2016; Bazzi 2017). This section explores this explanation in the context of the 1930s drought.

The liquidity constraint explanation is consistent with historic evidence on the Dust Bowl. Riney-Kehrberg (1994) conducted a survey of people who stayed in Dust Bowl counties. The most common response to the question of “why did you stay?” was that their family did not have the money to leave or anywhere to go. Although this survey was of people in the Dust Bowl specifically, it is likely that a similar sentiment extended through the broader drought. The 1930s were the decade of the Great Depression, the Depression was long lasting and severe in drought counties, and much of the drought region had begun to face hard economic times in the 1920s. These conditions likely contributed to difficulties in paying for the cost of migration.

To further examine the role of liquidity and Depression severity, I estimate whether the degree of selection into migration from drought varied based on Great Depression severity at origin counties. If it

was the case that people with lower human capital wanted to move from drought conditions but lacked the required liquidity to pay for the cost of migration, then we expect more selection from counties that suffered more severe economic downturns.

Figure 7, displays the results of splitting the sample between origin counties with lower and higher than average economic downturns from 1929 to 1935.²⁴ The coefficients of all of the interaction terms are larger from counties with more severe economic downturns, indicating that intermediate and positive selection from drought was more pronounced in counties where liquidity constraints were more likely to be binding. This result is consistent with the hypothesis that individuals with lower human capital more often lacked the liquidity required to move away from drought.²⁵

Sorting

Migration is a decision of whether to leave and where to go, and destination characteristics may also vary by individual circumstances. This section analyzes how migrant destinations changed with drought exposure and education attainment. Because city or non-city status is a defining characteristic in terms of employment opportunities and way of life, I focus on how destination differed in terms city status.

Equation 2 is a modification of Equation 1 that compares how destinations differed based on drought and education.

$$(2) R_{i1940} = \beta_1 E_i + \beta_2 D_c + \beta_3 (D_c \times E_i) + \theta_1 X_{i1935} + \theta_2 X_{c1935} + \gamma_{s1935} + \gamma_a + \varepsilon_i$$

Equation 2 has the same independent variables as Equation 1, but the outcome variable *migrant* in Equation 1 is replaced with an indicator variable (R_{i1940}) equal to one if a migrant's destination was a non-city (rural) location (where cities are defined as urban areas with more than 20 thousand residents in 1940).²⁶ The sample for Equation 2 is restricted to migrants. Crucially, Equation 2 includes state fixed effects and

²⁴ I define counties with *low* and *high* Depression severity based on being above or below the mean county-level Depression severity (*change in retail sales per capita from 1929 to 1935*).

²⁵ I present the results of estimating the regression with a split sample in the main text because these results are easier to interpret compared to one large interaction specification. The interaction regression is included in the Appendix. The results of the triple-interaction model are consistent with the findings in Figure 7 as discussed in the Appendix.

²⁶ This follows the IPUMS definition of *cities* for the 1940 census and is different than the IPUMS definition of *urban* which include smaller urban areas of 2,500 residents or more.

controls for the distance to the nearest city. Therefore, the results are unlikely driven by the fact that the drought region was relatively rural.

As in Equation 1, the coefficients of primary interest are contained in the vectors β_2 , β_3 , and the summation of β_2 and β_3 . The coefficients in β_2 estimates the difference between the propensity to move to non-city locations for the omitted group (individuals with less than an 8th grade education) from drought counties relative to similar migrants from non-drought counties. The coefficients in β_3 estimate whether more highly educated migrants from drought counties moved to rural destinations more often than the omitted category. The sum of a coefficient in the vector β_2 and the corresponding coefficient in the vector β_3 estimates whether more highly educated drought migrants moved to non-city destinations more than migrants in the same education category from non-drought counties.

Column 1 of Table 3 displays the results of estimating Equation 2 for the entire sample of migrants. The coefficient for *three or more drought years* indicates that migrants with less than an 8th grade education from drought counties were 4.6 percentage points more likely to relocate to non-city destinations compared to similar migrants from non-drought counties. To compare migrants of the same education category, as in the selection results, Figure 8.a. plots the sum of the coefficients for the impact of additional drought years (for the omitted category) and the relevant interaction term between drought years and education category. Figure 8.a. shows that migrants from counties with three or more drought years went to non-city destinations more often than their counterparts from non-drought counties across all education categories. Columns 2 and 3 of Table 3, and Figures 8.b. and 8.c., show that the increased propensity for non-city destinations held for drought migrants from both non-city and city origin origins.

The result that migrants from drought counties were less likely to relocate to city destinations is intriguing in light of previous literature stressing urbanization as an outcome of climate shocks. Moreover, my result is important because it shows that all education categories adjusted destination choices given drought exposure. That is, although less educated people did not move more in response to drought on average, they did adjust their migration decision in terms of where they went.

To better understand where migrants were going, Table 4 and Figure 9 disaggregate non-city destinations into two mutually exclusive subsets (non-farm and farm destinations) for migrants from non-city and city origins separately. Figure 9.a. shows that highly educated migrants originating from non-city locations in counties that suffered three or more drought years were disproportionately likely to move to non-farm locations. These small towns and unincorporated residences were also popular among migrants from drought cities across the educational spectrum (9.c.). By contrast, farm destinations were more popular among less educated migrants from both non-city and city origins (9.b. and 9.d.).

My results show that there was considerable heterogeneity in destination choice based on drought exposure and education attainment. Overall, migrants from drought counties tended to avoid cities more than other migrants. This was true for drought migrants who started in city and non-city locations. There was also heterogeneity in the type of non-city destination by education attainment. Less educated migrants from drought counties more often relocated to farm destinations compared to similar migrants from non-drought counties. More educated migrants, and all migrants who started in cities, were more likely to relocate to non-farm destinations, showing that there was less movement back into or between agricultural jobs among more educated migrants and for migrants from cities.

VII. Discussion

I show that drought impacted who moved and where migrants went heterogeneously by individual human capital. My findings complement and expand climate-induced migration research by detailing the response to a severe, widespread, and long-lasting shock. My findings, in connection and comparison to recent literature (Sedova and Kalkuhl 2020; Hornbeck 2020), are among the first to study environmental-migrant selection at the individual level.

Historic testimony and empirical evidence show that lack of cash-on-hand constrained drought-related migration for less-educated people during the 1930s. This finding is consistent with a broader literature showing that migration from environmental shocks depends on the affluency of the impacted area (Cattaneo and Peri 2016; Bazzi 2017; Benonnier, Millock, and Taraz 2019). But the most closely related

literature, on environmental migration at the individual level, shows that shocks may induce more or less selection (Hornbeck 2020; Sedova and Kalkuhl 2020). Hornbeck (2020) studies selection from 1930s U.S. soil erosion and finds that migrants from more eroded counties were *less* positively selected than other migrants from the Great Plains.²⁷ Sedova and Kalkuhl (2020) show that negative precipitation shocks in modern India increase migration to urban areas for illiterate individuals but not for literate people. These differing results highlight that environmental-migrant selection varies based on the characteristics of the shock (length, severity, type, etc.) as well as the average and individual circumstances of people (wealth, access to transportation, outside employment options, property ownership, etc.).

My results on where people moved from and to further emphasize the importance of economic structure and demographics in the selection response to climate shocks. During the 1930s, there was movement away from drought in both the rural and the city sectors. Many migrants, and especially drought migrants, relocated to rural and small-town destinations over larger cities. Here, again, the context of the 1930s and the details of the impacted region are important factors to consider.

Drought and migration principally intersected on the Great Plains. This region was agricultural, and even the metropolitan areas were dependent on local agricultural output to support economic opportunity and jobs. Additionally, on average, and outside the influence of drought, people living in cities had higher migration propensities compared to their rural neighbors. Finally, heat waves are highly correlated with drought and urban areas are typically hotter than the surrounding countryside through the urban heat island effect. Taken together, people left cities in the drought region at rates similar to rural areas. But, again, this result is dependent on the economic and demographic structure of the impacted region.

My result that migrants from drought counties avoided large cities, is important because previous research emphasizes urbanization as a result of climate shocks. Once more, I turn to the historic details of the 1930s drought. The 1930s were the decade of the Great Depression and the Depression was felt most keenly in large metropolitan areas, leading to a *back-to-the-land* movement in which people left the largest

²⁷ The Appendix studies difference between my findings and Hornbeck (2020) in more detail.

cities for smaller towns and rural areas (Todara 1969; Boyd 2002). In the drought region specifically, local urban areas were reliant on agricultural output, and given the crippling impact of drought, were unlikely places to find work for displaced people. Given these circumstances many migrants, and especially drought migrants, avoided cities as destinations.

Aspects of specific shocks and the characteristics of the impacted population are key to understanding climate migration. Climate-migration literature is moving from estimating only the quantity of migrants towards detailing the economic characteristics of migrants. This has introduced questions concerning differential demographic responses at different times and places. Without careful consideration of the characteristics underlying particular shocks, little progress will be made in understanding the migration response.

VIII. Conclusion

Adaptation to environmental disasters is vital to economic progress. In light of the importance of environmental adaptation and relative to the severity, length, and spatial expanse of the 1930s drought, we know little about the drought's economic consequences. Compared to most weather and climate shocks, this was a long and widespread shock that impacted an ecologically and economically diverse country. These characteristics allow for the study of who moved and where migrants went in scale and detail not possible at other times and places. My results contribute to our understanding of migration and settlement in U.S. history, the human capital distribution implications of environmental shocks, and provide perspective on the likely consequences of modern and future shocks.

The mass migration triggered by the Dust Bowl has been recognized since the time of its occurrence (Taylor and Vaset 1936; Hoffman 1938). More recently, there has been growing awareness that environmental degradation was correlated with migration far beyond the traditional bounds of the Dust Bowl (Gutmann et al. 2016). In this vein, my research contributes to our understanding of how large climate fluctuations influence migration and settlement.

Previous environmental-migration research focuses on the aggregate flows of migrants. This emphasis is in part because detailed data of individuals pre- and post-migration are usually not available, and introduces questions concerning why people move from certain shocks, but not others, and whether climate migrants differ from other migrants. I show that widespread drought did not uniformly increase migration across education. Instead, drought induced migration for a specific segment of the skill distribution.

How climate shocks impact migration decisions, based on individual characteristics, is key to understanding who bears the costs of shocks, the lasting consequences, and evaluating the gains of migration. My result that highly educated individuals increased their migration rates, while less educated individuals did not, shows that migration was an adaptation method adopted only by relatively affluent people. But this result is best considered in the setting of the 1930s drought, including people's average ability to migrate and broad economic conditions.

Studying migrant destinations further stresses the importance of qualifying results in terms of shock characteristics and the circumstances of the impacted population. Most migrants moved to rural destinations, and drought migrants were even more inclined to move to rural locations. My results highlight that the extent of urbanization resulting from climate shocks relies on the integration of local metropolitan areas with the agricultural sector, the vibrancy of employment in other sectors, and more distant options.

The frontier of climate-migration research employs individual-level data that enable the heterogeneous study of migrant characteristics and destinations. As research progresses, we begin to answer questions concerning migrant selection and sorting under specific conditions. Along these lines, my research builds a more intricate and comprehensive view of a particularly influential episode: who utilized mitigation as adaptation and how these migrants reshaped the geographic human capital distribution.

Online Appendix

Measures of selection

Equation 1 estimates whether drought increased individuals' propensities to migrate while distinguishing by education attainment. Positive coefficients from the interaction terms indicate that more highly educated individuals were more inclined to migrate from drought counties. But there are other ways to measure selection into migration. A measure similar to Equation A1 is used in Hornbeck (2020).

$$(A1) E_i = \beta_1 M_i + \beta_2 D_c + \beta_3 (D_c \times M_i) + \gamma_{s1935} + \gamma_a + \theta_1 X_{i1935} + \theta_2 X_{c1935} + \varepsilon_i$$

The difference between Equation 1 and Equation A1 is that *education attainment* is the outcome variable in Equation A1 whereas *education* is an independent variable in Equation 1. Correspondingly, *migrant* is an independent variable in A1 whereas *migrant* is the outcome variable in Equation 1. Moreover, in Equation A1, the outcome *education* is an integer for the number of years of school individual *i* completed rather than a series of categorical variables as in Equation 1. The rest of Equation A1 is the same as Equation 1.

The coefficient of interest in Equation A1 is β_3 . The coefficient β_3 estimates whether migrants from drought counties had relatively higher or lower education compared to migrants from non-drought counties. That is, β_3 is a measure of the average education for a migrant from a drought county relative to the average education of a migrant from a non-drought county: Equation A1 estimates whether migrants were positively or negatively selected on average.

The results of estimating Equation A1 are reported in Table A1. These results show that the average migrant from drought counties was not more positively or negatively selected compared to non-drought migrants (who were positively selected). Whether the average migrant from drought counties was positively selected depends on the impact of drought on selection, the relative distribution of education, and the migration rates for education levels at the county level. The drought region was comparatively well educated following the high school movement of the early 20th century (Goldin and Katz 1999) and likely had underlying characteristics that made individuals more likely to migrate compared to other parts of the United States. Therefore, my results that drought induced more positive selection at the individual level do not imply that migrants from drought counties were more positively selected on average.

For comparison to Hornbeck (2020) in estimating whether drought and soil erosion on the Great Plain were associated with the average migrant being more or less positively selected, columns 3 and 4 of Table A1 restrict the sample to the Great Plains. When restricting the sample to the Plains, the average migrant from counties with three or more drought years was more positively selected than migrants from non-drought counties but these results are not statistically significant. The opposite was true for erosion as

shown in columns 3 and 4 of Table A2. Severe erosion was associated with the average migrant from the Great Plains being more negatively selected as shown in Hornbeck 2020.²⁸

There are a number of possible reasons why the average migrant from eroded counties on the Plains was more negatively selected while the average drought migrant was not. First, drought and soil erosion were different shocks and impacted different areas. The worst drought on the Great Plains was west and north of the worst soil erosion. Second, the drought ebbed and flowed throughout the 1930s, but when the heat subsided and rains returned, agriculture and other aspects of life may have returned to their pre-drought status relatively quickly. The same was not true for counties with severe erosion as erosion was more permanent damage. Possibly, the persistence of erosion damage helps explain the difference in the selection response to drought versus soil erosion.

This section presents the basics of the difference between measuring how drought impacted individual-level selection versus measuring whether the average migrant from drought counties was positively selected. Moreover, this section presents some differences in the migration response to drought versus erosion. Both of these topics are areas for further investigation.

Triple interaction model: drought, education, and Depression severity

Figure 7 reports the results of estimating changes in migration propensity in response to drought by Depression severity at origin counties. The regressions underlying Figure 7 are based on Equation 1 with the sample differentiated by Depression severity. This method is straightforward and the results are relatively easy to interpret. The results of this estimation indicate that there was more positive selection into migration in counties that suffered more severe economic down turns during the Great Depression. This result is consistent with the hypothesis that individual liquidity constrained migration decisions. But the results of Figure 7 do not formally estimate the statistical differences in selection between counties by Depression severity.

Equation A2 is a triple interaction model that estimates the same relationship as is displayed in Figure 7 but enables the examination of the statistical significance of differences.

$$(A2) M_i = \alpha + \beta_1 E_i + \beta_2 D_c + \beta_3 S_c + \beta_3(D_c \times E_i) + \beta_3(S_c \times E_i) + \beta_3(D_c \times S_c) \\ + \beta_3(D_c \times E_i \times S_c) + \theta_1 X_{i1935} + \theta_2 X_{c1935} + \gamma_{s1935} + \gamma_a + \varepsilon_i$$

²⁸ Columns 1 and 2 of A2 estimate whether the average migrant was selected based on erosion severity across the U.S. as a whole. The results of columns 1 and 2 show that migrants from more eroded counties were not more positively selected for the U.S. as a whole as they were on the Great Plains as seen in columns 3 and 4. This indicates that erosion had a differential impact on selection into migration depending on the geographic region and is an area for future inquiry. The results of columns 3 and 4 are similar to the results of Hornbeck (2020) but are not an exact replication for two reasons. First, the erosion variables that I use are slightly different than Hornbeck (2020). I define counties as experiencing *moderate* or *severe* erosion if greater than 50 percent of the county had moderate or severe erosion for consistency between the drought and erosion specifications. Hornbeck (2020) interacts the fraction of the county with moderate and severe (medium and high) erosion directly with migrant status. Second, I include different controls than Hornbeck (2020). Nonetheless, the estimates are similar overall and nearly the same for severe erosion.

Equation A2 has the same basic structure and controls as Equation 1 but includes additional interaction terms to study the differential impact of drought, education, and Depression severity in one equation. The omitted category are individuals with less than an 8th grade education who started in non-drought counties that did not have severe Depression conditions.²⁹ The vector $(S_c \times E_i)$ includes two indicator variables: one indicator variable for whether individual i had an 8th to 11th grade education and was from a county with severe Depression, and another indicator for whether individual i had greater than an 11th grade education and was from a county with severe Depression. The vector $(D_c \times S_c)$ includes two indicator variables: one indicator variable for whether individual i was from a county with two years of drought and severe Depression, and another indicator for whether individual i was from a county with three or more years of drought and severe Depression. Finally, the triple interaction vector $(D_c \times E_i \times S_c)$ contains four indicator variables that are the combination of drought status, education level, and Depression severity.

The results of estimating Equation A2 are reported in Table A3. Table A3 is consistent with Figure 7 indicating that positive selection into migration from drought was more attenuated in counties with severe economic downturns. Specifically, the drought, education, and Depression triple interaction terms are positive and significant.

Alternate drought measure

I use the number of moderate or worse drought years as the primary independent variable in this paper. The number of drought years is a straight forward measure of drought exposure over a multi-year time horizon that uses the well-established yearly definitions of drought. Yet, there are other ways to measure drought over a multi-year time horizon. In the Appendix of Sichko (2021b) I define an alternate measure of drought that is the summation of the total yearly drought index values over the five-year time period for each county. Then, I define thresholds for *moderate* and *severe* drought from 1935 to 1939. Please see Sichko (2021b) for a more thorough discussion of this alternate drought measure including its benefits and drawbacks.

Tables A4 and A5 recreate the main selection and sorting results using the alternate measure of drought exposure. The results in Tables A4 and A5 are similar to the results in Tables 2 and 3 in the main text and show that the results of this paper are robust to an alternate definition of drought. One notable difference is that individuals with less than an 8th grade education and from city origins (Table A4, column 7, rows 3 and 4) had a large and significant increase in migration rates when drought is measured by the total drought intensity instead of years over the yearly *moderate drought* threshold. This indicates that this subset of the population was more responsive to large one-time shocks as the *total drought* measure, used

²⁹ Counties with severe Depression are those that suffered worse than average declines in retail spending from 1929 to 1935.

for Table A4, puts more weight on especially bad drought years. Again, more details on the differences between drought measures and the importance of specific drought years are in Sichko (2021b).

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Figures and tables

Figure 1: Number of drought years from 1935 to 1939

Notes: The roughly 100 Dust Bowl counties outlined are the largest set defined by the U.S. Department of Agriculture as counties severely impacted by wind erosion during the 1930s (Natural Resources Conservation Service 2012). The *Dust Bowl* has never been a precise scholarly term as discussed in Section II. This outline is simply intended to give an idea of the region of focus for previous literature. Data sources: Cook et al. (2010) and Manson et al. (2019).

Figure 2: Fraction of 1935 population to have left by 1940 by education category

Notes: This figure shows out-migration distinguishing by education level. Out-migration looks similar but has different intensities across education levels. Migration became more common (the figures become darker) as education increased, indicating positive selection into migration (not necessarily related to drought conditions). Sample includes adults (20 to 65 in 1935). Data sources: Ruggles et al. (2019) and Manson et al. (2019).

Figure 3: Fraction of individuals to have migrated by education and drought

Notes: The first bar shows that roughly eight percent of individuals with less than an 8th grade education and from counties with zero or one year of drought moved. The fraction of individuals who moved increased both with education and drought exposure. Data sources: Cook et al. (2010); Ruggles et al. (2019); and Manson et al. (2019).

Table 1: Migration and 1935 county demographics by drought years

Drought years	0 to 1	2	3+
<i>Migration</i>			
Migrated out (1935 to 1940)	0.11	0.18	0.20
Fractional population change (1920 to 1930)	0.17	0.16	0.16
<i>1935 fraction</i>			
In city	0.53	0.39	0.16
On farm	0.42	0.49	0.54
White	0.87	0.98	0.98
In birth state	0.62	0.52	0.54
Male	0.50	0.51	0.53
County acres in farming	0.52	0.69	0.84
<i>1935 average</i>			
Age	42.1	42.3	42.4
Education (in years)	8.5	9.2	9.1
<i>Per capita</i>			
Growth in spending (1929 to 1933)	-0.46	-0.54	-0.53
Public works and relief spending (1933 to 1935)	\$91	\$101	\$113
AAA spending (1933 to 1935)	\$18	\$64	\$157

Notes: This table displays average demographic variables based on the drought. The region most impacted by drought had a smaller fraction of the population in cities and a higher fraction on farms. People in the drought counties were more likely to be living outside of their birth state. Finally, AAA spending was highly allocated to drought counties. Sample includes adults (20 to 65 in 1935). Data sources: Fishback, Horrace, and Kantor (2005); Cook et al. (2010); Ruggles et al. (2019); and Manson et al. (2019).

Figure 4: New residents entered by 1940 as a fraction of 1935 population by education category

Notes: This figure shows in-migration distinguishing by education level. In-migration looks similar across education levels. Most migrants moved to counties in the western United States. Again, as seen in Figures 2 and 3, migration became more common as education increased. Sample includes adults (20 to 65 in 1935). Data sources: Ruggles et al. (2019) and Manson et al. (2019).

Figure 5: Fraction of migrants who moved to non-city locations

Notes: This figure shows the fraction of migrants by drought years and origin location (non-city or city) who relocated to non-city destinations. Nearly regardless of drought years at their origin county, roughly 75 percent of migrants who started in non-city locations moved to other non-city locations. Additionally, nearly 50 percent of migrants who started in city locations relocated to non-city locations. Data sources: Cook et al. (2010); Ruggles et al. (2019); and Manson et al. (2019).

Table 2: Migration response to number of drought years by education attainment

	(1) Migrant	(2) Migrant	(3) Migrant	(4) Migrant	(5) Migrant	(6) Migrant	(7) Migrant
8th to 11th grade ed.	0.011*** (0.002)	0.011*** (0.002)	0.012*** (0.002)	0.009*** (0.002)	0.037*** (0.005)	0.006* (0.003)	0.008*** (0.002)
> 11th grade ed.	0.062*** (0.003)	0.058*** (0.003)	0.056*** (0.002)	0.062*** (0.004)	0.121*** (0.005)	0.028*** (0.004)	0.056*** (0.005)
2 drought years	0.016*** (0.004)	-0.000 (0.007)	-0.003 (0.007)	0.002 (0.008)	0.018 (0.018)	-0.005 (0.009)	0.010 (0.022)
3+ drought years	0.022*** (0.006)	-0.004 (0.006)	-0.007 (0.006)	-0.001 (0.006)	-0.013 (0.021)	0.023 (0.016)	0.014 (0.011)
(2 drought years)x(8th to 11th)		0.011* (0.006)	0.013** (0.005)	0.009 (0.006)	0.016* (0.009)	0.004 (0.005)	0.009 (0.009)
(3+ drought years)x(8th to 11th)		0.018*** (0.004)	0.022*** (0.004)	0.016*** (0.005)	0.043*** (0.013)	0.011** (0.005)	0.017*** (0.006)
(2 drought years)x(> 11th)		0.037*** (0.009)	0.040*** (0.008)	0.036*** (0.011)	0.048*** (0.014)	0.011 (0.011)	0.027** (0.012)
(3+ drought years)x(> 11th)		0.065*** (0.008)	0.068*** (0.007)	0.063*** (0.009)	0.083*** (0.013)	0.039*** (0.011)	0.055*** (0.009)
Observations	64,800,518	64,800,518	32,176,444	32,624,074	8,534,998	7,467,703	32,781,307
Sample	Adults	Adults	Women	Men	Non-city non-farm origins	Farm origins	City origins

Standard errors clustered by 1935 state in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: These results estimate whether drought impacted migration differentially based on education level. As an example of how to interpret the magnitudes of these coefficients, the first coefficient in column 2 estimates that individuals (from non-drought counties) with an 8th to 11th grade education were 1.1 percentage points more likely to migrate than individuals with less than an 8th grade education. The third and fourth rows of column 2 show that drought had little impact on the migration propensity for individuals with less than an 8th grade education. At the same time, drought increased intermediate and positive selection into migration as seen in the last four rows. These results hold for both women and men (columns 3 and 4) and from non-city non-farm, farm, and city origins (columns 5, 6, and 7). These results are displayed in Figure 6 as a comparison of migration propensities within each education category for ease of interpretation. Sample includes adults (20 to 65 in 1935). Regressions include age and state fixed effects, and individual and county controls as discussed in the context of Equation 1.

Figure 6: Migration response to number of drought years by education attainment

Notes: These results correspond to columns 2 through 7 of Table 2. The coefficients are the estimated impact of drought years on migration propensity for individuals of different education levels relative to observably similar individuals in the same education category. As an example of how to interpret the magnitudes of these coefficients, the last coefficient in (a) estimates that individuals with greater than an 11th grade education and from a county with three or more drought years were 6.1 percentage points more likely to migrate than individuals of the same education level from non-drought counties. The primary impact of drought was to increase migration for individuals with a 12th grade education or higher. Drought had a more minor impact on the migration propensity for individuals with an 8th to 11th grade education. This result holds for women and men, and for individuals from non-city non-farm, farm, and city origin locations. Sample includes adults (20 to 65 in 1935). Regressions include five percent confidence intervals, age and state fixed effects, and individual and county controls as discussed in the context of Equation 1.

Figure 7: Selection into migration by Depression severity at origin counties

Notes: These are the results from estimating Equation 1, distinguishing by Depression severity at origin counties. Depression severity may have further constrained individual liquidity. The results that there was more positive selection from counties with worse Depression severity is consistent with the hypothesis that liquidity played a role in the increased positive selection into migration resulting from drought. Sample includes adults (20 to 65 in 1935). Regressions include five percent confidence intervals, age and state fixed effects, and individual and county controls as discussed in the context of Equation 1.

Table 3: Propensity of migrants to move to non-city destinations by education and drought

	(1) Non-city migrant	(2) Non-city migrant	(3) Non-city migrant
8th to 11th grade ed.	-0.088*** (0.006)	-0.085*** (0.005)	-0.089*** (0.009)
> 11th grade ed.	-0.172*** (0.008)	-0.181*** (0.006)	-0.154*** (0.012)
2 drought years	0.007 (0.011)	-0.006 (0.010)	0.063*** (0.018)
3+ drought years	0.046*** (0.015)	0.046*** (0.012)	0.059** (0.026)
(2 drought years)x(8th to 11th)	0.015* (0.008)	0.020*** (0.007)	-0.005 (0.011)
(3+ drought years)x(8th to 11th)	0.022*** (0.007)	0.023*** (0.007)	-0.014 (0.011)
(2 drought years)x(> 11th)	-0.005 (0.009)	0.004 (0.008)	-0.027 (0.017)
(3+ drought years)x(> 11th)	-0.002 (0.010)	0.014 (0.009)	-0.043*** (0.014)
Observations	7,195,041	4,238,812	2,956,229
Sample	All migrants	Non-city origins	City origins

Standard errors clustered by 1935 state in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: These results estimate whether migrants from drought counties were more likely to move to non-city destinations compared to other migrants. The coefficient in the fourth row of column 1 shows that migrants with less than an 8th grade education from counties with three or more drought years were 4.6 percentage points more likely to relocate to non-city destinations relative to similar migrants from non-drought counties. Columns 2 and 3 distinguish by non-city and city origins. The higher propensity to move to non-city destinations holds for migrants from non-city and city origins. These results are displayed in Figure 8 as a comparison of migration propensities within each education category for ease of interpretation. Sample includes migrants (20 to 65 in 1935). Regressions include age and state fixed effects, and individual and county controls as discussed in the context of Equation 2. Regressions include distance to the nearest city as a control.

Figure 8: Propensity of migrants to move to non-city destinations by education and drought

Notes: These results correspond to Table 3. The coefficients are the estimated impact of drought on the propensity of migrants to move to non-city locations relative to observably similar migrants (in the same education category) from non-drought counties. As an example of how to interpret the magnitudes of these coefficients, the last coefficient in (a) estimates that individuals with greater than an 11th grade education and from a county with three or more years of drought were 4.1 percentage points more likely to migrate to a non-city destination than individuals of the same education level from non-drought counties. Both migrants from non-city and city origins in drought counties had a higher propensity to move to non-city locations compared to other migrants as seen in (b) and (c). Sample includes migrants (20 to 65 in 1935). Regressions include five percent confidence intervals, age and state fixed effects, and individual and county controls as discussed in the context of Equation 2. These regressions include distance to the nearest city as a control.

Table 4: Propensity of migrants to move to different types of non-city destinations

	(1)	(2)	(3)	(4)
	Non-farm migrant	Farm migrant	Non-farm migrant	Farm migrant
8th to 11th grade ed.	0.028*** (0.007)	-0.111*** (0.010)	-0.033*** (0.005)	-0.055*** (0.004)
> 11th grade ed.	0.051*** (0.012)	-0.228*** (0.015)	-0.058*** (0.007)	-0.096*** (0.007)
2 drought years	0.001 (0.009)	-0.009 (0.012)	0.036*** (0.011)	0.025** (0.010)
3+ drought years	0.024 (0.015)	0.023 (0.018)	0.047** (0.020)	0.025*** (0.008)
(2 drought years)x(8th to 11th)	-0.011 (0.008)	0.033*** (0.011)	0.001 (0.010)	-0.005 (0.007)
(3+ drought years)x(8th to 11th)	-0.009 (0.010)	0.030** (0.014)	-0.009 (0.009)	-0.008 (0.005)
(2 drought years)x(> 11th)	0.002 (0.015)	0.006 (0.018)	0.000 (0.010)	-0.026** (0.012)
(3+ drought years)x(> 11th)	0.031* (0.017)	-0.020 (0.022)	-0.009 (0.012)	-0.035*** (0.009)
Observations	4,236,382	4,236,382	2,956,229	2,956,229
Sample	Non-city origins	Non-city origins	City origins	City origins

Standard errors clustered by 1935 state in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: These results disaggregate the result that drought migrants were more likely to move to non-city destinations into non-farm and farm destinations. There was heterogeneity in type of non-city destination based on individual education attainment and type of origin location (non-city or city). These results are displayed in Figure 9 as a comparison of migration propensities within each education category for ease of interpretation. Sample includes migrants (20 to 65 in 1935). Regressions include age and state fixed effects, and individual and county controls as discussed in the context of Equation 2. These regressions include distance to the nearest city as a control.

Figure 9: Propensity of migrants to move to different types of non-city destinations

Notes: These results correspond to Table 4. The coefficients are the estimated impact of drought on the propensity of migrants to move to different types of non-city destinations relative to observably similar migrants (in the same education category) from non-drought counties. Highly educated drought migrants and drought migrants who started in cities more often relocated to small town and non-farm destinations as seen in (a) and (c). Less educated drought migrants more often relocated to farm destinations as seen in (b) and (d). Sample includes migrants (20 to 65 in 1935). Regressions include five percent confidence intervals, age and state fixed effects, and individual and county controls as discussed in the context of Equation 2. These regressions include distance to the nearest city as a control.

Appendix Tables

Table A1: Average education for migrants by drought exposure

	(1)	(2)	(3)	(4)
	Highest grade	Highest grade	Highest grade	Highest grade
Migrant	0.765*** (0.054)	0.772*** (0.054)	0.674*** (0.061)	0.685*** (0.062)
2 drought years	-0.006 (0.022)		-0.036 (0.031)	
3+ drought years	0.004 (0.018)		-0.002 (0.021)	
(Migrant) × (2 drought years)	-0.045 (0.109)	-0.043 (0.110)	0.122 (0.116)	0.116 (0.115)
(Migrant) × (3+ drought years)	-0.046 (0.085)	-0.044 (0.087)	0.064 (0.065)	0.059 (0.067)
Observations	64,800,518	64,800,518	10,383,149	10,383,149
Fixed effects	1935 state	1935 county	1935 state	1935 county
Sample	U.S.	U.S.	Great plains	Great plains

Standard errors clustered by 1935 state in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table estimates whether the average migrant from drought counties was more or less positively selected than migrants from non-drought counties. Columns 3 and 4 restrict the sample to counties on the Great Plains for comparison to erosion as estimated in Table A2 and Hornbeck (2020). Sample includes adults (20 to 65 in 1935). Age and state fixed effects, and individual and county controls are included as discussed in Section V and Appendix.

Table A2: Average education for migrants by soil erosion

	(1)	(2)	(3)	(4)
	Highest grade	Highest grade	Highest grade	Highest grade
Migrant	0.731*** (0.050)	0.735*** (0.050)	0.731*** (0.079)	0.742*** (0.079)
Moderate erosion	-0.004 (0.008)		-0.004 (0.009)	
Severe erosion	-0.012 (0.009)		0.003 (0.007)	
(Migrant) × (moderate erosion)	0.176 (0.162)	0.208 (0.171)	-0.119 (0.076)	-0.125 (0.093)
(Migrant) × (severe erosion)	-0.029 (0.078)	-0.033 (0.090)	-0.328*** (0.081)	-0.429*** (0.130)
Observations	58,695,197	58,695,197	10,195,558	10,195,558
Fixed effects	1935 state	1935 county	1935 state	1935 county
Sample	U.S.	U.S.	Great plains	Great plains

Standard errors clustered by 1935 state in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table estimates the impact of soil erosion as studied in Hornbeck (2020). Sample includes adults (20 to 65 in 1935). Age and fixed effects, and individual and county controls are included as discussed in Section V and Appendix.

Table A3: Selection: migration from drought by education and depression severity

	(1) Migrant
8th to 11th grade education	0.012*** (0.002)
> 11th grade education	0.063*** (0.002)
2 drought years	-0.000 (0.006)
3+ drought years	-0.002 (0.007)
Severe Depression	-0.004 (0.003)
(2 drought years)x(8th to 11th)	0.004 (0.005)
(3+ drought years)x(8th to 11th)	0.013*** (0.004)
(2 drought years)x(> 11th)	0.026*** (0.008)
(3+ drought years)x(> 11th)	0.052*** (0.009)
(8th to 11th)x(severe Depression)	-0.002 (0.003)
(> 11th)x(severe Depression)	-0.009* (0.005)
(2 drought years)x(severe Depression)	-0.004 (0.012)
(3+ drought years)x(severe Depression)	-0.006 (0.007)
(2 drought years)x(8th to 11th)x(severe Depression)	0.018 (0.011)
(3+ drought years)x(8th to 11th)x(severe Depression)	0.011* (0.006)
(2 drought years)x(> 11th)x(severe Depression)	0.027* (0.015)
(3+ drought years)x(> 11th)x(severe Depression)	0.027** (0.010)
Observations	64,800,518

Standard errors clustered by 1935 state in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table present the results of Equation A2 as a robustness check to the results in Figure 7. Figure 7 is based on restricting the sample to high and low Depression counties whereas Equation A2 estimates the relationship with interaction terms. Sample includes adults (20 to 65 in 1935) in the full count 1940 census. Regression includes age and state fixed effects, and individual and county controls as discussed in the context of Equation 1 and A2.

Table A4: Migration response to drought by education attainment: alternate drought measure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Migrant	Migrant	Migrant	Migrant	Migrant	Migrant	Migrant
8th to 11th grade ed.	0.011*** (0.002)	0.011*** (0.002)	0.012*** (0.002)	0.009*** (0.002)	0.038*** (0.005)	0.006** (0.003)	0.009*** (0.002)
> 11th grade ed.	0.062*** (0.003)	0.060*** (0.003)	0.057*** (0.002)	0.063*** (0.004)	0.124*** (0.006)	0.028*** (0.004)	0.057*** (0.004)
Moderate drought	0.012* (0.006)	-0.009 (0.008)	-0.013* (0.007)	-0.006 (0.008)	-0.029* (0.017)	0.005 (0.010)	0.036** (0.015)
Severe drought	0.031*** (0.009)	0.001 (0.009)	-0.004 (0.007)	0.005 (0.009)	-0.027 (0.025)	0.024 (0.015)	0.073*** (0.018)
(Moderate)x(8th to 11th)		0.014** (0.005)	0.017*** (0.005)	0.012** (0.006)	0.026** (0.012)	0.005 (0.008)	0.013 (0.009)
(Severe)x(8th to 11th)		0.021*** (0.004)	0.026*** (0.004)	0.019*** (0.004)	0.045*** (0.012)	0.016** (0.006)	0.017*** (0.005)
(Moderate)x(> 11th)		0.051*** (0.009)	0.053*** (0.009)	0.050*** (0.010)	0.060*** (0.016)	0.023* (0.013)	0.045** (0.019)
(Severe)x(> 11th)		0.071*** (0.011)	0.074*** (0.009)	0.070*** (0.012)	0.082*** (0.015)	0.043*** (0.012)	0.058*** (0.011)
Observations	64,800,518	64,800,518	32,176,444	32,624,074	8,534,998	7,467,703	32,781,307
Sample	Adults	Adults	Women	Men	Non-city non-farm origins	Farm origins	City origins

Standard errors clustered by 1935 state in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table estimates the impact of drought on selection into migration using an alternate drought measure. These results are similar to the results displayed in Table 2 and show that the selection results of this paper are robust to an alternative measure of drought exposure. Sample includes adults (20 to 65 in 1935). Regressions include age and state fixed effects, and individual and county controls as discussed in the context of Equation 1.

Table A5: Propensity of migrants to move to non-city destinations by education and drought: alternate drought measure

	(1) Non-city migrant	(2) Non-city migrant	(3) Non-city migrant
8th to 11th grade ed.	-0.088*** (0.005)	-0.084*** (0.005)	-0.089*** (0.008)
> 11th grade ed.	-0.172*** (0.008)	-0.181*** (0.006)	-0.155*** (0.012)
Moderate drought	0.014 (0.010)	0.015 (0.010)	0.049** (0.020)
Severe drought	0.040*** (0.012)	0.038*** (0.011)	0.101*** (0.024)
(Moderate)x(8th to 11th)	0.019** (0.008)	0.020** (0.007)	0.006 (0.013)
(Severe)x(8th to 11th)	0.022*** (0.008)	0.021*** (0.007)	-0.012 (0.011)
(Moderate)x(> 11th)	-0.001 (0.010)	0.013 (0.010)	-0.009 (0.021)
(Severe)x(> 11th)	0.000 (0.011)	0.013 (0.009)	-0.043*** (0.015)
Observations	7,195,041	4,238,812	2,956,229
Sample	All migrants	Non-city origins	City origins

Standard errors clustered by 1935 state in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table estimates the impact of drought on sorting using an alternative drought measure. These results are similar to the results displayed in Table 3 and show that the sorting results of this paper are robust to an alternate measure of drought exposure. Sample includes migrants (20 to 65 in 1935). Regressions include age and state fixed effects, and individual and county controls as discussed in the context of Equation 2. Regressions include distance to the nearest city as a control.