

Two Population-Environment Regimes in the Great Plains of the United States, 1930–1990

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This paper analyzes factors that affect net migration rates in counties in the U.S. Great Plains between 1930 and 1990, emphasizing the roles of weather (especially drought), environmental amenities, employment, and population, making use of a rich county-level data set. Using a pooled time series model the paper shows that environment is important in population processes, with weather and agricultural change more important in the 1930s and 1940s, and environmental amenities more important in later time periods. The paper provides important insights into how environmental impacts on migration might change over time, and how those changes might be measured.

KEY WORDS: migration; drought; environment amenities; climate; heat; elevation.

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INTRODUCTION

The role of environmental conditions and change in determining migration is a major theme in the scientific literature about population and environment. It is a consistent subject in the pages of this journal (Hunter, 2005), and the topic of a recent book (Unruh, Krol, & Kliot, 2004). In this paper we study migration and environment, specifically in terms of a very large region, the counties of the Great Plains of the United States. We ask what made those counties experience varying levels of net migration from 1930 to 1940 through 1980 to 1990, and we ask about the role of environment in determining those differences. The Great Plains region is especially interesting from this perspective because of its relationship to one of the great natural disasters of the twentieth century, the Dust Bowl of the 1930s. Many researchers believe that the drought and dust storms of that era led to rural out-migration. We confirm that conclusion for the 1930s and 1940s, but the role of environment is not as strong as many would predict. Moreover, the relationship changes after the 1950s and 1960s to one where environment shapes population flows by providing environmental amenities—largely access to recreation—that attract migrants into parts of the region. These findings give us an important sense of the nuanced factors that underlay the movement of population in the U.S. over the past 75 years. These conclusions also determine our title: we see two population-environment regimes in the Great Plains, one operating in the 1930s and 1940s, when environment shaped agriculture and that drove changes in migration, and another operating later, when environmental factors largely operated through recreation.

Most earlier studies of county-level migration in the U.S. have built their hypotheses on long-term trends in social and economic conditions in the country as a whole, together with the characteristics of individual counties. Most have studied only one or two time periods. Our approach is different and broader. First, we are working with all of the decennial time periods from 1930 to 1990, using the same estimation model (we stop in 1990 because of a lack of crucial weather data). Second, we are adding hypotheses based on environmental and weather conditions into our analysis. These additional hypotheses offer an opportunity to extend the debate about both the causes of rural out-migration and the relationship between environment and population dynamics.

The Great Plains are part of the immense natural grassland that stretches across the central part of North America eastward from the Rocky Mountains. Figure 1 shows our study area, and puts it in the context of the

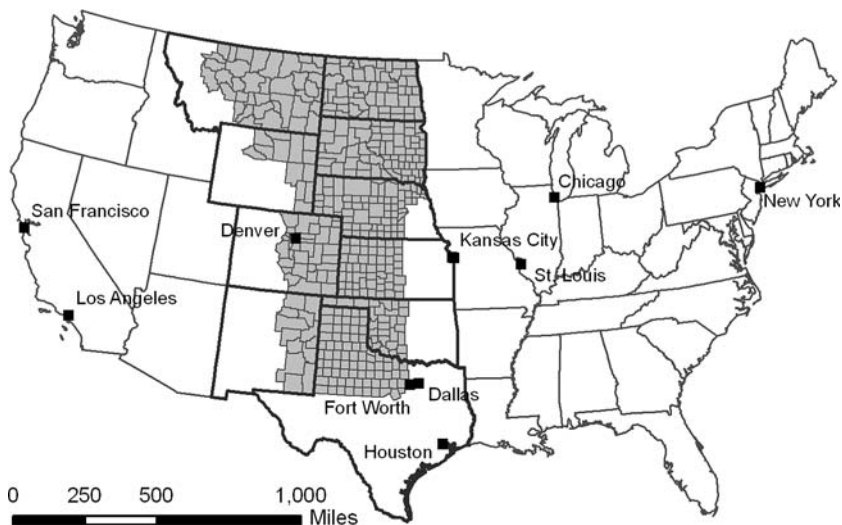


FIGURE 1. The Great Plains Study Area in the Context of the United States.

entire United States. This is one of the most rural regions of the United States, despite the cities on its western edge. In 1990, the region contained more than 14% of all counties in the United States and 17.6% of U.S. land area, but only 3.3% of the nation's population. On the other hand, this spatially large region has for a century produced a very large proportion of the grain and meat consumed in the U.S. The 448 counties that we include in our definition of the Great Plains grew in population by more than 2.5 million persons between 1930 and 1990, an increase of over 45% (by contrast, the entire United States grew by nearly 102% during the same period). Yet that overall growth was accompanied by an estimated net out-migration from the region of nearly two million persons (see Table 1).

Patterns of population change vary across the Great Plains. The region's population growth mostly took place in its Colorado counties (Table 2). Without Colorado, the counties in the other nine states had a negative net migration of nearly three million persons between 1930 and 1990. Counties that were heavily engaged in agriculture have been most likely to lose population. In every decade the 90% of counties with the most agricultural employment in 1990 had negative net migration, while the least agricultural had positive net migration. Over 60 years the most agricultural counties lost more than three million persons to migration, while the least agricultural counties gained more than one million. The overall social and economic history of the region since the 1930s would require a detailed history of its

TABLE 1
Population and Migration in 448 Great Plains Counties

Decade	1930-1940	1940-1950	1950-1960	1960-1970	1970-1980	1980-1990	1930-1990
Population at Start	5,639,256	5,457,761	5,821,146*	6,565,548	6,870,453	7,863,685	
Population at End	5,457,761	5,821,094*	6,565,548	6,870,453	7,863,849	8,194,185	
Natural Increase	487,427	742,095	1,087,010	797,580	678,885	736,456	
Net Migration	-668,922	-378,762	-342,608	-492,675	314,511	-405,956	-1,974,412
Net Migration Rate (/100)	-11.9	-6.9	-5.9	-7.5	4.6	-5.2	
Mean County Net Migration. Rate	-14.4	-13.3	-17.2	-15	-1.9	-11.9	

*The discrepancy in the "Population at End" of the 1940-1950 decade and the "Population at Beginning" of the 1950-1960 decade comes from the value in a single county (Dewey, SD), which has a 1950 population of 6782 in the 1940 data and a 1950 population of 6716 in the 1950 data. Given that we have no evidence to prefer one total over the other, we use the totals as reported.

TABLE 2
Migration in 448 Great Plains Counties, By State

	1930-1940	1940-1950	1950-1960	1960-1970	1970-1980	1980-1990	1930-1990
<i>Net Migration</i>							
Colorado	-9,978	70,696	188,648	221,681	345,526	68,356	884,929
Kansas	-69,109	-46,095	-76,685	-56,264	-20,609	-38,209	-306,971
Montana	-29,093	-26,885	-9,151	-57,707	-2,924	-46,413	-172,173
Nebraska	-100,810	-88,341	-108,721	-57,776	-11,294	-65,390	-432,332
North Dakota	7,923	-5,814	-17,897	-75,508	-8,267	-21,302	-120,865
New Mexico	-106,136	-106,882	-105,006	-95,290	-26,278	-71,952	-511,544
Oklahoma	-138,502	-95,876	-75,809	-38,961	25,380	-65,119	-388,887
South Dakota	-101,553	-66,399	-94,279	-93,942	-36,217	-49,821	-442,211
Texas	-119,973	-7,622	-28,876	-213,510	14,090	-89,852	-445,743
Wyoming	-1,691	-5,544	-14,832	-25,398	35,104	-26,254	-38,615
<i>Net Migration Rate, by State</i>							
Colorado	-1.2	7.8	17.0	14.6	17.6	2.7	
Kansas	-14.2	-10.2	-16.7	-12.4	-4.8	-8.7	
Montana	-8.9	-8.3	-2.7	-14.3	-0.7	-10.6	
Nebraska	-14.8	-14.1	-18.1	-10.0	-2.0	-11.1	
North Dakota	5.0	-2.9	-7.5	-26.7	-3.3	-7.7	
New Mexico	-15.6	-16.6	-16.9	-15.1	-4.3	-11.0	
Oklahoma	-20.9	-16.6	-14.0	-7.3	4.6	-10.5	
South Dakota	-14.7	-10.4	-14.4	-13.8	-5.4	-7.2	
Texas	-12.3	-0.8	-2.6	-16.2	1.1	-6.3	
Wyoming	-1.4	-4.2	-10.2	-15.9	23.0	-12.8	

TABLE 2
(Continued)

	1930-1940	1940-1950	1950-1960	1960-1970	1970-1980	1980-1990	1930-1990
<i>Average Net Migration Rate, Counties</i>							
Colorado	-7.4	-13.2	-13.4	3.9	22.4	2.8	
Kansas	-19.4	-7.3	-19.0	-13.8	-7.4	-10.4	
Montana	-15.6	-15.3	-12.8	-20.4	-4.5	-14.8	
Nebraska	-16.0	-18.7	-20.9	-14.6	-5.2	-13.5	
North Dakota	11.0	-10.9	-20.1	-25.5	-8.1	-8.7	
New Mexico	-19.1	-20.5	-23.1	-21.7	-9.5	-16.5	
Oklahoma	-22.0	-18.5	-19.9	-9.0	4.6	-12.3	
South Dakota	-17.9	-14.0	-18.8	-17.5	-10.3	-13.0	
Texas	-8.3	-5.0	-10.3	-16.0	2.2	-11.4	
Wyoming	-4.4	-10.7	-11.7	-10.6	27.6	-16.8	

own. Beyond rural out-migration (already noted) with its transfer of population from farms and small towns to larger towns and metropolitan areas, the most important changes have been a loss of agricultural employment, a growth of employment in food processing, services, government, education, and health care, some growth of mining and petroleum production, and a growth of recreation as a way of life in areas where the environmental amenities are suitable (Ojima et al., 2002).

Even in a region with the sweeping similarities that characterize the Great Plains (generally rural population, dry climate, reliance on grain and livestock production), there was variation in net migration from 1930 to 1990. Over this time period the overwhelming experience of the counties of the Great Plains has been net out-migration (Figure 2). The mean and median county always lost population, and all but one of the counties at the 75th percentile lost population. Only in the period of time between 1970 and 1980 did a substantial portion of counties actually gain net migrants. Interestingly, more counties had net out-migration during the 1950s than during the 1930s, probably because out-migrants had more potential destinations in the later decade, when post-war industrial growth in the

Net Migration Rate

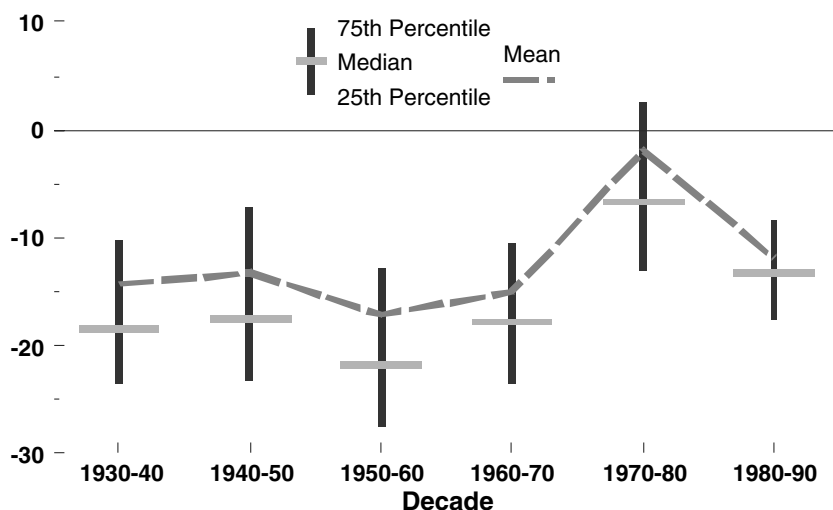


FIGURE 2. Net Migration Rate for Great Plains Counties (per 100 persons at beginning of time period). Positive net migration is inward; negative net migration is outward.

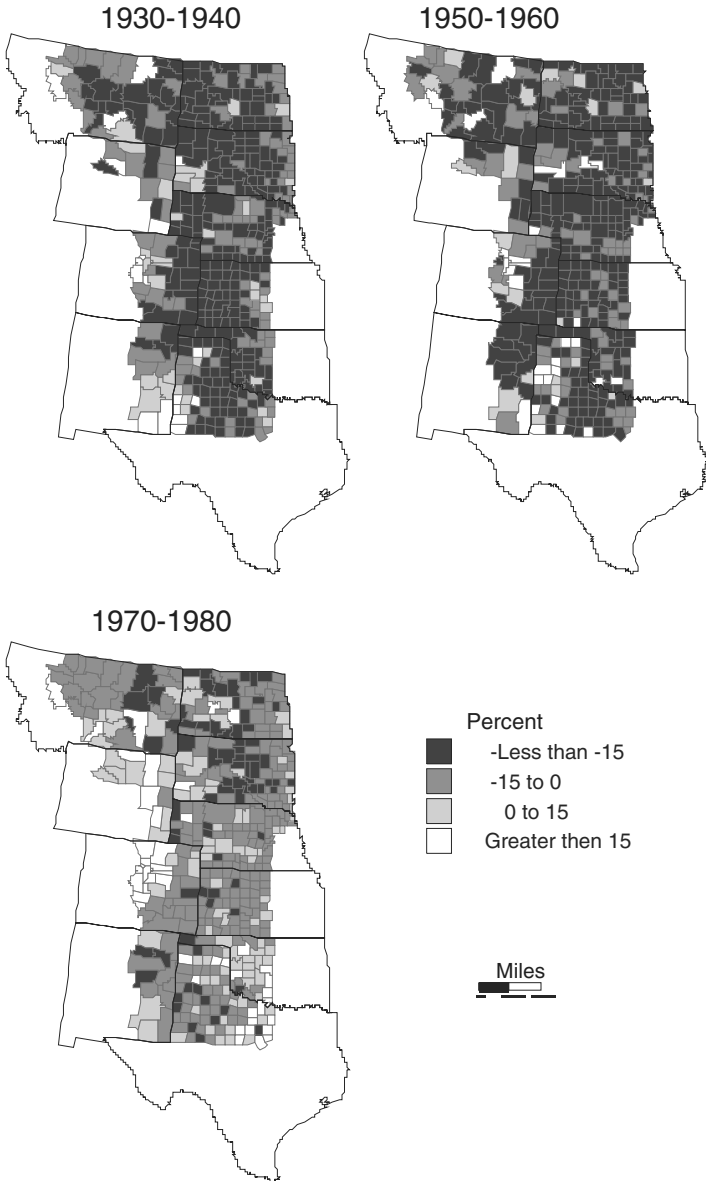


FIGURE 3. Spatial Distribution of Net Migration Rate (per 100 persons at beginning of time period). Positive net migration is inward; negative net migration is outward.

Midwest and California provided opportunities for migrants out of the Great Plains that had not existed earlier. Finally, the distribution of migration outcomes was narrowest during the 1980s. When we look at Figure 3, we see that the geographical distribution of net migration has changed relatively little in three time periods. In these selected decades the biggest change was from mostly out-migration in the 1930s and 1950s to less out-migration in the 1970s. The same conclusion would have been apparent had we mapped the remaining three decades.

The starting point for understanding environmental migration in the Great Plains is the Dust Bowl of the 1930s. The Dust Bowl involved a series of enormous dust storms in a region ranging from southwestern Nebraska through western Kansas, the Oklahoma and Texas panhandles, and eastern Colorado and New Mexico (Gregory, 1989; Gutmann & Cunfer, 1999). A number of historians have documented high rates of out-migration from this area between 1933 and 1935, relating migration patterns to environmental disasters (Carlson, 1991; Hurt, 1981; Worster, 1979). Yet Gregory (1989) shows that the causal argument linking environmental disaster to out-migration relies upon a series of untenable assumptions. The first assumption is that dust storms caused destruction of crops, a fallacy promulgated by the newspapers and magazines of the times (Gregory, 1989). While storms may have generated psychological damage (Sims & Saarinen, 1969), Gregory (1989) points to the roles of droughts, floods, and the boll weevil as more likely culprits. His argument is bolstered by studies of crop failure conducted by Hewes (Hewes, 1965; Hewes & Schmieding, 1956), supported by recent work by Lee and Tchakerian (1995), Gutmann and Cunfer (1999), and Cunfer (2002; 2005). It is not clear that dust storms were the major cause of crop failure, but it is still possible to argue that a combination of drought, economic depression, and difficult social conditions led to a deterioration in the agricultural economy that could have spurred out-migration.

Along with challenging the assumption that dust storms lay behind crop failures, Gregory also challenges the idea that crop failures caused the majority of out-migration (Gregory, 1989). Most of the out-migrants from the Great Plains in his study were not small landowners who lost their crops to environmental disasters, but instead tenant farmers and city dwellers. Many tenant farmers were forced out of farming by landowners eager to cash in on government programs offering financial incentives to remove land from production (Gregory, 1989; Lewis, 1989). In turn, the expulsion of tenant farmers contributed to increasing unemployment and decreasing opportunity in the towns and cities of the Great Plains, because their migration toward town created more competition for scarce jobs. More than

half of the out-migrants in Gregory's sample fled these urban areas of the Great Plains (Gregory, 1989). He also points out the declining importance of agricultural failure for most of the population, and offers alternative explanations for out-migration relying on policy factors and economic depression (Gregory, 1989).

Environmental determinants of migration in the Great Plains go beyond the experience of the Dust Bowl, as our earlier descriptive presentation showed. The variations in time and space that we recognize in Great Plains net migration lead us to develop an approach that recognizes temporal and spatial differences. In any given decade, counties differ from one another, although predictors of these differences may fluctuate. In the next section, we discuss earlier literature on this subject, use that review to establish our approach, and discuss data and statistical methods. In section III we report results, and in section IV we conclude our presentation.

A THEORETICAL AND METHODOLOGICAL APPROACH

Earlier research into migration in the United States since the 1930s provides a compelling narrative about the redistribution of population, especially between metropolitan and non-metropolitan areas. For the period prior to the 1970s, the key issue was out-migration from non-metropolitan areas, which lost population to large cities (Fligstein, 1981; Frisbie & Poston, 1978). At the national scale, this pattern was fueled by the declining profitability of farming; the mechanization of agriculture and loss of jobs; the restructuring of the labor force provoked by the Second World War; and the post-war urban, suburban, and industrial boom that lasted into the 1960s. At the regional scale of the Great Plains, these problems were made more severe by drought in the 1930s and 1950s, and by the relative lack of large industrial cities that could attract population within the region. The decade of the 1970s constitutes a distinct migration time period. During the 1970s there appeared to be a "turnaround", in which non-metropolitan areas gained population (Brown & Wardwell, 1980; Fuguitt, 1992; Fuguitt & Beale, 1984; Fuguitt & Beale, 1995; Fuguitt, Pfeffer, & Jenkins, 1985; Jobs, Stinner, & Wardwell, 1992; Richter, 1985; Wheat, Wardwell, & Faulkner, 1984). The metropolitan turnaround apparently lasted little beyond the decade of the 1970s, as the economic reversals of the 1980s led to a new period of net out-migration from rural and agricultural counties, which has continued through the 1990s and beyond (Frey and Speare, 1992; Albrecht, 1993; McGranahan and Beale, 2002; Johnson and Rathge, 2006).

We place our work into context through the social scientific literature linking migration to environment, which has a number of interesting themes. We especially emphasize the strongest of those themes, which link environmental disasters and environmental amenities to migration. We are less interested in the question of environmental hazards, because hazards do not appear to be an important determinant of migration in the region we study (Hunter, 1998; Hunter, 2005). Environmental disasters result from disruptions in human ecological conditions making it difficult to sustain human settlement in a given location. Environmental amenities are properties of locations that attract migrants. We argue that the character of environmental influence on migration has shifted from a strong causal relationship between disasters and out-migration to a strong causal relationship between amenities and in-migration.

Following Hewes (1965), we hypothesize a shift away from environmental disasters as determinants of migration patterns, in part because of the importance of technological adaptation in reducing the impact of environmental disasters on crop success, and government policies in reducing financial risks to farmers (Hewes & Schmiedling, 1956; Borchert, 1971). Although most of Gregory's (1989) argument is about recasting the story of the single time point of the Dust Bowl, and not about change over time, he emphasizes the long-term and steady decline in the proportion of the population in agriculture, and therefore at risk of crop failure due to environmental hardship.

Unlike environmental disasters, which occur in the short term, environmental amenities reflect long-term differences in recreational and lifestyle benefits offered by various locations. Ullman's (1954) early treatment of amenities as a factor in migration considers the role of climate in the choice of migrant destinations (Svart, 1976; Ullman, 1954). Twenty years later, Svart (1976) reviewed the state of migration theory with respect to the environment in the geographic literature. Svart finds support for a variety of environmental influences on migration, and surveys indicate they rank highly as criteria for choosing migration destinations. In order of importance, positive criteria include high job availability, low to mid-level population density, warmth and sun exposure of winter climate, mountainous topography, natural vegetation, coolness and dryness of summer climate, presence of lakes and rivers, and nearness to the seacoast (Svart, 1976). People weigh these factors in their migration decisions. For instance, an avid skier may choose to forego a certain amount of the income she might earn by remaining in Illinois in order to move to Colorado for a lower-paying job and easy access to the mountains (Jobes, 1992).

At the same time that Svart was surveying the geographical literature, a group of authors in regional economics (Graves, 1976, 1980, 1983; Graves & Knapp, 1989; Graves & Waldman, 1991; Mueser & Graves, 1995) began to develop new approaches to understanding the role of climate and amenities in migration decisions. These authors innovated on economic models of demographic behavior by adding the concept that the demand for, availability, and price of "location-specific goods" (Graves & Linneman 1979, p. 383) is a measurable determinant of migration. What these authors have concluded is that both social and natural amenities contribute to migration, with desirable metropolitan areas and counties attracting migrants. Most of this work has focused on single time periods, with a few valuable exceptions (Mueser & Graves, 1995) that show change over time.

Also in the 1970s, migration trends in the United States shifted from a net metropolitan gain to a net non-metropolitan gain. A number of authors emphasize the importance of environmental factors in the urban to rural migration revolution (Jobes, Stinner, & Wardwell, 1992). On the other hand, Mueser (1989) points out that long-term environmental characteristics specific to migration destinations fail to explain *changes* in migration patterns. Environmental characteristics themselves change only slowly, if at all. As a result, changes in the influence of environmental characteristics on migration must result either from changes in human preferences, changes in the economic or social context, or changes in the technology and infrastructure allowing humans to better act upon preferences (Mueser, 1989; Wardwell, 1980, 1992).

Few theorists have argued that there has been an intrinsic change in environmental preferences over time, and Svart (1976) asserts a biophysical basis for assuming that most preferences remain constant. Baltensperger (1991), confirming this, shows a preference for low-lying areas within counties (as opposed to the preference for counties at higher elevations that we will see in our results) as part of the long-term loss of rural population in the Great Plains. What is likely is that the context in which people have been able to act on their environmental preferences has changed. One way that we might see this is in the distinctive behavior of the older population, which because of increasing life-spans and more secure retirement incomes have been able to choose different migration paths than those in the working population (Graves & Waldman, 1991; Walters, 1994). A second way that constant preferences have been manifested in new behavior is in the rise in migration to recreational destinations, enabled by greater overall prosperity and other factors (Beale & Johnson, 1998; Johnson & Beale, 2002; Johnson & Fuguitt, 2000; McGranahan, 1999). A third explanation for the increasing importance of environmental factors relies upon changes in

human technology and infrastructure. These changes somehow alter the balance between environmental and other factors impinging upon migration decisions (Richter, 1985; Wardwell, 1980, 1992), for example the role of air conditioning in allowing greater population densities in hot locations (Sell, 1992; Wardwell, 1992), or the improvement of communications leading to the growth of population in remote but otherwise desirable locations (Fuguitt & Brown, 1990; Millward, 1996; Richter, 1985). In turn, technological and infrastructural changes also lead to the re-structuring of local economies, further increasing the flow of in-migrants to newly desirable locations (Graves and Waldeman, 1991; Mueser and Graves, 1995; Svart, 1976; Wardwell and Gilchrist, 1980).

This summary of ways of looking at the role of environment in determining migration outcomes helps shape our approach. Gregory (1989) and Hewes (1965) provide a justification for challenging an established set of generalizations about the role of heat and drought in driving migration, both in the 1930s and later, by arguing that other factors spurred out-migration, and that the impact of these factors should have diminished over time. We also draw from the literature on environmental amenities as forces driving migration to test that role. We bring this analysis into context by asking about other structural elements in the rural population, such as the role of employment, education, and population size. In effect, we ask two questions each about weather and amenities: first, did they play a measurable role in determining levels of net migration in Great Plains counties, and second, did their roles change over time? Although we know a great deal about environment and migration, the combination of these factors and the set of questions about changing roles over time are what makes this analysis significant.

Data

The data used in this study are part of a database of county-level information that describes the population, social conditions, land use, agriculture, and environment of the Great Plains from about 1870 until the recent past (Gutmann et al., 1998; Gutmann, 2000; Gutmann, 2005a, b). While political units, counties, constitute the unit of analysis, we define our region of study primarily in terms of natural conditions. We set its boundaries on the east approximately at the line of 700 mm of average annual precipitation, and on the west at 5000 feet of elevation. Much of the Great Plains is a high plain, more than 2000 feet above sea level and sloping upward as it moves west. We bound the Great Plains on the north at the Canadian border, and on the south in Texas and New Mexico at the

32nd parallel. We use data from 448 counties. Because of boundary changes over the duration of the study period, we group two sets of counties: Jackson and Washbaugh, South Dakota (which we call the Jackson aggregation), and Adams, Arapahoe, Denver, and Jefferson Counties, Colorado (which we call the Denver aggregation). These groupings leave us with 444 units for the regression analyses. By choosing a large region that is overwhelmingly rural and has a climate that falls within a well-defined range, we get the simultaneous benefit of being able to control the research setting while still having it represent a large portion of the United States, with potential implications for other grasslands in the developed world.

Counties are a natural small-scale unit of analysis for a study of net migration because migration is typically defined as a residential change that crosses a county boundary (Long, 1988). Environmental characteristics, like temperature and precipitation, are not so naturally scaled to county boundaries. As a consequence, county values of these variables will tend to be correlated, thus violating assumptions of our regression analysis. We account for this violation through our panel-corrected standard errors that allow for contemporaneously (that is, spatially) correlated errors.

Dependent Variable

The dependent variable in our analyses is an estimate of decennial net migration for counties, for the decades from 1930 to 1940 through 1980 to 1990 (Bowles et al., 1975; Gardner & Cohen, 1992; U.S. Bureau of the Census, nd; White, Mueser, & Tierney, 1987). We must use estimates of net migration, and not actual net migration or more detailed data about in-migration or out-migration, because the United States does not register migration. Although the U.S. Census has asked a question about migration since 1940, the responses to that question are not useful for this analysis, because they do not always measure the same process (some indicate five year migration, some one-year), because they do not always reflect the same universe, and because they were not always tabulated into the same aggregate measures. The estimates of net migration that we use are constructed slightly differently for each decade, but they share certain assumptions. Except for the most recent decade, the estimates of net migration are based on projecting forward the enumerated county population divided by age, sex, and race at the beginning of the period, and then comparing it with the enumerated county population at the end of the period. The forward projections make use either of estimates of fertility and mortality for the county based on national-level data, or known levels of fertility and mortality in the county based on vital registration. We assume

that the difference between the actual end-period population and the result of the projection represents net migration. The estimates of net migration begin with 1930, the first year since 1860 that the Census Bureau published county-level population data disaggregated by age, sex, and race. Data for the most recent decade, 1980–1990, are based on a Census Bureau compilation of the “components of change” for that period (U.S. Bureau of the Census, nd). The authors of this compilation of data simply added the births and subtracted deaths from the initial population of each county, added estimates of enumeration error, and compared the result with the enumerated population for the county in 1990.

We report the net migration rate as a percentage of the population at the beginning of the decade. A *positive* net migration rate indicates that the population of the county increased by that percentage *due to migration* during the decade; a *negative* net migration rate, indicates that the population of the county decreased by that percentage due to migration during the decade. Importantly, positive net migration does not suggest that all migration characterizing a particular county was inward. A positive value means that there were more in-migrants than out-migrants, while a negative value means that there were more out-migrants than in-migrants. The net migration rate is a *relative measure*. It summarizes the portion of population increase in a county that is due to migration. As a rate, its value is dependent on the overall balance of migration (the number of out-migrants subtracted from the number of in-migrants) as well as the population at the beginning of the period. It is also a *summary measure*, so that substantially different migration streams can produce the same result. As an example, a net migration rate of 10%, in a county of 1000 persons, could be the product of 100 persons moving in, and no one leaving, or 400 in-migrants and 300 out-migrants.

Independent Variables

Our goal in this paper is to present parsimonious models of the factors that are associated with net migration in the Great Plains, focusing on short and long-term precipitation and temperature variation, environmental amenities, employment, and a group of general demographic variables. Our variables fall into four general categories. (1) long term patterns and change in temperature and precipitation; (2) environmental amenities; (3) employment conditions; and (4) population, including sex ratio, level of education, and population size. In all cases, our independent variables refer to the county’s characteristics at the beginning of the decennial period (for example, percent employed in agriculture), or to the change in the characteristic for the period (change in percent employed in agriculture in the

decade), except for the long-term natural conditions, for which we measure no change. These data are drawn from a variety of sources (shown in Table 3), with descriptive statistics reported in Table 4. This is a small group of variables and a parsimonious approach, which we arrived at after attempting a number of other strategies that used larger groups of variables but never produced results that were either more easily interpretable or accounted for an appreciably higher proportion of variation in the dependent variable.

Environmental data: Temperature and precipitation. We hypothesize that if there is a relationship between migration and environment that acts through agriculture, it should be measurable in terms of temperature and precipitation. In order to test that hypothesis, we differentiate between counties in terms of their long-term average temperature and precipitation, and over time within counties in terms of their temperature and precipitation deviations from the long-term average. The climate history data we have are drawn from the VEMAP database (Kittel et al., 1995; Kittel et al., 1997), which divides the U.S. into a half-degree by half-degree grid, and assigns daily or monthly weather characteristics to each of the cells of the grid. We have averaged monthly grid values for each county, then summed monthly precipitation values into annual totals, and averaged monthly minimum and maximum temperature values into annual averages. Because these data do not extend as late as the year 2000, we are unable to extend our analysis beyond the year 1990.

Environmental data: Amenities. Recent literature on amenities has defined a variety of measures of locational desirability, essentially including climate and proximity to recreation and social and economic infrastructure (Graves, 1976; Johnson & Beale, 2002; McGranahan, 1999; Mueser & Graves, 1995). All of these approaches have considerable merit. Because we use climate and weather variables in other ways, and because we have chosen a region with limited variability in how those concepts can be used to define desirable places to live, we have not made use of them in our analysis. In order to keep our approach simple, we have chosen two variables, one that takes elevation as an attribute, and the other that takes the area of water bodies as an attribute. These capture proximity to mountains and proximity to opportunities for boating, which are reasonable ways to measure access to environmental amenities. The data are derived from standard U.S. Geological Survey digital representations of elevation and natural features in the 1990s, with county boundaries overlaid. These variables are time-invariant, meaning that they represent a static moment in time. This is not a problem for elevation, but

TABLE 3
Independent Variables Used and their Sources

Variable	Definition	Source
<i>Temperature/Precipitation</i>		
Long-term average temperature	County average temperature, 1930–1990	Computed from VEMAP data
Decennial temperature deviation	Difference between long-term average temperature and decennial average temperature	Computed from VEMAP data
Long-term average precipitation	County average precipitation, 1930–1990	Computed from VEMAP data
Decennial precipitation deviation	Difference between long-term average precipitation and decennial average precipitation	Computed from VEMAP data
<i>Environmental Amenities</i>		
Mean County Elevation	Mean elevation of county	Computed from USGS Digital Elevation Model - USGS no date.
Bodies of water	Area of the county covered by bodies of water	Computed from DLG files from USGS 1990.
<i>Employment</i>		
Employed in Agriculture, previous decade	Percent of all employed persons in agriculture	Census of population
Change in % Employed in Agriculture	Change in % employed in agriculture over decade	Census of population
Percent unemployed	Percent of total labor force (employed + unemployed) that are unemployed	Census of population
Change in % unemployed	Change in % unemployed over decade	Census of population
<i>Population</i>		
College education*	Persons aged 25+ with college education	Census of Population

TABLE 3
(Continued)

Variable	Definition	Source
Sex Ratio	Ratio of males per 100 females	Census of population
Population size	Total population size	Census of population

*No college education data exist for 1930, when educational attainment was not a census question. We use 1940 data for 1930.

Sources of Census data, by year:

1930: U.S. Department of Commerce 1933; ICPSR 1972. Haines and ICPSR 2005.

1940–1950: ICPSR 1972; Haines and ICPSR 2005; U.S. Department of Commerce 1978.

1960: U.S. Department of Commerce 1978.

1970: U.S. Department of Commerce 1978; U.S. Department of Commerce 1973.

1980: U.S. Department of Commerce 1988; U.S. Department of Commerce 1981.

1990: U.S. Department of Commerce 1992; U.S. Department of Commerce 1993.

there is a small but immeasurable likelihood for the water body data in that it overestimates their presence in the small number of cases where a man-made lake was created between 1930 and 1990, as a number were.

Employment data. Beside the impact of environment on population through agriculture, we hypothesize that there has been a more direct impact of employment conditions on migration, with declines in agricultural employment and increases in unemployment leading to out-migration. Again, we measure the relative differences between counties by taking the percent employed in agriculture and the percent unemployed at the beginning of each decade, and the change within decades as an indicator of change.

Population data. Our final set of independent variables capture other, more general characteristics of the population, specifically the proportion of the population aged 25 that has a college education, the sex ratio of the population, and the overall population size of the county. We expect, based on other analyses, that counties with a large proportion college-educated will generally have large streams of in-migrants. The sex ratio and population size variables allow us to determine whether counties with divergent size or sex structure have different migration characteristics.

Statistical approach. Our data represent 444 counties/county units observed over six time periods. Under this data structure (many cross-sectional units and few time periods), we expect ordinary least squares is not optimal because (1) the error process is likely to differ from one county to

TABLE 4
Descriptive Statistics for Dependent and Independent Variables*

	1930-40	1940-50	1950-60	1960-70	1970-80	1980-90	All Years
<i>Dependent Variable</i>							
Net Migration Rate	-14.4	-13.3	-17.2	-15.0	-1.9	-11.9	-12.3
<i>Independent Variables</i>							
<i>Environment</i>							
Long-term average temperature	10.24	10.24	10.24	10.24	10.24	10.24	10.24
Decennial temperature deviation	0.47	-0.02	0.03	-0.21	-0.34	0.06	0.00
Long-term average precipitation	495.69	495.69	495.69	495.69	495.69	495.69	495.69
Decennial precipitation deviation	-65.94	34.55	-19.11	15.09	9.63	26.02	0.00
Mean County Elevation (meters)	830	830	830	830	830	830	830
Area of water bodies	0.68	0.68	0.68	0.68	0.68	0.68	0.68
<i>Employment</i>							
% Employed in Agriculture	54.5	47.7	42.5	33.8	26.3	22.9	37.9
Change in Ag. employment	-6.7	-5.3	-8.7	-7.5	-3.4	-2.8	-5.7
% Unemployed	2.4	7.4	3.0	3.6	3.3	3.6	3.9
Change in unemployment	5.0	-4.4	0.6	-0.3	0.3	1.1	0.4
<i>Demographic Covariates</i>							
Current Population	12,701	12,292	13,111	14,787	15,461	17,711	14,344
Sex Ratio (males/100 females)	113	110	108	103	99	99	105
Percent with college education**	3.46	3.46	4.29	5.37	7.42	11.91	5.99

* All values are for start of period except those representing change or long-term natural conditions.

** No data for college education reported for 1930. 1940 data substituted for analysis.

the next (panel heteroscedasticity), (2) the errors for a particular county at one time period are related to the errors for that county at any other time, a violation of the assumption of no serial correlation, and (3) the errors for a county are related to the errors for other counties, a violation of the assumption of no spatial correlation. These are typical panel error assumptions (Beck & Katz, 1995). We report OLS estimates of the pooled cross-sectional time series model parameters, but replace the OLS standard errors with panel-corrected standard errors. Monte Carlo analysis by Beck and Katz (1995) shows that these new estimates of sampling variability are very accurate, even in the presence of complicated panel error structures. Beck and Katz argue that this method is superior to alternative estimators, including the feasible generalized least squares (FGLS) used by many software packages for pooled cross-sectional time series.

The term panel-corrected standard errors is used because the standard errors include the variance matrix estimated under the panel assumptions of the error terms. Our panel-corrected standard errors, estimated via STATA's XTPCSE procedure, allow for serial autocorrelation of the errors between panels and contemporaneous correlation of the errors (and perforce heteroscedasticity) within panels (StataCorp, 2005). The correction for contemporaneous correlation of the errors is important because the likelihood of spatial dependence among migration destinations and large-scale environmental conditions. As a result, we do not have to make use of specifically spatial econometric techniques; although in parallel analyses we included decade-specific spatial lag terms, Wy_t (Anselin, 1988), and these did not appreciably change the coefficients on the independent variables. Our ability to incorporate panel heteroscedasticity is also important in light of the between-state variability in net-migration rates shown in Table 2. In most decades the estimate of the spatial autoregressive parameter, $\hat{\rho}_t$, did not attain statistical significance.

Panel-corrected standard errors are a version of the sandwich covariance estimator (Huber, 1967; White, 1980). Indeed the form of the variance of the OLS estimates

$$\text{Cov}(\hat{\beta}) = (X'X)^{-1}(X'\Omega X)(X'X)^{-1}$$

will be recognized by all who are familiar with White's heteroscedasticity-consistent standard errors (or robust standard errors in the language of STATA software). Where they differ is that the covariances of the errors are collected within each panel rather than across all NT observations (as though these were all independent observations). This can be seen in the covariance matrix of the errors

$$\hat{\Omega} = \frac{(E'E)}{T} \otimes I_T,$$

where \mathbf{E} denotes the $T \times N$ matrix of OLS residuals and $\hat{\Omega}$ is an $NT \times NT$ block diagonal matrix with an $N \times N$ matrix of contemporaneous covariances

$$\hat{\Sigma} = \frac{(E'E)}{T}$$

along the diagonal. Thus the name “panel-corrected.”

We begin our analyses with a relatively simple regression model that pools time periods and fits constant slopes for the independent variables over time. From that we draw conclusions about the overall attributes of each independent variable, and show the necessity to allow slopes to vary over time for the environmental independent variables. In the final phase of the analysis we allow these slopes to vary and draw conclusions about the changing role of different kinds of environmental variables over time.

We interpret the decade-specific intercepts in the constant slopes model (reported in Table 5) as the expected levels of net migration for an average county. We can give this interpretation because all environmental and employment variables have been mean-centered and the decade-specific intercepts have been recalculated with the reference period so that they no longer reflect deviations from the reference period.

We investigate varying slopes by adding interactions between the environmental variables and each decade, keeping the two central decades—the 1950s and 1960s—as the omitted category. The magnitude and sign of the decade interactions, and the statistical inference on these interactions, only signal deviations in effects from the reference period. Our interest is quantifying, comparing, and making statistical inference on, the decade-specific effects of environmental variables. To do this, we construct the decade-specific effects by adding each of the decade interactions to its main effect (the 1950's and 1960's effect) and derive their standard errors from the well-known formula for the variance of a sum. For the k th independent variable in the t th time period, this is given by

$$\text{s.e.}(\beta_{k,t}) = \sqrt{\text{Var}(\hat{\beta}_{k,1950-70}) + \text{Var}(\hat{\beta}_{k,t}) + 2\text{Cov}(\hat{\beta}_{k,1950-70}, \hat{\beta}_{k,t})}.$$

The decade-specific effects, their standard errors, and z-ratios of effects are labeled “True Effect of Variable for Time Periods” in Table 7. We also report the covariances between the main effects and their decade interactions (used in the formula given above) in Table 7 because, unlike the variances that are the squared standard errors of the regression coefficients

TABLE 5

Estimated Regression Model of Net Migration Processes in Great Plains Counties—Pooled Model without Interactions

	Unstandardized Regression Coefficient <i>B</i>	Standardized Regression Coefficient β	<i>Z</i>
<i>Temperature/Precipitation</i>			
Long-term mean temperature	-0.26	-0.06	-1.37
Temperature deviation	-5.89	-0.10	-1.87
Long-term mean precipitation	0.01	0.09	0.74
Precipitation deviation	-0.00	-0.01	-0.15
<i>Environmental Amenities</i>			
Mean elevation	0.01	0.16	1.63
Area in bodies of water	0.01	0.01	0.70
<i>Employment</i>			
% Employed in Agriculture	-0.54	-0.53	-9.24
Change—% Employed in Agriculture	-1.28	-0.40	-9.26
% Unemployed	-1.62	-0.24	-4.37
Change—% Unemployed	-0.61	-0.11	-1.86
<i>Population</i>			
Current Population	0.00	-0.02	-0.54
Sex Ratio	0.09	0.04	0.76
Percent Attended College	0.95	0.19	2.61
<i>Decade Dummies</i>			
1930s	-2.05		-13.28
1940s	-2.64		-12.02
1950s–1960s	-19.56		-23.41
1970s	-8.92		-22.84
1980s	-20.88		-8.25
$R^2 = 0.35$			
$\chi^2_{\text{Wald}} = 2738$			
Probability $> \chi^2_{\text{Wald}} = 0.00$			
Number of cases = 2664 (444 per decade)			

Z-values significant at ≤ 0.10 , two-tailed test, are indicated in bold.
Calculation of Beta (β) is described in the text.

reported under the column “Model as Estimated,” these are not directly available as standard regression output.

We then convert these decade-specific regression coefficients to standardized (Beta) coefficients by multiplying the decade-specific effect by the ratio of the decade-specific standard deviation of the independent variable

TABLE 6

**Five-Period Model Standardized Coefficients for Single-Decade Models,
Environmental Variables only**

	β	Total Beta		β	Total Beta
1930–1940			1960–1970		
<i>Temperature/Precipitation</i>		0.84	<i>Temperature/Precipitation</i>		0.23
Long-term mean	-0.19		Long-term mean	-0.07	
temperature			temperature		
Temperature deviation	-0.18		Temperature deviation	-0.13	
Long-term mean	0.30		Long-term mean	0.12	
precipitation			precipitation		
Precipitation deviation	0.18		Precipitation deviation	-0.10	
<i>Environmental Amenities</i>		0.05	<i>Environmental Amenities</i>		0.20
Mean elevation	0.08		Mean elevation	0.20	
Area in bodies of water	-0.03		Area in bodies of water	0.00	
1940–1950			1970–1980		
<i>Temperature/Precipitation</i>		0.61	<i>Temperature/Precipitation</i>		
Long-term mean	0.18		Long-term mean	-0.09	0.40
temperature			temperature		
Temperature deviation	0.16		Temperature deviation	0.02	
Long-term mean	-0.36		Long-term mean	0.32	
precipitation			precipitation		
Precipitation deviation	0.09		Precipitation deviation	0.01	
<i>Environmental Amenities</i>		0.14	<i>Environmental Amenities</i>		0.46
Mean elevation	-0.11		Mean elevation	0.42	
Area in bodies of water	-0.04		Area in bodies of water	0.04	
1950–1960			1980–1990		
<i>Temperature/Precipitation</i>		0.27	<i>Temperature/Precipitation</i>		0.14
Long-term mean	-0.06		Long-term mean	0.04	
temperature			temperature		
Temperature deviation	-0.21		Temperature deviation	0.07	
Long-term mean	0.10		Long-term mean	0.24	
precipitation			precipitation		
Precipitation deviation	-0.11		Precipitation deviation	0.01	
<i>Environmental Amenities</i>		0.18	<i>Environmental Amenities</i>		0.46
Mean elevation	0.18		Mean elevation	0.33	
Area in bodies of water	0.00		Area in bodies of water	0.13	

Beta shown in bold when z-value for the regression coefficient is significant at ≤ 0.10 , two-tailed test, in Table 7.

Calculation of Beta (β) and Total Beta is described in the text.

TABLE 7

Estimated Regression Model of Net Migration Processes in Great Plains Counties. Five-Period Model

	Model as Estimated			True Effect of Variable for Time Periods			Cov(B _k , 1950-70, B _{k,t})
	Coefficient	SE	Z	Coefficient	SE	Z	
Long-term mean temperature	-0.28	0.26	-1.07			-1.07	
1930s interaction	-0.73	0.46	-1.58	-1.01	0.34	-2.96	-0.08
1940s interaction	1.13	0.67	1.68	0.85	0.59	1.44	-0.09
1970s interaction	-0.22	0.44	-0.49	-0.50	0.35	-1.41	-0.07
1980s interaction	0.39	0.49	0.79	0.11	0.42	0.25	-0.07
Temperature deviation	-14.02	2.73	-5.14			-5.14	
1930s interaction	-5.57	5.70	-0.98	-19.58	5.17	-3.79	-6.58
1940s interaction	37.63	18.97	1.98	23.61	18.85	1.25	-6.04
1970s interaction	18.83	7.89	2.39	4.81	7.28	0.66	-8.29
1980s interaction	17.05	6.86	2.49	3.04	6.25	0.49	-7.71
Long-term mean precipitation	0.02	0.02	1.00			1.00	
1930s interaction	0.04	0.03	1.50	0.06	0.02	2.53	0.00
1940s interaction	-0.08	0.03	-2.96	-0.06	0.02	-2.69	0.00
1970s interaction	0.04	0.03	1.68	0.06	0.02	2.74	0.00
1980s interaction	0.01	0.03	0.25	0.03	0.03	0.83	0.00
Precipitation deviation	-0.09	0.03	-2.92			-2.92	
1930s interaction	0.24	0.06	3.74	0.15	0.06	2.66	0.00
1940s interaction	0.17	0.07	2.54	0.08	0.06	1.36	0.00
1970s interaction	0.10	0.07	1.41	0.01	0.06	0.17	0.00
1980s interaction	0.09	0.10	0.92	0.00	0.09	0.03	0.00
Mean elevation	0.01	0.00	2.48			2.48	
1930s interaction	0.00	0.00	-0.71	0.00	0.00	0.93	0.00
1940s interaction	-0.01	0.00	-3.04	0.00	0.00	-1.41	0.00
1970s interaction	0.01	0.00	3.17	0.02	0.00	5.39	0.00
1980s interaction	0.00	0.01	0.23	0.01	0.01	1.66	0.00
Area of bodies of water	0.00	0.00	0.18			0.18	
1930s interaction	-0.03	0.01	-2.36	-0.03	0.01	-2.34	0.00
1940s interaction	-0.03	0.01	-4.83	-0.03	0.01	-4.20	0.00
1970s interaction	0.03	0.00	9.64	0.03	0.00	7.66	0.00
1980s interaction	0.06	0.01	8.27	0.06	0.01	8.45	0.00

TABLE 7
(Continued)

	Model as Estimated			True Effect of Variable for Time Periods		
	Coefficient	SE	Z	Coefficient	SE	Z
% Employed in agriculture	-0.56	0.06	-9.01			
Change—% Emp. in ag.	-1.30	0.14	-9.40			
% Unemployed	-1.73	0.37	-4.65			
Change—% Unemployed	-0.97	0.32	-3.05			
<i>Current Population</i>	0.00	0.00	-0.39			
Sex Ratio	0.11	0.10	1.07			
Percent attended college	0.83	0.35	2.34			
1930s	27.25	15.11	1.80			
1940s	51.79	12.97	3.99			
1950s–1960s	-27.98	16.91	-1.65			
(Omitted)						
1970s	-15.79	11.72	-1.35			
1980s	-9.61	20.38	-0.47			
$R^2 = 0.41$						
$\chi^2_{\text{Wald}} = 742,000,000$						
Probability $> \chi^2_{\text{Wald}} = 0.00$						

Z-values significant at ≤ 0.10 , two-tailed test, are indicated in bold. Calculation of decade-specific effects, standard errors, and z-ratios under "True Effect of Variable for Time Periods" is described in text.

to the decade-specific standard deviation of net migration. We are able to calculate unique 1950–1960 and 1960–1970 Betas because they are derived from decade-specific standard deviations (even though these decades share estimated regression coefficients). These standard deviations are not reported but are available from the authors upon request. In addition to the decade-specific Betas, Table 6 presents what we call a "Total Beta" separately for the temperature/precipitation variables, and for the environmental amenities variables. For environmental amenities, Total Beta is the absolute value of the sum of the Betas on mean elevation and area in bodies of water. Because we expect temperature and precipitation to work in opposite directions, we reverse sign on either temperature or precipitation

variables, then calculate Total Beta as the absolute value of the sum of the Betas.

RESULTS

We begin our discussion of results by considering a relatively simple regression model, in which we have used the panel-correlated standard errors approach with time-period dummies, referencing the transitional 1950 and 1960 decades, but to which we have not introduced time-period specific interactions. In effect, these results (Table 5) present the pooled main effects for our independent variables, while allowing decade-specific differences in the level of net migration. If we start by looking only at the signs of the coefficients, without yet emphasizing statistical significance, we draw a series of conclusions. Looking at the environmental variables, we see that over the entire six-decade time period, our hypothesis about temperature deviation (hot weather leads to out-migration) holds, while that about precipitation deviation (less rainfall leads to out-migration) does not. On the other hand, our generalization that higher elevation and areas with water that might be suitable for recreational use and are therefore desirable for migrants have signs that conform to our expectations: more water and higher elevation generally lead to in-migration. When we then turn to the employment variables, we see that all four have the expected sign. Greater out-migration is associated with more labor force employed in agriculture, increases in agriculture, more unemployment, and increases in unemployment. Finally, while the size of the county has a negative effect (large counties lost population), we see that counties with large proportions who have attended college generally have inward migration.

Once we consider statistical significance and magnitude of effects (as shown in the scale of the Betas), we see that some county characteristics have a much stronger correlation with net migration than others. The strength of the employment variables stands out most, along with the weakness of the environmental variables (with marginal significance for temperature deviation and the average elevation). The strength of the college education variable suggests that counties have attributes that attract population in general that are highly correlated with attributes that attract a college-educated population.

If the effects of environment and employment are constant over our study period, the expected levels of net migration, the decade-specific intercepts, in Table 5 will match the mean levels of net migration shown previously in Figure 2. Although the expected values of net migration in Table 5 reveal considerable instability, as we saw in Figure 2, the expected

levels in Table 5 do not closely match the observed means in Figure 2. The explanation must be that the effects of independent variables are different at different periods. We next investigate varying slopes by adding interactions between the environmental variables and each decade.

We begin by discussing a subset of results as reported in Table 6, which is drawn from the full model results reported in Table 7. Our goal in Table 6 is to provide an efficient way to compare the results of the decade-specific environmental interactions, at the same time allowing us to make an argument about the changing level of importance of environmental hardship variables (temperature and precipitation), compared to the environmental amenity variables. Thus, in addition to the decade-specific Betas for the six environmental variables, Table 6 presents "Total Betas" separately for the temperature/precipitation variables, and for the environmental amenities variables.

In evaluating the temperature and precipitation variables, we are primarily interested in those labeled "deviation," because we assume that what matters from decade to decade is the extent to which rainfall and heat varied from the six-decade norm. Here the results show that there are significant coefficients only for the 1930s and the combined 1950s and 1960s, suggesting that there is a connection between migration and weather that was significant in those decades with the most problematic weather. Turning to the amenities variables, we see that elevation is positive and significant from the 1950s through the 1970s, while area in water bodies is positive (as we predict) and significant in the 1970s and 1980s.

One of our goals in this paper is to compare the relative importance and trend of the temperature and precipitation variables, in contrast with the environmental amenities variables, based on the models with interactions. The "Total Betas" (Figure 4) allow us to see both the absolute level and trend in the two sets of environmental variables over time. While the trend isn't always monotonic, what is clear is that the combined coefficients for weather variables were generally declining from the 1930s to the 1980s (with a brief surge in the 1970s), while the combined coefficients for the amenities variables were generally increasing from the 1930s to the 1980s. This rough calculation leads to an important set of conclusions to which we return later.

Adding the decade-specific environmental interactions to the model (Table 7) does more than improve the overall fit and allow us to show the temporal change in importance of different environmental variables. We see a more consistent pattern in the employment variables (all are negative and significant), and in the importance of the college-educated population, and we see that the decade dummies are no longer significant, except for the 1940s. These improvements confirm the value of adding the

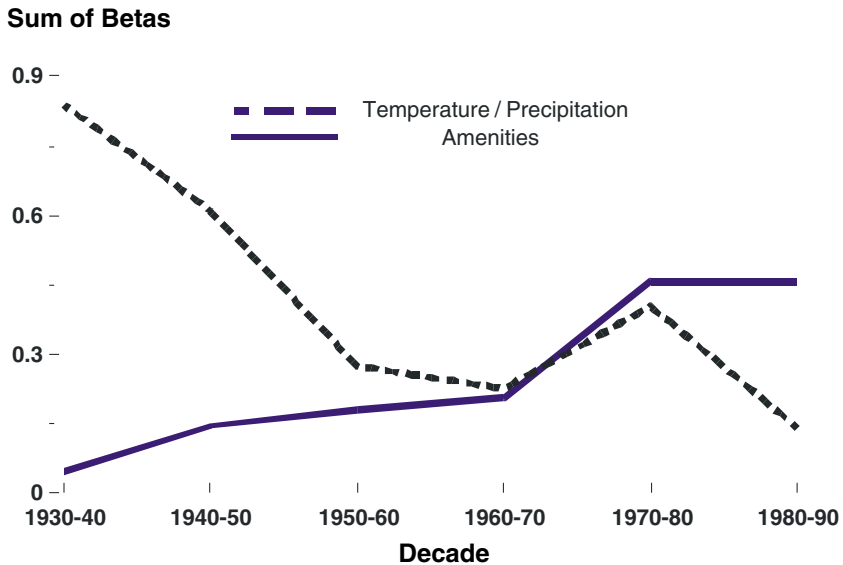


FIGURE 4. Sums of Betas for Weather and Amenities Variables, 1930s–1980s. For detailed explanation of method, see text and Table 6.

interactions, yet also sustain our decision to stay with a relatively parsimonious approach.

DISCUSSION AND CONCLUSIONS

We summarized our discussion of some of the literature about environment and migration by emphasizing two sets of questions about the role of drought and heat, and about environmental amenities, the two factors that we found the most compelling for our analysis. We asked whether each group of variables was a meaningful cause of net migration at the scale of the county, and we asked whether those contributions changed over time. All this takes place in a context of social and economic conditions in the U.S. Great Plains from the 1930s through the 1980s. The results we have presented tell a simple story. We measure the role of a number of factors in determining county-level net migration in the U.S. Great Plains, and find both stability and change across time. By focusing on a small number of variables we bring a parsimonious picture of important variables, while recognizing that we are not telling the entire story. Other authors who write

about the Great Plains or Rural America (see Brown & Swanson, 2003) often have more complex or nuanced profiles, but lack our ability to track longitudinal shifts empirically.

What is consistent through time is the role of two key sets of variables related to employment, and one variable measuring educational attainment, in determining levels of net migration. The employment variables measure the level of agricultural employment and unemployment at the start of each decade, and then the amount of change that takes place in each decade. They consistently show that areas with the most agricultural employment and unemployment, and with increasing agricultural employment and increasing unemployment all had the greatest out-migration. The unemployment variables are easy to understand: people do not stay in locations where there is high and rising unemployment. The agricultural employment variables are more complex, because they suggest to us not that agricultural employment led to out-migration, but that counties with the most concentrated agricultural employment have been ones where there have been the fewest other opportunities; without those other opportunities, out-migration occurs.

Educational attainment is another consistent factor in predicting levels of net migration in the Great Plains counties. Over the six decades, counties whose adult populations had been more likely to have attended college had higher levels of in-migration. In this case there is no easily stated causal explanation. It is unlikely that counties with higher college graduation rates attracted more in-migration directly. What is much more understandable is that counties that had attributes attractive to in-migrants were especially attractive to those with college degrees, and conversely that counties that were unattractive to in-migrants had relatively low educational attainment.

Our environmental variables stand up against this simple and consistent backdrop with a set of temporally specific characteristics. Following Gregory (1989), we did not expect strong effects from the temperature and precipitation variables, but we see that they play interesting and significant roles in the 1930s and 1950s (and possibly the 1960s), when weather conditions would have been important for shaping migration flows. In particular, the significant effects with appropriate signs for the decadal deviation of temperature and precipitation in the 1930s confirms long-standing beliefs. Our computation of a sum of betas for the temperature and precipitation variables, and the decline in their importance over time, suggests that the impact of temperature and precipitation on migration has diminished over time. That too is an important finding. In the same way, we show the emergence of environmental amenities—proximity to high elevations and bodies of water—as an increasingly important factor in

attracting migrants to the Great Plains. Amenities appear as significant in the 1950s and 1960s, and generally continue that impact in later decades.

Put another way, the starting point is that a key set of structural economic and social factors are correlated with net migration throughout the six decades that we have studied. It is unlikely that there is anything about these attributes that is peculiar to the Great Plains, or particular to a specific time. Instead, we suspect that these are long-term givens in the ways that county populations developed, at least in the last three-fourths of the twentieth century. Certain attributes of county employment related to agriculture and unemployment drive migration in the Great Plains. Those counties with largely agricultural employment and with unemployment appear to have lost population; conversely, we might say those with diverse employment opportunities and relatively less unemployment attracted population. Educational attainment is strongly correlated with this process, which means that our attainment variable is positively associated with net in-migration, but we are not sure how the process operates. We suspect that factors that attracted population in the twentieth century also attracted an educated population.

The environment enriches the story. Precipitation and temperature have an impact on net migration, but that impact can only be seen clearly in decades with the worst heat and drought. In other decades, they have no predictable outcome, which means that after the 1950s the Great Plains sees little meaningful impact from those variables. On the other hand, we see that there is a role for environmental amenities, but it arises only after the 1940s, when a society more attuned to recreation develops in the United States.

Few of the individual components of our conclusions may be surprising, but taken together they give us an important understanding of how these social, demographic, and environmental processes work out, and how they work together. Demographers have long known that environmental hardship spurred out-migration from agricultural regions, that environmental amenities have come to attract in-migration in recent years, and that all this takes place within an employment-driven structure where high levels of education are increasingly associated with regions in the U.S. that are attracting population. What is important about these findings is that these various conditions can be seen to coexist well within a single intellectual and data-driven structure. We show—using the same data and a single set of statistical models—that the impact of weather was largely as expected, but only during the decades with the worst weather conditions. In later decades it became less and less important, confirming the resilience that Gregory and Hewes (among others) assert gradually emerged among farmers.

Similarly, amenities have a role, but their positive role in attracting population emerges later. And the social structure and determinants of migration that exist more broadly are clearly visible, yet linked into a broader framework in which population and environment factors can clearly be seen.

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