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Land Use and Family Formation in the Settlement of the U.S. Great Plains

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Abstract

In agricultural settings, environment shapes patterns of settlement and land use. Using the Great Plains of the United States during the period of its initial Euro-American settlement (1880–1940) as an analytical lens, this article explores whether the same environmental factors that determine settlement timing and land use—those that indicate suitability for crop-based agriculture—also shape initial family formation, resulting in fewer and smaller families in areas that are more conducive to livestock raising than to cropping. The connection between family size and agricultural land availability is now well known, but the role of the environment has not previously been explicitly tested. Descriptive analysis offers initial support for a distinctive pattern of family formation in the western Great Plains, where precipitation is too low to support intensive cropping. However, multivariate analysis using county-level data at 10-year intervals offers only partial support to the hypothesis that environmental characteristics produce these differences. Rather, this analysis has found that the region was also subject to the same long-term social and demographic changes sweeping the rest of the country during this period.

Introduction

The pattern of initial human settlement in a region reveals key information about the connections between population and environment, allowing us to test core theories about this relationship at a time of fundamental change. This article aims to examine propositions that link processes of family formation and agricultural settlement to environmental conditions in the grasslands of the Great Plains of the United States.

The Great Plains presents an ideal setting to explore the impact of environment on family formation because the region can be divided into two precipitation zones, where different agricultural systems prevailed (Burke et al. 1989, 1990, 1991; Cunfer 2005; Gutmann et al. 2004). The eastern sub-region is relatively dry, but nonetheless permits consistent cropping;

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the western sub-region is very dry, with most land devoted to pasturing livestock. In this article we ask whether the different labor regimes associated with these agricultural systems led to specific family formation systems, revealed by differences in each population's age-sex structure. We hypothesize that because livestock producing areas depended less on family labor than did cropping regions, areas unsuited to cropping were characterized by an unbalanced sex ratio and lower levels of fertility. Earlier work has demonstrated that environmental endowments determine the timing of settlement and the population density of a region, especially in rural areas (Gutmann et al. 2011), and we know that environmental change can have an impact on density through migration (Gutmann et al. 2005a; Gutmann and Field 2010). Our goal here, however, is to ask whether environment, through land use, shapes population structure via family formation, a question that has the potential to improve our understanding of how people respond to their environmental conditions.

The article begins with descriptive data that illustrate the temporal and spatial distribution of population dynamics in the Great Plains from 1880 to 1940, which must be understood in the context of complex social changes in the United States during the same period, specifically the steady decline in fertility (Hacker 2003; David and Sanderson 1987; Coale and Zelnick 1963). We continue with a multivariate statistical analysis that allows us to draw clearer conclusions by isolating environmental characteristics from broader social and cultural contexts. Our results suggest that environmental factors have little or no influence on family formation, an important negative finding. Instead, we suggest that family strategies from 1880 to 1940 were anchored in a larger set of social and cultural conditions.

One of the central preoccupations of historical demographers in the United States has been explaining the antebellum decline in fertility, which predated declines in mortality rates, against the prediction of demographic transition theory, and occurred among a rural population. Yasuba (1962) linked fertility to the availability of arable land, suggesting that the secular decline in fertility was a product of increasing land scarcity. While subsequent scholars have refined Yasuba's measures and methods of analysis, few have produced results that challenged the association between fertility and land availability (Easterlin 1971, 1976a, b; Forster and Tucker 1972; Leet 1976; Schapiro 1982; for an exception, see Vinovskis 1976). Easterlin (1976a, b) further specified inheritance as the mechanism through which this relationship worked: parents had only as many children as they could reasonably expect to endow with their own livelihood, so the availability of land to purchase for or bequeath to children constrained fertility.

These works suggest both temporal and spatial components to the fertility-land availability relationship: over time, as land becomes more densely settled and hence more expensive, parents have fewer children; at any given time, couples in more recently and less densely settled areas will have more children than couples in older and more densely settled areas, as more land is available for their children (Easterlin 1971; Leet 1976). In the United States, agricultural settlement has mainly followed an east-west trajectory, with states farther west having more-recently and less-densely settled populations than those to the east. Scholars therefore have tended to use cross-sectional analysis to explain secular fertility change, collapsing change over time into difference across space. Schapiro (1982), however, points out that families historically solved the land scarcity problem in both spatial and temporal dimensions at once, through migration on the one hand and fertility reduction on the other. Therefore, the movement of population across space is intimately connected with changes in demographic behavior over time. Indeed, the literature on westward migration illustrates the ways in which family priorities played a continuing and decisive role in this process, as migration to cropland areas was organized around family succession and inheritance strategies (Loewen 1993; Bouchard 1994, 1996; Gjerde 1997; Gjerde and McCants 1999;

Sylvester 2001). Less is known, however, about the importance of family reproduction in subsequent generations.

Scholars working on contemporary developing populations have similarly created multiphasic models to explain how human populations negotiate the Malthusian limits of the land (Davis 1963; Bilsborrow 1987; Moran 1993). The organizing idea is that human populations initially respond economically to increasing population density and land scarcity by bringing more land under cultivation or intensifying production on existing agricultural land. After these responses have been exhausted, populations pursue the economic and demographic strategy of temporary migration, followed by permanent out-migration. Only after these responses does fertility reduction occur (Bilsborrow and Carr 2001). In both historical and contemporary models, settlement produces land scarcity, which then leads to demographic change in the form of migration, fertility reduction, or both. These models therefore predict that fertility will be higher where settlement is sparser, which, in the late-nineteenth and early-twentieth century United States, was in the west and particularly on the frontier.

What is missing from all of these studies, however, is explicit attention to the space over which people are moving and to the question of how settlers might have responded to the environmental conditions they found on the frontier. Although Yasuba (1962) and other proponents of the settlement timing and land availability hypotheses specify that fertility is related to arable land, they do not include measures of environmental variation. Moreover, most of the work on the relationship between fertility and land availability is confined to the antebellum era, when people typically moved from places in the east that were less suited to agriculture or were suffering from soil depletion to places in the Midwest that offered better growing conditions and less depleted soils. Shortly after the Civil War, however, the U.S. government began to promote settlement in the Great Plains, where rainfall was not sufficient to guarantee success in growing corn, the main cash crop of the nineteenth-century Midwest. This land was useful for livestock production, and farmers developed dryland cropping techniques that allowed the growing of wheat (particularly spring wheat in the northern Plains), but these activities involved more land and had different labor requirements than did traditional crop-based agriculture, and therefore may have produced different patterns of family settlement and formation. Studies of the relationship between environment and settlement have demonstrated that settlement timing was influenced by environmental conditions, with counties better suited to cropping being settled first. Likewise, studies of the environment and agriculture have also shown that land use choices in the Great Plains were sharply constrained by the same environmental factors (Gutmann et al. 2004, 2011; Lauenroth et al. 2000; Sala et al. 1988; Burke et al. 1994, 1997; Parton et al. 2007).

This article fills in the missing piece, examining whether counties less suited to crop-based agriculture developed unique population structures, as indicated by higher sex ratios and lower child-woman ratios, which may have reflected responses to the need for more farmland (given its low productivity), or more adult male labor (rather than family labor) for livestock production. Most scholarly work, across a variety of disciplines, has modeled the impact of human activity on the environment (VanWey et al. 2005), with population as the independent variable and environment as the dependent variable. However, both classical and contemporary theories of the relationship between population and environment suggest that populations respond to their ecological contexts and to environmental change, with newer models of human-environment interactions readily acknowledging bidirectional causality. Along with previous work on settlement and agriculture in the U.S. Great Plains, this study makes an important contribution to the literature with its antipodal modeling, where the *environment* is the independent variable and *population* is the dependent variable.

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We therefore start with the environment, move through land use possibilities, and end with the family, exploring whether familial responses to environmental constraints on land use options shaped population structure at the time of agricultural settlement in the U.S. Great Plains. Explicitly, we ask whether natural limitations on the potential for productive cropping led to either a lower rate of family formation—as measured by the sex ratio—or to smaller families—as measured by the child-woman ratio. This analysis will contribute to refining theories both about the fertility-land availability association and about the relationship between population and the environment by examining how the quality and capacity of available land influences the demographic behavior of those who settle there and therefore how the environmental conditions of a place shape the structure of the population that develops.

The wider demographic context of the late-nineteenth and early-twentieth century United States shaped the process of settlement in the Great Plains and therefore influences the ways we test our hypotheses. Studies of frontier settlement suggest that in most cases the earliest settlers were single men who worked in ranching or a specialized industry, such as mining, trade, or manufacturing, and sex ratios were therefore quite high (Eblen 1965). Soon after, nuclear families or young couples arrived, building on the earliest infrastructure. During this period of transition, the sex ratio became more balanced, suggesting a higher proportion of married couples relative to single men, and therefore a sign of family formation. However, as the Great Plains region was settled, fertility was declining throughout the United States, potentially confounding the analysis of any relationship between sex ratio and fertility. For this reason, we analyze the two measures separately. A final factor worth noting is high immigration rates in the United States during this period, which spans the shift in immigrant origin from Northern and Western Europe to Southern and Eastern Europe. A variety of ethnic groups settled in the Great Plains over time (Luebke 1980; Gutmann et al. 2004), and immigrants from some sending countries clustered within the region, creating communities that often had distinct demographic characteristics, such as relatively high or low fertility.

Precipitation decreased from east to west, as did time since settlement, suggesting that land availability increased from east to west. The settlement timing and land availability hypotheses and the environmental hypothesis predict higher sex ratios in the west, associated with more recent settlement and with an environment better suited to livestock raising than crop production, and therefore requiring more single male labor than family labor. However, the settlement timing and land availability hypotheses suggest a different fertility outcome than does the environmental hypothesis: more recent settlement and greater land availability in the west predict higher fertility, while an environment less suited to family labor predicts lower fertility. In the temporal dimension, the settlement timing and land availability hypotheses suggest that, in any given place, sex ratios and fertility will decrease over time, as single male settlers are replaced by families, and then as increasing land scarcity leads to reduced fertility and the out-migration of single men and larger families. However, the environmental hypothesis suggests that these temporal processes will be mediated in areas with lower precipitation, as the unsuitability of the land for traditional crop-based agriculture will forestall the initial settlement and formation of families.

The analysis that follows begins by showing the differences between the eastern and western halves of the region, which form two environmental sub-regions, mostly by virtue of variations in precipitation. We then turn to a multivariate analysis designed to answer the question of whether family formation activities—as measured by the sex ratio and the child-woman ratio—can be shown to be determined by environmental variation.

Data

This analysis draws on county-level data for the U.S. Great Plains (www.icpsr.umich.edu/plains), described in detail elsewhere (Gutmann et al. 1998, 2004; Gutmann and Pullum 1999; Gutmann 2000, 2005a, 2005b). Developed largely from published U.S. Agricultural and Population Censuses, the data allow us to examine spatial and temporal relationships between population, agricultural land use, and a limited set of environmental characteristics over a large space and a long period of time. The basic data are listed in Table 1 and summarized in Tables 2 and 3. We use a limited number of variables for a group of counties within ten states in the western United States. Two aspects of the data require some explanation here: the age distributions used to calculate child-woman ratios and adult sex ratios, and our method for dealing with changing county boundaries.

For most of the past 150 years, the U.S. Census has published tabulated age distributions for states and counties for five-year (and sometimes single-year) age groups. These tabulations are sufficiently detailed for most demographic analyses. That was not the case for the five decennial censuses from 1880 through 1920, when published tables for counties were much more limited, generally distinguishing between adults and children, and sometimes between those of school age and others, but not including five-year age groups. Because our analysis requires greater detail, we devised a procedure for using published age-sex distributions for states (which are always available) and the more limited age-sex distributions of individual counties to estimate the five-year age distributions of those counties. In the case of children, this estimation procedure applies the proportions in detailed age groups for the state to the known total number of children of all ages in each county; it does the same for adults by applying the known five-year age distribution for the state to the quantities of people in the broad county-level categories published by the census.

In general our population distributions appear to represent the underlying population adequately, but we recognize that this approach creates potential problems for any analysis that requires accurate child-woman ratios for counties. This is so because our age distributions for counties are heavily influenced by state age distributions, while accounting for the variation between counties is our real interest. It is, however, worthwhile to say that we have not attempted to standardize the child-woman ratios, even though we are aware that the age structure of women that underlay them are not the same across sub-regions and through time. Direct standardization is not possible for these data, and given the amount of temporal and spatial variation, an appropriate standard for indirect standardization is extremely difficult to choose. In addition, to the extent that the child-woman ratio is affected by the age structure of the population (due to the typical inverted-U shape of age-specific fertility of women ages 15–49), which changes over time, our inclusion of fixed effects for decades will adjust the child-woman ratios in much the same manner as standardization.

The second aspect of the data—and our approach to it—is a function of the process by which the region was settled and political institutions were created. In the years from 1880 through 1930 the number of counties, as well as their sizes and boundaries, changed substantially as new counties were created to reflect growing population and local political pressures. Nothing about this is unique to the region we are studying. In general, county-level analyses that span time are plagued by problems of boundary comparability because counties split or merge, or new counties are founded. The typical solution to boundary changes in longitudinal analyses is to group counties involved in any kind of shared boundary shifts (Horan and Hargis 1995). One problem with this solution is that of inappropriate spatial scale. Counties are a natural unit of analysis because they are meaningful geo-political units; county clusters are not. We employ a solution that enables us to retain counties as our unit of analysis, rather than county clusters.

The challenge posed by not aggregating counties into clusters is the lack of availability of data for newly created counties prior to their date of creation. If, for example, County A exists in 1890 but is divided into two counties (County A and County B) before 1910, certain attributes of County B (for example the date when it reached a threshold population density) would be wrongly assigned if we assumed that there was no population in the area prior to 1910. Our solution in most cases is to use the value of the precursor county (in this case County A). This solution is explained in greater detail by Gutmann et al. (2011).

Environment, Land Use, and Population Change

Patterns of initial settlement are strongly linked to the precipitation and temperature gradients in the Great Plains (Gutmann and Sample 1995; Gutmann et al. 2005b, 2011). The region has a well-known pattern of precipitation, with mean annual levels declining from approximately 700 mm in the east to 250 mm in the west, and a south to north gradient of decreasing temperature (Gutmann et al. 2005b).

The settlement of the Great Plains by people of European descent between the Civil War and the Great Depression is one of the more familiar episodes in the history of the United States, and does not require lengthy discussion here (Webb 1931; Worster 1979; Cunfer 2005; Gutmann et al. 2005b). Population and cropland in the Great Plains grew steadily from 1880 until 1930. As a consequence of drought and depression, population stopped growing in the east after 1930 and harvested cropland declined between 1930 and 1940.[1] As a result of contrasting environmental conditions, eastern areas were originally settled for farming, while the western part of the region was used for extensive grazing before farmers attempted cropping (Webb 1931; Gutmann and Sample 1995; Cunfer 2005).

As land use changed over time, demographic patterns changed too. In the early years of settlement, many counties had a high proportion of males, as unmarried men migrated to the frontier to work in ranching, industry, trade, and high-risk jobs. As time passed, however, more women, young couples, and nuclear families migrated to the region. We see this trend clearly in Figure 1, which shows the adult sex ratio (males per 100 females aged 20 and older) for the entire region as well as the eastern and western tiers of states. In this and subsequent figures we report the data for the entire region (the solid black line), as well as for two sub-regions labeled the “eastern tier” (the dashed gray line) and the “western tier” (the solid gray line). The eastern tier consists of six states (Kansas, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas) that are more involved with cropping agriculture than their four neighbors in the western tier (Colorado, Montana, New Mexico, and Wyoming).The frontier settlement pattern (with sex ratios higher at the beginning of the period and declining steadily) differs between the eastern and western tiers of states. In the early years, we find higher sex ratios in the west, which may reflect either later settlement or a persistent difference in land use. By 1920 the two sub-regions have identical sex ratios, a pattern of regional balance that holds in 1930 and 1940, though the 1940 sex ratio is still high at 107 men for every 100 women.

We see the pattern of change in sex ratios spatially in Figure 2, which indicates the year at which women exceeded 40 percent of the total population in each county (a sex ratio of 150). This is still a high sex ratio, but its spread through time reveals the pace at which families began to settle or form in the region. The eastern sections of the Dakotas, as well as

[1]However, total cropland continued to increase, a consequence of a definition of cropland used by the agricultural census in 1940 that probably over-estimated cropland in that year. In 1940 the census asked farmers to report their acreage in “plowable pasture,” defined as “land used only for pasture in 1939 which could have been used for crops without additional clearing, draining, or irrigating” (U.S. Bureau of the Census 1942). It was the only time that this definition was used, and it appears to have led to the inclusion of land that was never otherwise considered cropland.

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Nebraska and Kansas, reached the 40 percent mark in 1880 or 1890. Most of northern Texas and eastern Colorado reached this level from 1890 to 1910. Many counties in Montana, Wyoming, and New Mexico, however, did not reach 40 percent or more until 1920 or 1930. In general, we find sex ratios coming into balance in the east before the west, with persistently high sex ratios clustering in the northwest corner of the region.

In our discussion of family formation and land use change we emphasized the possibility that fertility differentials might reveal how families adapted to their environment. Fertility differentials are difficult to measure with the kinds of data that we have for the period up to 1940, with the best consistent measure being the child-woman ratio (Haines and Hacker 2011). Figure 3 shows steadily declining child-woman ratios in the Great Plains from 1880 to 1940, consistent with the accepted scholarship (Coale and Zelnick 1963; Hacker 2003). Another approach uses individual-level data to estimate age-specific fertility rates with own-child methods (United Nations 1983). We have done this using data from IPUMS (Ruggles et al. 2010) for the Great Plains states, divided into eastern and western tiers (Figure 4). Both approaches show that fertility was lower in the west than in the east, though the two sub-regions began to converge between 1910 and 1920, and their convergence was nearly complete by 1940. Lower child-woman ratios and age-specific fertility rates in the west could reflect lower marital fertility or a higher proportion of single women. In any case, relatively low fertility in this sparsely settled area suggests that the properties of the land, and therefore the ways in which it can be used, may also shape fertility outcomes, in addition to what is already known about land availability and time since settlement (Easterlin 1971).

The evidence of this descriptive analysis is mixed. Lower sex ratios and higher child-woman ratios in the eastern tier—where land was more conducive to cropping—suggest that family formation and cropland development went hand-in-hand, but the time scale at which we are working—decades—does not make the process easy to understand. Sex ratios followed a predictable pattern through time, with women arriving later than men, and arriving in the west later than the east. Fertility was falling everywhere in the region, from high levels in the east and lower levels in the west. The east/west difference in fertility might be associated with differences in labor needs resulting from different degrees of land capability, though their convergence suggests these differences were not persistent. Moreover, given that some areas in the west were settled by groups of immigrants from the same country of origin, cultural differences may have also played a role in creating spatially-distinct fertility patterns. In any case, the secular decline in fertility experienced by the entire region likely reflects broader demographic changes affecting the country as a whole.

Our descriptive analysis identifies four factors influencing sex ratios and fertility:

- The environment. Variations in soil quality and availability of moisture make the land suitable for different uses, with some areas better for pasture and others for cropping. Descriptive analysis offers limited but inconclusive evidence that family formation patterns differ by land use and environment.
- The settlement process itself. The amount of time elapsed between settlement and the time of analysis allows the communities under study to experience a series of transformations, including the balancing of the sex ratio, the filling out of the population, and the conversion of land to uses that are most satisfactory for land owners.
- Social and demographic change. Broad social changes were at work between 1880 and 1940. The most dramatic of these is the steady decline in fertility. There are others as well, such as increased urbanization; for the average Great Plains county

urbanization grew from 2 percent to more than 15 percent between 1880 and 1940 (Table 4).

- Other cultural and social differences. Differences between sub-regions of the Great Plains and between the populations that inhabit those regions are also apparent in our descriptive analysis. We suspect that the most important of these differences are between ethnic groups, which we know to have had varying fertility levels, and between urban and rural populations (Morgan et al. 1994).

Regression Models: Analytic Design and Estimation Method

We attempt to better understand the process of family formation in the Great Plains by estimating regression models with variables that reflect our best efforts to measure the four factors mentioned above: ***environment and land use, the settlement process, social and demographic change, and cultural and social differences***. Our dependent variables are adult sex ratio and child-woman ratio. As in all analyses of this type, and especially in quantitative historical analyses, the independent variables we choose are imperfect, but they give us a sense of the direction and strength of relationships. We report summary statistics for the variables used in the regression analyses in Table 4. Some of the figures reported in Table 4 differ from those in Table 2 because those in Table 4 are the unweighted means of the county figures, while those in Table 2 are summaries over the entire area of study.

Environment and Land Use

We measure environment through precipitation, temperature, and soil characteristics, which we and others have found to be the strongest determinants of agricultural land use (Gutmann et al. 2004; Lauenroth et al. 2000; Sala et al. 1988; Burke et al. 1994, 1997; Parton et al. 2007). The precipitation and temperature are long-term averages for the period 1900–1939, computed for each county. We begin these averages with 1900 because the source data for long-term weather estimates for the United States are rarely available before 1895. We characterize soil with county-level averages of the percent sand in the soil and the depth of topsoil. Like the weather variables, these are not tied to a single time period in our analysis, but unlike the historical weather variables, they are based on recent soil survey data from the 1970s and 1980s. While less than perfect, the soil data are adequate and the best available at this time. In general, we expect deep topsoil to lead to more cropping and high percentages of sand in the soil to less cropping.

There is a strong correlation between levels of temperature and precipitation, the timing of settlement, and the percent of land in a county devoted to crops (Gutmann et al. 2011). The pace of settlement from east to west generally reflected the kind of environment that settlers found. The areas best suited environmentally to cropping were settled first; those areas had higher levels of rainfall and moderate temperatures. Areas with less rainfall were settled later, and those with very high or very low temperatures were generally settled later than those with moderate temperatures. Areas settled earlier were more likely to have higher proportions of their land cropped than those settled later during the period prior to the rapid growth of irrigation starting in the 1940s and 1950s.

This simple relationship between climate, time of settlement, and extent of farming means that variables measuring those phenomena are collinear; for that reason, we have simplified our models to include only some of those characteristics. Specifically we do not include the extent of cropping. We include precipitation as an indicator variable, classifying as “high precipitation” counties receiving a long-term average annual precipitation above 465 mm.

The Settlement Process

The timing of settlement is important because it indicates the moment when the family building process begins. In the decade immediately prior to the time that we define a county as first settled, migrants arrive in quantity, agricultural and other enterprises are founded, and families start to grow through marriage and childbearing. We measure the settlement process by identifying the year in which each county first had a population density of two persons per square mile or greater, the threshold used by the 1890 Census (Turner 1894). About one-fourth of all counties were settled by 1880 (125 counties), and another one-fourth were settled by 1890 (129 counties). The remaining half came in gradually between 1900 and 1940, with the largest group (120 counties) settled between 1900 and 1910, and 14 counties remaining with population densities less than two persons per square mile even after 1940.

Time since settlement does not necessarily affect our dependent variables in a linear way, so we treat the settlement variable categorically. For purposes of simplicity, we combine counties that reached the settlement density in 1940 with those that reached it later or never reached that level. This is the reference category in the third time period model. In the two earlier time period models (1880–1890 and 1900–1910), we identify the decade of settlement for counties meeting our population density threshold prior to and during our observation period; our reference category represents counties that were settled after our observation period. We therefore use all of the years after the last year included in the model as the reference category: settlement in 1900 and later is the reference for the 1880–1890 models, and settlement in 1920 and later is the reference for the 1900–1910 models.

Social and Demographic Change

The Great Plains, along with the rest of the United States, experienced dramatic demographic and social transformations during the period of study. Changes associated with the settlement of a county are captured in the settlement year variable described above. However, broader social changes affected the region and country as a whole, particularly the secular decline in the national fertility rate and changes associated with economic development and integration and social policy. In our models we use year of enumeration (expressed as a categorical variable) as a simple proxy for changing social conditions that would have affected the entire region under study, with an emphasis on the expectation that fertility was declining from census to census.

Cross-Sectional Cultural and Social Differences: Ethnicity, Urbanization, and Population Density

Demographic behavior and land use differ within the Great Plains beyond the consequences of the settlement process and environmental variation. A substantial literature about ethnic variations in fertility in U.S. history (Gutmann 1990; Gutmann and Fliess 1993; Morgan et al. 1994) suggests that the settlement of ethnic and national groups in clusters may have influenced the spatial patterning of our dependent variables. We include the percentage of specific ethnic groups in the population in 1910 as a way to see this effect, focusing on the three largest European-origin ethnic groups, and on persons of Mexican origin. We also measure the Hispano (native-born European-descended Spanish-speaking) population in 1990, the first year for which they can be readily measured.[2] We further hypothesize that counties with large urban populations and with relatively dense populations have different social and cultural characteristics—and experienced more rapid fertility decline—than those

[2]This population has been very stable geographically since the beginning of the twentieth century, making their proportion in the population in 1990 a reasonable measure of their relative distribution in the population (see Gutmann et al. 2000 and Gratton and Gutmann 2000).

that are more rural and less dense. For this reason, we include both population density and percent of the county's population living in an urban area.

Method

Our analysis employs a traditional cross-sectional time-series data design in which cross-sectional observations (counties) are aggregated over time to yield a small number of time slices (panels comprising 1880–1890–1900–1910, and 1920–1940). These three sets of models represent the region during the early phase of settlement, during the middle phase of settlement, and during the later phase of settlement, when convergence in sex ratios and child-woman ratios between the two sub-regions was well underway. In each decade, some counties will be founded, thus leaving them with missing values in the earlier decade(s) of the model. To these counties we assign the values of their precursor (origin) county or counties, as explained earlier. We also allow for the possibility of extra-local spatial dependence between counties that do not share a county cluster, but are nearby in location. Regression analysis assumes that observations are independent, yet our analyses likely violate this assumption in three ways: (1) temporal autocorrelation because of repeated measures in the time slices, (2) spatial autocorrelation due to geographic proximity, and (3) within-cluster autocorrelation between counties and their precursor county or counties. We resolve the dependence within county clusters and over panels with generalized estimating equations (GEE). In GEE, parameter estimates are solutions of estimating equations that resemble likelihood equations with a predetermined error covariance structure (Agresti and Liu 2001; Hardin and Hilbe 2003). We account for spatial dependence by including a spatial-lag term, W_1y, estimated with the two-stage procedure described by Anselin (1988), though we find evidence of (negative) spatial dependence only at the end of the nineteenth century (our first time period model).

Regression Results

We report the results of the regression models in Tables 5 and 6. We begin with specific observations about the models for each of the two dependent variables and three time periods before turning to general conclusions about the models and the process.

Sex Ratio Models

The models with the adult sex ratio as dependent variable (Table 5) reflect a pattern that we will see throughout our analysis. In models for all three periods, time of settlement is strongly related to the sex ratio: the values of the coefficients suggest that the longer a county has been settled, the more balanced the sex ratio, although there may not be statistically significant differences between consecutive decades, as we see from 1880 and 1890 to 1900 in our first time period model. In addition to substantial differences by time of settlement, there are persistent variations between individual years in each of the models, with coefficients for the year of enumeration variables differentiating 1880 from 1890 (although not statistically significant), 1900 from 1910, and 1920 and 1930 from 1940. As we move forward in time, sex ratios decline across counties. Bringing these patterns together, we find that men generally dominated the pool of early migrants into the Great Plains, with women increasingly entering the area over time.

In the second and third time period models we see other very interesting results. Beyond the importance of time of settlement and year of enumeration, the environmental, social, and cultural variables are significant. The environmental variables generally confirm our hypotheses. We associate two of the variables—high precipitation and depth of topsoil—with greater opportunities for crop-based agriculture. These variables are correlated negatively with the sex ratio (but not usually statistically significant), meaning that more moisture and better soil are associated with more balanced sex ratios, all other things equal. The positive coefficient associated with the percent sand in soil leads to the same interpretation: the most balanced sex ratio could be found where conditions were most propitious for agriculture. Coefficients for the temperature variable are negative, indicating that sex ratios were more balanced in warmer places than in colder regions initially settled at the same time.

Results associated with the percent urban and the population density are also statistically significant: counties with denser and more urban populations had lower sex ratios (except for urban places in the 1900–1910 period). With the exception of this unusual finding, we believe the results for these variables to be a consequence of the association of urbanization and density with greater diversity of occupational opportunity, therefore attracting women and families as well as single men. In the cultural domain, there are noticeable variations by ethnicity: counties with more inhabitants from the UK, Scandinavia, and Mexico had higher sex ratios, while those with more inhabitants from Germany and Eastern Europe, and those with more members of the Hispano ethnic group, had lower sex ratios. The particularly large coefficient for Mexico in the second time period likely corresponds to high levels of immigration by male workers rather than agricultural families.

Child-Woman Ratio Models

The child-woman ratio models (Table 6) differ from the sex ratio models in that they achieve statistically significant results as early as the first time period. Time of settlement is again an important and consistent predictor. We find positive coefficients for counties that were settled within the last 20 years of our second and third observed time periods, and these coefficients decline with time since settlement. This finding suggests two things: first, that the process of settlement itself involves families, whether arriving from elsewhere or forming on site; second, that fertility declines with time since settlement, supporting the settlement timing hypothesis. In fact, fertility tends to be the lowest (though not always statistically significant) in counties settled before 1880. As expected, in all three time periods the year of enumeration variable shows that fertility was declining with time. The combination of coefficients for the year of enumeration variables and the settlement time variables indicates a complexity of social and demographic conditions operating over time and space. Here we see with great clarity the simultaneous rise in the number and/or size of families associated with the initial settlement of a community, paired with a decline in fertility as the community develops, all within the broader context of the dramatic social change that was sweeping the United States.

The environmental variables in the child-woman ratio models do not generally confirm our hypothesized expectations. We had predicted higher fertility in areas with greater precipitation, higher temperatures, and better soils, as these would be more conducive to cropping. The results for soil are mixed but consistent, with high sand content predicting higher child-woman ratios (counter to our expectations), while the coefficients for topsoil have positive signs (also reflecting higher child-woman ratios and consistent with our expectations), but are never statistically significant. Results for precipitation and temperature are inconsistent, with high precipitation being associated with lower child-woman ratios (contrary to expectation) in the first and third time periods but not the second, and higher mean temperature associated with higher child-woman ratios (in keeping with expectation) in the first and second time periods but not the third.

The social and cultural variables in the child-woman ratio models reflect the differential behavior of urban and ethnic groups. As we expected, counties in which a higher proportion of the population was urban had lower child-woman ratios, but those with denser populations had statistically significant effects only in the third time period, in the expected direction of lower child-woman ratios. Counties with larger Scandinavian, German and Eastern European, and Hispano populations generally had higher child-woman ratios, while those with larger UK and Mexican populations generally had lower child-woman ratios.

Conclusion

This article has examined whether environmental conditions and land use potential shape the process of family formation in the early years of settlement, as reflected in the resultant age-sex structure. The Great Plains of the United States is an ideal arena in which to test hypotheses about the connection between environment, settlement, and family formation because the region was settled by European-origin peoples recently enough that relatively good data exist and because it can be divided into two sub-regions, one of which was conducive to intensive crop-based agriculture and the other better suited to extensive cropping and livestock raising. The existing demographic literature links fertility to land availability, demonstrating that fertility is higher in less densely and more recently settled areas, where agricultural land is easier to obtain. However, this scholarship did not explicitly test the effects of environmental variables on fertility, and studies of environment and land use have demonstrated that environmental characteristics affect both settlement timing and land use, with places that receive more precipitation being settled first and cropped more intensively.

We asked whether the unique patterns of settlement and land use associated with low precipitation—which required more single male labor than family labor—also went along with a pattern of fewer and smaller families. Because our analysis relies on aggregate data for counties collected at 10-year intervals, it cannot capture the dynamics of individual families, but instead looks to sex ratios and child-woman ratios as indicators of family formation. Nonetheless, the insights are important, especially because the settlement process of the Great Plains coincides with important social changes in the United States involving immigration, urbanization, and fertility decline.

Descriptive analysis offered some support for our hypotheses. It suggested that sex ratios were initially higher in the drier west than in the wetter east but balanced over time, and that child-woman ratios were initially higher in the wetter east than in the drier west, but converged in the early twentieth century, with child-woman ratios everywhere falling over time, an indication of the secular decline in fertility. This latter result was substantiated by age-specific fertility rates estimated using census microdata and own-child methods, which also indicated initially higher fertility in the east, convergence over time between east and west, and declining fertility rates in both east and west. These results suggest an initially unique pattern of family formation in the western Great Plains, with higher sex ratios and lower child-woman ratios reflecting fewer and smaller families, but also suggest that, over time, the age-sex structure in the dry west became nearly indistinguishable from that in the wetter east, as more women settled in the west and as generally declining fertility rates fell faster in the east, converging with those in the west.

One of our challenges in this article has been to see whether it is possible to disentangle environmentally-produced differentials in sex ratios or child-woman ratios from countervailing forces of fertility declining because of long term social trends throughout the United States, sex ratios declining with time since settlement, immigration patterns creating areas with distinctive demographic signatures, and urbanization—where it happened—speeding the balancing of sex ratios and decline of child-woman ratios. In order to distinguish between these effects, we turned to multivariate regression. Our models for sex ratios largely confirmed our environmental hypothesis, with sex ratios lower—indicating the balance between men and women associated with a higher rate of family formation—in places more conducive to crop-based agriculture. The model also supported the settlement timing hypothesis, with sex ratios becoming more balanced with time since settlement. Our models for child-woman ratios, however, offered less support for the environmental hypothesis, with the effects of these variables weak and inconsistent. As predicted by the settlement timing hypothesis, these models demonstrate declining fertility over time and with time since settlement, after an initial rise associated with settlement itself.

Previous histories of settlement and of fertility and fertility change in the United States have ignored any distinctive role that might have been played by environment in determining family formation, possibly because the theoretical models behind them did not necessarily point in that direction. In this article, we proposed that the same environmental factors that shaped settlement and land use may have also shaped family formation, but multivariate methods offered only partial validation, suggesting a higher rate of single malehood in areas less conducive to crop-based agriculture, but no persistent difference in family size.

Acknowledgments

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References

Agresti A, Liu I. Strategies for modeling a categorical variable allowing multiple category choices. Sociological Methods and Research. 2001; 29:403–34.

Anselin, L. Spatial Econometrics: Methods and Models. Dordrecht: Kluwer Academic; 1988.

Bilsborrow R. Population pressure and agricultural development in developing countries: A conceptual framework and recent evidence. World Development. 1987; 15:183–203.

Bilsborrow, R.; Carr, DL. Population, agricultural land use and the environment in developing countries. In: Lee, DR.; Barrett, CB., editors. Tradeoffs or Synergies? Agricultural Intensification, Economic Development and the Environment. Wallingford: CAB International; 2001. p. 35-55.

Bouchard G. Family reproduction in new areas: Outline of a North American model. Canadian Historical Review. 1994; 75:475–510.

Bouchard, G. Population, Économie, Famille au Saguenay, 1838–1971. Montréal: Boréal; 1996. Quelques arpents d'Amérique.

Burke IC, Yonker CM, Parton WJ, Cole CV, Flach K, Schimel DS. Texture, climate, and cultivation effects on soil organic matter content in U.S. grassland soils. Soil Science Society of America Journal. 1989; 53:800–805.

Burke IC, Schimel DS, Yonker CM, Parton WJ, Joyce LA, Lauenroth WK. Regional modeling of grassland biochemistry using GIS. Landscape Ecology. 1990; 4:45–54.

Burke IC, Kittel TGF, Lauenroth WK, Snook P, Yonker CM, Parton WJ. Regional analysis of the central Great Plains. BioScience. 1991; 41:685–92.

Burke, IC.; Lauenroth, WK.; Parton, WJ.; Cole, CV. Interactions of landuse and ecosystem function: A case study in the central Great Plains. In: Groffman, PM.; Likens, GE., editors. Integrated Regional Models: Interactions Between Humans and Their Environment. New York: Chapman Hall; 1994. p. 79-95.

Burke IC, Lauenroth WK, Parton WJ. Regional and temporal variability in aboveground net primary productivity and net N mineralization in grasslands. Ecology. 1997; 78:1330–40.

Coale, AJ.; Zelnik, M. New Estimates of Fertility and Population in the United States. Princeton: Princeton University Press; 1963.

Cunfer, GA. On the Great Plains: Agriculture and Environment. College Station: Texas A&M University Press; 2005.

David PA, Sanderson WC. The emergence of a two-child norm among American birth-controllers. Population and Development Review. 1987; 13:1–42.

Davis K. The theory of change and response in modern demographic history. Population Index. 1963; 29:345–66. [PubMed: 12335951]

Easterlin RA. Does human fertility adjust to the environment? American Economic Review. 1971; 61:399–407.

Easterlin RA. Factors in the decline of farm family fertility in the United States: Some preliminary research results. Journal of American History. 1976a; 63:600–614.

Easterlin RA. Population change and farm settlement in the northern United States. Journal of Economic History. 1976b; 36:45–75.

Eblen JE. An analysis of nineteenth-century frontier populations. Demography. 1965; 2:399–413.

Forster, C.; Tucker, GSL. Economic Opportunity and White American Fertility Ratios, 1800–1860. New Haven: Yale University Press; 1972.

Gjerde, J. The Minds of the West: Ethnocultural Evolution in the Rural Middle West, 1830–1917. Chapel Hill: University of North Carolina Press; 1997.

Gjerde J, McCants A. Individual life chances, 1850–1910: A Norwegian-American example. Journal of Interdisciplinary History. 1999; 30:377–405.

Gratton B, Gutmann MP. Hispanics in the United States, 1850–1990: Estimates of population size and national origin. Historical Methods. 2000; 33:137–53.

Gutmann MP. Denomination and fertility decline: The Catholics and Protestants of Gillespie County, Texas. Continuity and Change. 1990; 5:391–417.

Gutmann MP. Scaling and demographic issues in global change research. Climatic Change. 2000; 44:377–91.

Gutmann, MP. Great Plains Population and Environment Data: Agricultural Data, 1870–1997 [machine-readable dataset]. Ann Arbor, MI: Inter-university Consortium for Political and Social Research; 2005a.

Gutmann, MP. Great Plains Population and Environment Data: Demographic and Social Data, 1870–2000 [machine-readable dataset]. Ann Arbor, MI: Inter-university Consortium for Political and Social Research; 2005b.

Gutmann MP, Fliess KH. The determinants of early fertility decline in Texas. Demography. 1993; 30:443–57. [PubMed: 8405608]

Gutmann MP, Sample CG. Land, climate, and settlement on the Texas Frontier. Southwestern Historical Quarterly. 1995; 99:137–72.

Gutmann, MP.; Pullum, S.; Cunfer, GA.; Hagen, D. The Great Plains Population and Environment Database: Sources and User's Guide. Austin: Texas Population Research Center Papers; 1998. Version 1.0www.icpsr.umich.edu/files/PLAINS/pdf/prc10.pdf

Gutmann MP, Pullum S. From a local to a national political culture: Social capital and civic organization in the U.S. Great Plains. Journal of Interdisciplinary History. 1999; 29:725–62.

Gutmann MP, Haines M, Frisbie WP, Blanchard KS. Intra-ethnic diversity in Hispanic child mortality, 1890–1910. Demography. 2000; 37:467–75. [PubMed: 11086572]

Gutmann, MP.; Pullum-Piñon, SM.; Baker, SG.; Burke, IC. German-origin settlement and agricultural land use in the twentieth century Great Plains. In: Kamphoefner, W.; Helbich, W., editors. German-American Immigration and Ethnicity in Comparative Perspective. Madison: University of Wisconsin Press; 2004. p. 136-68.

Gutmann MP, Deane GD, Lauster N, Peri A. Two population-environment regimes in the Great Plains of the United States, 1930–1990. Population and Environment. 2005a; 27:191–225.

Gutmann, MP.; Parton, WJ.; Cunfer, G.; Burke, IC. Population and environment in the U.S. Great Plains. In: Entwisle, B.; Stern, P., editors. New Research on Population and the Environment. Washington, D.C: National Academy Press; 2005b. p. 84-105.

Gutmann MP, Field V. Katrina in historical context: Environment and migration in the U.S. Population and Environment. 2010; 31:3–19. [PubMed: 20436951]

Gutmann, MP.; Deane, GD.; Witkowski, K. Finding frontiers in the U.S. Great Plains from the end of the Civil War to the eve of the Great Depression. In: Gutmann, MP.; Deane, GD.; Merchant, ER.; Sylvester, KM., editors. Navigating Time and Space in Population Studies. New York: Springer; 2011. p. 161-84.

Hacker JD. Rethinking the early decline of marital fertility in the United States. Demography. 2003; 40:605–20. [PubMed: 14686133]

Haines, MR.; Hacker, JD. Spatial aspects of the American fertility transition in the nineteenth century. In: Gutmann, MP.; Deane, GD.; Merchant, ER.; Sylvester, KM., editors. Navigating Time and Space in Population Studies. New York: Springer; 2011. p. 37-64.

Hardin, JW.; Hilbe, JM. Generalized Estimating Equations. Boca Raton: Chapman & Hall/CRC; 2003.

Horan, PM.; Hargis, PG. County Longitudinal Template 1940–1990 [machine-readable dataset]. Ann Arbor, MI: Inter-university Consortium for Political and Social Research; 1995.

Lauenroth WK I, Burke C, Paruelo JM. Patterns of production and precipitation-use efficiency of winter wheat and native grasslands in the central Great Plains of the United States. Ecosystems. 2000; 3:344–51.

Leet DR. The Determinants of the fertility transition in antebellum Ohio. Journal of Economic History. 1976; 36:359–78.

Loewen, RK. Family, Church, and Market: A Mennonite Community in the Old and New Worlds, 1850–1930. Urbana: University of Illinois Press; 1993.

Luebke, FC. Ethnicity on the Great Plains. Lincoln: University of Nebraska Press; 1980.

Moran, EF. Through Amazonian Eyes: The Human Ecology of Amazonian Populations. Iowa City: University of Iowa Press; 1993.

Morgan, SP.; Watkins, SC.; Ewbank, D. Generating Americans: Ethnic differences in fertility. In: Watkins, SC., editor. After Ellis Island: Newcomers and Natives in the 1910 Census. New York: Russell Sage Foundation; 1994. p. 83-124.

Parton WJ, Gutmann MP, Ojima D. Long-term trends in population, farm income, and crop production in the Great Plains. BioScience. 2007; 57:737–47.

Ruggles, S.; Alexander, JT.; Genadek, K.; Goeken, R.; Schroeder, MB.; Sobek, M. Integrated Public Use Microdata Series: Version 5.0 [Machine-readable dataset]. Minneapolis: University of Minnesota; 2010.

Sala OE, Parton WJ, Joyce LA, Lauenroth WK. Primary production of the central grassland region of the United States. Ecology. 1988; 69:40–45.

Schapiro MO. Land availability and fertility in the United States, 1760–1870. Journal of Economic History. 1982; 42:577–600. [PubMed: 11632258]

Sylvester, KM. The Limits of Rural Capitalism: Family, Culture, and Markets in Montcalm, Manitoba, 1870–1940. Toronto: University of Toronto Press; 2001.

Turner, FJ. Annual Report of the American Historical Association for 1893. Washington, D.C: Government Printing Office; 1894. The significance of the frontier in American history.

U.S. Bureau of the Census. Agriculture. Washington, D.C: Government Printing Office; 1942. Sixteenth Census of the United States: 1940.

United Nations. Manual X: Indirect Techniques for Demographic Estimation. New York: United Nations; 1983.

VanWey, LK.; Ostrom, E.; Meretsky, V. Theories underlying the study of human-environment interactions. In: Moran, EF.; Ostrom, E., editors. Seeing the Forest and the Trees: Human-Environment Interactions in Forest Ecosystems. Cambridge: MIT Press; 2005. p. 23-56.

Vinovskis MA. Socioeconomic determinants of interstate fertility differentials in the United States in 1850 and 1860. Journal of Interdisciplinary History. 1976; 6:375–96.

Webb, WP. The Great Plains. Boston: Ginn and Company; 1931.

Worster, D. Dust Bowl: The Southern Plains in the 1930s. New York: Oxford University Press; 1979.

Yasuba, Y. Birth Rates of the White Population in the United States, 1800–1860: An Economic Study. Baltimore: Johns Hopkins University Press; 1962.

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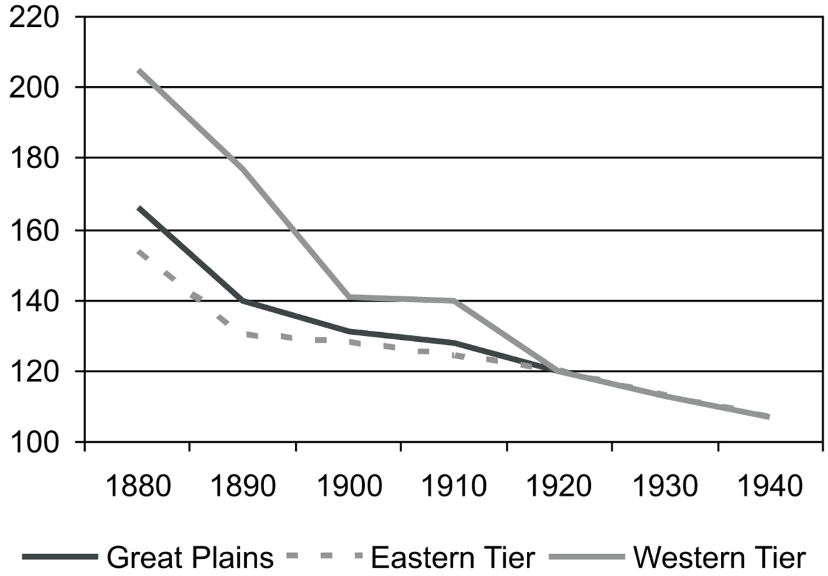

Figure 1.
Adult Sex Ratio, Great Plains, 1880–1940

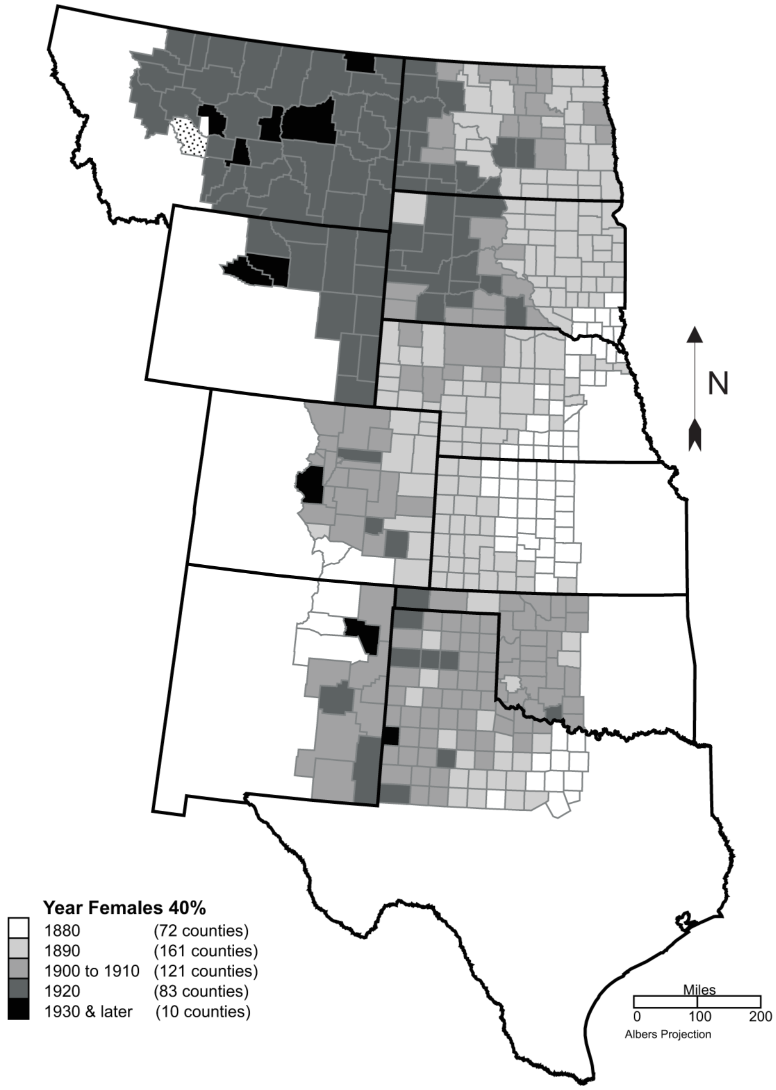

Figure 2.
Year when Females Exceeded 40% of Population

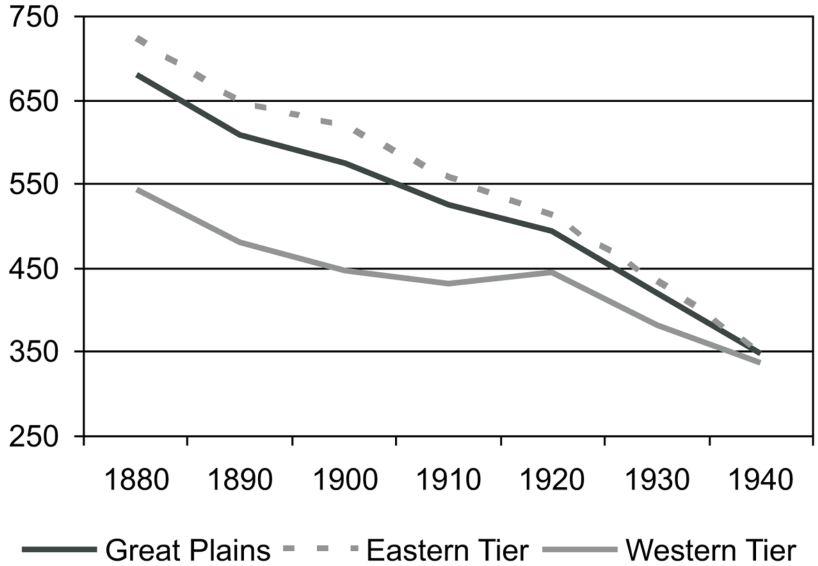

Figure 3.
Child-Woman Ratio, Great Plains Region, 1880–1940

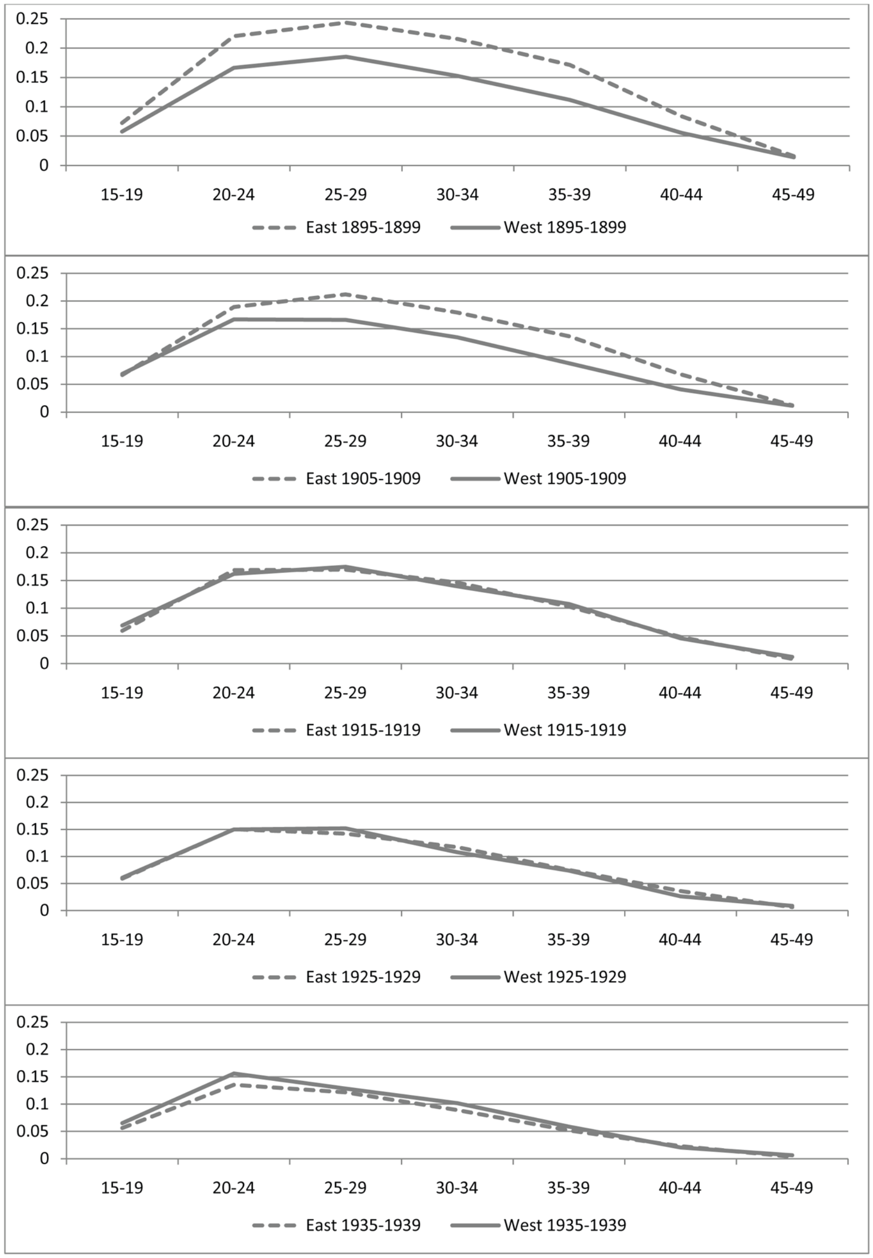

Figure 4.
Age-Specific Fertility Rates, Great Plains Region, 1895–1939

Table 1

Variables used in the analysis

Variable	Definition
Adult Sex Ratio	Ratio of males to 100 females aged 20 and older
Child-Woman Ratio	Ratio of children aged 0–4 to women aged 15–49[a]
Cropland Acreage	Sum of acres harvested for major crops and for land in fallow and failed crops, for 1880–1920; in 1930 and 1940, census tabulations of total cropland
Farmland Acreage	Number of acres of land in farms
Total County Acreage	Area of county, in acres
% Farmland in Crops	Cropland as a percentage of Farmland
% County Area in Crops	Cropland as a percentage of Total County Acreage
% Farmland	Farmland as a percentage of Total County Acreage
Mean Precipitation	Average annual precipitation, millimeters[b]
High Precipitation	Counties with Mean Precipitation greater than 465 millimeters
Mean Temperature	Average county temperature (mean of minimum and maximum), degrees Celsius[b]
% Sand in Soil	Average percent sand in soil[c]
Depth of Topsoil	Average depth of topsoil layer[c]
Population Density	Persons per square mile
% Population Urban	Percent of total county population living in places of 2,500 persons or more
% in Ethnic Group in 1910 (Scandinavian, German/Eastern European, UK, Mexican) or 1990 (Hispano)	Percent of total county population either born in the place specified, or the child of at least one parent born in the place specified

Source: All data are from the Great Plains Project Database (Gutmann 2005a, b; Gutmann et al. 1998).

[a]The U.S. Census does not report five-year age groups for counties from 1880 through 1920. We have taken state-level five-year age groups and fitted them to counties for these years, while attempting to maximize the amount of information available in those years for other age groups. For example, in some years data are available for the proportion aged 21 and over, or for the proportion aged 18–49. In 1930, the census reports the number aged 35–44, and 45–54. For the child-woman ratio we have divided the number aged 45–54 in half to estimate the number aged 45–49.

[b]Averages computed over 1900–1939 if data exist for that period, and over shorter periods if necessary.

[c]Soil survey data averaged to the county level from late twentieth century sources.

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Table 2

Agriculture and population in Great Plains counties, 1880–1940

All States	**1880**	**1890**	**1900**	**1910**	**1920**	**1930**	**1940**
Number of Counties	234	348	359	402	443	450	450
Cropland Acreage	3,829,701	21,428,953	37,482,510	62,357,658	83,757,717	117,904,302	148,445,737
Farmland Acreage	19,202,079	60,786,828	143,319,963	189,659,283	252,606,665	288,516,246	304,907,238
Total County Acreage	279,210,458	319,426,542	371,793,920	382,556,160	379,771,320	383,532,800	383,218,480
Population	788,486	1,961,782	2,610,326	4,349,863	4,962,422	5,641,163	5,459,592
% Farmland in Crops	19.9	35.3	26.2	32.9	33.2	40.9	48.7
% County Area in Crops	1.4	6.7	10.1	16.3	22.1	30.7	38.7
% Farmland	6.9	19.0	38.5	49.6	66.5	75.2	79.6
Population Density	1.8	3.9	4.5	7.3	8.4	9.4	9.1
Adult Sex Ratio	166	140	131	128	120	113	107
Child-Woman Ratio	680	609	574	526	494	420	348

Table 3

Agriculture and population in Great Plains counties, 1880–1940: Eastern and Western tier states

Eastern Tier States[d]	**1880**	**1890**	**1900**	**1910**	**1920**	**1930**	**1940**
Number of Counties	206	302	302	339	351	352	352
Cropland Acreage	3,561,960	20,551,025	35,607,851	58,749,488	75,078,229	98,016,466	118,999,365
Farmland Acreage	17,661,562	54,939,683	123,513,578	157,197,256	181,496,302	194,819,902	204,539,152
Total County Acreage	145,247,093	198,595,026	216,908,160	229,296,640	231,579,320	231,904,000	231,494,960
Population	601,155	1,530,874	1,991,630	3,311,120	3,625,143	4,181,089	3,901,720
% Farmland in Crops	20.2	37.4	28.8	37.4	41.4	50.3	58.2
% County Area in Crops	2.5	10.3	16.4	25.6	32.4	42.3	51.4
% Farmland	12.2	27.7	56.9	68.6	78.4	84.0	88.4
Population Density	2.6	4.9	5.9	9.2	10.0	11.5	10.8
Adult Sex Ratio	154	130	128	124	120	113	107
Child-Woman Ratio	723	646	617	557	514	434	352
Western Tier States[e]	**1880**	**1890**	**1900**	**1910**	**1920**	**1930**	**1940**
Number of Counties	28	46	57	63	92	98	98
Cropland Acreage	267,741	877,928	1,874,659	3,608,170	8,679,488	19,887,836	29,446,372
Farmland Acreage	1,540,517	5,847,145	19,806,385	32,462,027	71,110,363	93,696,344	100,368,086
Total County Acreage	133,963,365	120,831,516	154,885,760	153,259,520	148,192,000	151,628,800	151,723,520
Population	187,331	430,908	618,696	1,038,743	1,337,279	1,460,074	1,557,872
% Farmland in Crops	17.4	15.0	9.5	11.1	12.2	21.2	29.3
% County Area in Crops	0.2	0.7	1.2	2.4	5.9	13.1	19.4
% Farmland	1.1	4.8	12.8	21.2	48.0	61.8	66.2
Population Density	0.9	2.3	2.6	4.3	5.8	6.2	6.6
Adult Sex Ratio	205	177	141	140	120	113	107
Child-Woman Ratio	543	481	448	432	444	382	338

[d] Kansas, Nebraska, North Dakota, Oklahoma, South Dakota, Texas.

[e] Colorado, Montana, New Mexico, Wyoming.

Table 4

Descriptive statistics for variables used in regression models

Variable	1880	1890	1900	1910	1920	1930	1940
Adult Sex Ratio[a]	318.91	169.35	149.42	130.79	123.20	119.98	113.31
Child-Woman Ratio[a]	773.36	631.76	603.24	539.87	526.85	458.93	380.02
Mean Temperature[a]	10.80	10.15	10.42	10.44	10.16	10.13	10.13
% Sand in Soil[a]	35.32	38.28	38.48	38.96	38.64	38.62	38.62
Depth of Topsoil[a]	9.27	8.84	8.92	8.97	8.68	8.64	8.64
Population Density[a]	3.91	6.03	7.32	19.23	20.37	22.76	23.47
% Urban[a]	2.02	3.25	4.68	8.53	9.92	12.53	15.21
% Scandinavian 1910[a]	5.33	6.08	5.63	5.77	5.78	5.77	5.77
% German & EE 1910[a]	11.72	12.35	11.60	11.27	11.19	11.14	11.14
% UK 1910[a]	3.12	2.98	2.96	2.85	3.02	3.05	3.05
% Mexican 1910[a]	0.38	0.33	0.35	0.32	0.31	0.31	0.31
% Hispano 1990[a]	1.30	1.06	1.29	1.30	1.26	1.35	1.35
High Precipitation[b]	210	292	309	335	344	345	345
Year of Settlement[b]							
1880	107	119	121	124	123	125	125
1890	65	113	117	122	127	129	129
1900	15	20	30	37	40	40	40
1910	24	54	49	72	80	80	80
1920	6	9	13	17	39	41	41
1930	2	7	11	12	14	14	14
1940	1	4	4	4	5	5	5
Not by 1940	8	14	13	13	14	14	14
Total Cases[b]	228	340	358	401	442	448	448

[a]Mean value.

[b]Number of cases.

Table 5

GEE models with exchangeable working correlation matrix, Adult Sex Ratio as dependent variable

Variable	Period 1 1880–1890	Period 2 1900–1910	Period 3 1920–1940
Settlement Year[a]			
1880	−238.985	−75.646***	−19.421***
1890	−170.558	−66.025***	−13.336***
1900		−67.976***	−13.684***
1910		−48.275***	−10.244**
1920			−6.762
1930			−2.076
1940 and later			
Year (Social & Demographic Change)[b]			
1880	191.430		
1890			
1900		20.730***	
1910			
1920			9.244***
1930			6.263***
1940			
Environmental Variables			
High Precipitation	−170.591	−4.076	−1.419
Mean Temperature	−30.413	−2.035***	−0.263
% Sand in Soil	0.696	0.447 *	0.047
Depth of Topsoil	4.195	1.154	−0.462 ***
Cultural & Social Differences			
% Scandinavian in 1910	−2.879	0.438 **	0.204 ***
% German/E. European in 1910	2.884	−0.293 **	−0.085 ***
% UK in 1910	−12.592	1.002	0.892 ***
% Mexican in 1910	93.821	8.436 *	0.442
% Hispano in 1990	−6.528 **	−0.392 **	−0.054
Population Density	3.411	−0.006**	−0.003***
% Urban	− −0.031	0.223**	−0.144***
Spatial Lag (P-Star)	−0.763 **	−0.032	0.011
Intercept	691.840 ***	181.201 ***	131.097 ***
Number of Cases	568	759	1,338
AIC	9,340	8,340	9,754

[a]Reference category is all omitted years (1900 and later in Period 1; 1920 and later in Period 2; 1940 and later in Period 3).

[b]Reference category is last year represented in model (1890 in Period 1; 1910 in Period 2; 1940 in Period 3).

*p<.1;

**p<.05;

***p<.01.

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Table 6

GEE models with exchangeable working correlation matrix, Child-Woman Ratio as dependent variable

Variable	Period 1 1880–1890	Period 2 1900–1910	Period 3 1920–1940
Settlement Year[a]			
1880	−94.720	−19.194	−34.483 ***
1890	−84.352	15.229	0.384
1900		51.093 ***	13.622
1910		54.189 ***	17.251
1920			32.781 **
1930			38.924 ***
1940 and later			
Year (Social & Demographic Change)[b]			
1880	166.301*		
1890			
1900		65.402 ***	
1910			
1920			140.443 ***
1930			75.516 ***
1940			
Environmental Variables			
High Precipitation	−203.098	7.500	−9.656 *
Mean Temperature	18.628**	6.986 ***	−4.120 ***
% Sand in Soil	5.862	0.486 *	0.552 ***
Depth of Topsoil	8.484	0.612	0.525
Cultural & Social Differences			
% Scandinavian in 1910	6.535***	3.724 ***	−0.434
% German/E. European in 1910	1.870	2.168 ***	1.226 ***
% UK in 1910	−14.662	−7.574 ***	−7.858 ***
% Mexican in 1910	−58.931	−8.821 *	−2.980 *
% Hispano in 1990	−2.757	1.027 **	2.528 ***
Population Density	6.074	0.001	−0.013 ***
% Urban	−2.503*	−0.506 ***	−1.125 ***
Spatial Lag (P-Star)	−0.252*	−0.017	0.020
Intercept	372.737**	408.604 ***	430.911 ***
Number of Cases	568	759	1,338
AIC	8,953	8,771	14,278

[a]Reference category is all omitted years (1900 and later in Period 1; 1920 and later in Period 2; 1940 and later in Period 3).

[b] Reference category is last year represented in model (1890 in Period 1; 1910 in Period 2; 1940 in Period 3).

[*] $p<.05$;

[**] $p<.01$;

[***] $p<.005$.

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