Population Change and Farm Dependence: Temporal and Spatial Variation in the 20th Century U.S. Great Plains*

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Abstract

Using census data, I employ spatial error regression and other GIS techniques to assess temporal and spatial variation in county population change throughout the 20th century, and, working from ecological theory, examine the relationship between such change and farm dependence. Temporally, the Great Plains witnessed more growth than decline during earlier decades of settlement, the population turnaround in the 1970s, and the 1990s, perhaps due to non-farm industry expansion. Spatially, clear demarcations in growth-decline patterns exist across the region, with changing form; an east – west division was characteristic at the beginning of the century but a central – border demarcation emerged during the middle and end of the period. Finally, the nature and magnitude of the relationship between farm dependence and population changes dramatically over the century. While a relatively low, negative relationship persists in the post-mechanized era following the 1940s, higher yet less stable associations prevail prior to agricultural mechanization.

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While the United States has witnessed considerable population growth over the 20th century, certain sub-regions have not shared in the nation's general expansion. As populations multiplied on the east and west coasts, some periods have found the center of the U.S. struggling to ward off decline. Most U.S. residents have heard of the Great Plains and thousands of peopled aboard transnational flights pass over this vast region daily. From the window, passengers inspect the seemingly endless green and brown checked plains, finding scant evidence of inhabitance let alone urban development. Yet at points in its history, this region was the intended and desired destination for thousands of individuals, families, and sometimes communities looking to achieve the American Dream. Enticed by free land, migrants stopped short of California's golden hills and Oregon's fertile valleys during the late 19th and early 20th century. The plains were put into production, paving the way for individual success and regional dependence on agriculture.

In this paper, I first estimate the nature and extent of temporal and spatial variation in patterns of county population change in the U.S. Great Plains throughout the 20th century. While residents of New York or Philadelphia may not readily distinguish North Dakota from Nebraska, there is significant diversity within the Great Plains region, including patterns of population change. Temporally, although the Great Plains is commonly associated with population loss, especially in recent decades (Rathge and Highman 1998b), certain periods within the region's history are associated with growth rather than decline. Spatially, not all counties within this vast region share the same pattern of population change. Even in periods of widespread growth, some counties actually lost population and, likewise, in periods of decline some counties have maintained or increased population.

Such temporal and spatial variation leads to the second objective of the current analysis: relating the pattern of county-level population change to farm dependence over an extended period of time. Previous work has identified farming dependence as an important factor in understanding the negative population growth characterizing the post-World War II Great Plains such that counties with high dependence tend to suffer greater loss relative to those with less dependence (e.g., Albrecht 1986; Rathge and Highman 1998a). I extend the scope of investigation to include the pre-WWII era, thereby allowing for a broader specification of the ecological theory and the anticipated relationship between farm dependence and population change. Although it has been documented that farm dependence is negatively associated with growth in periods following mechanization and the accompanying agricultural shift, whether it positively related to growth prior to the industry's mechanization has not yet been systematically explored.

Using decennial population and agricultural census data from 1900 through 2000, I employ spatial error regression and other GIS techniques to empirically assess and illustrate the extent of county-level variation in population change among 745 county clusters comprising the Great Plains and estimate its relationship with farm dependence over time and space. In doing so, I offer a more comprehensive and spatially-focused analysis of classic theoretical arguments pertaining to the relationship between a location's economic base and population processes.

The Theoretical Context

Social researchers have long been occupied with the relationship between economic base and population processes. The present analysis of population change in the Great Plains draws from ecological theory, purporting that an area's population size is associated with its capability of economically supporting its inhabitants (Duncan 1964; Gibbs and Martin 1959; Hawley 1950, 1986). In essence, equilibrium is struck between population size and economic opportunities, yet other factors operate to imbalance the relationship, chiefly environmental and technological changes. The area responds to imbalances created by these changes by adjusting its population size through such demographic processes as fertility, mortality, and migration.[1]

Technological changes have been of particular interest among discussions of population change in the Great Plains, specifically the technological innovation occurring within the agricultural industry since approximately 1940. This research posits that population trends during the post-WWII era are associated with the degree of farm dependence, and that the nature of the relationship is negative (Albrecht 1986; Beale 1988; Bender et al. 1985; Rathge and Highman 1998a). Briefly, as the industry became increasingly mechanized, it required less human labor, and larger and fewer farms which, in turn, resulted in a loss of equilibrium between population size and economic opportunities. The response to this imbalance was, and presumably continues to be, population loss; the economic need for fewer hands is met by population readjustments that ultimately produce fewer hands to employ.

This readjustment has far-reaching consequences extending beyond farm jobs and affecting the service and professional sectors of a local area, including seed and parts distributors as well as educational and financial providers. Between 1940 and 1970, many rural communities lost upwards of 50% of their residents (Beale 1978, 1980; Larson 1981), not all of whom were directly engaged in farm employment. While farm dependent communities lost population, not all U.S. nonmetropolitan counties, and by extension not all Great Plains counties, suffered loss during the post-mechanization period. In fact, those counties where farming was not a dominant source of employment actually experienced population growth (Elo and Beale 1985).

Studies of the relationship between population change and farm dependence have suggested that this negative relationship does not significantly change over time (Albrecht 1986). Certainly, the overall presence of farm employment on the Great Plains is anticipated to decline from 1940 forward, altering the within-county influence of farm dependence (it weakens as the presence of the "treatment" dissipates). Yet the nature of the relationship is expected to remain consistent, and negative. However, I argue that the character of the association may differ over time depending on the period under analysis. Rather than focusing on the post-mechanization period alone, an exploration of the entire 20th century might reveal a positive association between farm dependence and population growth in the years preceding mechanization. By extending the time scope of the analysis, one can more aggressively, if not more comprehensively, assess the import of ecological theory to population change in the Great Plains and further clarify the nature of the relationship between population growth and farm dependence.

The Historical Context

The agricultural industry boomed on the plains in the early years of the 20th century, fueled by favorable environmental conditions and an expanding need for agricultural goods stimulated by the war and increased industrial wages among consumers on the eastern seaboard. Innovations in agricultural technology impacting seed, soil, and equipment also aided industry expansion. Following World War I, young soldiers returned to the farm equipped with a renewed desire for the American Dream accompanied by low land prices and a demanding global market to assist their enthusiasm. Given the varying dates of settlement across the Great Plains, population growth accompanying the agricultural expansion was likely geographically distributed such that places that were un- or sparsely-settled were likely to experience greater growth compared to counties with already established farms and communities.

This period of growth, sometimes referred to as the "golden age" of the Great Plains (Ottoson et al. 1966), was followed by severe drought and an agricultural, and more general economic downturn during the 1920s. While most of America identified 1929 as the turning point, those reliant upon the agricultural industry realized that the economic climate had gone sour much earlier. Low levels of rain and high quantities of grasshoppers and wind gusts offered many plains folk early admission to the Depression Era. Those on the Texas and Oklahoma panhandle were spared from the ravages of the grasshoppers and still prospered in the mid-1920s. But while they entered the depression slightly later, they did so under the grand introduction of the Dust Bowl (Gregory 1989).

Despite the sour climate, agricultural dependence may have maintained a positive association with population growth during 1920s and into the 1930s for two reasons. First, given the dismal conditions in urban centers, economic and otherwise, a return to the land movement drew people to rural areas to eke out an existence through subsistence farming rather than falling labor wages. Second, while the stocks crashed and agricultural prices fell across the nation, and world, the Dust Bowl disaster was limited to a specific geographic region. While drought conditions also confronted farmers on the Northern Plains, the dust storms were not as dramatic or detrimental as in the Southern Plains.

By the 1930s, the government responded to the economic and environmental crises with federal aid. But until these programs were in place, farmers and their community dependents relied upon family and local organizations for support (Grant 2002). Those with substantial capital preceding the depression were able to take advantage of the government programs, usually consisting of seed loans and temporary off-farm employment through the Civil Works Administration (CWA) and then the Works Progress Administration (WPA). Other, less fortunate and less capitally endowed farmers most often ended up selling their property—including land, machinery, and stock—to pay their debts. They were ill equipped to enter the new agricultural industry, more accurately characterized as a business rather than a way of life. It is at this point in the U.S.'s agricultural history that a negative association between farm dependence and population growth emerges, and persists throughout the remaining years of the 20th century.

Mechanization, economic pressures, and political maneuverings transformed farming and ranching from family run operations to corporate enterprises. This shift demanded expansion of land and equipment, and diversification of crops and livestock. Farm sizes began to increase while the number of farms declined, especially after 1940 (National Agricultural Statistics Service 2003). Tractors began replacing the mule and horse, and by 1940, 55% of plains farmers had tractors compared to 23% among all other U.S. farmers (Grant 2002:15). Those squeezed out of farming often looked to the newly established industrial market. Here, no financial capital was necessary to gain entrance and larger paychecks were generally brought home.

Not only did this new model of agricultural production weed out smaller operations without the financial backing to expand, but it also required fewer farms in general. Rather than calling for a multitude of small farms, the mechanized industry demanded fewer but larger operations (Labao and Meyer 2001). Therefore, unlike the veterans of WWI, young soldiers returning from WWII headed to town for better-paying industrial jobs rather than back to the farm, if there was even a farm to which to return.

The U.S. experienced a great deal of change during the post-war period, spanning the years between 1950 and 1970. The nation was coming off of the industrial high associated with WWII and entering the Cold War. Urbanization, suburbanization, industrialization, and trade expansion rapidly took hold, dramatically altering the country's landscape. The agricultural industry continued to adapt to the demands of a large-scale operation while manufacturing and other industries flourished. In fact, much of the U.S. economic boom was centered in the expansion of the non-agricultural sector (Johansen and Fuguitt 1984). And most of the labor force was found in or called to locations outside of the Great Plains.

The demand for U.S. goods, agricultural and otherwise, reached beyond the nation's borders. During this era, the federal government passed legislation directly influencing the agricultural industry, namely the Agricultural Trade Development and Assistance Act of 1954 and the Trade Expansion Act of 1962. By reducing trade tariffs these acts expanded the market for U.S. goods and, presumably, the opportunity for U.S. profit. But while trade expanded, the proportional value of agricultural exports actually declined between 1930 and 1950 from 32% to 22%, and then remained stable until contracting further in 1970 to 19% of all exports (U.S. Department of Agriculture 2003). In contrast, agricultural products accounted for 58% of the value of all U.S. exports in 1900. Further, the prices farmers received for their products continued to decline relative to the costs of production (National Agricultural Statistics Service 2003).

While the proportional significance of the agricultural industry dwindled, rural places began to promote or at least be recognized for alternative features during the later part of the century, including recreational amenities and quality of life. Perhaps rooted in the country's earlier economic boom, more of the U.S. population looked for recreation and relaxation than before, whether it was in the form of a short-term vacation or a more long-term residential or retirement move (Berry and Duhmann 1980; Fuguitt and Zuiches 1975; Long 1985; Long and Frey 1982; Zuiches 1981; Zuiches et al. 1978). It was during this era that the "population turnaround" occurred, albeit only for a brief period between 1970 and 1980. During this decade, population researchers noted a reversal in the typical rural-to-urban migration (Fuguitt 1985; Long and DeAre 1988; Wardwell and Gilchrist 1980). Instead of observing this pattern, they noticed growth among the rural locations accompanied by some decline within more urban places. Beyond retirement and recreation, the later part of the 20th century also witnessed a movement of small manufacturing companies and energy developments in the Great Plains. With the companies came jobs and, some have argued, population stability and even growth (McGranahan 1998; Murdock, Leistritz, and Schriner 1980). Importantly, regarding the present concern with the relationship between farm dependence and population change, while some counties within the Great Plain experienced growth during this period, it was concentrated among those with low or no farm dependence.

Data, Measurement, and Methods

Defining the Great Plains

There is no consistent geographical definition of the Great Plains among historians, geographers, demographers, and sociologists. Inclusion ranges from six U.S. states in their entirety to counties within 13 states plus Canadian and Mexican territories. The eastern border is sometimes drawn at the 98th meridian, the 100th meridian, or the line following 20 inches or less of rainfall, while the western boundary is typically demarcated at the base of the Rocky Mountains. Yet, scholars agree that the Great Plains is distinct from its surrounding areas by its semi-arid quality.

The Great Plains region is semi-arid, meaning that in some years it is dry and even arid, or desert-like, while in other years it is very wet. Still, in other years it is wet or dry at the wrong time from the viewpoint of agricultural production (Kraenzel 1955:12). It is this unpredictability, or annual variation that separates the Plains from its more predictable eastern and western neighbors. The Great Plains are not the only area considered semi-arid. In fact, nearly 15% of the world's surface is similarly classified. Yet it is the only semi-arid region within the U.S.

The sample for this study follows the U.S. Geological Survey definition and, therefore, includes approximately 876 counties within 13 states (aggregated into 745 county clusters, as described in greater detail below).[2] Data are drawn from the *Historical, Demographic, Economic, and Social Data: The United States, 1790-1970*, made available by the Inter-University Consortium for Political and Social Research (ICPSR 1976), and supplemented with population and agricultural census data to gain county level data for all decades between 1900 and 2000.

Counties are the selected unit of analysis given that they are governmental units functioning to unify the population within its boundaries. Government taxes and programs involving agriculture, social welfare, education, and transportation construction and maintenance operate at the county-level. Because few large metropolitan centers are found within the Great Plains, concerns regarding metropolitan overflow incessantly bothersome in studies of more urban locations do not apply to the present analysis.

However, county borders change over time. And county borders tend to change for political reasons mainly associated with population size. Using a template developed by Horan Hargis, and Killian (1989), each county is converted into its 1900 form and given a unique county cluster code, producing 745 county clusters for analysis according to the 1900 boundaries.[3] Some counties do not change their shape while others are dramatically different. For example, most of the counties in Iowa have not changed their boundaries since 1900, yet almost every county in Oklahoma has. In fact, in 1900, Oklahoma had not yet become a state and was largely considered "Indian Territory." The southern and northeastern parts of the state were divided between two sizeable areas, while smaller county divisions were made in the northwestern part of the state, resulting in a few relatively huge county clusters.

Measurement

Population change serves as the dependent variable throughout the analysis and is calculated as a percent change by $[1 - (P_t/P_{t+1})]$ then multiplied by 100, where P_t is the population at time 1 and P_{t+1} is the population at time 2, with values generally ranging from –1 to 1 (Farley 1964). A zero indicates stability, while a value less than zero implies decline and a value greater than zero suggests growth. While I refer to this measure as "percent change" it is different from typical formulas of percent change, although generally comparable to alternative measures of percent change and growth rates. In essence, this equation calculates the relative size of the old to the new population.

The key independent variable is farm dependence, operationalized as the proportion of the population employed in farm jobs for the first decade of the period under analysis. For example, population change between 1900 and 1910 is regressed on the 1900 proportion employed in farm jobs. Previous studies of similar focus have used the term "agricultural dependence" rather than "farm dependence," yet this concept is similarly measured through the proportion employed in farm jobs (e.g., Albrecht 1986; Rathge and Highman 1998a). It is not my intention to demean this earlier work, but the proportion of farm employment more accurately captures *farm* dependence than *agricultural* dependence. The agricultural industry includes not only farming, or crop production, but extends to livestock production, the transportation and processing of products as well as the services enabling its production. A more appropriate measure of agricultural dependence would incorporate the proportion of the population engaged in this work in addition to strict farm employment. Rather than implementing a new measure of agricultural dependence, I have chosen to use a measure consistent with previous studies but employ a more restrictive term to describe the approximated concept. By doing so, this research not only extends our understanding of the measure, but the analysis remains inherently comparable to its predecessors.[4]

Several covariates are also included in the analysis to control for exogenous spatial and contextual factors. A spatial dummy variable is introduced to explicitly account for anticipated spatial patterning in the distribution of population change. Between 1900-10 and 1910-20, population growth is expected to be concentrated in the western portion of the Great Plains, given that this sub-region was less settled at the beginning of the 1900 relative to the eastern portion. Therefore, an east – west control is introduced, where east is coded “0” and includes counties in and east of North Dakota, South Dakota, Nebraska, Kansas, Oklahoma and Texas. West is coded “1” and includes all counties within Montana, Wyoming, Colorado and New Mexico. However, between 1920-30 and 1930-40, spatial variation is anticipated to fall along a north – south division. This is the period of the Dust Bowl and New Deal administration and programs. Although drought conditions plagued the entire Great Plains, the severity and wind was particularly bad in the Southern Plains (Gregory 1989). In addition, while the New Deal policies affected the Great Plains, much of the agricultural programs that were applied to the region as a whole were developed around the economic and environmental conditions and the agricultural and social organization of the Northern Plains, thereby having less applicability and influence in the Southern Plains (McDean 1980). South is coded “0” and includes all counties within and south of Colorado, Kansas, and Missouri, while north is coded “1” and consists of all counties north of these states. After 1940, growth within the U.S. and the Great Plains began to fall along metropolitan – nonmetroplitan lines, such that growth was higher in metropolitan counties. Therefore, in the decades following 1940, a control for whether the county contains a city of 10,000 or more is introduced. Counties containing a city are awarded a “1” while those without are coded “0.” Further, each of these spatial dummy variables is interacted with farm dependence given that the influence of farm dependence is anticipated to vary according to spatial location within the Great Plains.

In addition to the spatial variables, county characteristics associated with time and growth potential are considered. These factors are county settlement date (measured as the first year the county appeared in the census), county size in acres per 100,000 acres, and initial population size per 1,000 persons.

Methodological Approach

I begin the exploration of variation in population change with an assessment of average growth rates, or percent population change, across the century. Here, emphasis is placed on the temporal aspect of variation in patterns of population change. The county averages are compared to national figures in order to situate the Great Plains' level of change in a meaningful context. I then place varying patterns of growth within a geographic environment and relate them to the distribution of farm dependence through spatial error regression techniques. The advantage of such an approach is that notable spatial patterns of population change are revealed when mapping the patterns of growth for the Great Plains counties across key points during the century.

The use of a spatially oriented regression technique deserves justification and elaboration. When analyzing georeferenced data, or data distributed within a larger spatial unit—such as a country, region, or state—the researcher must be sensitive to potential underlying spatial relationships or spatial autocorrelation (Anselin 1988; Cliff and Ord 1973, 1981). Spatial autocorrelation arises simply because locational proximity is typically accompanied by value similarity. The presence of a spatial relationship violates the assumption of independence inherent within non-spatial forms of regression analysis since, for instance, the value of one county's attribute is related to or dependent upon its neighbor's value. Failure to account for such relationships, or spatial autocorrelation, will likely result in biased parameter estimates.[5]

Spatial error regression focuses on the dependent covariance structure through an autoregressive framework. This model is rooted in the basic OLS regression equation, where a constant, covariate coefficients, and an error structure are included in the regression equation. In addition to the basic building blocks of the OLS equation, the spatial error model introduces an error term by including an additional explanatory variable: the mean of the dependent variable for adjacent spatial units. In terms of matrix algebra, the dependent variable is transformed into a vector of adjacent means, where the value of the dependent variable is related to its location within the larger spatial area; an adjacency matrix for the specific spatial units is used to produce an adjacent-mean variable or the spatial error term which is introduced into the regression analysis as an explanatory variable. To emphasize, the spatial correlation in the dependent variable on the left-hand side of the equation is extracted and included as an explanatory variable on the right-hand side of the equation. The resulting output format is notably similar to that obtain through OLS with the exception of an autoregressive coefficient and a model fit statistic based on maximum likelihood (AIC) in lieu of an R^2.

Findings

Temporal Patterns of Population Change

Given the historical circumstances, it is reasonable to expect that patterns of county-level population change within the Great Plains would vary over the course of the 20th century. Further, it is unlikely that patterns of change were consistent across the vast region. I address precisely how these patterns changed, referring to counties as either having declined, grown, or remained stable. A county cluster was considered stable if the difference between two time points neither increased nor decreased by more than 5% of its value in the earlier year. Such classifications, reported in Table 1, are accompanied by regional and national growth rates in order to place the patterns of population change in a more general context.

[Table 1 About Here]

When reviewing the decennial growth patterns, the distribution of growth was unstable during the years before mechanization. The majority of the Great Plains counties grew during the first and third decades of the 20th century, with about 59% and 93% experiencing growth for 1900-10 and 1920-30, respectively. Among these growing counties, more than 88% grew by over 10% in 1900-10 and 92% in 1920-30. This suggests that the high concentration of growth during these two decades is not attributable to low level increase.

Yet these decades of considerable growth were surrounded by periods marked by decline. An estimated 74% of all Great Plains counties lost more than 5% of the 1910 population by 1920, while 45% declined in 1930-40. In contrast to the decades of growth, the majority of losing counties declined by less than 10%. Harsh weather has been targeted in discussions of the decline during the 1910s. North Dakota experienced drought conditions in 1917 while Nebraska suffered a severe winter between 1916 and 1917, and both of these states in addition to South Dakota experienced poor production in 1918 and 1919 (Ottoson et al. 1966). And a likely culprit for the noted decline of the 1930s is the devastating combination of the Dust Bowl and Depression.

During the post-mechanization period, the years following 1940, around half of all counties declined with the exception of only two decades. More counties gained population than lost during the 1970s and 1990s. This pattern is consistent with notions regarding the population turnaround of the 1970s and increased manufacturing during the 1990s. It is worth reiterating that neither of these phenomena point to farm dependence as a contributor to positive growth.

The pattern of population change in the Great Plains can be placed in context by comparing the percent change in population for the Great Plains to that of the entire U.S. As evidenced in Table 1, the growth rates for the Great Plains are generally less consistent with those observed for the U.S. in the early part of the century, relative to the degree of correspondence observed toward the end of the one-hundred year period. Researchers have suggested that growth rates for smaller, more rural geographical units become increasingly similar to national rates in later periods, as economic structures become more similar (Bender 1980). It is in these later periods that employment patterns in rural areas became closely linked to national economic activity and, as discussed, economic activity is presumably associated with population growth.

The Great Plains growth rates exceed the U.S.'s rates between 1920 and 1930 by 15%. The magnitude of the growth over this ten-year period, following WWI and accompanying continued seed strain advancements, is substantial. Yet, between 1910 and 1920, during the war and dismal environmental conditions, the Great Plains suffered a 5% loss as the U.S. experienced a 15% gain. And between 1950 and 1960, the U.S. experienced an increase larger than the surrounding years (19%), yet growth in the Great Plains was not as dramatic (12%). This was a decade of marked suburban growth for the U.S. in general (Edmonston and Guterbock 1984; Guest 1978; Schnore 1962). The divergence between the Great Plains and U.S. trends suggests that suburbanization was mainly located beyond the Great Plains boundaries. However, by the end of the century, especially after 1960, the growth rates between the Great Plains and nation became more similar, deviating from one another by only three points at most. Importantly, these deviations typically favored the Plains, such that the region underwent a slightly higher percentage increase in population relative to the entire U.S. For example, between 1990 and 2000, Great Plains counties grew by 16% while the U.S. experienced a 13% increase.

Farm Dependence and Population Growth

Analysis of the relationship between farm dependence and population change over the 20th century is motivated by previous research suggesting a negative association during the post-mechanized period of the Great Plains' history and ecological theory arguing that the relationship between economic base and population size is influenced by technological change. In the present context, agricultural mechanization occurring around 1940 is the technological agent altering the equilibrium in the post-1940 period (Albrecht 1986; Rathge and Highman 1998a; Grant 2002; National Agricultural Statistics Service 2003). The estimates reported in Table 2 demonstrate that this relationship is spatially dependent. Controls for suspected spatial factors in Model 2 (including sub-region before 1940, city status after 1940, and county settlement, size and initial population in all periods) do not fully account for the spatial autocorrelation present within the Great Plains data. Instead, the autoregressive coefficient estimated in the spatial error analysis accounts for the spatial dependence, thereby producing reliable parameter estimates for farm dependence and allowing for confident interpretation of the relationship between farm employment and population change.

[Table 2 About Here]

Model results suggest that, indeed, farm dependence is negatively associated with population change throughout the post-mechanized period. The strongest influence is noted for 1940-50, with a lower yet stable influence in the remaining decades. Consistent with prior studies, counties with high farm dependence were significantly more likely to experience population loss during the post-mechanized period.

The relationship between farm dependence and population change was notably less stable during the years preceding agricultural mechanization. Farm dependence was strongly associated with population growth between 1900 and 1940, yet the nature of the relationship varied with each decade. For 1900-10, farm dependence was positively associated with growth ($\beta = 0.13$), suggesting, in terms of ecological theory, that there was greater economic opportunity than population. Thus, population needed to increase in order to meet the needs of the farming opportunities in the various locations. Recall that this is a period of massive settlement on the Great Plains, where nearly 60% of the counties experienced growth, with 58% growing by more than 10%. Remarkable gains are also noted in 1920-30, and a strong, positive relationship between population growth and farm dependence is evidenced ($\beta = 0.26$). This decade followed WWI, where many young men returned to the family farm or established their own, motivated by government incentives and a burgeoning national and international demand for U.S. crops.

However, this positive association did not persist throughout the pre-mechanized period, suggesting a less stable relationship between farm dependence and population growth prior to the corporatizing of farming. For 1910-20 and 1930-40, farm dependence was negatively related to growth, yet the magnitude varied between these two decades. During the 1910s, farm dependence was strongly associated with population change ($\beta = -0.34$). The circumstances, such as poor environmental conditions, that negatively impacted farming similarly affected population growth. In contrast, the negative association observed during the 1930s was comparatively weak (β = -0.08). While the Dust Bowl may have been regionally-specific, the Depression was of consequence for all industries and regions, and not exclusively farming or the Southern Plains.

Tests for significant variation in the influence of farm employment across decades further supports the notion that the relationship was less stable prior to mechanization. As evidenced in Figure 1, the estimated influence of farm dependence significantly varied between decades from 1900-10 to 1950-60, yet remained virtually unchanged throughout the remaining decades.

[Figure 1 About Here]

Spatial Patterns of Population Change

Although not fully accounting for spatial autocorrelation, tests for an interaction between city status and farm employment, reported in Table 2, suggest that the influence of farm dependence significantly varied according to whether a county contained a city at three points in the post-mechanized period. However, the nature of the variations was inconsistent. In 1950-60 and 1980-90, farm dependence was more detrimental for counties containing a city while the reverse was observed in 1960-70. And while both 1950-60 and 1980-90 witnessed a negative interaction, the magnitude was considerably smaller in 1980-90 relative to the earlier period.

Likewise, tests for variation in the influence of farm dependence across sub-regions during the pre-mechanized period indicate that the fluctuating influence of farm dependence varied over the Plains. In 1900-10, the positive impacts of farm employment were more dramatic among western counties than those further east. This is consistent with arguments that growth, and farm expansion, was particularly concentrated in the less settled western area. Similarly, in 1910-20, when the region was marred by population loss, the negative influence of farm dependence was particularly pronounced in the western sub-region. The strong association between farm dependence and population change appears to have both more dramatically helped and hindered the Western Plains during this early period of settlement.

For 1920-30 and 1930-40, the magnitude of the relationship also varied across the region, but according to a north – south division. The positive influence of farm employment in 1920-30 and negative influence in 1930-40 was less prominent within the Northern Plains. In fact, the strength of the interaction term virtually cancels the additive impacts of farm employment, suggesting that there was very little association between farm dependence and population change among the northern counties of the Great Plains.

While Figure 1 focuses on the temporal patterns of the relationship between farm dependence and population change, the spatial distributions of population change, farm dependence, and their relationship are illustrated for three key decades in Figures 2 through 4. The periods 1900-10, 1940-50, and 1990-2000 were selected to demonstrate the varying temporal and spatial distributions of the relationship of concern. Between 1900 and 1910, much of the growth dominating the decade is spatially concentrated in the western portion of the Great Plains.[6] And, as suggested in the regression analysis, the incidence of farm employment is similarly concentrated in the western portion. Those counties experiencing growth tend to have high proportions of farm employment.

[Figure 2 About Here]

In contrast, between 1940 and 1950, the distribution of growth is also concentrated, yet in a radically different spatial pattern. Rather than an east – west demarcation, a central – border difference emerges with most of the loss restricted to the central plains while growth is found along the eastern- and western-most counties. Although not as strong of an association relative to the 1900-10 period, the distribution of farm employment negatively corresponds to that of population growth, where the highest farm employment is located in the central part of the Plains and among those counties experiencing decline between 1940 and 1950.

[Figure 3 About Here]

Finally, between 1990 and 2000, the period with the weakest association between farm dependence and population change, the distribution of growth is somewhat similar to that observed between 1940 and 1950. Population loss tends to be located in the central plains while growth is mainly concentrated in the border counties. One notable difference between these two periods is the intensity of growth along the southeastern boundary of Texas, housing oil fields and metropolitan areas, relative to the southwestern border, as observed in the 1940-50 period. Also noteworthy is the dramatic reduction in the presence of farm employment across the region during this final decade. Most of the counties had fewer than 5% of the population employed in farm jobs. Spatially, those counties with more than 5% farm employment were almost entirely limited to the central plains. Despite the overall reduction in the presence of farm employment, the spatial distribution of population change and farm dependence, and the association between the two are generally comparable for 1940-50 and 1990-2000, whereas a remarkably different pattern prevails in 1900-10.

[Figure 4 About Here]

Summary and Discussion

The Great Plains witnessed rapid and extensive growth during the first thirty years and modest growth at two points during the final years of the 20th century. Growth in the Plains actually exceeded that observed for the U.S. as a whole during the 1900s and the 1920s. At the beginning of the century, spatially, most of the expanding counties were located in the western part of the region while those suffering loss were limited to the east, thus highlighting the locational distribution of 20th century settlement. Yet this period of remarkable growth was followed by dramatic loss. Most decades between 1930 and 1990 witnessed more decline than growth, and the spatial distribution altered notably. Those counties maintaining growth were found along the region's boundaries while the center, with higher proportions of farm employment, was riddled with loss.

Growth returned to the Plains at two points during the post-mechanized years, in the 1970s and the 1990s, yet it remained concentrated at the region's boundaries. The population turnaround appears to have impacted the Great Plains, as almost 43% of the counties grew between 1970 and 1980. A similar proportion of growth was also observed for the 1990-2000 decade, where slightly more than 40% experienced growth. This increase, and the corresponding rate of growth with that of the nation in the later years, may be attributable to a shift in the Great Plains' economic structure. Researchers have noted an increase in the number of manufacturing businesses and employees within the region in recent years (Beale 1980; McGranahan 1998), while others have emphasized energy developments (Murdock et al. 1980) and recreational expansion (Heaton, Clifford, and Fuguitt 1981). Such research suggests that the region is economically diversifying and becoming more similar to the nation's. Therefore, regional growth patterns more similarly approximate the national trends (Bender 1980). And, we might add, the relationship between population change and farm dependence has diminished in more recent decades relative to earlier periods.

Consistent with previous research, the association between farm dependence and population growth was negative and stable in the years following mechanization, indicating that counties with greater farm dependence could anticipate a higher likelihood of population loss rather than growth, and demonstrating support for the ecological theory. Yet prior to mechanization, the relationship was unstable, such that farm dependence was both positively and negatively associated with growth in the years before 1940, and at levels significantly higher than those observed in the post-mechanized period. By expanding the period of analysis, the previous conclusion that the relationship between farm dependence and population change is stable must be rephrased to clarify stability during the post-mechanized period only. When considering the relationship over the course of the entire century, one would most accurately argue that the nature of the relationship has changed over time, in both nature and magnitude.

This spatially-oriented analysis also reveals considerable spatial dependence and should caution researchers employing non-spatial methods of analysis to this and similar, future topics using georeferenced data. As mentioned, the influence of manufacturing or other economic industries is a worthwhile line of study for those interested in the nature of the relationship between economic base and population change, or the continued extension of ecological theory, and the future of the Great Plains. These analyses must consider space given that the distribution of population growth and the distribution of various industries are most certainly not equally dispersed across this region.

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Notes

[1] The more basic presentation of a unidirectional association between technological and population changes can also be treated more complexly. For example, the unidirectional conceptualization can be omitted in lieu of a multidirectional relationship—where the two factors are involved in a feedback relationship characterized by reciprocal effects—or the technological innovations involved extend beyond the U.S. borders—here global markets and competition are explicitly implicated in the technological transitions experienced by the agricultural industry. Regardless of the degree of complexity specified by the researcher or theorists, the hypothesized association between technological and population changes in the current context remains unchanged.

[2] I have selected a broader definition than some studies of the Great Plains in an attempt to remain as inclusive as possible. Minnesota, Iowa, and Missouri are often omitted from studies of this region due to the variation in precipitation, grass length, and altitude. For example, *The Great Plains Population and Environment Project* excludes counties within these three states, thereby creating a sample of 450 counties (Gutmann et. al 1998). Other contemporary Great Plains research has restricted analysis to 396 (Adcock 1995) or 478 (Cromartie 1998) counties, while others have limited it to 294 nonmetropolitan counties (Albrecht 1986). However, while places within these states may receive more than 20 inches of rainfall, evaporation maintains semi-arid conditions among the western counties within these states (Kraenzel 1955).

[3] Use of the template has the following implications: if county A and B are not involved in the formation of a new county there would be no change in their county code, and would each be assigned a separate county cluster code. But, if county A split to produce county B, they

would share the same county cluster code. Similarly, if county B merged with county A, they would also have the same county cluster code.

[4] An additional note regarding the measure of farm dependence is necessary. Since 1850, the census definition of what constitutes a farm has changed according to various acreage, sales, and operation requirements. Definitional changes instituted between 1959 and 1974 had dramatic impacts on the census number of farms, as well as farm related variables including farm employment. From 1959 to 1974, "the acreage requirement was raised to 10 acres or more, with at least $50 or more in agricultural products sales. A place of less than 10 acres qualified as a farm if it had sales of $250 or more during the census year" (USDA 2002:B-11). The new definition was introduced to account for non-farmers residing on formerly operational farms. The consequence of this definitional change is an estimated 1.1 million farm-employed persons having been dropped: (1) one million persons with secondary jobs in agriculture, (2) 84,000 salary farm workers, and (3) 23,000 unpaid family workers (USDA 1961). By 1978, the acreage requirement was dropped. When reviewing the mean number and proportion of persons employed in farm jobs over the century, there is a striking decline in the 1970 estimate from the 1969 Ag Census compared to the preceding and following decades (the mean proportions: 1960 = 0.11, 1970 = 0.04, and 1980 = 0.12). This remarkable, temporary decline appears to be an artifact of the definition change.

[5] Spatial autocorrelation might take on two forms: spatial heterogeneity and spatial dependence. Heterogeneity can be conceptualized as first order effects, where the researcher observes variation in the moments of a spatial process in an area resulting from spatial location, or from relationships with explanatory variables that vary regularly in their values across the

spatial unit under analysis. Such a drifting process is indicative of spatial non-stationarity. In contrast, spatial dependence is a second order effect and, according to Anselin, "can be considered to be the existence of a functional relationship between what happens at one point in space and what happens elsewhere" (1988:11). In this context, a spatial process underlies the relationship between some independent variable and covariates of interest in a stationary fashion such that, for example, the deviations in values of the process from its mean tend to follow each other in neighboring sites. Importantly, it is often difficult for the researcher to determine which is operating, heterogeneity or dependence, or whether both are at play. The researcher might best determine which spatial effect is operating by introducing a method that would account for first order effects (heterogeneity) then examine whether a spatial pattern persists. If so, second order effects (dependence) are operating instead of or in addition to first order effects.

In this analysis, I tested first for spatial heterogeneity by estimating a Moran's I statistic (see Cliff and Ord 1973, 1981; Moran, 1950) for residuals from various models (results not reported)—first, the bivariate association between farm dependence and population change; second, a multivariate model adding a spatial dummy variable (discussed in greater detail in the *Measurement* section) and an interaction between the spatial variable and farm dependence; and third, a model further adding controls for settlement date, county size, and initial population. Spatial autocorrelation persisted despite the addition of the covariates. Therefore, I conducted a set of tests against specific forms of spatial processes based on the maximum likelihood principle (see Anselin 2001; Anselin and Bera 1998). Diagnostics suggested a general superior fit for the spatial error regression technique relative to a spatial lag model. The exceptions include 1950-60, 1960-70, 1980-90, and 1990-2000. In the 1950-60 and 1960-70 analysis, there was no difference in fit between the two models. For 1980-90 and 1990-2000, the spatial lag model was a better fit, yet the model estimates were virtually the same with only the constant parameter varying. Given these non- and negligible-differences, the spatial error model using a queen weights matrix was selected for the analysis of all decades.

[6] The rectangular red county in Colorado along the western border is the Arapahoe/Adams County Cluster. Here, population loss was recorded between 1900 and 1910, as much of the population moved west to its neighbor, Denver.

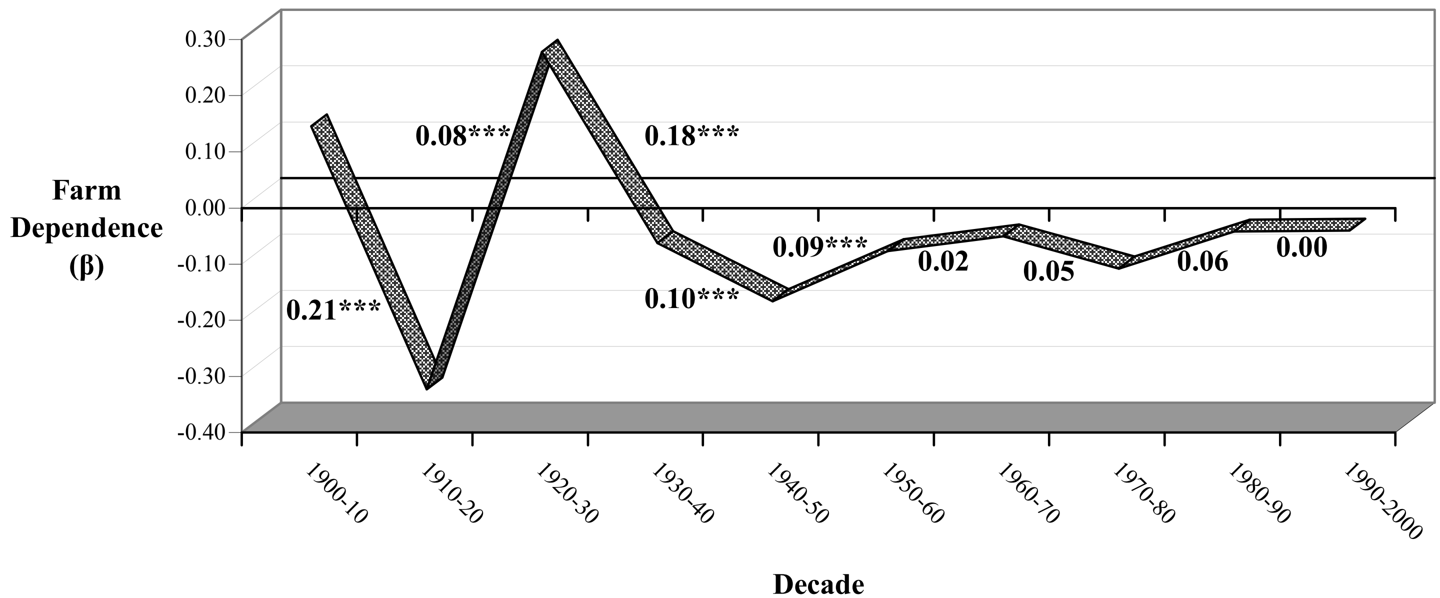

Figure 1. Estimated Influence of Farm Dependence on County Population Change with Differences in the Influence of Farm Dependence Across Decade

Note: Estimated betas are from Model 2 of Table 2. Absolute differences in the coefficients for farm dependence across decade are noted within the figure.

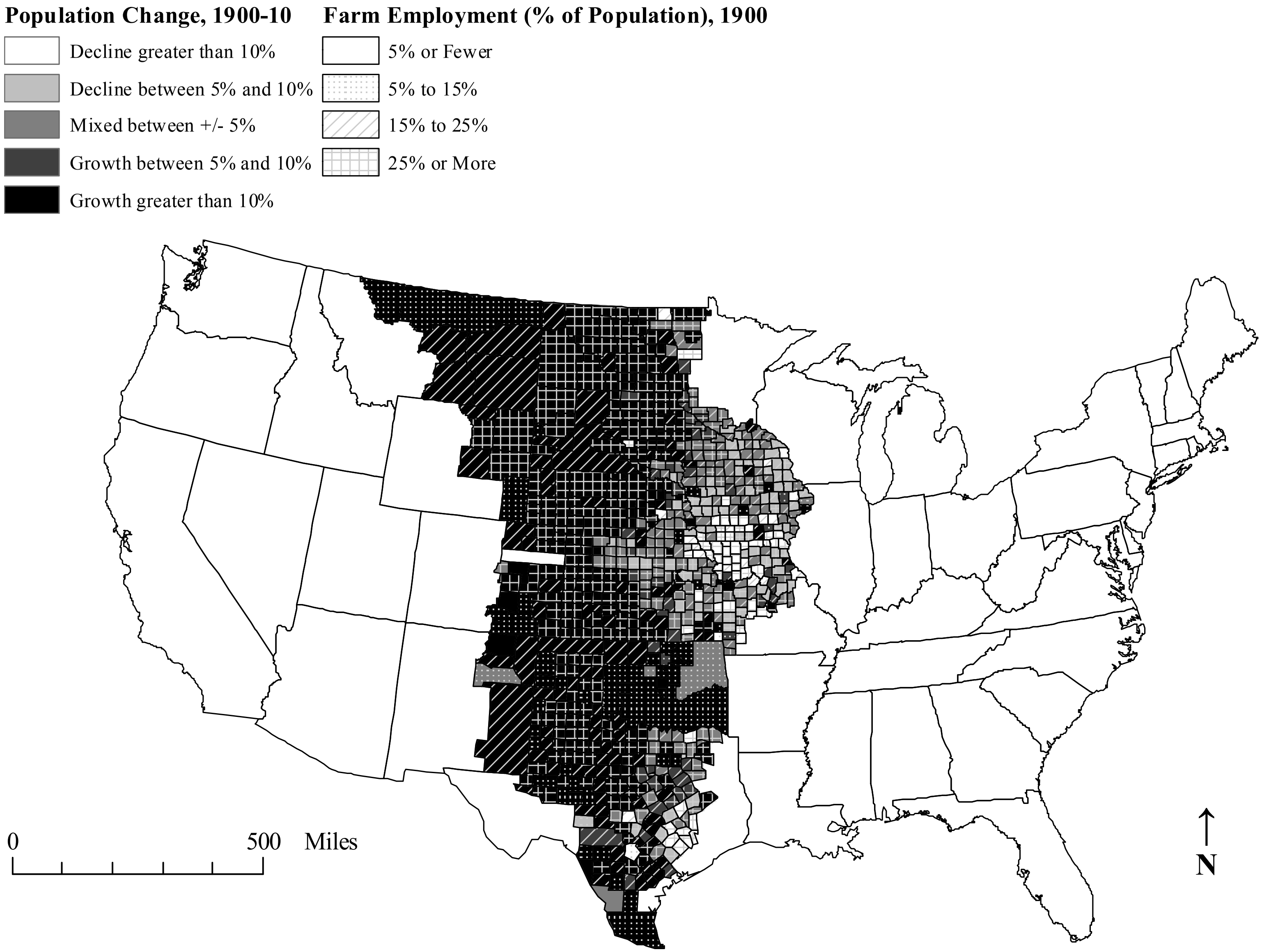

Figure 2. Spatial Distribution of Population Change and Farm Dependence, 1900-10

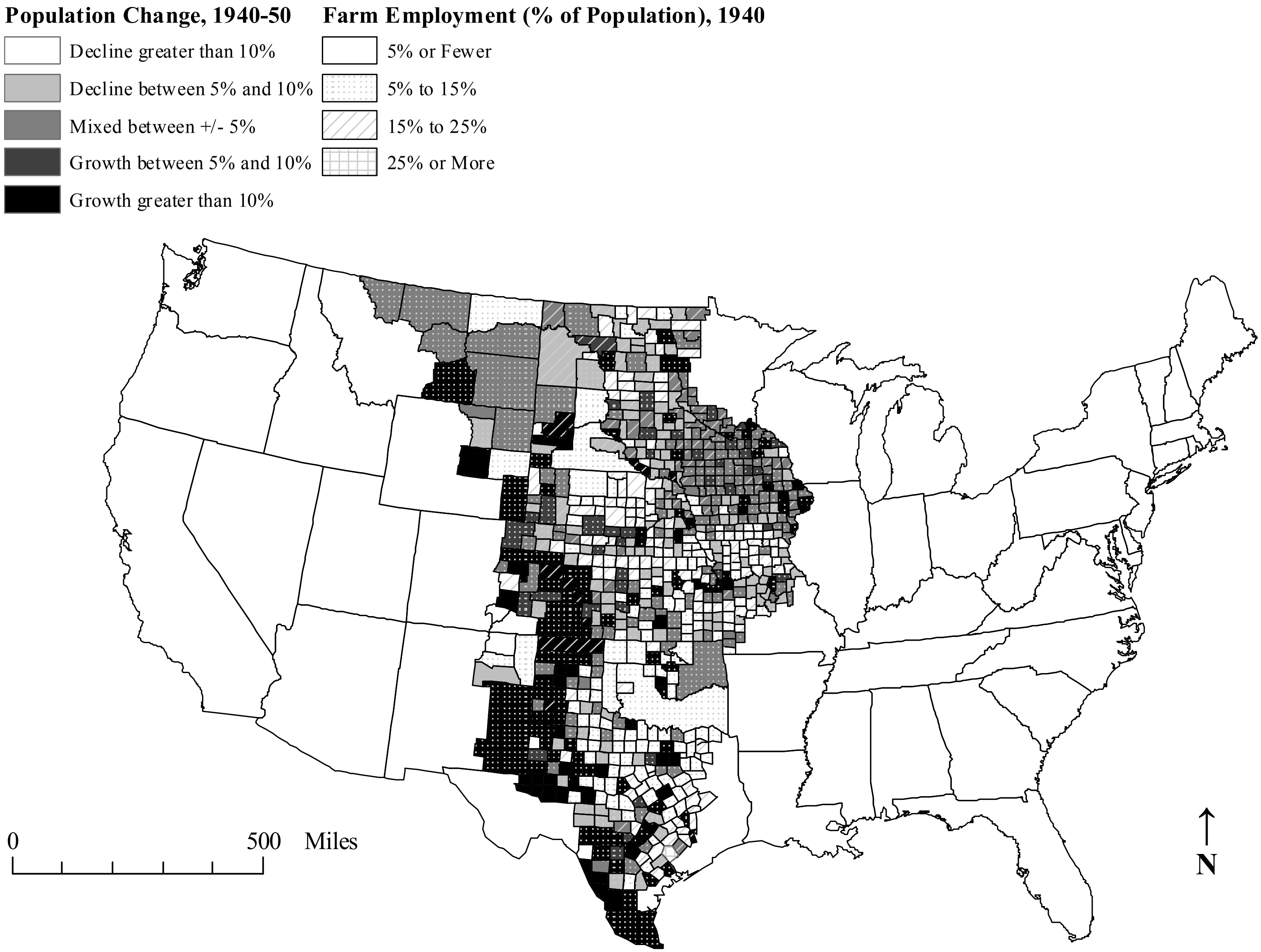

Figure 3. Spatial Distribution of Population Change and Farm Dependence, 1940-50

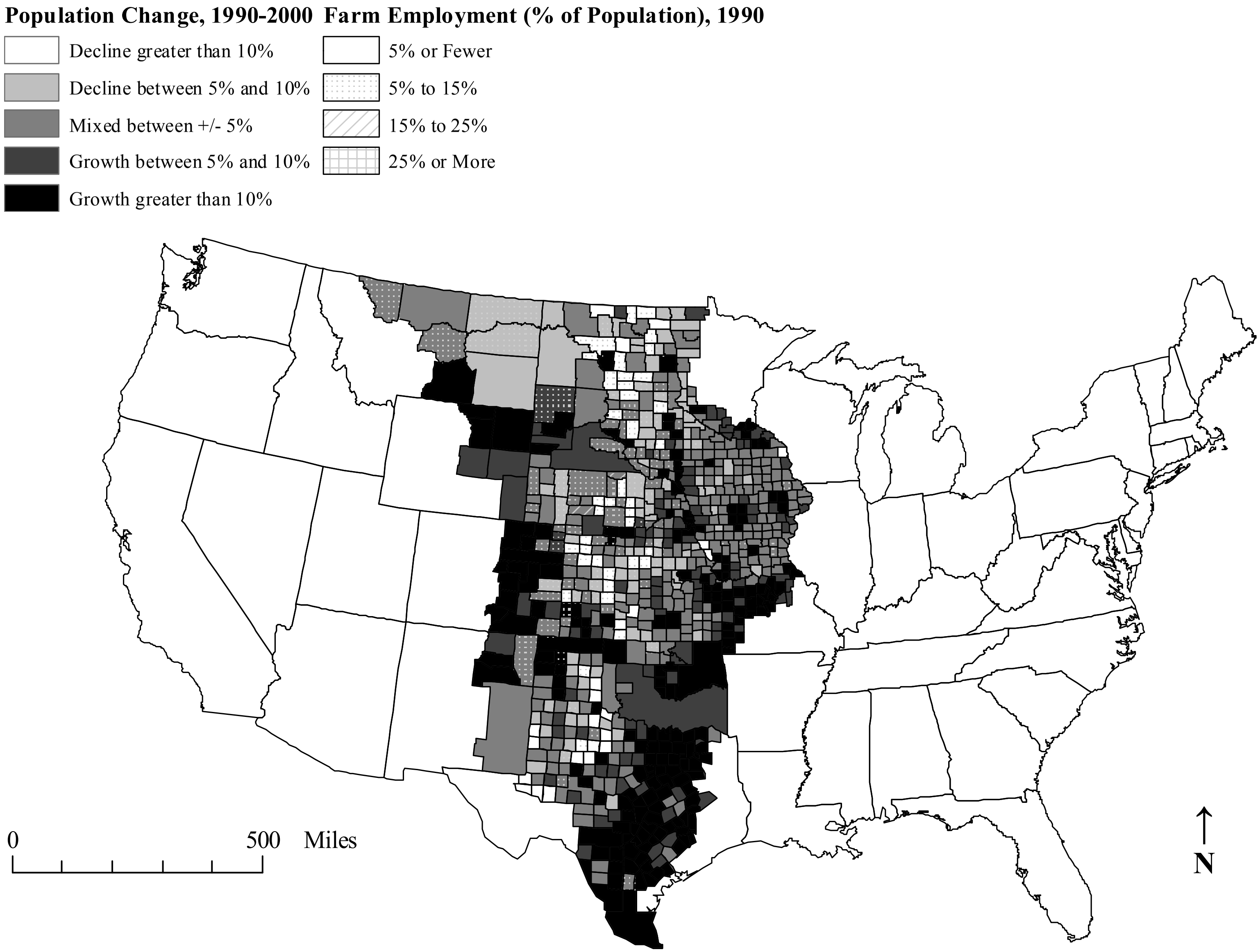

Figure 4. Spatial Distribution of Population Change and Farm Dependence, 1990-2000

Table 1. Growth Characterizations for Great Plains Counties Relative to the U.S. by Decade

	N	%		N	%
Pre-Mechanization			***Post-Mechanization***		
1900-10			**1940-50**		
Decline	153	20.5	Decline	392	52.6
Stable	155	20.8	Stable	179	24.0
Growth	437	58.7	Growth	174	23.4
Great Plains Growth Rate		*17.2*	*Great Plains Growth Rate*		*5.9*
U.S. Growth Rate		*21.0*	*U.S. Growth Rate*		*14.5*
1910-20			**1950-60**		
Decline	551	74.0	Decline	358	48.1
Stable	81	10.9	Stable	203	27.2
Growth	113	15.2	Growth	184	24.7
Great Plains Growth Rate		*-5.9*	*Great Plains Growth Rate*		*12.2*
U.S. Growth Rate		*15.0*	*U.S. Growth Rate*		*18.5*
1920-30			**1960-70**		
Decline	12	1.6	Decline	404	54.2
Stable	43	5.8	Stable	182	24.4
Growth	690	92.6	Growth	159	21.3
Great Plains Growth Rate		*31.2*	*Great Plains Growth Rate*		*8.1*
U.S. Growth Rate		*16.2*	*U.S. Growth Rate*		*13.3*
1930-40			**1970-80**		
Decline	337	45.2	Decline	157	21.1
Stable	265	35.6	Stable	270	36.2
Growth	143	19.2	Growth	318	42.7
Great Plains Growth Rate		*0.4*	*Great Plains Growth Rate*		*14.2*
U.S. Growth Rate		*7.3*	*U.S. Growth Rate*		*11.5*
			1980-90		
			Decline	414	55.6
			Stable	184	24.7
			Growth	147	19.7
			Great Plains Growth Rate		*9.3*
			U.S. Growth Rate		*9.8*
			1990-2000		
			Decline	161	21.6
			Stable	282	37.9
			Growth	302	40.5
			Great Plains Growth Rate		*16.1*
			U.S. Growth Rate		*13.2*

Note: Counties experiencing decline are those losing more than 5% of the previous decade's population, counties experiencing growth are those gaining more than 5%, and counties fluctuating by no more than 5% in either direction are considered stable.

Table 2. Spatial Error Regression Results Characterizing the Relationship between Agricultural Dependence and Population Change among Great Plains Counties, 1900-2000

	1900-1910	1910-1920	1920-1930	1930-1940	1940-1950	1950-1960	1960-1970	1970-1980	1980-1990	1990-2000
	β	β	β	β	β	β	β	β	β	β
Model 1										
% Farm Employed	0.16 ***	-0.27 ***	0.14 ***	-0.10 ***	-0.21 ***	-0.11 ***	-0.08 ***	-0.10 ***	-0.07 ***	-0.05 ***
	(0.03)	(0.04)	(0.03)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
Autoregressive Coefficient	0.85 ***	0.52 ***	0.76 ***	0.67 ***	0.62 ***	0.27 ***	0.25 ***	0.61 ***	0.67 ***	0.63 ***
	(0.02)	(0.04)	(0.03)	(0.03)	(0.04)	(0.05)	(0.05)	(0.04)	(0.03)	(0.04)
Constant	0.01	0.02 ***	0.013 *	0.01 ***	0.02 ***	0.01 ***	0.004	0.01 ***	0.003 **	0.01 ***
	(0.01)	(0.01)	(0.01)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)
AIC	-2366.95	-2789.49	-2839.01	-4189.75	-4070.28	-3172.19	-3326.31	-4247.88	-4584.19	-4656.93
Model 2										
% Farm Employed	0.13 ***	-0.34 ***	0.26 ***	-0.08 ***	-0.18 ***	-0.09 ***	-0.07 **	-0.12 ***	-0.06 ***	-0.06 ***
	(0.01)	(0.04)	(0.04)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.01)	(0.01)
Spatial Dummy Term[a]	-0.04	-0.03	0.03 **	0.01	0.006	0.02 *	-0.02 ***	-0.001	0.005 **	0.0002
	(0.02)	(0.02)	(0.01)	(0.004)	(0.004)	(0.01)	(0.004)	(0.002)	(0.002)	(0.001)
Farm Employed*Spatial Dummy	0.25 ***	0.39 ***	-0.27 ***	-0.06 *	0.003	-0.21 **	0.61 ***	0.05	-0.06 *	0.002
	(0.07)	(0.10)	(0.06)	(0.04)	(0.05)	(0.08)	(0.06)	(0.09)	(0.02)	(0.03)
Settlement Date	0.0003	-0.000004	0.0002	-0.0001	0.000002	0.00001	-0.0002 **	-0.00002	-0.0001	0.000004
	(0.0002)	(0.0001)	(0.0002)	(0.00006)	(0.00006)	(0.00009)	(0.00007)	(0.00006)	(0.00005)	(0.00004)
County Size in Acres (per 100,000)	0.0002	0.0002	-0.0002	0.0001 **	0.0001	0.0002	-0.0001	0.0001 **	0.0001	0.00001
	(0.0002)	(0.0002)	(0.0001)	(0.00005)	(0.00006)	(0.0001)	(0.00008)	(0.00005)	(0.00004)	(0.00004)
Initial Population (per 1,000)	-0.0004 ***	-0.0001	0.0001 *	-0.000002	-0.00002	-0.000004	0.00004 **	-0.00003 ***	-0.00002 ***	-0.00001
	(0.00007)	(0.00007)	(0.00006)	(0.00002)	(0.00002)	(0.00002)	(0.00001)	(0.000007)	(0.000004)	(0.000004)
Autoregressive Coefficient	0.85 ***	0.51 ***	0.76 ***	0.67 ***	0.63 ***	0.29 ***	0.24 ***	0.65 ***	0.68 ***	0.66 ***
	(0.02)	(0.04)	(0.03)	(0.03)	(0.04)	(0.05)	(0.05)	(0.04)	(0.03)	(0.03)
Constant	-0.52	0.04	-0.32 ***	0.14	0.01	-0.02	0.43 **	0.05 ***	0.13	0.004
	(0.41)	(0.26)	(0.29)	(0.11)	(0.12)	(0.17)	(0.13)	(0.11)	(0.09)	(0.08)
AIC	-2422.93	-2807.27	-2858.06	-4192.98	-4074.70	-3173.55	-3458.77	-4262.93	-4594.26	-4660.33

Note: Number of counties = 745. Standard errors are in parentheses

[a] East is reference group in 1900-10 and 1910-20; South is reference group in 1920-30 and 1930-40; Contains a City is reference group from 1940-50 through 1990-2000.

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$ (two-tailed tests)