Drought and Other Driving Forces behind Population Change in Six Rural Counties in the United States

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The possible impacts of climatic change on postindustrial population patterns in the United States have been largely ignored. In this study, we examined population change in six rural counties of three different regions in the United States. In addition to determining the role of traditional variables known to influence population change, we also examined the potential influence of drought as measured by the Cook et al. (2004) study. We used correlation and regression analysis to determine the driving forces behind population change in each case study county. The traditional variables accounted for the majority of population change. While drought explained a small percentage of the variance in population change, it was significant in three out of the six counties and in each region we examined. Spatially, with the exception of the climatic variables, counties within the same region tended to have similar driving forces for population change.

Los posibles impactos del cambio climático en los patrones de población postindustriales en los Estados Unidos han sido ampliamente ignorados. En este estudio examinamos los cambios demográficos en seis condados rurales de tres regiones diferentes en los Estados Unidos. Además de determinar el papel de las variables tradicionales que se conoce influyen en los cambios demográficos, también examinamos la posible influencia de la sequía, medida por el estudio de Cook et. (2004). Utilizamos análisis de correlación y regresión para determinar las fuerzas que impulsan los cambios demográficos en cada caso de estudio de condado. Las variables tradicionales explicaron la mayoría de los cambios demográficos. Sin embargo, aunque la sequía explicó un pequeño porcentaje de variación de la población, fue significativo en tres de los seis condados y en cada región que examinamos. Espacialmente, con la excepción de las variables climáticas, los condados dentro de la misma región tienden a tener similares fuerzas propulsoras del cambio de población.

KEY WORDS: agricultural counties, climate change, drought, population change

INTRODUCTION

The spatial patterns of human population commonly shift in the United States. These changes can indicate shifts in economic, social, and demographic characteristics (Deming 1996). A suite of variables have been shown to affect population change, including income (Becker 1981; Clark 1986; Kremer 1993), technological change (Coale 1975; Kremer 1993; Galor and Weil 2000), vital rates (e.g., birth rates) (Easterlin 1976; Clark 1986), unemployment (Blanco 1964; Pissarides and McMaster 1990), educational attainment (Clark 1986; Soares 2005) and climate (Galloway 1986; Rehdanz and Maddison 2005). While research in population change is diverse due to synergistic interactions, the most basic analysis of population change come from Thomas Malthus' (1798) model called the Malthusian Model (Galor and Weil 2000). This model states that population will continue to grow at a constant rate until resources are no longer available, eventually leading to poverty and decreasing populations. More recent population change models (e.g., Galor and Weil 2000) include the rapid increase in the rate technological change following the industrial revolution and the following transition to permanently declining fertility rates.

Changes in birth and death rates influence population directly because as rates increase (decrease), the amount of births or deaths of the population will increase (decrease) (Easterlin 1976; Clark 1986). Easterlin (1976) found that fertility rates were critical for explaining the decline in farm populations in the northern United States. In contrast, the impacts of income can be positive or negative. When income levels are low, population increases with an increase in income. However, at high levels of income, population actually decreases or plateaus as income increases. When income levels are high, time is valuable and this results in a decline in fertility rates (Becker 1981; Lee 1987; Kremer 1993). The effects of educational attainment on population are similarly complex. Individuals with higher educational attainment are likely to have lower fertility rates (Soares 2005) and are likely to relocate more frequently relative to those with lower education levels (Clark 1986). However, Clark and Murphy (1996) found that both high school and college attainment influenced population positively, indicating higher levels of educational attainment result in an increase in population.

Unemployment typically has a negative influence on population because residents out-migrate from regions with high unemployment to regions with greater job availability (Blanco 1964). However, unemployment rates can reduce regional differences in population and income. Areas with high unemployment have a decreasing labor force as residents migrate to areas with lower unemployment, thus raising wages in the area with high unemployment and lowering wages in the area with low unemployment (Pissarides and McMaster 1990).

The impact of climate on population is different from most of the commonly studied variables (e.g., income) because it is naturally unpredictable and not human-induced (Galloway 1986). Climate can affect "societal, psychological, economic and ecological conditions," leading to impacts on population (Rehdanz and Maddison 2005, p 112). In most studies that examine the impact of climate on population patterns, the focus is on aspects of temperature and cloud-free days (Cushing 1987; McGranahan 1999). Heat stroke and hypothermia are direct impacts temperature extremes inflict on humans (Kilbourne 1992). In Spain, Ballester et al. (1997) found a seasonal relationship between temperature and mortality, with peaking mortality in winter because of hypothermia. Rehdanz and Maddison (2005) found that temperature has a significant impact on people's happiness and is a strong determinant on where people choose to live. Graves (1979) discovered that residents will work for less where temperature is favorable, whereas in areas with unfavorable temperature residents demand higher monetary compensation. Cushing (1987) found that migrants favor moderate temperatures rather than extreme climates. Using various historical records, Galloway (1986) examined long-term relationships between temperature and population for mid-latitude locations during the time-period before 1800. He found that periods of warmer conditions coincided with a growth in population, while population slowed or declined during cooler periods. The influence of temperature on population change was attributed to changing temperatures altering the elevations at which crops are effectively grown. Thus, during cooler periods crops could only be grown at lower elevations, resulting in out-migration from higher altitudes. In Russia, Frijters and Van Praag (1998) found that both cold-windy winters and hot-humid summers related negatively to the well-being of residents in Russia. Locations with warmer climates have been found to attract people for retirement and health reasons (Warnes 1992; Williams et al. 2000).

While the impacts of weather and climatic conditions on society are complex, unfavorable climatic change can lead to out-migration. Many studies have shown that drought has at least contributed to the demise or migration of historical societies (Euler et al. 1979; Anderson et al. 1995; Stahle et al. 1998; Billamboz 2003). However, there has been little attention toward the possible impact of drought conditions on modern population changes, with the exception of the Dust Bowl era in the United States. The influence drought conditions may have on postindustrial rural populations and the possible population shifts that result forms the core of our research.

Drought is a natural hazard that occurs throughout the United States and is one of the world's most costly natural hazards (Cook et al. 1999; Wilhite 2000). In the United States, the 2007 drought caused \$1.3 billion in losses in Georgia alone and ranked as the most severe drought in recorded history for localized areas throughout the southeast and southwest (Flanders et al. 2007; Maxwell and Soulé 2009). When drought is severe, water demand increases, agriculture is at risk, and the production of energy is more difficult (Diaz 1983; Cook et al. 1999). Drought has been the catalyst for substantial human migrations, wars, and famines in the past (Wilhite and Vanyarkho 2000) and may still have the ability to negatively affect modern societies enough to encourage migration.

Our primary objective in this study is to determine the main driving forces behind population change in selected regions within the United States. Specifically, we examine both climatic and socioeconomic variables that may have contributed to population change within the last 200 years to determine their importance. Our secondary objectives are 1) to determine if one specific element of climate, drought, has affected annual population change from the 1800s to the present and 2) to examine the spatial variability of the primary driving forces for population change within the mix of locations included in this study.

DATA AND METHODS

To compare the impact drought has on population changes, we chose one county from six selected states (Figure 1) that were similar in terms of their urban development and economic structure. We chose counties that were dominantly agricultural and rural. Counties could not have large metropolitan areas. The presence of large cities might indicate that agriculture is not an important source of economic income. Large urban areas, unlike agricultural areas, are thought to reduce the impact of short-term climate fluctuations on population. In addition, counties could not have an interstate highway passing through them. Interstate highways often bring abnormal development along exits, potentially skewing the results. Next, it was important that the county's farms were dominantly family-owned and not owned by large companies. Typically, corporations own large acreages and can adjust the amount of acres farmed to account for dry times (Barlett 1984). Lastly, we avoided counties with substantial irrigation as this could offset the impact of drought on agriculture and climatically-induced population change.

We obtained three variables relating to income for each county; per capita income, agricultural prices, and manufacturing prices. We obtained per capita income from the United States Decennial Census (1960–2000). To represent agricultural prices, we used data from the agricultural census and used the *value of all farm products* as the representative variable. For census years when the value of all farm products was not recorded, we summed *value of all crops* with *value of livestock* to obtain a number similar to value of all farm products. For manufacturing prices, we acquired *value added by manufacturing* from the manufacturing census. This variable subtracts the various costs manufacturers incur from the products manufactured and other service incomes received (U.S. Census Bureau 2002). Both agricultural and manufacturing prices were recorded from 1850–2007 ranging from 4 to 10 year intervals. We adjusted for inflation (2007 equivalent) using the online inflation calculator (accessed at http:/www.westegg.com/in flation/) for all three income variables and standardized the variables to allow comparison.

We used the U.S. decennial census to gather educational attainment and unemployment variables. We used both *high school attainment of persons above 25* and *college attainment of persons above 25* from 1940–2000 and *employment status of persons above 16 years of age* (1930–2000) for the unemployment variable. To standardize the variables, we divided them by the county population of the same year. Next, we gathered the annual crude birth and death rates (vital rates) for each of the counties studied from each state's health department. North Carolina recorded annual vital rates since 1930, Kansas since 1939, Indiana since 1900, South Dakota since 1953, Oklahoma since 1943, and Tennessee since 1927.

For climatic variables, we obtained temperature data from the National Climatic Data Center (NCDC 2008) from 1895 to 2000 for each climatic division that included the counties of interest. To quantify drought, we used the Palmer Drought

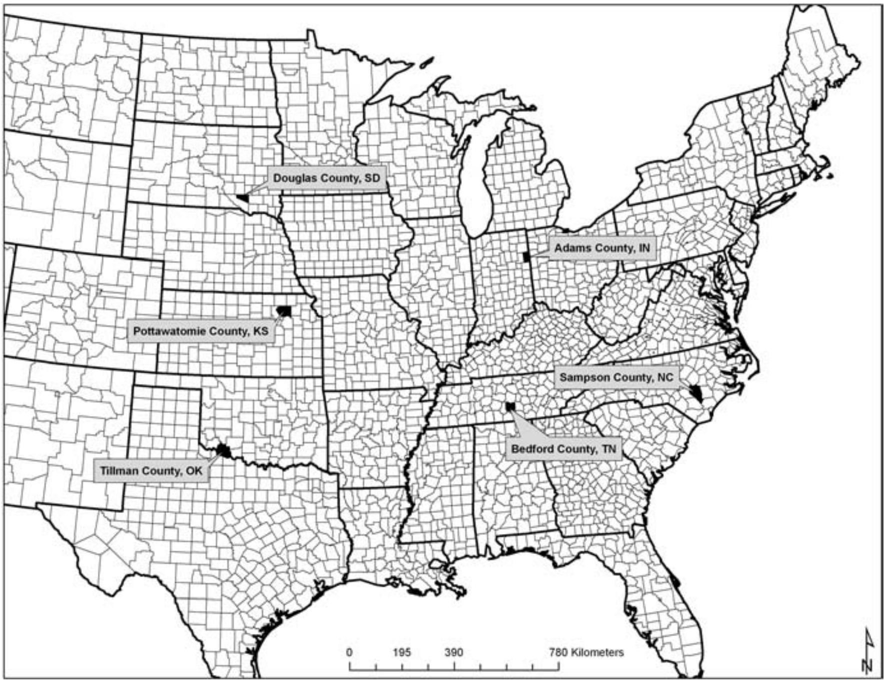

Figure 1. The location of each county.

Severity Index (PDSI: Palmer 1965). Balanced on the supply and demand of moisture, the PDSI is a common and well-known drought index used in the United States (Cook et al. 1999; Heim 2002). For the drought variable, we used the Cook et al. (1999) reconstruction of PDSI via tree rings (via: http://www.ncdc.noaa.gov/paleo/newpdsi.html). They have produced a two-degree latitude by three-degree longitude grid of reconstructed summer PDSI values throughout North America. The tree ring reconstructions represent drought well; all grid points that we used in this study had an R^2 value greater than 0.51 when comparing grid point values to corresponding climatic division values over the period 1895–2000 (Cook et al. 2004). The tree-ring reconstruction allows us to compare PDSI with population beyond the instrumental record. The census started recording population in the counties we examined as early as 1790 (Sampson County, NC).

Since we obtained most of the socio-economic variables from censuses, there were gaps in the annual record ranging from two to ten years. As these gaps led to a small available sample size for examining relationships via simple correlation, we interpolated the census data to create annual values and completed our analyses using the interpolated data. Because the data had more complex trends than a linear trend line could predict, we used a cubic spline to fill in the missing data.

Because temperature and PDSI varied dramatically from year to year, we cal-

Table 1. Abbreviations of Independent Variables Used in Multivariate Regression Models

Variable	Abbreviation
Standardized Agriculture Value	Agval
Standardized Manufacturing Value	Manval
Standardized Income Per Capita	Incomepc
Birth Rates	Birth
Death Rates	Death
High School Attainment Per Capita	Hsedpc
College Attainment Per Capita	Coledpc
Unemployment Per Capita	Unemplpc
11-year Moving Average of PDSI	Sm11pdsi
11-year Moving Average of Temperature	Sm11temp

A number following the abbreviation is the number of years the variable was lagged.
LN = variable was transformed using the natural log.
LG10 = variable was transformed using the base 10 log.

culated an 11-year moving average to smooth the data and make the multi-decadal trends more evident. To determine relationships between the socioeconomic and climatic variables and population change, we used Pearson's or Spearman's correlation. We used the Pearson's r-value to measure the strength of the bivariate relationships when linear, and Spearman's r_s-value for non-linear but monotonic relationships. To establish if the variables may have a lagged effect on population, we constructed lags of one to ten years on the predictor variables and ran Pearson's/Spearman's correlation to determine what impact the lags had on the correlation. Lagged influence on migration has been shown in a number of studies (Greenwood 1969, 1970; Vedder and Gallaway 1972; Levy and Wadycki 1973). These lagged effects are partially attributed to the role of previous migrants' influence on current migrants and is called the "family-friends effect" (Dunlevy and Gemery 1977, p 143). We chose the lag that had the highest Peason's/Spearmans's correlation with population change, which was never longer than a ten year lag.

To determine what combination of variables best explained the variance in population, we first developed a stepwise multiple regression model for each county to identify potential strong multivariate models. We then examined multiple combinations of variables that met all the assumption of regression models, and chose the variables that were the most strongly related with population, and were logical. To prevent multicollinearity, we avoided excessively strong relationships among explanatory variables (i.e., variance inflation factor (VIF) < 5.0 (Kutner et al. 2004). When a non-linear relationship existed between the independent and dependent variables, we transformed the predictor variable using the appropriate transformation (e.g., the natural log) to create a linear relationship. For each county, the final model was one that was logical, produced a high level of explanatory power (high R^2), was significant ($p < 0.05$), and included only significant ($p < 0.05$) explanatory variables (Table 1). The time span associated with the final model varied for each county. The significant predictor with the least amount of years determined the time period covered for each model. For example, if the significant predictor was only recorded from 1940–2007, then the final regression model is only useful for the same period. We calculated the partial R^2 value of each variable when the best model was a multivariate regression model. In addition, we created a bivariate regression model using only the highest correlated drought variable (when correlated significantly) to determine the amount of variance in population that drought alone explained.

RESULTS AND DISCUSSION

We present our findings of the driving forces behind population change for the six counties under examination in three regions: the Southeast, Ohio Valley, and Great Plains. Presenting our findings in this manner allows us to compare both counties within regions and between regions. Further, it allows us to examine if predictor variables influence population change similarly in a spatially context.

The Southeast

Sampson County, located in southeastern North Carolina (Figure 1), is the second largest county in the state at 245,271 hectares (Woodside 2003; Sampson County 2005). Historically, Sampson County has been predominately agricultural (Woodside 2003). Through the 20th century, agriculture continued to expand in Sampson County and it remains an important source of income and economic activity. In 2002, the county produced $675.7 million in agriculture sales, which is the second largest amount in North Carolina, and 49 percent of the county's land area was cultivated (USDA 2002; Woodside 2003). During the latter half of the 20th century, manufacturing emerged as an important part of the economy in association with agricultural expansion. Currently, most of the manufacturers relate to agriculture (Clinton Sampson Chamber of Commerce 2000). The average farm size in 2002 was 102 hectares, suggesting that farms might be family owned.

In Sampson County, NC, the primary driving force for population change is manufacturing value (Table 2), with agricultural value and education levels relating significantly (Table 3). Manufacturers supply jobs, thus attracting people into the county. We expected agricultural value to influence population in all three regions because the counties selected for this study have economies dominated by agricultural activities, thus agricultural values help to determine the income of many residents. When agricultural values are low for consecutive years, families may choose to abandon agriculture and pursue employment in other industries or migrate out of the county. Conversely, when agricultural values are high, people from outside the county may migrate into the county. All of these decisions take time, thus explaining the lagged response.

Bedford County is located in south-central (central basin) Tennessee (Figure 1). Agriculture and logging manufacturers appeared early in the county (as early as 1880). In 1885, 61 percent of the 123,025 hectares in the county were cultivated (Goodspeed and Woolridge 1886).

Table 2. Final Regression Models for Each County

County	Model	R^2 Value	p − Value
Sampson, NC	Pop = −36851.925 +13644.979 (LnManval10; $p < 0.001$; partial $R^2 = 0.748$)	0.748	< 0.001
Bedford, TN	Pop = 22968.049 + 389521.920 (coledpc8; p < 0.001; partial $R^2 = 0.944$)	0.951	< 0.001
	− 172.667 (sm11temp3; $p = 0.024$; partial $R^2 = 0.007$)		
Adams, IN	Pop = 16272.299 + 53341.178 (Hsedpc10; $p < 0.001$; partial $R^2 = 0.983$)	0.988	< 0.001
	+ 644.061 (Sm11pdsi2; $p < 0.001$; partial $R^2 = 0.005$)		
Pottawatomie, KS	Pop = 24590.561 + 61894.382 (Coledpc; $p < 0.001$; partial $R^2 = 0.668$)	0.869	< 0.001
	− 5932.079 (LNdeath; $p < 0.001$; partial $R^2 = 0.184$)		
	+ 454.026 (sm11pdsi5; $p = 0.008$; partial $R^2 = 0.017$)		
Tillman, OK	Pop = 21686.457 + 51751.983 (hsecpc10; $p < 0.001$; partial $R^2 = 0.960$)	0.966	< 0.001
	− 164.977 (death; $p = 0.005$; partial $R^2 = 0.006$)		
Douglas, SD	Pop = 3874.368 + 17162.009 (coledpc; $p < 0.001$; partial $R^2 = 0.787$)	0.900	< 0.001
	+ 61.869 (birth; $p < 0.001$; partial $R^2 = 0.113$)		

Table 3. Independent Variables Correlated with Population

County	Independent Variables	*r*-Value	*n*
Sampson, NC	Agricultural Value Lagged 9 Years	***.630*****	***142***
	High School Attainment Lagged 10 Years	.630**	51
	College Attainment	.667**	61
	Manufacturing Value	***.903*****	***141***
Bedford, TN	11-Year Moving Average of PDSI Lagged 2 Years	.572**	184
	Agricultural Value Lagged 10 Years	.886**	141
	11-Year Moving Average of Temperature Lagged 10 Years	−.702**	91
	High School Attainment Lagged 10 Years	***.967*****	***51***
	College Attainment Lagged 8 Years	.972**	53
	Manufacturing Value Lagged 9 Years	.874**	132
Adams, IN	11 Year Running Average of PDSI Lagged 1 Year	.302**	15
	Agricultural Value Lagged 7 Years	***.860*****	***144***
	High School Attainment Lagged 10 Years	.991**	51
	College Attainment	.827**	61
	Death Rates Lagged 1 Year	***−.723*****	***100***
	Manufacturing Value Lagged 10 Years	.835**	131
Pottawatomie, KS	11 Year Running Average of PDSI Lagged 5 Years	.625**	136
	Death Rate	***−.793*****	***62***
	College Attainment	−.817**	61
Tillman, OK	Birth Rates	.789**	58
	Death Rates	−.850**	58
	High School Attainment Lagged 10 Years	−.981**	51
	College Attainment Lagged 10 Years	−.978**	51
	Annual Income Lagged 5 Years	.978**	36
Douglas, SD	Birth Rates	.851**	48
	Death Rates	−.464**	48
	High School Attainment Lagged 4 Years	−.992**	58
	College Attainment	***−.824*****	***61***
	Annual Income Lagged 6 Years	.882**	35

**Significant at $p < 0.01$.
Bold and Italics = Spearman Correlation.

Agriculture did not account for a large amount of the workforce in the county in 2000, with only four percent of the population working in the *agriculture, forestry, fishing, and hunting* industry. However, it is still an important component of the economy in Bedford County with 71 percent of the total land cultivated (USDA 2002), and 86 million dollars in agricultural sales in 2002 (ranking second in the state). The average size of farms in the county was 53 hectares, which might be indicative of smaller, family-owned farms. Less than two percent of the farms and less than one percent of the land farmed were irrigated in 2002 (USDA 2002). Manufacturing is also currently important in Bedford County, with numerous manufacturers (e.g., Sharpie®) supporting economic growth (The City of Shelbyville, Tennessee 2008).

The multiple regression model for Bedford County, TN shows that the primary driving forces of population change were college attainment and temperature (Table 2), with agricultural value, manufacturing value, high school attainment, and drought conditions also significantly influencing population (Table 3). Temperature is inversely related to population, a finding similar to Cushing (1987) and Kilbourne (1992) who found that migrants do not favor extremes in temperature. Although the literature shows complex relationships between educational attainment and population, our results for this county agree with Clark and Murphy's (1996) findings whereby increasing educational attainment results in an increase in population.

The relationship between population change and drought is logical for agricultural populations. Periods of extended drought can increase financial stress on farmers through both lost revenue from reduced yields and increased expenses from irrigation. In turn, this can lead to farm failure and out-migration of the agricultural work force. Drought has been shown to influence migration and population patterns for both historical societies (Euler et al. 1979; Anderson et al. 1995) and during the 1930s dust bowl in the United States (Gregory 1991). However, our results indicate that drought continues to impact population change in modern agricultural populations.

Ohio Valley Region

Adams County is located in northeastern Indiana (Figure 1). In 1871, the railroad allowed easier access to the area for additional settlers, which led to the expansion of agriculture (Indiana County History Preservation Society 2006; Berne, Indiana Chamber of Commerce 2000). Agriculture remains important in the county, with nearly all (> 95 percent) of the county's 88,060 hectares cultivated in 2002 (USDA 2002), and with *agriculture, forestry, fishing, and hunting* as the third leading industry in 2000 (USCB 2000).

The best model for population change in Adams County included high school attainment, PDSI, and death rates (Table 2). These results agree with Clark (1986), who states that both death and birth rates are fundamental driving forces of population patterns. Further, he suggests that death rates should always correlate negatively with population because as mortality rates increase, population directly decreases. Agricultural value, manufacturing value, and college attainment significantly influenced population change (Table 3), but were not retained in the final model.

The Great Plains

Pottawatomie County is located in northeastern Kansas (Figure 1). The county was part of Riley County until the territorial legislature organized a split in 1857 (Cutler 1883). Pottawatomie County is 218,569 hectares (USCB 2000) and because of rich soils, has historically been predominantly agricultural along with cattle ranching (Cutler 1883). The county remains agricultural with 86 percent of the 218,595 hectares cultivated in 2002

(USDA 2002). In addition, nine percent of the male workforce (3rd leading industry) and six percent of the county's population worked in the *agriculture, forestry, fishing, and hunting* industry in 2000 (USCB 2000).

College attainment, PDSI, and death rates were significantly associated with population change (Table 3) in Pottawatomie County and were retained in the final model (Table 2). PDSI and death rates have similar influences on population change as in Adams County. However, college education is negatively related to population change, which is the opposite of the Southeast and Ohio Valley regions. Although this is a seemingly contradictory finding, prior research has shown that educational attainment can influence population change positively by increasing job security of higher educated employees (Clark and Murphy 1996) and negatively by increasing the likelihood of relocation and lowering fertility rates of higher educated individuals (Clark 1986; Soares 2005).

Tillman County is located in southwestern Oklahoma (Figure 1). The Oklahoma Constitutional Convention established the county in 1907. The first European settlers used the county for grazing of cattle. Later in the early 1900s, homesteaders began to settle and farm in the county. The county developed around the railroad, which bisected the county while it was still part of a territory (Maxwell 1976; Tillman County Historical Society 2005). Tillman County continues to be predominantly agricultural with 86 percent of the 227,661 hectares cultivated in 2002 (USDA 2002). In addition, 11% of the county's workforce in 2000 was employed in the *agriculture, forestry, fishing, and hunting* industry, which is the third leading industry (USCB 2000).

The primary driving forces in Tillman County were high school attainment and death rates (Table 2), while birth rates, college attainment, and annual income also significantly influenced population change (Table 3). These results agree with Clark's (1986) findings that population is always positively related to birth rates. The strong positive association between income and population is supported by the work of Becker (1981), Clark (1986), and Lee (1987), who all demonstrate that income is a driving force of population. These findings show that increases in population are associated with increases in income.

Douglas County is located in southeastern South Dakota (Figure 1). The Dakota Territorial legislature created the county in 1837. It took five years after the creation of Douglas County before any permanent settlers resided there. The county settlers mainly farmed and traded their crops to the towns of the county. By 1886, railroad routes were established and this allowed for easier access to the county and for farmers to export crops. The agricultural industry continued to grow, and in 1938 two thirds of the county's population worked on farms (Works Progress Administration in the State of South Dakota 1938). The county remains predominantly agricultural in the 21st century with 85 percent of the county's 112,406 hectares cultivated in 2002 (USDA 2002). The best model for Douglas County retained high school attainment and birth rates (Table 2). Similar to Tillman County, death rates, college attainment and annual income

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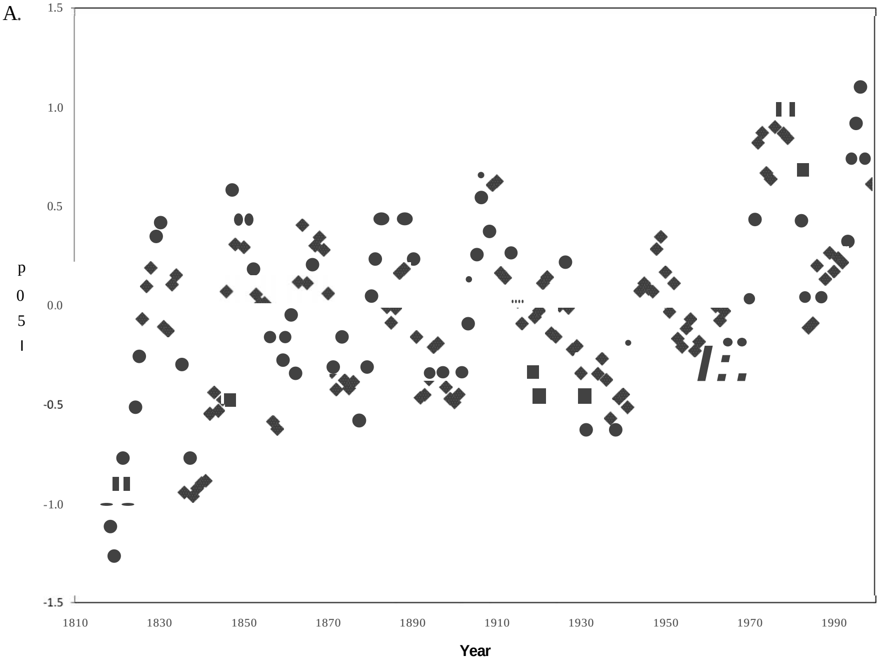
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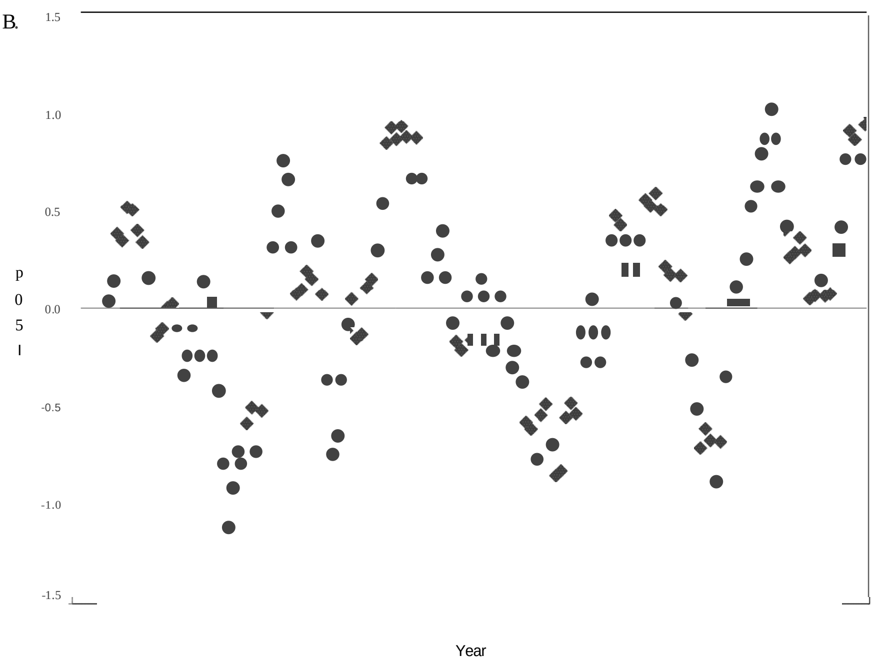
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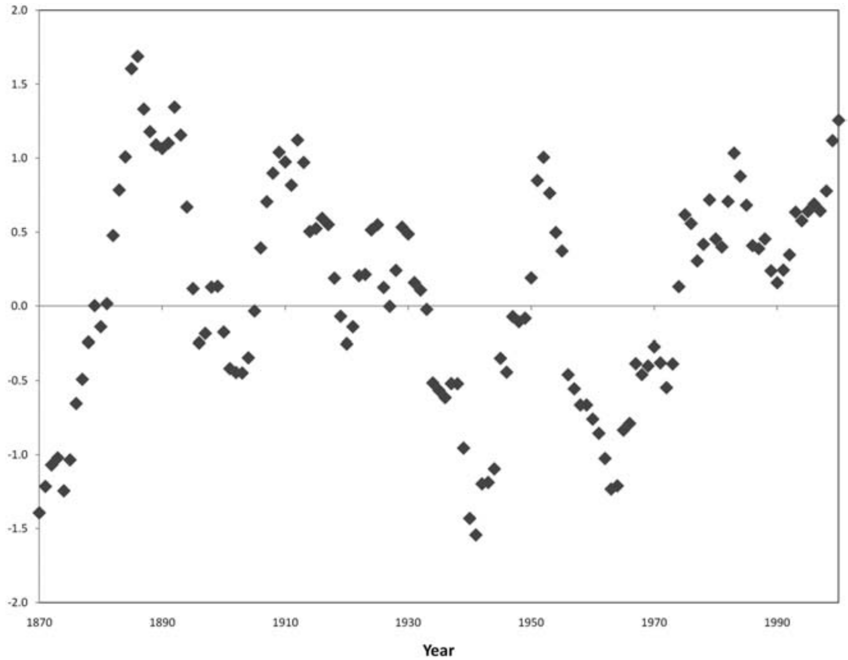

Figure 2. The linear relationship between population change and PDSI for: a.) Bedford County, TN $r = 0.572$; $n = 184$, *b.) Adams County, IN* $r = 0.302$; $n = 154$, *and c.) Pottawatomie County, KS* $r = 0.625$; $n = 136$. *All three are significant* $p < 0.001$.

were significantly associated with population change.

CONCLUSIONS

The driving forces behind population change varied for each county. Each county has a unique history that influenced the population. In this study, we picked counties that had a similar economic makeup to minimize the influence of unique county situations. Further examination of each county's history will assist in understanding the variability in the driving forces behind population change in counties that have similar socio-economic characteristics. Although the driving forces behind population change were not identical, we found that there were similarities among counties in the same region and between regions.

We found that population change in three out of the six counties was positively related to moisture availability, as measured by the PDSI (Figure 2). Thus, in the context of population change research, drought demands more attention. Today, the Southeast and Southwest are the most rapidly growing regions in the United States. Both of these regions have recently experienced severe drought conditions (Maxwell and Soulé 2009), which resulted in legal conflicts between states over water rights, destructive forest fires reducing the retention of soil moisture, and required water restrictions on residents for non-vital uses.

Drought conditions will continue to influence population change in the future. However, droughts are predicted to increase in both frequency and intensity based on current climate change models (McCabe et al. 2004), indicating that drought may have more drastic results on future societies. Our results indicate that the populations of agricultural regions are vulnerable to changing drought conditions, thus these vulnerabilities could increase if future droughts are more intense or frequent.

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