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POPULATION CHANGE IN THE HIGH PLAINS OGALLALA REGION: 1980-1990

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Abstract. *This study explores the role of groundwater exploitation on population change in the High Plains Ogallala region. Results from several multiple regression analyses are examined to assess the relationship between 1980-1990 population changes in 184 counties with the dominance of irrigated agriculture, change in irrigated acreage, historical population change, farm size change, population density, urbanization, and the level of agricultural employment.*

Change in irrigated acreage is significantly associated with population change for Nebraska and for the 90 counties that have an urban place. However, the more important factors are the degree of urbanization among the urban counties and long term patterns of historical change in the nonurban counties. Population has actually increased slightly for the entire region between 1960 and 1990 but has become more concentrated. The findings challenge the feasibility of applying the buffalo commons approach to the Ogallala region. The implications of adopting other regional development policies are discussed.

The recent public image of the American High Plains is of a region in trouble due to massive population decline and agricultural failure. Deborah and Frank Popper (1987), promoting this view, have forecast that "the small towns in the surrounding countryside will empty, wither, and die. The rural Plains will be virtually deserted. A vast, beautiful, characteristically American place will go the way of the buffalo that once roamed it in herds of millions. [The most likely future is] gradual impoverishment and depopulation that in many places go back to the 1920s" (p. 575). They add that "much of the Plains will inexorably suffer near-total desertion over the next generation. [There won't be many places] where agriculture, energy development, mining, or tourism remains workable" (p. 576). The outcome according to

TABLE 1

POPULATION CHANGE IN THE HIGH PLAINS OGALLALA REGION

	Population			
	1960	1970	1980	1990
Colorado	81,608	76,205	77,434	71,869
Kansas	184,427	183,141	188,462	194,873
Nebraska	636,226	621,296	647,477	612,105
New Mexico	122,539	122,726	130,099	130,608
Oklahoma	91,793	90,378	100,551	90,892
Texas	994,291	961,334	1,080,042	1,097,559
Region	2,110,884	2,055,080	2,224,065	2,197,906

	Percentage Change			
	1960-70	1970-80	1980-90	1960-90
Colorado	-6.6	+1.6	-7.2	-11.9
Kansas	-0.7	+2.9	+3.4	+5.7
Nebraska	-2.4	+4.2	-5.6	-3.8
New Mexico	+0.2	+6.0	+0.4	+6.6
Oklahoma	-1.5	+11.3	-9.6	-1.0
Texas	-3.3	+12.4	+1.6	+10.4
Ogallala Region	-2.6	+8.2	-1.2	+4.

*Source: Kromm and White (1992).

the Poppers should be deprivatization to a federally administered and ecologically safe buffalo commons.

The 1990 total population for the Ogallala region of 2,197,906 was 1.2% fewer than in 1980 but about 4.1% more than in 1960 (U.S .Bureau of Census 1960-1990; Table 1). These data suggest a region of stability or perhaps stagnation depending on one's perspective, but certainly not one of massive population decline or desertion. Since 1960, the three areas experiencing the most growth are the Platte River Valley of Nebraska, southwestern Kansas, and the western portion of the Texas Panhandle (Figure 1).

The image of massive depopulation has been reinforced by the widespread attention given to the decline of agriculture in the Great Plains during the early 1980s (Dallas 1990). The farm recession, which began in 1981, was characterized by overproduction, low crop prices, dramatically increasing interest rates, a decline in exports, and a decrease in land values. The recession was not to last, however. A period of farm recovery began in 1987 when land values began to recover and exports improved (Drabenstott and Barkema 1990).

Is the return to a buffalo commons inevitable? This research argues that the public image of a withered and dying High Plains is more popular myth than reality in the Ogallala aquifer region. While the buffalo commons is a catchy metaphor, it ignores the internal complexities of the region. Many communities and counties are undoubtedly suffering from the ills associated with depopulation, but the High Plains is not homogeneous, and the nature of demographic and economic ailments vary as do their solutions.

This study examines county level population change in the Ogallala region of the High Plains between 1980 and 1990 to uncover the causes of subregional changes. Specifically, the objectives of the study are to answer the following questions: Is population change significantly associated with the distribution of irrigated agriculture in the Ogallala region? To what degree is population change associated with levels of urbanization, population density, farm size, dominance of the agricultural labor force, and the historical pattern of population change? Are the factors that are most closely associated with population change uniform throughout the Ogallala region, or are there significant subareal differences? What do the above findings suggest about the feasibility of adopting and implementing triage, growth pole, local sustainability, or abandonment policies as solutions for regional economic improvement?

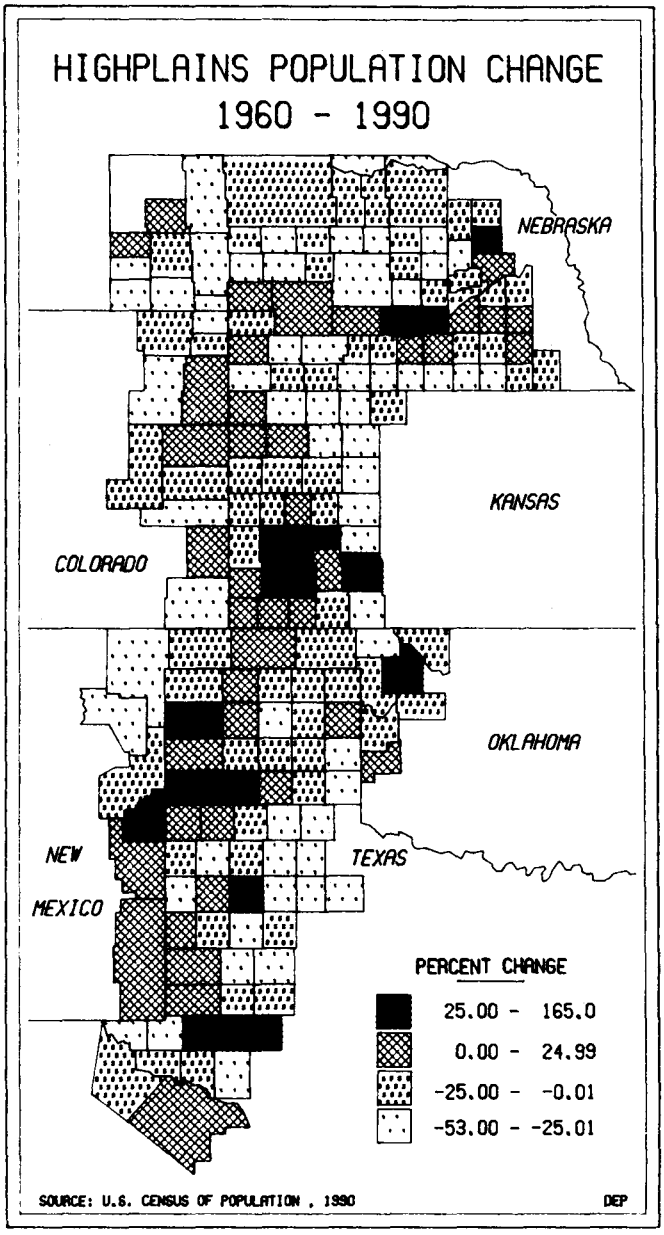

Figure 1. Population change in the high plains, 1960-90. Reprinted from Kromm and White 1992 by permission of University Press of Kansas.

The Study Area

The major factor that differentiates the study area from other portions of the High Plains is access to water. The study area, extending over six states, includes 184 counties that lie over the Ogallala aquifer or another usable water-bearing rock formation such as the Dakota (Figure 2). It corresponds to the region defined by the congressionally mandated Ogallala Regional Aquifer Study, which was conducted between 1978 and 1982 (High Plains Associates 1982). Approximately 161,000 mi^2 (417,000 km^2) overlie a drainable aquifer, of which about 134,000 mi^2 (83%) is over the Ogallala.

Irrigated agriculture has played an important role in the historical development and population change of the region since the late 1800s (Green 1973). Although most irrigation expansion has occurred since 1950, water played an early role in community success. For example, Garden City, Kansas grew from a score of log cabins and prairie dugouts in 1880 to a community of 8,000 people in 1888 due to the construction of a small irrigation ditch (Sherow 1990). The invention of the center pivot irrigation system in 1952, revolutionized irrigated agriculture by permitting irrigation of rolling and hilly terrain that could not be previously irrigated, (Duncan 1987). A study of 294 non-metropolitan Great Plains counties revealed that between 1940 and 1980 intense irrigation counties generally experienced population increases while most other counties had population declines (Albrecht and Murdock 1985). In 1987 37.4% of the region's cropland was irrigated (Kromm and White 1992). Thirty percent of all irrigation water pumped in the United States is pumped in the Ogallala region (Weeks 1986).

The popular image of a rapidly depleting Ogallala aquifer supports a buffalo commons mentality, but it is an exaggerated perspective. The Ogallala region had about 3.25 billion acre-feet (4009 km^3) of water before the advent of irrigated agriculture. By 1980, about 166 million acre-feet (13.5 km^3) or 5% of the drainable water had been pumped (Weeks 1986). Recent rates of withdrawal have averaged about 11 million acre-feet (13.5 km^3) per year (Kromm and White 1992).

The saturated thickness of the Ogallala is highly variable ranging from no water in some areas to over 1000 feet (305 m) in the Nebraska Sandhills. Access to water also depends on the depth to the water table, which tends to be associated with pumping costs in a linear fashion, and the price of energy (Gutentag et al. 1984). Many areas, such as portions of the Texas Panhandle where 25% of the drainable water has been pumped, are experiencing severe

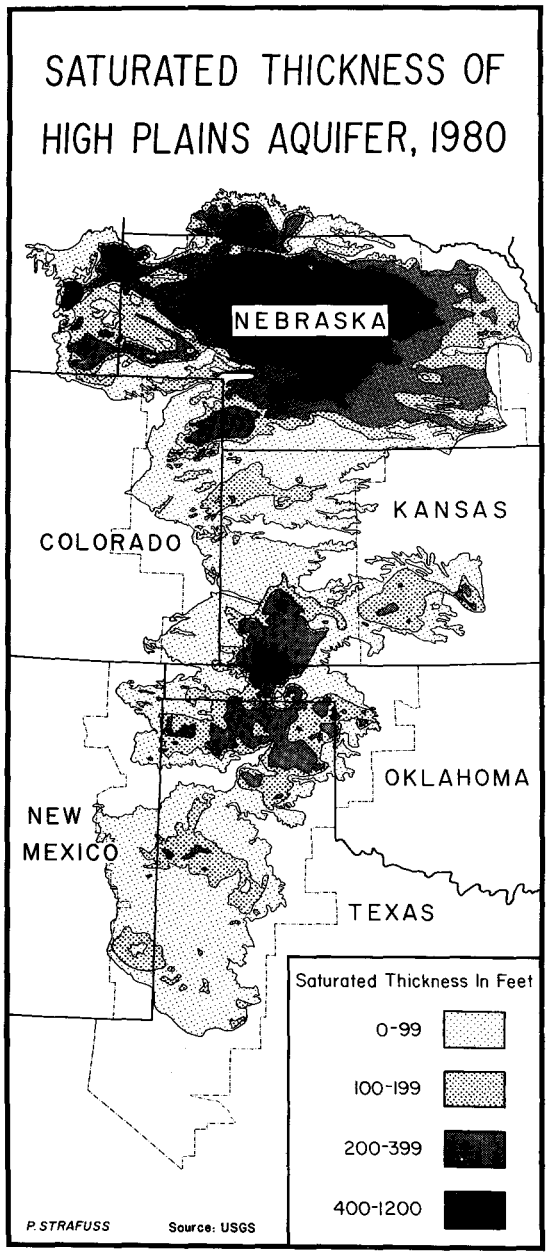

Figure 2. Saturated thickness of the high plains aquifer in 1980. Reprinted from Kromm and White 1987 by permission of the *Journal of Geography*.

declines but other areas, notably large parts of Nebraska and southwestern Kansas, have a thick aquifer with a very long life expectancy.

Several factors have occurred since the mid-1970s that reduce the often perceived impending catastrophe of groundwater depletion. Local groundwater management, natural resource, and conservation districts have become better organized and more restrictive, offer more educational programs for conserving groundwater, and have developed plans and policies to extend the life of the aquifer (Kromm and White 1987, 1990a, 1990b). Also, irrigation water efficiency technology has improved. Many technologies such as surge irrigation, low pressure center pivots, ridge till, drop tubes, and irrigation scheduling have been developed that give irrigators an opportunity to conserve water. Irrigators are accepting these technologies because saving water means saving energy, which translates to lower production costs and greater profit. Regardless of an irrigator's conservation ethic, it pays to conserve water (Kromm and White 1990a).

Another effort that has limited irrigated production are federal government programs such as the PIK (Payment in Kind) and the Conservation Reserve Programs that subsidize irrigators for taking marginal land out of production. Total irrigated area grew from 6.9 million acres (27,900 km^2) in 1959 to 12.9 million acres (52,200 km^2) in 1978, but declined to 10.4 million acres (42,100 km^2) by 1987 (U.S. Bureau of the Census 1989). While groundwater depletion has played a role in reducing irrigated acreage in some specific areas since 1978, the major factors are economic: crop prices, energy costs, and government subsidies.

Methodology

The primary tools used to accomplish the objectives of the study are correlation and multiple regression analyses. The entire study area of 184 counties was stratified in several ways: into north (Nebraska, 69 counties), central (Colorado and Kansas, 43 counties), and the south (Oklahoma, New Mexico and Texas, 72 counties) subregions; and into 94 nonurban and 90 urban counties.

The percentage change in population between 1980 and 1990 (%POP CHG) for each of the 184 counties in the region is defined as the dependent variable. The independent variables are:

%IRR CHG = Percentage change in irrigated acres between 1978 and 1987.

%IRRACRES = Percentage of total cropland harvested in 1987 that was irrigated.
%SIZE CHG = Percentage change in farm size between 1978 and 1987.
%URBAN = Percentage of county population that was urban in 1980.
POPDEN = County population density in 1980.
%HIST CHG = Percentage population change between 1960 and 1980.
%FARM EMP = Percentage of the labor force employed in agriculture, 1980.

Although the list of independent variables is far from inclusive, it is sufficient to permit a comparison of the way that a number of factors influence population change among subareas and to provide a basis for some questioning of the policy options offered in the literature.

Both the dominance of irrigation in a county and the recent expansion of irrigation may be important determinants of population changes. The percentage change in irrigated acres between 1978 and 1987 (%IRR CHG) permits a straightforward comparison of rates of change between population and irrigation. An additional consideration is the dominance of irrigated agriculture in a particular county (percentage of total cropland harvested in 1987 that was irrigated, %IRR ACRES).

Population clustering may encourage growth. Is the Ogallala region becoming what Philip Burgess of the New West Institute has termed the "Archipelago Society," "thriving urban centers connected to each other via computer and plugged into the global economy" (*Christian Science Monitor* 1990, p. 12)? Do counties with urban nodes have an advantage? The percentage of county population that was urban in 1980 (% URBAN) is an appropriate measure. Only 90 of the 184 counties have urban areas as defined by the census; more than one-half of all counties do not have an incorporated place of at least 2,500 inhabitants. The variable is thus highly skewed complicating multiple regression analysis. The variable is initially excluded as an independent variable and analyzed separately as explained later. Population density in 1980 (POPDEN) is an index of concentration that has nonzero values for all counties.

Large farm size may tend to encourage out-migration whereas smaller and therefore more numerous farms provide the base for a thriving retail sector with multiplier effects, which encourage population growth. The

percentage change in farm size between 1978 and 1987 (% SIZE CHG) measures this influence. While this hypothesis has been debated in the literature, the expected direction of association between farm size and population change is negative. Flora and Flora (1988), for example, found that for 234 Great Plains counties, the decline in the number of retail services and retail sales between 1974 and 1982 was greatest in those counties with very large farms. They argued that operators of medium size farms use more labor per unit of agricultural product and tend to buy more locally, whereas larger operators buy in bulk from outside the region and are more often absentees who shop out of the area.

One proposition of the buffalo commons argument is that the processes that encourage depopulation have been in place for a very long time and are difficult to turn back. The percentage population change between 1960 and 1980 (%HIST CHG) is used to measure the degree to which the pattern of past population shifts explain the recent trends. Is future population decline in the Ogallala region simply an inevitable outcome with little likelihood of former losers becoming future gainers?

The percentage of the labor force employed in agriculture in 1980 (%FARM EMP) is a surrogate measure of the importance of agriculture to the total economy of each county. Small values for %FARM EMP suggest greater economic diversity and less dependence on agriculture. Given the decline in agriculture during the 1980s, it is hypothesized that %FARM EMP will be inversely associated with %POP CHG.

Analysis of the Results

Regional and Subregional Analysis

Simple Pearson product-moment correlation coefficients revealed significant associations (at the .05 significance level) between population change and each of the seven independent variables for the entire study area and for the northern subregion. In the central subregion only %SIZE CHG was not significant. %IRR ACRES and %IRR CHG were significant for the entire study area, the northern and central subregions, but not in the southern subregion (Table 2). At the aggregate level, %HIST CHG ($r = +.445$) and %FARM EMP ($r = -.391$) were most closely associated with population change. The relative magnitudes of the correlation coefficients were substantially higher for each of the subregions. The variables most strongly correlated with %POP CHG varied from region to region: %HIST CHG (r=

TABLE 2

CORRELATION OF 1980-1990 PERCENT POPULATION CHANGE WITH INDEPENDENT VARIABLES

Independent variable	Entire study area	Nebraska	Colorado/ Kansas	New Mexico/ Oklahoma/ Texas	Nonurban counties	Urban counties
% IRR CHG	.136*	.206*	.366**	.165	.023	.235*
%IRR ACRES	.188**	.367**	.427**	.145	.059	.172
%SIZE CHG	-.178*	.204*	-.227	-.382**	-.081	-.265**
POP DEN	.357**	.672**	.515**	.386**	-.038	.372**
%HIST CHG	.445**	.624**	.637**	.335**	.443**	.382**
%FARM EMP	-.391**	-.487**	-.421**	-.448**	-.136	-.521**
%URBAN	NA	NA	NA	NA	NA	.439**

* Significant at the .05 level
** Significant at the .01 level

+.637) in the central subregion, POPDEN in the northern subregion, and %FARM EMP in the southern subregion.

Simple correlation analysis fails to account for the association between a dependent variable and an independent variable while controlling for the effects of the other independent variables. Multiple regression analyses were therefore performed for the entire study area and each of the subregions. Beta weights (standardized regression coefficients) identify the relative importance of each independent variable in explaining the dependent variable after controlling for the influence of all the other independent variables in the regression equation. For the entire study area, only %HIST CHG and %FARM EMP proved significant (at the .05 level; Table 3). The six independent variables collectively explained just 28.5% of the variance in the dependent variable.

TABLE 3

BETA WEIGHTS FROM REGRESSION

Independent variable	Entire study area	Nebraska	Colorado/ Kansas	New Mexico/ Oklahoma/ Texas	Nonurban counties	Urban counties
% IRR CHG	.132	.211*	.224	.084	.205	.202*
%IRR ACRES	-.037	-.091	-.349	-.009	-.179	.039
%SIZE CHG	-.078	.078	-.028	-.227	.053	-.077
POP DEN	.156*	.449**	.280	.217	-.070	.297*
%HIST CHG	.256**	.318*	.676**	.075	.497**	.125
%FARM EMP	-.232**	-.023	.072	-.270*	-.098	NA
%URBAN	NA	NA	NA	NA	NA	.314**
R^2 VALUE	.285	.538	.484	.330	.226	.340

* Significant at the .05 level
** Significant at the .01 level

The analysis for the entire study area obviously masks some meaningful associations that are occurring at the subregional scale. The explained variance for the southern subregion was only 33.0%, not much greater than that for the region as a whole, but almost half the variance (R-squared = .484) was explained in the central subregion, and more than half (R-squared = .538) in the northern subregion. The variables with the largest beta weights differ somewhat among the subregions.

%HIST CHG was most important in the central subregion and was the second most important variable in the northern subregion, but was not significant in the southern subregion. POPDEN was the most important variable in the northern subregion, but was not significant in the central subregion. %IRR CHG was significant in the northern subregion, but neither irrigation variable significantly added to the explanation of popula-

tion change in the southern or central subregions. %SIZE CHG was not significant for any of the analyses.

In summary, the ability to explain population change increased when the Ogallala region is decomposed into three subregions. The subregional analyses suggested varying factors most responsible for population change. Long term historical patterns of population change were more important in Kansas and Colorado than elsewhere. Population density, historical patterns of change, and changes in irrigated agriculture were important in Nebraska. Farm employment and population density best explained population change in Oklahoma, Texas, and New Mexico.

Urban and Nonurban Analysis

When separate urban and nonurban analyses were performed, three important findings appeared. First, historical population growth was the only variable significantly associated with population change for nonurban counties (Tables 2 and 3). The two variables have a moderately high correlation ($r = +.443$) and a large beta weight (+.497). This result lent support to the notion that very sparsely populated counties without urban areas have futures interlocked with past patterns of population decline. Additional support for this argument came from comparison of aggregate population change for urban and nonurban counties. The population of nonurban counties declined 8.6% from 340,186 to 310,856 inhabitants whereas urban counties added 3,179 inhabitants, a 0.2% increase between 1980 and 1990.

Second, the urban counties that grew the most tended to be the most urban and had higher population densities. Although the level of urbanization and population density were correlated, the beta weight analysis showed that population density was still a significant variable even when we account for the effects of urbanization (Table 3). Whereas population density was not associated with population change in nonurban counties, it was important in maintaining population in counties that contain an urban place. %FARM EMP was strongly collinear with %URBAN for the urban counties, and was not included in the regression analysis of that subset.

Third, %IRR CHG was also a significant variable for the urban counties. Water matters more as an agent of population change in the urban counties than nonurban counties, but takes third place to the agglomerative processes reflected by level of urbanization and population density. Although %HIST CHG correlates significantly with population change, an

insignificant beta weight suggested that the past has relatively little impact on recent population changes when the influence of other independent variables are correlated. The fact that irrigated agriculture was significantly associated with population change in urban counties was particularly meaningful because urban counties tend to have a greater proportion of irrigated cropland (41.4%) than nonurban counties (26.9%).

Policy Implications

How best might the Ogallala region use scarce resources to promote regional economic viability? Five options are available: grass roots self-help types of approaches, whereby each county or community fends for itself; efforts combining and centralizing services and economic activities among several counties thus eliminating costly duplication of effort; targeting resources for specific growth regions at the expense of other locations; abandonment and deprivatization of the land returning it to a buffalo commons; or some combination of all of these at the regional scale, depending on local conditions.

The results of this study suggest that perhaps the last option is the most likely. The subregional categorization resulted in larger explained variance in population change than did the analysis for the entire region or for the urban-nonurban stratification. The relative importance of the independent variables varied from region to region, suggesting that regional development policies to encourage population growth may need to be tailored to meet the conditions of specific subregions.

Population decline is not a uniform process throughout the High Plains. While the total population of the Ogallala region has changed very little between 1960 and 1990, it has become more concentrated. Population redistribution may be associated with economic agglomeration. For example, in 1980 the four largest beef packing firms controlled slightly more than a third of the cattle slaughtered. By 1990 their share of the market had more than doubled to 70%. In 1980 farm feedlots with less than 1,000 head of cattle accounted for 25% of feed-lot cattle in the nation, while lots with more than 32,000 head represented 22.3% of the cattle. By 1988, concentration had changed distribution to 16.3% and 31.6% respectively (Barkema and Drabenstott 1990). Some counties that are gaining population depend on surrounding counties that may be simultaneously losing people. For example, Finney county in southwestern Kansas was that state's most rapidly growing county, increasing 38.8% between 1980 and 1990. Part of Finney

county's growth can be attributed to its accessibility to nearby irrigated grain producing counties that support its feedlots, beef-packing plants, and spin-off industries.

In addition, counties without an urban node are in a long-term pattern of decline very different from those with urban places and a greater population density. Even when population density was added to the regression analysis, the level of urbanization was still significantly associated with population growth. This finding suggests that both density and urbanization are important factors. Growth pole or triage strategies, which target resources for specific locations while excluding places that should be either abandoned or that can stabilize or grow without help, cannot, therefore, be dismissed.

Growth pole and triage strategies recognize the forces of agglomeration and the advantages of targeting resources to specific locations for the greatest gain. Daniels and Lapping (1987) argued that regional settlement policy should seek to promote regional centers with a critical mass of people to take advantage of economies of scale. Based on work in Iowa, they propose a triage strategy to first promote rural central places of 2,500-5,000 people. Second in priority are larger, growing towns that have the ability to generate new economic activity. Stagnant towns without much prospect for rejuvenation receive last priority. However, growth pole or triage strategies are unpopular policy avenues. In a 1990 poll, only 22% of rural Kansans agreed that "economic development assistance only be given to communities with the best chance of progress" (Institute for Social and Behavioral Research 1991). Acceptance of a triage philosophy requires that one be willing to abandon a community in crisis. As it encourages the acceleration of depopulation in selected areas, it is, in a sense, compatible with the buffalo commons approach.

Daniels (1989), in a review of the community economic development literature noted that local economic development researchers are split into two camps, "those who believe that local efforts can generate sustainable growth and those who feel that outside efforts are the arbiters of whether or not a small town will grow" (p. 414). Outside factors that have worked against local initiative include the loss of manufacturing jobs to overseas plants and the loss of federal revenue sharing funds for local development projects.

Strange and colleagues acknowledged the existence of external forces that restrict local community development efforts, but advocated a comprehensive region-wide approach that focuses on local individual incentive (Strange, et al. 1990). They believe that small midwestern communities

constitute a region as unique as Appalachia or the Mississippi Delta and that interstate cooperation is the best approach. Investment should focus on ways for people in small communities to start businesses and promote agricultural programs that support population and community based development programs. Such an approach combines local initiative within a larger regional framework of interaction and communication. The need for complementary federal, regional, and local efforts to sustain small communities is supported by a study of the Office of Technology Assessment (1986), which noted that while many rural centers will benefit from changes in agricultural technology, they will do so at the expense of other less competitive communities. Thus, community leaders must recognize more and more that they simultaneously operate within a local, regional, national, and global economy. Grass roots efforts alone may not be enough.

Popper and Popper (1987) recommended that one possible role of the federal government is to establish buy-back programs. Dallas (1990) argued that the land could be administered by consortia of the government and private groups to prevent a repetition of the devastation of the 1930s dust bowl. Wallach (1991) cited the Little Missouri National Grasslands in North Dakota as an example of a successful federal buy-back program in the High Plains. According to Wallach (1991, p. 142) unproductive lands "should be put in a public-land reserve that grows apace with technology itself—that absorbs lands no longer needed because our requirements can be met with fewer, more intensively used acres."

Abandonment of large tracts of land to federal control may perhaps be a reasonable option in certain portions of the High Plains, but it is a premature policy in the Ogallala region for several reasons. First, the results presented here suggest that the Ogallala region is not experiencing massive depopulation in the aggregate. Over the past three decades the region has gained over 87,000 inhabitants. Many counties are growing while others are almost stable. Buy-backs would of necessity be piecemeal parcels that presently serve as the hinterlands for islands of growth in an integrated regional economy.

Second, the role of groundwater in sustaining economic growth and thus stabilizing population has not been adequately addressed by land abandonment proponents. Popper and Popper (1988) argued that declining water tables in water rich areas spell impending doom for the region at large. Though true for some local areas, this notion is too simplistic to be true for the region at large. The "depletion problem" is not an aggregate, region-wide problem but a local one. Long-term economic survival is assured by the

presence of water in many areas. The results here have demonstrated a statistically significant association between population growth and the prevalence of irrigated agriculture in Nebraska and in those counties that have urban centers. The multivariate analysis may underestimate the role of groundwater on population growth because the areal unit of observation, the county, assumes that the use of groundwater in one county corresponds with population change only in that specific county. The spin off advantage some counties may have through proximity to the groundwater in other counties is not measured.

Third, many of the policy options discussed here have not been developed and certainly not implemented and should be given a chance to evolve. Perhaps positive steps should be undertaken to preserve the economic viability of the region before the region is deprivatized in a piecemeal fashion.

Fourth, the buffalo commons approach assumes that land can be selectively abandoned without harm to other places. In an area like the Ogallala region this approach would assume a lack of interdependency among places. That is, we must assume that growing places do not need the water, feed grains, labor force, and markets that exist in those places losing people. The buffalo commons approach overlooks the basic geographic concepts of linkage, regional specialization, and complementarity.

Finally, there is implicit in a buffalo commons mentality a very naive assumption that the High Plains is a homogeneous region that is destined for failure. What is lacking is the understanding that the cultural landscape, energy resource base, hydrology, soils, climate, and urbanization vary.

Conclusions

Access to groundwater makes the Ogallala region different from other portions of the High Plains. But are patterns of groundwater exploitation associated with those of population change? At the regional level, population increased slightly between 1970 and 1980 during a time of irrigation expansion. Since 1980, the population has declined slightly during a period of irrigation decline. Percent irrigated change and percent of cropland irrigated are both significantly correlated with population change in urban counties and in the northern and central subareas of the Ogallala region.

When other variables are accounted for, regression analyses reveal that percent irrigated change is still important among urban counties and for Nebraska. The more important factors associated with population change appear to be the degree of urbanization for urban counties and long term,

historical patterns of change for counties without urban places. Urban counties have a higher percentage of cropland under irrigation than nonurban counties suggesting an interdependency between groundwater exploitation and urbanization. In the southern Ogallala subregion the percentage of population employed in agriculture is more negatively correlated with population change than for the other subareas suggesting that the most important factors associated with growth lie outside agriculture. Also, the correlation between level of irrigation and population change is weaker in the southern subarea than for other areas of the Ogallala region.

The degree of the impact of groundwater exploitation on population change varies significantly within the Ogallala. The importance of other variables also changes spatially and for urban and nonurban counties. Broad-based, regional policies directed toward population growth will have less impact than those that are sensitive to local differences in the cultural landscape.

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