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Farm Fragmentation: Mapping the Status and Trends of Agricultural Lands in Colorado

Abstract

Statistical spatial analysis was used in this research to assess the factors contributing to the downsizing of farms as well as overall farm size choice in Colorado. The areas of research focus will be the spatial effects and the economic landscape. This work will challenge the common belief that large, corporate farms are swallowing up small farms in a consolidation effort. Further, the analysis will quantify and visualize the status of agricultural lands in Colorado. The research will help to inform the theoretical understanding of agricultural decision processes within the context of economic and spatial factors.

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FARM FRAGMENTATION

Mapping the Status and Trends of Agricultural Lands in Colorado

Statistical spatial analysis was used in this research to assess the factors contributing to the downsizing of farms as well as overall farm size choice in Colorado. (The areas of research focus will be the spatial effects and the economic landscape). This work will challenge the common belief that large, corporate farms are swallowing up small farms in a consolidation effort. Further, the analysis will quantify and visualize the status of agricultural lands in Colorado. The research will help to inform the theoretical understanding of agricultural decision processes within the context of economic and spatial factors.

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By: Gabrielle Friedman
Date: May 1, 2011

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Background

Theodore Schultz began his acceptance speech for the 1979 Nobel Prize in Economics observing: “Most of the people in the world are poor, so if we knew the economics of being poor we would know much of the economics that really matters. Most of the world's poor people earn their living from agriculture, so if we knew the economics of agriculture we would know much of the economics of being poor” (Shultz 1979).

History and Background

For over a hundred years, economists have predicted the demise of the small farm which is often deemed as less productive and more inefficient (Rosset 1999) than large and corporate-owned farms that would seem to have the benefits of scale in their favor. Within the 20th century in America, technological changes during the 1950s and 1960s led to a significant loss of farms. This trend continued during the 1970s and accelerated again during the 1980s, with a loss of 14 percent from 1982 to 1992 (Brasier 2005). Industrialization of production systems and consolidation into corporate farms is said to have contributed to this change. This drop in farm numbers has led to an ongoing, often heated, discussion about the rise of corporate farms. These large farms have been blamed for everything from swallowing up small family farms to contributing to rising obesity rates and world poverty on the one hand and credited with protecting the world's food security and keeping food costs low on the other. Literary works from multiple disciplines note small, family farmers being pushed out of rural areas across the world in the millions. Rural historians say 20th-century federal policies that

encouraged mechanization and consolidation helped speed the demise of the family farm (Benson 2009). While there are several ways to define farm size, the most common methods involve farm sales and the number of farm acres operated. Small farms (those with less than 1,000 acres) constitute 92.1 percent of all American farms yet account for less than 49 percent of the \$74,581,098 net income from farm operations in the United States (USDA 2007). Some of this may be due to the fact that small farms receive a smaller share of government subsidies.

As of late in the last 15 years, in the United States the average acreage on individual farms has steadily been decreasing from 487 acres in 1997 to 441 in 2002 to 418 in 2007 (USDA 2011). This does not appear to be due to consolidation as the total number of farms is increasing. More pronounced, the average size of farms in the state of Colorado has decreased from 1071 acres to 991 to 853 over the same time period, respectively (USDA 2011). Based on United States Department of Agriculture data, from 2002-2007, Colorado increased its total number of farms 18 percent while the average size of the farms decreased 14 percent. Several causes have been proposed for this trend and they will be examined in this research.

A fair amount of research has been published documenting the economic, social and environmental benefits of smaller farms. The family farm is often touted as a cure-all for the ills of rural communities and a necessary element in the fight against corporate consolidation. Smaller farm operators are shown to contribute greater amounts to the local economy and to participate more in local politics than operators of large farms (Crowley 2004). Small farms also typically hire employees from the local community as opposed to migrant workers at larger operations helping to create a stronger local economy. This research, along with public ideas,

contributes to the contentious discussion about corporate farm operations overtaking the idealized family farm.

The concept of economies of scale has been a desirable trend in the industrialized world for decades. The term economies of agglomeration is used to describe the benefits that firms obtain when locating near each other ('agglomerating'). This concept relates to the idea of economies of scale and network effects. As more firms in related industries cluster together, costs of production may decline significantly (firms have competing multiple suppliers, greater specialization and division of labor result). However, this appears to not be the case with agricultural operations. Even with an overall reduction in agricultural acres during the last century and a reduction in individual farm acres during the last 20 years, food production outputs have increased due to improved practices and equipment (CO Dept. of Agriculture 2011). Farmers seem acutely aware of this and thus the 20th century trend in America to consolidate farms appears to have shifted back towards smaller operations. This is clearly evident in Colorado where 59 out of 62 counties¹ showed the average size of their farms shrink from 1997 to 2007 (USDA 2011). The aim of this research is to quantify the current status of farm sizes as well as the variables affecting the choices of farm size. Another objective of this work is to visualize the true size characteristics of farms in Colorado throughout the past decade.

Colorado's economy is deeply dependent on agribusiness with the value of all agricultural products sold in 2007 totaling \$6 billion. Agribusiness contributes \$16 billion to the

¹ Mineral and San Juan Counties were excluded because of lack of data. Denver County was excluded as an outlier with only 24 farms and an average size increase of 500%.

state economy each year (Co Dept of Agriculture). Over 25% of Colorado's counties are deemed to have farm dependent economies (USDA 2011) with the Colorado Department of Agriculture stating that "nearly one-third of Colorado's counties are economically dependent on the cattle industry". Visualizing the trends in Colorado of this vital economic sector will guide the understanding of its current status and future direction.

Literature Review

An examination of the literature reveals that agricultural issues are primarily discussed within two distinct disciplines, economics and environmental studies. There is, however, a wide divide between these disciplines and they are rarely discussed in tandem. In terms of decisions regarding farm size, researchers have identified four influential sets of factors: changes in agricultural structure, ecological characteristics, socioeconomic conditions and spatial effects (Brasier 2005). An assessment from a geographic approach depends on incorporating aspects from these different areas. The spatial effects factor is essential as the innate value of a farm is its land and thus its location. The centrality of land for production firmly ties farms to the places in which they are located. Affective attachment to the land leads to a disinclination to move, even when economic circumstances are not ideal (Crowley 2004). Furthermore, this study seeks to incorporate the natural amenities ratings into the analysis as these may play a role in the local economy and agricultural landscape.

Environmental Studies

Agricultural research in the geography arena tends to be focused on environmental

characteristics such as land suitability and soil types, the use of GIS for precision farming and land management. Research has also examined ecosystem management as it relates to agriculture such as applications of sustainable farming and the environmental impacts of farming. County level or smaller studies of agriculture are common with precision farming assessment typically done at the single farm level. Furthermore, farm study from a geographic perspective is typically the practical application of GIS, remote sensing/LiDAR and the use of GPS rather than theoretical analysis of geographic influences on agriculture.

Agricultural Economy

Extensive literature and research exists commenting on the economic variables of agriculture. This ranges from analysis of market value of crops and the economics of commodities to the effect of government subsidies on the US and world food markets. Researchers have studied the effect of farm concentration and its effect on poverty and inequality, unionization and political power. One such study in the north central US found that farm operators play a significant role in both the economic and cultural aspects of rural communities. The Goldschmidt hypothesis argues that a community's level of social, economic, and political well-being are lower in areas with more large-scale, non-family owned farms. He further hypothesizes that farm concentration is positively correlated to higher poverty levels (Archibald 2002). The United States Department of Agriculture (USDA) National Commission on Small Farms 1998 report entitled *A Time to Act* writes of how decentralized land-ownership produces more equitable economic opportunity for people in rural areas. In various states and regions in the US, small farms are vital to the economy.

Studies have shown that on farms in the U.S., as well as in other countries around the world, gross farm output decreases with farm size. Further, the typical method of measuring yields to rank a farm's productivity work for large farms that are often monocultures (one crop) but these measures do not adequately quantify small farms that typically use multiple cropping, more efficient irrigation methods and emphasis on resource-intensive use of the land (Rossett 1999). The combination of these factors paints a clearer picture of small farm's production advantage over large farms.

Spatial Effects

With regard to spatial analysis of agriculture and economy, few works exist. The paper *The Causes of Enduring Poverty* does provide a spatial analysis of the determinants of poverty in the U.S. and they do touch on agriculture in their research. However, their focus is on social capital and democratic governance variables. Agriculture was merely a sector within the industry composition variables considered as determinants of poverty (Rupasingha 2003). Another study in India uses the approach that the utility of poverty maps can be enhanced by spatially disaggregating the underlying causes of poverty. One method explored in this paper is the use of livelihood assets – natural, physical, human, social and financial – the building blocks of sustainable livelihoods (Erenstein 2010). Although based on foreign economies and different levels of environmental manipulation, research involving spatial analysis of the association between forests and poverty in several tropical countries was found to be somewhat theoretically similar to this research (Sunderlin 2008). Agricultural studies of the Great Plains in the spatial effects realm have involved examination of the relationship between farm

dependence and county population during 1900-2000 using spatial analysis techniques (White 2008). No published work was found that specifically addresses the spatial relationships between the variables of farm size, economic conditions and location.

Research Specifics

Study Area

The study area for this research is the state of Colorado at the county level. While this aggregated some data that can be obtained at the Census block or tract level, the majority of agricultural data is at this broader county level. Other social, economic and political data are also aggregated at this level thus allowing for a consistent temporal and spatial analysis scale. People tend to associate themselves with other members of their county especially in rural areas where county services contribute a great deal to the political and social environment. Further, using the county level as the unit of analysis allows for a distinction between metro politan and non-metro politan counties.

Originally, metro counties or those with low rural continuum scores were to be excluded from data analysis. This was due to the belief that these counties would naturally have decreasing farm sizes due to urban development fragmenting agricultural land. However, this was not the case as some metro counties actually had increased average farm sizes. This is probably in part due to the complete conversion of land designated agricultural to non-agricultural use as opposed to the splitting of this land. Also, contrary to what would be expected from increased development, counties that are predominantly ski-industry oriented

did not see a decrease in farm size. For example, Summit County was one of only three counties that saw an increase in size.

Variables

Several theories as to why farms are fragmenting have been proposed. Based on email correspondence in March of 2011 with Amy Hays, geospatial extension specialist with the Texas A&M Institute of Renewable Natural Resources, these have been determined to include fragmentation due to urban/suburban sprawl, splitting of farms to heirs by retiring farmers and sale of land for economic reasons such as to meet tax needs or decreasing returns. To analyze these theories, the variables used were: Farm size, direct sales from farm, market value, county net migration, organic acres, part-time farmers, government payments per acre, percent cattle, poverty rate, rural continuum code,² and years on operation. Direct sales, market value, government payments and poverty level were all used as variables to quantify the relationship between farm size and the surrounding economic conditions. The organic acres variable was used to examine whether or not the current movement towards increased organic food consumption would affect farm size choice. The time period that was examined for changes was 1997 to 2007, the most recent complete NASS data. The resultant correlation table of these variables is displayed on page 16.

Data Sources

Extensive data has been acquired from the United States Department of Agriculture (USDA). The datasets are part of the USDA's National Agricultural Statistics Service (NASS)

² This is a code established by the USDA that distinguishes metropolitan counties by size and nonmetropolitan counties by degree of urbanization and proximity to metro areas. The codes range from 1 to 9 with 1 the most urban, 9 the most rural.

which collects, summarizes, analyzes and publishes agricultural production data on a wide range of items including farm characteristics, yield, and production. Specifically, the data has been obtained from USDA's Agriculture Resource Management Study (ARMS) surveys (formerly the Farm Costs and Returns Surveys) and its Program Payments Reporting System (PPRS). The ARMS surveys are USDA's primary vehicle for collecting data on a wide range of issues about agriculture resource use and costs and farm financial conditions, while the PPRS is its main database on farm program payments. Again, the overall analysis of the USDA datasets is isolated to data from counties in Colorado. Much of this data takes the form of ~~database~~ spreadsheets that are not spatially defined. Therefore, these tables are joined in ESRI ArcMap to county shapefiles³ obtained from the Colorado Department of Transportation with the join based on the county name.

Comment [SRH3]: I think these are mutually exclusive.

Statistical Analysis

Statistical analysis on the above variables with the use of regression line and correlation coefficient was conducted to quantify the relationships between farm size and other conditions. A correlation table of Pearson's product moment correlation coefficient was created to allow for visualization of the relationships between variables. Maps of outputs were created for visualization of the current status and trend of agricultural lands.

³ A shapefile is a common digital format for storing geometric location and associated attribute information.

Results

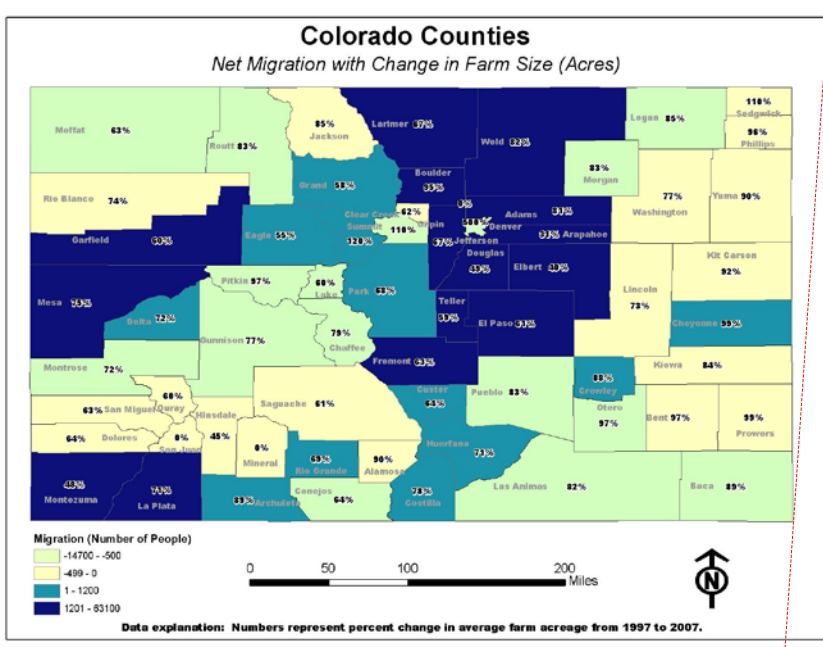
Colorado Agricultural Characteristics and Statistical Results

The percent of total land area in Colorado that is deemed farm land was 48.7% in 1997 and 47.6 in 2007 (USDA 2011) representing a decrease of 1.1% or approximately 730,000 acres. Conflicting data does exist regarding the conversion of agricultural land to other uses with the Colorado Department of Agriculture stating that between 1997 and 2002, 1.2 million acres were converted to other uses. Thus, the USDA and Colorado Dept. of Agriculture differ in their estimates by approximately 470,000 acres. During this same time period (1997-2007), Colorado's population increased by more than 16%. Most of the population growth was along the Front Range between Colorado Springs and Fort Collins, in the Grand Junction area and in the extreme southwest corner of the state (see map on page 13).

The following table illustrates the farm ownership make-up in Colorado. Family entities and non-family corporations saw slight decreases during the study period while partnerships and other types of farm entities saw small increases.

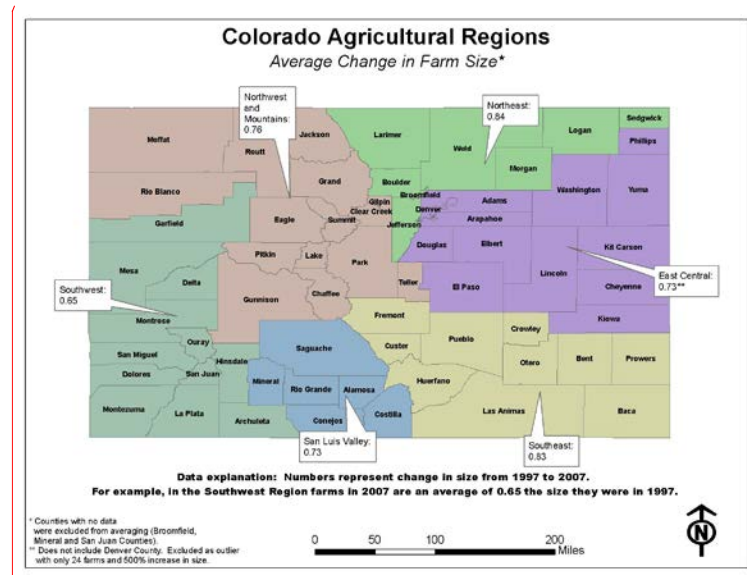
Change in Farm Ownership Types:

| Type of Ownership | Percent in 1997 | Percent in 2007 |
|---|-----------------|-----------------|
| Individuals/Family, sole proprietorship | 82.9 | 81.4 |
| Family-held corporation | 5.8 | 5.7 |
| Partnership | 9.6 | 10.2 |
| Non-family corporation | 0.7 | 0.6 |
| Other-cooperative, estate or trust, institutional | 1.1 | 2.1 |



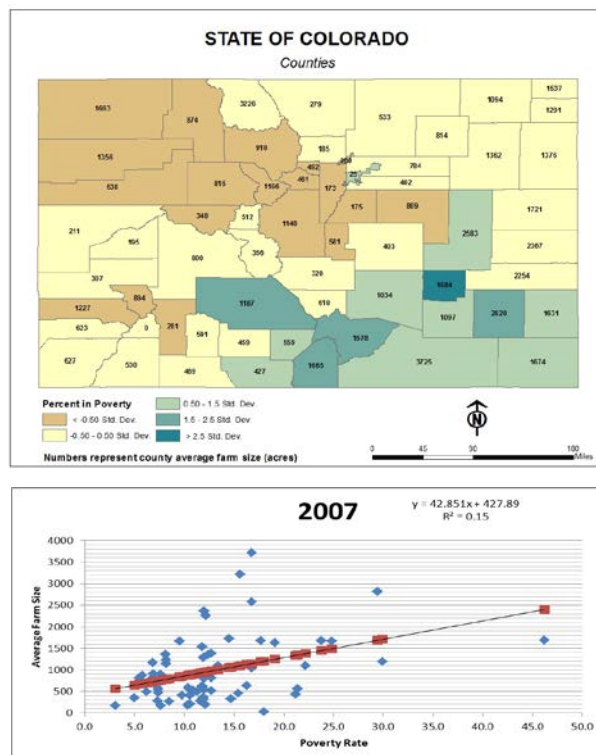
Comment [SRH4]: Project map!
Why not balance data classes as shown in map legend? Can you create comparable scales above and below zero?

When divided into six regions, average change in farm size ranges from 65 to 84% with the northeast region maintaining the most acreage per farm and the southwest the least.



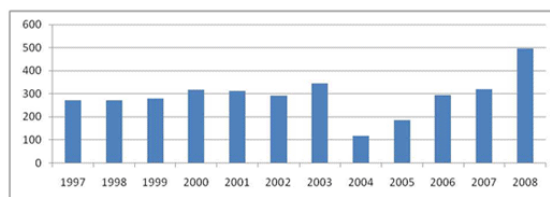
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High poverty rates are focused in the southeast region of the state and in the county of Denver while low poverty rates are mainly found in a corridor extending from Elbert County northwest through the mountains to the northwest region. Average farm sizes are slightly larger in the higher poverty regions and slightly smaller in the lower poverty regions.

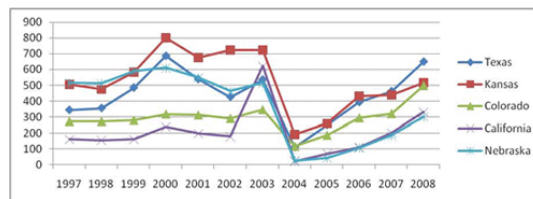


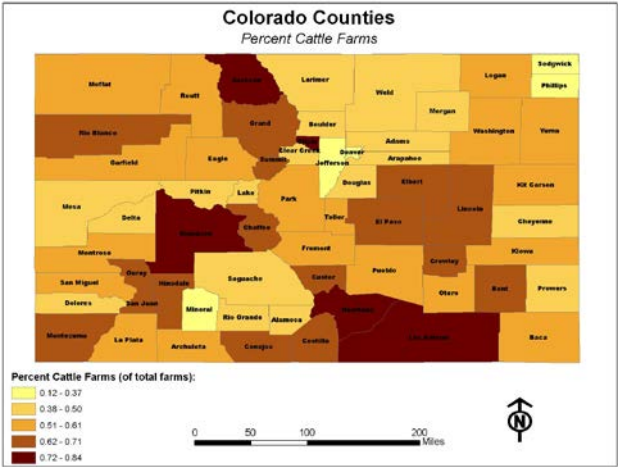
The type of products output by Colorado farms was analyzed for its effect on farm size. Cattle production is the top agricultural commodity in Colorado. In 2009, cattle and calves represented 46.9% of total farm receipts (USDA 2011). Colorado's growth in beef exports continues to outpace total US exports. Exports of beef from Colorado increased at a rate 33 percent faster than total U.S. beef exports (CO Dept. of Agriculture 2011).

Total Exports of Beef from Colorado
Value in US\$ Millions



US Beef Exports By State
Value in US\$ Millions





Correlation Table

| | (Farm Size) |
|------------------------|-------------|
| Farm Size | 1 |
| Direct Sales from Farm | -0.49 |
| Market Value/Acre | -0.19 |
| Net Migration | -0.23 |
| Organic Acres | -0.21 |
| Part-time Farmers | -0.38 |
| Govern. Payments/Acre | 0.24 |
| Percent Cattle | 0.41 |
| Poverty Rate | 0.39 |
| Rural Continuum Code | 0.47 |
| Years on Operation | 0.58 |

Comment [SRH6]: r/correlation data in this column right? Revise label.

As shown above, farm size has a fairly strong positive correlation with percent of farms producing cattle, poverty rates, rural continuum code and the number of years on an operation. There are fairly strong negative correlations between farm size and direct sales and part-time farmers. Weak negative relationships exist between market value per acre, net migration and organic acres. If the majority of fragmentation is due to splitting of farms to child heirs then it would be expected to see the years on operation to be positively correlated with farm size (as farm size decreases so do the years on the operation). At 0.58, there is a fairly strong correlation between these variables overall in Colorado.

Conclusion

Agriculture was once the simply way of life for most humans. Born out of man's hunter-gatherer existence, cultivation of crops led to the formation of settlements then cities then a population explosion. Today, however, American farming is part of a complex economic system that is not simply supply and demand and does not follow the standard laws of economies of scale. Government subsidies, corporate consolidation and rural community dependence on agriculture all complicate the practical and theoretical examinations of this system.

Agricultural land size varies throughout Colorado and interestingly varies greatly within the State's separate agricultural regions. While several reasons were proposed as causes for the fragmentation of agricultural lands in Colorado, statistical correlation did not clearly demonstrate a single determining factor. Urban development, splitting of farms to heirs as well as economic pressures and conditions all contribute to the complex agricultural landscape of

Colorado. Through the use of GIS including spatial statistical analysis, patterns and relationships can begin to be exposed leading to further understanding of a vital part of the culture and economy of America.

Where might we go from here? What further analysis might be called for?

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