ABSTRACT

MARTICORENA, DREW CHANDLER WILLIAM. Statistical Analyses of Diverse Issues in Sustainable Agriculture. (Under the direction of Dr. Nancy Creamer.)

More and more so, diverse fields of studies are informing other areas of research and questioning many commonplace assumptions that these fields have held. The common theme that runs through this dissertation work is the value of using statistical and “big data” tools to take a fresh look at a range of contemporary issues relevant to the “Local Foods Movement” to find innovative solutions to today’s problems.

The initial question studied in this dissertation is whether there are consequences of transitioning farmland from conventional to Organic use in different ways. In order for land to be certified for Organic production, all synthetic inputs (i.e., fertilizers, herbicides, and pesticides) must all be removed for three years prior to the land being certified. Most commonly growers remove all three categories of inputs simultaneously in order to minimize the duration of the requisite transition period; farmers typically experience a decline in yields during this period. Given the fact that each of these inputs has both unique and synergistic impacts on both soil biota and tilth, it may be the case that the order in which these inputs are withdrawn matters. It is possible that a longer transition period due to a staggered withdrawal of synthetic inputs may result in less yield reduction through the transition. A long term field study run at the Center for Environmental Farming Systems in Goldsboro, NC was conducted to test this hypothesis. Results indicated that staggered and longer transition periods can be effective at minimizing and even eliminating the commonly experienced yield reduction.

One of the most outstanding issues confronting civil society today is how to best allocate public resources for the betterment of total social welfare. In order for these allocations to be rational and informed decisions, society must have an understanding of how stimulating one part of
the economy will ripple through the rest. Because of differing degrees some businesses work with other businesses in their local communities, these ripples can vary in magnitude. The size of these ripples is commonly known as the “multiplier effect.” An unsettled question is whether farms/agricultural related businesses that sell “locally” (i.e. direct to consumers as opposed to traditional wholesale channels) have a different multiplier than those that don’t. While there are databases that claim to contain this information, there are strong reasons to believe they do not accurately represent the Local Foods economy. This project found evidence that farms that sell “locally” are associated with a higher multiplier and that currently available databases represent the relevant portion of the agricultural economy poorly.

The final issue considered in this dissertation is a holistic and unbiased analysis of various drivers of farmland loss. It is well know that once farmland goes out of use it rarely returns to production. Economic theory argues that farmland going into and out of production is tied to changes in the net economic value of that land being used in a variety of ways. However, both work in sociology and related fields has raised the possibility that these changes may also be influenced by non-economic factors as well. The possibility exists that vibrant communities may be able to harness synergies between agricultural businesses and supporting industries so that the overall impact of the economy is greater than the sum of the individual parts; the potential for these synergistic relationships to impact the movement of land into and out of farming needs to be further explored. In order to determine what changes in society drive changes in the amount of farmland, a complex exploratory analysis was undertaken. This analysis found that both economic and social changes are important drivers of farmland loss.
Statistical Analyses of Diverse Issues in Sustainable Agriculture

by

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A dissertation submitted to the Graduate Faculty of North Carolina State University in partial fulfillment of the requirements for the degree of Horticultural Science

Raleigh, North Carolina

2015

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Drew likes math. He also likes agriculture and sustainability. At some point Drew started a dissertation combining the things he likes. At some later point he finished the dissertation. He still likes math, agriculture, and sustainability.
# TABLE OF CONTENTS

LIST OF TABLES .......................................................................................................................... vi
LIST OF FIGURES ......................................................................................................................... viii
INTRODUCTION ............................................................................................................................... 1
  The Necessity of Global Agriculture ............................................................................................ 1
  The Importance of Sustainable Agriculture ................................................................................. 2
  Issues Facing the Wide Scale Adoption of Sustainable Agriculture in the US ..................... 3
  Role of Statistical Research in Supporting Sustainable Agriculture ........................................... 5
  Contributions of this work ........................................................................................................... 5
  References .................................................................................................................................... 8

A COMPARISON OF TRANSITIONING STRATEGIES FROM CONVENTIONAL TO ORGANIC

PRODUCTION ................................................................................................................................. 12
  Abstract ..................................................................................................................................... 12
  Literature Review ....................................................................................................................... 12
  Methods ...................................................................................................................................... 12
  Results ......................................................................................................................................... 17
  Discussions and Conclusions .................................................................................................... 23
  Figures ......................................................................................................................................... 28
  Tables .......................................................................................................................................... 32
  References .................................................................................................................................... 36
PRIMARY AND SECONDARY ANALYSES OF FARM HOUSEHOLD ECONOMIC DATA IN NORTH CAROLINA: A QUANTITATIVE STUDY ON LOCAL FOODS

- Literature Review: Background
- Goals of the Local Foods Movement: Promoting Rural Job Creation
- Goals of the Local Foods Movement: Promoting Mid-Sized Farms
- Goals of the Local Foods Movement: Promoting Environmental Improvement
- Goals of the Local Foods Movement: Farmland Preservation
- Literature Review: Goldschmidt Hypothesis
- Literature Review: Why Isn’t Local Foods the Dominant Form of Agriculture?
- Literature Review: Local Foods Nationally
- Literature Review: Local Foods in NC
- Literature Review: What is Needed to Move Local Foods Forward?

METHODS

RESULTS: SURVEY

RESULTS: IMPLAN ANALYSIS

EVALUATION OF UNMODIFIED IMPLAN DATA

DISCUSSIONS AND CONCLUSIONS

FIGURES

TABLES

REFERENCES

A STUDY OF HISTORICAL AGRICULTURAL LAND USE CHANGE IN NORTH CAROLINA

- Introduction
- Literature Review of Economic Theory Explaining Farmland Loss
- Literature Review of Sociological Theory Explaining Connection Between Agriculture and Community Wellbeing
- History of Farmland Change in North Carolina
- Description of Considered Variable Categories
LIST OF TABLES

A COMPARISON OF TRANSITIONING STRATEGIES FROM CONVENTIONAL TO ORGANIC PRODUCTION

Table 1.1: Treatment Plan for Experiment ................................................................. 32
Table 1.2: Pre-Organic Management Period Regression Results – Optimal Model ................................................................. 32
Table 1.3: Organic Management Period Regression Results – Optimal Model .... 33
Table 1.4: Combined Data Regression Results Regression Results – Optimal Model .............................................................................. 33
Table 1.5: Pre-Organic Management Period Regression Results – Organic Management Period Optimal Model ................................................................. 34
Table 1.6: Combined Data – Organic Management Period Regression Results - Optimal Model .............................................................................. 34
Table 1.7: Principle Components Analysis Results ........................................................... 35

PRIMARY AND SECONDARY ANALYSES OF FARM HOUSEHOLD ECONOMIC DATA IN NORTH CAROLINA: A QUANTITATIVE STUDY ON LOCAL FOODS

Table 2.1: Comparison of North Carolina to Nine-County Subset for Horticultural/Direct Sales .............................................................................. 92
Table 2.2: Selected Characteristics of Direct Sales Farms: North Carolina and the US .............................................................................. 92
Table 2.3: Estimated Regional Direct Sales Impacts .............................................................................. 92
Table 2.4: Estimated Statewide Direct Sales Impacts .............................................................................. 93
Table 2.5: Estimated Regional Fruit and Estimated Regional Fruit and Vegetable Sales Impacts .............................................................................. 93
Table 2.6: Estimated Statewide Fruit and Vegetable Sales Impacts .............................................................................. 93
Table 2.7: Estimated Regional Greenhouse, Nursery, & Floriculture Sales Impacts .............................................................................. 93
Table 2.8: Estimated Statewide Greenhouse, Nursery, & Floriculture Sales Impacts ................................................................. 94
Table 2.9: Total Economic Contributions per $Million of Direct Output for County Subset ..................................................................................... 94
Table 2.10: Total Economic Contributions per $Million of Direct Output for State ......................................................................................... 94
Table 2.11: Estimated Regional Direct Sales Impacts (Unmodified IMPLAN) ........ 95
Table 2.12: Estimated Regional Fruit and Vegetable Sales Impacts (Unmodified IMPLAN) ................................................................. 95
Table 2.13: Estimated Regional Greenhouse, Nursery, & Floriculture Sales Impacts (Unmodified IMPLAN) ................................................................. 95
Table 2.14: Total Rowan County Economic Contributions per $Million of Direct Output (Modified IMPLAN) ................................................................. 96
Table 2.15: Total Rowan County Economic Contributions per $Million of Direct Output (Unmodified IMPLAN) ................................................................. 96

A STUDY OF HISTORICAL AGRICULTURAL LAND USE CHANGE IN NORTH CAROLINA
Table 3.1: Variables Included in Bayesian Variable Selection Analysis ............ 156
Table 3.2: Instrumentation Results Number of Farms (1975-2000) .................. 161
Table 3.3: Analysis Results for Predicting the Drivers of Changes in Land in Farms (1975-2011) ......................................................................................... 164
Table 3.4: Analysis Results for Predicting the Drivers of Changes in Land in Farms - Number of Farms Instrumented (1975-2000) ......................... 165
Table 3.5: Analysis Results for Predicting the Drivers of Changes in Number of Farms (1975-2011) ......................................................................................... 166
Table 3.6: Analysis Results for Predicting the Drivers of Changes in Number of Farms (1975-2000) ......................................................................................... 167
LIST OF FIGURES

A COMPARISON OF TRANSITIONING STRATEGIES FROM CONVENTIONAL TO ORGANIC PRODUCTION

Figure 1.1: Example Plot from Experiment .......................................................... 28

Figure 1.2: Yield Variables from Pre-Organic Management Period. This figure shows the histograms and associated Lilliefors test used to assess normality for each of the crops grown .............................................. 29

Figure 1.3: Yield Variables from Pre-Organic Management Period. This figure shows the histograms and associated Lilliefors test used to assess normality for each of the crops grown .............................................. 29

Figure 1.4: Histogram of Residuals from Optimal Model Fits via AIC. This figure shows the histograms and associated Lilliefors tests of the residuals associated with the regressions used to study the Pre-Organic (top) and Organic (middle) Management periods as well as all data combined together (bottom) in order to assess whether they are normally distributed ................................................................. 30

Figure 1.5: Relationship between Baseline Levels of Organic Nitrogen and Yield (Pre-Organic Management Period). This figure shows the linear relationship and associated 95% confidence intervals between each of the studied crops (soybeans, sweet potatoes, wheat) and baseline levels of Organic Nitrogen ............................................. 30

Figure 1.6: Relationship between Baseline Levels of Organic Carbon and Yield (Organic Management Period). This figure shows the linear relationship and associated 95% confidence intervals between each of the studied crops (soybeans, sweet potatoes, cabbage, wheat) and baseline levels of Organic Carbon ............................................. 31
Figure 1.7: Relationship between Baseline Levels of Organic Carbon and Yield (All Data Combined). This figure shows the linear relationship and associated 95% confidence intervals between each of the studied crops (soybeans, sweet potatoes, cabbage, wheat) and baseline levels of Organic Carbon................................. 31

PRIMARY AND SECONDARY ANALYSES OF FARM HOUSEHOLD ECONOMIC DATA IN NORTH CAROLINA: A QUANTITATIVE STUDY ON LOCAL FOODS

Figure 2.1: Map of Percentage Change in Number of Farms (1975-2011)........... 88
Figure 2.2: Average and Median Farm Size, North Carolina and the Study Counties.......................................................... 89
Figure 2.3: Average Sales per Harvested Acre, North Carolina and the Study Counties........................................................................................................... 89
Figure 2.4: Average Per Acre Sales ($1,000), North Carolina and the Study Counties............................................................................................................. 90
Figure 2.5: Distribution of Farm Sales by Farm Product for the Study Counties............................................................................................................. 90
Figure 2.6: Statewide Distribution of Farm Sales by Farm Product .................. 91

A STUDY OF HISTORICAL AGRICULTURAL LAND USE CHANGE IN NORTH CAROLINA

Figure 3.1: Map of North Carolina Counties/Geographic Regions (Source: NCPedia) ................................................................................................................. 134
Figure 3.2: Change in Farmland at County Level (1975-2011). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations ........................................ 135
Figure 3.3: Change in Farmland at County Level (1975-1985). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations ............................................... 136
Figure 3.4: Change in Farmland at County Level (1985-1995). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations ........................................ 137

Figure 3.5: Change in Farmland at County Level (1995-2005). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations ........................................ 138

Figure 3.6: Change in Farmland at County Level (2005-2011). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations ........................................ 139

Figure 3.7: Change in Number of Farms at County Level (1975-2011). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations ........................................ 140

Figure 3.8: Percentage Change in Number of Farms at County Level (1975-2011). Green lines are the state’s interstate highway system, green dots are the locations of registered CAFO operations ............ 141

Figure 3.9: Change in Number of Farms at County Level (1975-1985). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations ........................................ 142

Figure 3.10: Change in Number of Farms at County Level (1985-1995). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations ........................................ 143

Figure 3.11: Change in Number of Farms at County Level (1995-2005). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations ........................................ 144

Figure 3.12: Change in Number of Farms at County Level (2005-2011). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations ........................................ 145

Figure 3.13: Change in Tobacco Acreage (1975-2004: Tobacco Subsides in Place). Black lines are the state’s interstate highway system ........................................ 146
Figure 3.14: Change in Tobacco Acreage (2004-2011: Tobacco Buyout).

Black lines are the state’s interstate highway system .......................... 147

Figure 3.15: Elasticity of Change for Farm Acreage by County (1975-2011).

All Data first differenced. Autoregressive term included.
Residuals fitted with student-t distribution (dF = 6) ......................... 148

Figure 3.16: Regression Diagnostics – Change in Farm Acreage by County

(1975-2011) .................................................................................. 149

Figure 3.17: Elasticity of Change for Farm Acreage by County (1975-2000)

– Number of Farms Variable Instrumented with Number of
Farm Proprietors. All Data first differenced. Autoregressive
term included. Residuals fitted with student-t distribution
(dF = 6) .......................................................................................... 150

Figure 3.18: Regression Diagnostics – Change in Land in Farms by County –
Endogenous Variable Instrumented (1975-2000)............................ 151

Figure 3.19: Elasticity of Change for Number of Farms by County (1975-
2011). All Data first differenced. Autoregressive term
included. Residuals fitted with student-t distribution (dF = 6) ...... 152

Figure 3.20: Regression Diagnostics – Change in Number of Farms by County

(1975-2011) .................................................................................. 153

Figure 3.21: Elasticity of Change for Number of Farms by County (1975-
2000). All Data first differenced. Autoregressive term
included. Residuals fitted with student-t distribution (dF = 6) ...... 154

Figure 3.22: Regression Diagnostics – Change in Number of Farms by County

(1975-2000) .................................................................................. 155
INTRODUCTION
THE NECESSITY OF GLOBAL AGRICULTURE

Agriculture has and continues to play a profound role in shaping the global landscape. Modern human civilization relies on agriculture for the provision of food and fiber. Given the fact that the world’s human population has already exceeded 7 billion and is expected to continue to grow (FAO, 2012), the provision of these resources is impossible through traditional hunting and gathering methods. Depending on the specific region of the planet being focused upon, these methods of provision typically require between 18-1,300 km² per capita (Diamond, 2005; Anderson, 2005). Furthermore, approximately only 29.2% of the World’s surface is covered by land (148.94 million km²; The World Factbook, 2013) implying that the maximum theoretical population that could be maintained on the planet through such means is between 115,000 — 8,275,000 people. Given that hunting/gathering is not a viable strategy to support the current global population, agriculture will remain an important human activity across the planet.

Of the total land area on the planet approximately ½ is covered by either deserts or high mountains; these areas are not suitable for either the practice of agriculture or being used for dense human settlement. Approximately 13% of total land area is suitable for farming and another 25% is suitable for pastureland. Given the relatively small amount of land available for the production of food and fiber across the planet it is not surprising to learn that agriculture has profoundly impacted a number of aspects of agronomically useful land including the way it is used (Ramankutty & Foley, 1999), the state of the vegetation, whether erosion ultimately makes the land no longer arable over the long term (Towards Sustainable Agriculture in the 21st Century, 2010), and the way the land’s ecology is structured over time (Giller et al, 1997). Given the fact that the global human population is expected to continue to grow, increased strain will be put upon this land and other resources necessary for the practice of agriculture. Some of the resources that are expected to become more limited are nitrogen fertilizer due to the dependence on fossil fuels as a necessary input (Wen-yuan, 2009), phosphorus fertilizer which is mined from finite supplies worldwide (ibid), and organic matter rich soils that are being degraded faster than they can be restored (Glatzel, 1991). Furthermore, changes in historical weather patterns caused by “Global Warming” (Rozenweig et al, 2001) are challenging agriculture to maintain current levels of output (Kirschbaum, 1995) given current levels of inputs.
THE IMPORTANCE OF SUSTAINABLE AGRICULTURE

Advocates of “Sustainable Agriculture” argue that a paradigm shift in the way that the relationship between nature and agriculture is viewed is necessary to combat the aforementioned issues. For the purpose of this dissertation sustainable agriculture is defined as agricultural practices that can be practiced in perpetuity because no input used is being used at a faster than it can be replaced. These advocates argue that by making the process of agriculture more consistent with naturally occurring ecological processes, both the amounts of inputs necessary as well as the negative impacts on the environment can be minimized while maintaining consistent levels of agricultural output (Altieri, 1998). These changes would occur both because there would be more efficient use of inputs (Tilman et al, 2002) as well as the substitution of inputs with the byproducts of naturally occurring processes happening as part of a field/farm’s ecology (Peoples, Herridge, & Ladha, 1995; Gliessman, 1998). Furthermore, by making agricultural output more reliant on naturally occurring ecosystem processes that are known to be highly redundant (Gunderson, 2000), it has been hypothesized that potential negative impacts of changing weather patterns can be mitigated (Wall & Smit, 2005; Rodale Institute, 2012).

While there is no single form of agriculture that is practiced across the planet, certain gross dichotomies can be drawn. The first relevant dichotomy is whether the agriculture is highly mechanized and conducted on large acreage plots or relies primarily on hand labor and done on a much smaller scale. In the developed world, high rates of mechanization are the norm (Ag Census, 2014). In the developing world however, a great deal of subsistence agriculture that relies primarily on manual/animal labor is commonplace (Morton, 2007). High rates of mechanization are associated with the use of agrochemicals including but not limited to synthetic fertilizers, herbicides, and pesticides/fungicides (Ag Census, 2014). These agrochemicals are used to shape the growing environment to be more conducive to crop growth by altering nutrient dynamics, pest/weed pressures, and the prevalence of various crop diseases; the commonplace and systemic use of these chemicals is known to have negative effects on environmental health (Bruinsma, 2003). On the other hand, the reliance on manual labor and small acreage farming plots requires that a much larger percentage of the population engage in agricultural production relative to highly mechanized systems. However, these smaller acreage plots typically use resources more efficiently and are more environmentally friendly (Barrett, 1996; Assuancao & Braido, 2007).

The second relevant dichotomy is whether the agriculture relies on naturally derived inputs/ecological processes or on synthetically derived substitutes. This dichotomy applies most
obviously to the use of fertilizer but can also be seen in the way tillage (Holland, 2005), crop breeding (Price, 2011), crop rotations (Govaerts et al, 2007), and whether the integration of crop and livestock systems (Sulc & Tracy, 2007) are practiced. While farmers in the developed world have a choice between these two strategies, farmers in the developing world are often limited to reliance on inputs derived from ecologically processes primarily occurring on the farms themselves (such as nitrogen fixation through leguminous crops) due to limited financial credit and availability of alternative options. In the developed world, agricultural practices that rely on naturally derived inputs and ecological processes are oftentimes referred to as “Organic”; many countries in the world regulate the use of this term to ensure its authenticity. Because Organic practices rely largely on ecological processes for the provision of nutrients, control of pests/diseases, control of erosion and other issues they tend to be more environmentally friendly than conventional alternatives. Conventional alternatives often overwhelm the agroecosystem’s natural processes and preclude their proper functioning (Tilman et al, 2001).

The third relevant dichotomy is whether the agriculture is primarily concerned with the production of food for humans or for livestock. For the discussion of this point I exclude consideration of agriculture concerned with the production of fiber. The majority of the world’s agricultural production today is conducted to grow crops that will primarily be used for livestock feed. These commodity crops can be stored for long periods of time making them conducive to being treated like other resource commodities. In addition, their methods of cultivation are highly suited for large scale mechanized agriculture thus allowing them to be produced cost effectively at large scales. On the other hand, humans rely on the portion of agricultural production used to produce food that is directly consumed by people. This food can either be horticultural crops (i.e. fruits and vegetables) or grain crops (such as wheat/rice). In the case of horticulture production, these crops are more perishable and oftentimes must be harvested through a combination of mechanization and hand labor due to the fragility of the final product. Because of this fact, there are limitations on the distribution of these goods without sufficient infrastructure networks that are sometimes out of reach of individual producers (such as in field refrigeration).

ISSUES FACING THE WIDE SCALE ADOPTION OF SUSTAINABLE AGRICULTURE IN THE US

While the long term value of adopting more sustainable farming techniques across the agricultural landscape of the United States have been well defined (Horrigan, Lawrence, & Walker, 2002), there are several structural constraints that are keeping it from occurring. The first of these
constraints is that markets of all kinds are designed to favor large scale agricultural production. While the practices of sustainable agriculture are applicable to all forms of agriculture, the commonplace desire of its practitioners to produce primarily horticultural goods on smaller than industrial scales limits its applicability to large scale row crop production. Because of this, the bias of markets towards large scale production limits the ability of sustainable agriculture to become more commonplace amongst the average grower. This bias can be seen in the ways in which Federal Agricultural Subsidies are administered (RMA-USDA, 2015), the preference of supermarket and other large scale horticultural buyers to work with a small number of high volume producers instead of a large number of small volume ones, and the manner in which capital is made available to agriculture (Union of Concerned Scientists, 2012) amongst others. Only by altering these market practices can true sustainable agricultural production become commonplace amongst farms of all different sizes.

The second of these constraints is the dwindling number of farmers across the country. The average age of a farmer in the US is near 60 (the median age is between 55-64; Agricultural Census, 2014); “farmer” is no longer even listed as a possible profession on the decennial census. This decline in the number of farmers nationwide has occurred for a number of social, economic, and structural reasons (Dimitri, 2005). While there is a growing number of young people interested in taking up farming, they often lack the skills and capital necessary to engage in agricultural production at any but the smallest scale. Typically these individuals are not interested in large scale commodity production but desire to engage in the production of food intended for direct human consumption. Because of this fact, these individuals require access to land of sufficient acreage near available markets to make their operations profitable. This last point is especially important because young people will only pursue their interest in agriculture if it consistently can provide them with a livelihood.

The third of these constraints is that farmland that is sufficient for the use of sustainable agriculture is becoming more limited. As noted above, while the practices of sustainable agriculture are applicable to all forms of agriculture, in terms of the number of practicing farms it is primarily applied by those engaging in horticultural production. Because of both perishability and marketing constraints as well as consumer demand, many producers choose to market these goods direct to consumer and nearby the location of production. This practice is typically referred to as “Local Foods.” Because of this marketing strategy these farmers require farmland relatively near the
location of their markets. Because of this fact, urban encroachment on surrounding farmland is a major issue and threatens the long term viability of this popular movement.

ROLE OF STATISTICAL RESEARCH IN SUPPORTING SUSTAINABLE AGRICULTURE

The practice of Sustainable Agriculture is incredibly complicated on both the production and marketing sides. Because of this complexity, it is typically not feasible to empirically test every possible combination of practices, inputs, cultivars, and harvesting/marketing strategies to find the optimal combination. However, the application of statistics/modeling to these problems is a promising way of finding optimal solutions. In order for this approach to be effective, the statistics/modeling needs to accurately represent the relevant parts of the world in a sufficiently nuanced way and not simply the gross interactions between various component parts for the sake of a simplified analysis. In addition, because of the interconnections between different naturally occurring processes, attempts must be made to model important issues holistically instead of piecemeal as is oftentimes done. Furthermore, these statistics/models must be able to fully and simultaneously represent all of the important variables in order to establish a framework to understand any tradeoffs that will need to be made between them when finding an optimal solution.

The world is not simple and the statistics/models being used need to reflect that complexity; inherent in many naturally occurring processes are non-linear dynamics and other complexities that are typically not modeled. All too often, these fundamental aspects of the processes we hope to better understand are assumed away, sometimes without the researcher even realizing it, for the sake of simplifying the analysis. While it is impossible to model all of the complexities of the world around us, care must be taken to ensure that the most relevant ones are adequately represented and that the researcher is aware of any assumptions they have implicitly made.

CONTRIBUTION OF THIS WORK

The work presented in this dissertation uses complex statistical procedures to inform a number of ongoing investigations within the broad field of sustainable agriculture. This work uses multivariate analytical techniques and Bayesian variable selection tools combined with extensive and thorough data collection to make novel insights and findings on a range of relevant issues. The topics studied within this dissertation are the ongoing issue of farmland conversion to other uses, agronomic strategies for more efficient conversions of land used for conventional production to
Organic usage, and the holistic economic impacts of farms that choose to market their goods in different manners.

There is growing evidence of the ecological harm that is occurring due to the commonly employed practices of conventional agriculture. One of the commonly proposed alternatives to conventional production techniques is organic agriculture which is typically more ecologically friendly than alternative production systems. While the difference in ecological impact between conventional and Organic production narrows as the scale of production grows, on average organic agriculture has more positive impacts on the agroecosystem. In addition, because of the price premium received for Organic products many advocates argue that Organic production is a way for smaller acreage growers to receive adequate enough returns to sustain a livelihood. Despite these benefits of Organic production, there is evidence that Organic production sometimes has lower yields relative to conventional alternatives, especially during the requisite three year transitional period between Conventional and Organic production. Furthermore, because producers are unable to receive the price premium associated with Organic production during this transition period in addition to possibly facing a loss in yield, the transition to Organic production oftentimes causes economic hardship. In order to find ways of minimizing the magnitude of this hardship due specifically to the commonly experienced loss in yield during the transition, a long term study using a real world crop rotation was undertaken. The analysis of this experiment was conducted at the level of the crop rotation instead of on a crop by crop basis. This analysis found that a transitioning strategy that is different from what is currently commonly used by growers eliminates the loss in yields during the transition period.

There is growing interest in the idea of Local Foods to combat a number of today’s pressing issues. These issues range from economic development to environmental to health/food justice. For the purpose of this analysis Local Foods is defined as being produced within the state that it is consumed and sold direct to consumers or through an intermediary whose primary function is to conduct aggregate purchasing/selling with business partners located in the local area. Typically when one thinks of Local Foods they think of horticultural production focusing specifically on fruit and vegetables but the touted economic benefits could apply to other sectors of agriculture as well. These benefits are derived from the fact that because the buyer and seller are effectively part of the same community, the total economic impact of each sale is more beneficial to that community relative to an equivalent purchase from a producer located far away. This would be because a greater percentage of these funds will circulate through this community instead of enriching others
elsewhere. While this idea is not novel there is little empirical evidence to support this hypothesis within the United States. Furthermore, what data is available is derived from secondary sources, it may be biased against horticultural production broadly and Local Foods specifically. In order to determine if the relative locations of buyers and sellers of agricultural goods will differentially impact communities, a representative economic survey of farmers across North Carolina was undertaken. In addition, the currently available datasets were studied alongside the most recent Agricultural Census to determine their accuracy/validity. The results of this analysis found that currently available data does not accurately reflect horticultural production/Local Foods in North Carolina today. Furthermore, the analysis also found that the proximity of buyer and seller does increase the economic impact of each sale of agricultural goods.

Over the past several decades a large amount of farmland has been removed from active production. North Carolina is one of the leading states in this trend in percentage terms. This trend is worrisome for a number of reasons including the provision of ecosystem services such as water infiltration/filtration, having an adequate land base for the growing Local Foods movement, as well as for strategic reasons as they relate to the United States Military amongst others. Neoclassical economic theory states that this change in land usage is tied to the net expected economic returns of using that land for agriculture relative to other potential usages. However, the sociological literature as well as anecdotal evidence suggests that there are a much broader range of factors that determine participation in agriculture, both in terms of land and personnel. In order to evaluate the relevant merits of these differing but potentially complementary theories an analysis using Bayesian Variable Selection tools was conducted. The use of Bayesian Variable Selection tools provides a framework in which to compare on equal footing disparate variables in order to form a holistic understanding of the problem at hand. This analysis found evidence that a greater range of variables than those traditionally considered in economic analyses needs to be considered when attempting to understand the dynamics of land use conversions in agriculture.
REFERENCES


A COMPARISON OF STRATEGIES FOR TRANSITIONING FROM CONVENTIONAL TO ORGANIC PRODUCTION

ABSTRACT

In order to determine whether there exists a more effective way to transition agricultural land used in conventional production to organic production, the present experiment was undertaken. Various orders of removing different categories of synthetic inputs (fertilizers, herbicides, and pesticides) and replacing them with organic alternatives were tested alongside both a conventional control as well as the standard transition strategy used by farmers. In addition, a treatment where all synthetic conventional inputs were substituted for Organic approved production practices and inputs gradually was also conducted. This experiment was conducted in order to determine if one of these alternative transition strategies could eliminate the yield drag often observed by farmers during the requisite three year transition period during which no synthetic inputs may be applied prior to the land being certified. A 3 year, 4 crop typical rotation used in the Coastal Plain of North Carolina was employed over a 6 year period to study potential effects. All agronomic practices used were consistent with common agronomic practices in the area and included the use of cover crops when appropriate. The results of this analysis found a direct relationship between increases in soil organic carbon and yields across the whole rotation, regardless of whether employs conventional or Organic production techniques. Furthermore, the agronomically optimal order of removing synthetic inputs while transitioning from conventional to Organic production was to jumpstart the transition by discontinuing the use of synthetic fertilizers and replace them with Organic approved alternatives, followed by removal of the synthetic herbicides and pesticides in the subsequent year. In addition cover crops should be used during the non-cash-crop portion of the growing season. Under this transition strategy there was no observed yield loss across the rotation as a whole when compared to conventional production.

LITERATURE REVIEW

In the United States one of the fastest growing subsectors of the agricultural sector is Organic products. Over the past decade this subsector of the agricultural economy has grown at just below double digit rates and expectations for continued growth remain high (Dimitri, 2002; Greene, 2013; Greene, 2014). While this growth is often concentrated around urban areas, there is growing adoption of this market niche across the general population (Greene, 2014). The widespread
growth of this subsector is creating both economic opportunities for producers and is facilitating the improved stewarding of more and more land across the United States. Organic production relative to conventional often allows producers to receive greater returns per acre, in some cases even without accounting for price premiums received for Organic products (Rodale Institute, 2012). Much of this difference is due to variations in necessary field activities and inputs for each production system (Delante et al., 2003; Chase, Delate, & Johann, 2009). These greater returns per acre allow individual producers to work with smaller plots of land, thus facilitating less consolidation of the sector and potentially greater stewardship at the farm level (Pimentel et al., 2005). However, issues that arise in gaining certification for eligible land are frequently cited as one of the current barriers for growth of this industry (Chase, Delate, & Johann, 2009; ERS-USDA, 2003).

In the United States, the Organic Agriculture certification program is administered by the USDA and conforms to Federal legislation. In order for land to be certified Organic, a series of management plans must be devised in order to facilitate improved stewardship of the land. Furthermore, all synthetic inputs are banned and must not have been in use for three years prior to the date of certification. Because of this rule, there exists a de facto “transition period” for converting a parcel of land where its products cannot be labeled Organic (and thus receive a price premium) but conventional farming practices cannot be employed either (because these practices often utilize synthetic products). Producers that earn less than $5,000 in revenue annually are exempt from the certification process although they are still required to follow the same stewardship standards (AMS – USDA, 2014).

A review of the literature shows that when discussing the same crop grown in the same field, the yields from historical conventional production will exceed the yields from concurrent Organic production (both during and sometimes after the transition period). This effect varies in size but can range from significant (Seufert, Ramankutty & Foley, 2012; Maeder et al., 2002; Delbridge et al., 2011; Brumfield, Adelaja, & Reiners, 1993) to negligible (Seufert, Ramankutty & Foley, 2012; Clark et al., 1999; Dobbs & Smolik, 1997; Hanson et al., 1997). Of particular importance is the meta-analysis conducted by Seufert, Ramankutty & Foley (2012) which found that the typically experienced yield loss is highly variable across different types of crops, growing conditions, and cropping systems. Typically as time goes on the yields from Organic production systems will ultimately match those from historical conventional production (Rodale Institute, 2012), as soil quality and other biological control properties improve. The studies that have looked at this issue often focus on yields from “ideal” growing conditions in individual years; when one considers a
longer stretch of time, more complex rotations, or when the crops are grown under non-ideal conditions (such as during drought years) the differences in yield consistently become negligible (Chase, Delate, & Johann, 2009; Rodale Institute, 2012) and in some cases Organic yields exceed conventional (Rodale Institute, 2012).

When they do occur, the aforementioned yield losses are economically burdensome to producers. When this occurs during the transition period producers are not able to earn the price premium associated with Organic production, are producing less on a per acre basis, and often times are also incurring greater costs both in terms of greater input costs and capital expenditures as they transition to a new production system. (ERS-USDA, 2003) Finding ways to minimize the average yield loss associated with transitioning to Organic production would help remove a major barrier to more widespread adoption of Organic production and associated improvements in environmental stewardship. It is important to note that this yield loss is observed both for growers new to and those experience with Organic production; this fact implies that the yield loss is due to ecological aspects of the land and not merely lack of grower skill in Organic production systems.

An outstanding question in the literature is why this loss of yields occurs when one transitions from conventional to Organic production and why that difference ultimately recovers. Some have attributed this yield loss to the dynamics of changes in soil chemical, physical, and biological properties that govern nutrient cycling, plant growth and development, and the biological control properties of the system in response to changes in inputs to the agroecosystem (Maeder et al, 2002; Berner et al, 2008; Scow et al., 1994; Wander et al., 1994; Reganold et al., 2001; Pfiffner and Niggli, 1996). Many studies have documented differences in the soil biology/quality between established Organic and conventional systems. (Rodale Institute, 2012; Berner et al, 2008; Maeder et al, 2002; Fraser et al., 1988; Mulla et al., 1992; Jordahl and Karlen, 1993; Sivapalan et al., 1993; Wander et al., 1994; Wander and Traina, 1996), insects (Crowder et al, 2010; Bengtsson et al, 2005; Wickramasinghe et al, 2004; Dritschiolo and Wanner, 1980; Moreby, 1996; Carcamo et al., 1995, Hesler et al., 1993; Pfiffner and Niggli, 1996; Moreby et al., 1994), and diseases (Litterick et al, 2004; Bailey & Lazarovits, 2003; Lazarovits et al, 2001; Workneh and van Bruggen, 1994; van Bruggen, 1995; Workneh et al., 1993) Some of these changes have the potential to impact yields negatively while others may typically increase yields by improving soil health/tilth/biodiversity (Maeder et al, 2002). In conventional systems, these changes/dynamics are often minimized through the use of a complex regime of inputs derived from synthetic sources in order to ensure uniformity of growing conditions from one year to the next. In Organic production however, these inputs can no longer be
used and these dynamics slowly become undampened. For a period of time until a steady state is reached in the agroecosystem, the fluctuating baseline activity will pose a challenge to ensuring consistent yields across growing seasons. It is hypothesized that implementing an Organic transition strategy that minimizes perturbations in these ecological dynamics while also jumpstarting the beneficial ecological transitions alluded to above will be the optimal transition strategy.

It is thought that the primary method by which Organic management strategies attain yields comparable to conventional systems while minimizing inputs is by cultural practices that increase organic matter within the soil. Typically improvements in tilth are tied to increases in soil organic matter (SOM). Increasing amounts of SOM are associated with overall increases in yields (Seufert, Ramankutty, & Foley, 2012; Reeves, 1997) with decreased levels of water stress (Rodale Institute, 2012; Kononova, 2013; Bot & Benites, 2005), increased resistance to pest/diseases (Paul, 2014; Ratnadass et al, 2012), and decreased fertilizer needs (Rodale Institute, 2012; Seufert, Ramankutty, & Foley, 2012). One cultural practice that is commonly used to increase the amount of SOM is growing some type of cover crops and then leaving that plant debris in the field to decompose as a mulch layer in addition to other crop residue that may be present. Over time, this continual crop growth but lack of removal from the field can significantly increase the agronomically relevant amount of SOM (Kononova, 2013; Katterer, 2011). Typically benefits of these practices are first observed between 5-6 years after the use of cover crops is implemented (Schjønning et al, 2007). Other practices that are known to increase SOM are reducing the amount of tillage; however the lack of available herbicides in Organic cropping systems typically makes reduced tillage systems impractical. While changes in the amount of SOM are known to have effects on overall yields regardless of production system, a number of other differences that occur between conventional and Organic systems have been shown to impact yields.

Typically, when a producer begins the transitioning process, they remove all synthetic inputs at once and replace with agronomically viable and Organic approved alternatives. In many cases the synthetic inputs had been used habitually for a long period of time; it is likely that the agroecosystems had adapted to their systemic presence. When all of these inputs are withdrawn at once, it may cause a series of cascading reactions that ultimately influence both above and below ground biodiversity and soil tilth. The removal of synthetic inputs such as pesticides can lead to both increases and decreases in biodiversity; the latter occurs if the removal of these inputs results in a pest outbreak that overwhelms other organisms that occupy similar ecological niches (Hobbs & Huenneke, 1993; Crowder et al, 2010). Negative effects on biodiversity are known to have negative
effects on yields (Richards, 2001). Soil tilth is affected by these changes because the typical replacement for herbicides in Organic production systems is increased tillage which is known to have detrimental impacts on soil structure and SOM (Reeves, 1997; Six et al, 2004). SOM and biodiversity are known to interact with one another in non-linear ways and affect yields through the process of biological control of pest/disease species (Hoitinik & Boehm, 1999; Rodríguez-Kabana, Morgan-Jones, & Chet, 1987; Ahktar & Malik, 2000; Witmer et al, 2003). As these agroecosystems adapt to no longer receiving these systemic synthetic inputs and natural biodiversity improves, yields return to historical levels even while holding the amount of SOM constant. It is believed that as biodiversity improves the ecosystem becomes better able to “implement” effective biocontrol to respond to and suppress outbreaks of any single pest species. Cases where yields never return to baseline levels may be explained with bifurcation theory which postulates that if a shock to dynamic system is large enough, it may move the system to a new local minima/maxima (Schefer et al, 2001); in these cases it may be that the agroecosystems establish a new status quo instead of returned to the previous historical one.

In order to find ways to encourage more producers to enter into Organic production, the following research was conducted to discover novel agronomic practices that would lessen relevant barriers to entry. While practicing a four crop rotation used in production agriculture systems in the Coastal Plain of North Carolina, the effects of various transitioning strategies on yields were studied. These strategies differed as to the relative order that synthetic fertilizers, herbicides, and pesticides/fungicides were discontinued from use and replaced with Organic approved alternatives. In addition, a condition that saw the gradual removal and replacement of synthetic inputs through the use of banding applications, strip tillage, and other relevant agronomic techniques was implemented. In all cases except for the control condition appropriate cover crops were also used. The control condition consisted of continued conventional management strategies being used. In addition, a condition which saw the immediate removal and replacement of synthetic inputs was also implemented; this is consistent with the way growers commonly transition their land today. Our main hypothesis was that the use of cover crops would “jump start” the conventional to Organic transition process and potentially allow producers to avoid any yield loss relative to alternative conventional strategies that don’t use cover crops. We expected that the amount of SOM (proxied by the amount of soil organic carbon (hereafter SOC) in the current experiment) at the start of the experiment would be associated with higher yields regardless of production system used. Our secondary hypothesis is that the removal of different categories of synthetic inputs will differentially
affect the ecology of agroecosystems. We further hypothesize that by staggering the removal and substitution of these various inputs with agronomic alternatives known to improve soil health/tillt/biodiversity we may be able to decrease the size of the expected yield loss. This would be because certain orders of withdrawing these inputs would upset the ecological balance more so than others and more greatly impact biodiversity/soil till in negative ways.

METHODS

The data used in the analysis was collected between 1999-2006 at the Center for Environmental Farming Systems research facility at the North Carolina Department of Agriculture Cherry Farm Research Facility in Goldsboro, NC. At the conclusion of the experiment all land (except the conventional control) used within the experiment was certified for Organic production.

The experiment was organized in a split-plot design in three complete blocks. Fields used in the experiment were soil sampled prior to the start of the experiment at the block level. All fields were sandy loam of the Wickham and Tarboro Soil Series. Each block contains two whole plots corresponding to two start dates (see below). Within each whole plot are six, 0.1 hectare sub-plots (25 m x 40 m). Each complete block was buffered from adjoining land by 20 m on all sides, and within each block, plots were separated by 10 m alleys. Prior to the experiment starting, a uniform corn crop followed by rye was planted over the experimental area. The crop rotation, implemented twice was Soybean -> Sweet Potato -> Wheat/Cabbage; this rotation is used in the region of study. For one of each of the whole plots per each block, this rotation began in the 1st year of the experiment and for the other whole plot it began in the 2nd. Thus at any time within the experiment the agronomic activities in ½ of the fields were lagged one year behind the other fields. This design was used so that weather/year related fixed effects may be included in the analysis. Yield data was collected for each of the studied agronomic crops from five GPS referenced sampling points across each of the experimental subplots (18 in total each .25 acre, 3 complete replications, see example plot in Figure 1.1). The data across each set of sampling points was averaged prior to being used in analysis. These same sampling points were used for the full duration of the experiment. Thus all analyses were conducted at the level of the experimental subplot.

A total of six different experimental treatments were used in this experiment (see Table 1.1). The first of these experimental treatments was a control treatment in which the plot was farmed using the same conventional growing practices that had been used on the land previously. The second treatment (Table 1.1) saw the immediate removal of all synthetic inputs from the
experimental plot, with substitutions of Organic inputs and practices immediately made. Synthetic fertilizers were replaced with livestock based manures and cover crops, synthetic herbicides were replaced with increased amounts of tillage/cultivation, and synthetic pesticides were removed from use and not replaced with any Organic products unless necessary; no rescue treatments were necessary during the experiment. The amounts of each input applied to the various plots were calibrated based on need/recommendation from standard soil testing conducted by the North Carolina Department of Agriculture and Consumer Services. Cover crops (winter rye and hairy vetch) were used between growing seasons except in the conventional control condition; appropriate agronomic strategies were used to handle cover crop rolldown, tillage, and other infield issues. The 3rd-5th treatments (Table 1.1) saw the removal of one of the three types of synthetic inputs (i.e. fertilizers, herbicides, and pesticides) during the first Soybean and Sweet Potato phases of the rotation (data collection years ½ and 2/3 depending on the respective field) and the removal of all synthetic inputs starting during the 1st Wheat/Cabbage cropping year and continuing through the duration of the experiment. The final treatment saw the gradual removal over those first two data collection years of all three categories of synthetic input with their complete removal occurring by the start of the 1st Wheat/Cabbage growing year; this was done through banded applications of inputs, strip tillage, and limiting the application of inputs to be based on immediate need rather than a calendar schedule. Given this design, all plots used in the experiment except for those in the control condition were free of synthetic inputs and eligible for Organic certification part way through the 2nd round of the overall crop rotation.

Because of the fact that all data used in this experiment were collected from a fixed set of sampling points across the experimental area, a repeated measures analysis design is called for. In addition, because the purpose of this experiment was to study the effects of removing various categories of synthetic inputs in different orders on a traditional crop rotation (often used in the Coastal Plain of North Carolina where this experiment took place) and not just a single crop, a multivariate analysis was conducted. In such an analysis, a number of dependent variables (DVs) are considered simultaneously. Furthermore, because of the fact that there might be differential impacts on soil tilth/productivity at different points during the transition of farmland from conventional to Organic agronomic use depending on the relative order that different synthetic inputs are replaced with their Organic alternatives, the first round of the crop rotation during which data was collected (Soybean -> Sweet Potato -> Wheat/Cabbage) was analyzed independent of the 2nd. In addition the data was analyzed as a whole as well. Because the experiment was designed to
investigate the effects of these different treatments as a function of the time since the start of the Organic transitioning period, data from each of the matched fields was grouped together. For a given crop, this meant that half of the contained data was from a given year and the other half was from the subsequent growing year.

The analysis was conducted using Matlab™ (Mathworks Inc.) using the MVREGRESS function. This function allows for the analysis of Panel Data (repeated measures data over a cross section) which is the format of this dataset. This function assumes there will be correlation amongst one dimension (i.e. time, space, or crop) of the dataset but not additional dimensions. Thus, in the context of the present experiment, the function is able to model a correlation structure either across a given experimental field (i.e. the a priori assumption that subsequent observations from a single experimental field would be more highly correlated with one another than subsequent observations across a number of experimental fields) or across crops (i.e. that the effects of a given treatment would be more similar on a single crop than across a number of crops) but not both simultaneously. The analysis was conducted using both correlation structures with little qualitative change in the results. All results presented assume the first correlation structure described above.

In order to accommodate the multivariate analysis, all data was normalized using zscoring within each crop. Prior to the application of this normalization all data was inspected for normality both visually as well as using Lilliefors tests. The two agronomic crops that showed non-normality in their yield responses were the 1st rounds of Soybeans and Cabbage (See Figures 1.2 & 1.3). Of the two, cabbage was far more non-normal; the transplants used during one of the growing years succumbed to disease/pest pressure early in the season skewing the yield data for this crop dramatically. The subsequent analysis was conducted both including and excluding cabbage from one of the simultaneously considered dependent variables with little qualitative change in the results. In addition appropriate dummy variable coding was used for all variables that are best viewed as categorical in the context of the considered experiment (i.e. field, growing year, treatment, etc.).

In order to determine the optimal model for modeling the aforementioned collected data, a global search of the available variable space was conducted using Akaike Information Criteria (hereafter AIC) as the metric. AIC is a penalized likelihood metric that facilitates model comparison across nested models that differ in the number of terms considered. AIC is based in information theory and penalizes itself for including additional model terms that do not significantly improve model fit. In this global search, all possible permutations of the variable space (including 1st order
interactions and quadratic effects) were modeled in order to find the one with the lowest AIC value (indicating most optimal fit). The treatment used was always an included variable. Variables that have been implicated in the literature as affecting soil tilth/productivity and which we had sufficient data coverage for were used in this analysis; there are treatment, crop, plot, baseline level of organic nitrogen, baseline level of organic carbon, soil textural class, year the data was collected.

Finally, as a justification for the analysis method used in this approach, a principle components analysis (hereafter PCA) was conducted on the yield data. PCA analyses attempt to uncover different relationships/patterns in multivariate data; found patterns are constrained in having to be orthogonal to all other found patterns. In this analysis all data was normalized and then grouped together; this had the effect of combining yield data across multiple crops. Given the fact that each crop has different ideal growing conditions, it seems likely that combining such data together would not be sound analytically. However, this ultimately is an empirical question and PCA analysis was used to quantify the strength of the various patterns contained within the yield dataset.

RESULTS

The above described experiment was analyzed with the dataset both partitioned and non-partitioned. In the partitioned case, the dataset was divided temporally in half so that one subset corresponded to the period of time before the land was certified for Organic production and the other subset corresponded to just prior the land would be eligible for certified Organic production. These subsets were analyzed independently of one another. This subsetting of the data was done because of the a priori hypothesis that the various treatments may have different effects as the land is being transitioned and once it has been fully transitioned to Organic use. In the non-partitioned case, the entire dataset was analyzed as a single unit. As mentioned above, the dataset was treated as a panel dataset (repeated observations across a number of sampling units) and appropriate analyses were used. Furthermore, a number of simultaneous dependent variables were considered as opposed to looking at each individually in order to better model the effect of each treatment on the entire employed crop rotation.

As mentioned above, the cabbage yield data from the pre-Organic management period was dropped from the analyses due to non-normality. Cabbage yield data was used in the analysis of the Organic management period data and the combined dataset. The results of the regressions for the pre-Organic, Organic management period, and whole dataset are presented in Tables 1.2-1.4. Based
upon the AIC based global search, the optimal model for modeling the pre-Organic period consisted of the variables Treatment (Treatment; names in parenthesis correspond to variable names in tables) / Plot (Block) / Year the Data Was Collected (actualYear) / Baseline Organic Carbon (BaselineSprn2000OrgC). The same model was found when one includes cabbage yields in analyzing the results from this time period. For the Organic management period the optimal model consisted of the variables Treatment (Treatment) / Crop Grown (CropGrown) / Year the Data Was Collected (actualYear) / Baseline Organic Carbon (BaselineSprn2000OrgC). When one does not consider cabbage yields when analyzing data from this phase of the experiment, the same optimal model is used except the “Crop Grown” variable is no longer included. When all of the data is combined together, only the variables Treatment (Treatment) / Baseline Organic Carbon (BaselineSprn2000OrgC) compose the optimal model. The non-partitioned dataset was analyzed with cabbage yield data included. Histograms of residuals of the various models used are presented below (see Figure 1.4). All presented results correspond to the models/dataset combinations described immediately above. In addition, the optimal model for the Organic management period is also presented for the pre-Organic period and combined data so that direct comparisons can be made.

With the exception of the measurements of the baseline levels of SOC, all other variables were treated as categorical and appropriately dummy coded. Thus all coefficients should be viewed as relative to a reference level. The reference levels are the “Conventional Treatment” for the treatment variable, Soybeans for the crop grown variable, Block 1 for the experimental block, and the Year 2000 or 2003 respectively for the year the data was collected.

Looking at the pattern of results across the three ways the data was analyzed one can find two consistent patterns that have agronomic relevance. For all presented analyses coefficients with p-values below 0.05 were declared significant. The first concerns the effects of the various treatments. Looking first at how the five tested treatments compared to conventional agronomic practices (the reference group), the first thing to note is that the sign of the coefficient fitted to all five of these terms, regardless of the dataset used, is negative. The sole exception to this is for the substitution of fertilizer when all data is combined. This is consistent with the conventional criticism of Organic production in that it typically yields less per acre when compared to matched conventional production. However, boring down further into this pattern of results when one considers the pre-Organic and Organic production periods separately, the synthetic fertilizer substitution condition consistently is shown to be no different than conventional (p =0.44 & p = 0.18
respectively). While it may be the case that this lack of a significant difference is due to inadequate sampling size instead of there not being differences between the effects of the two treatments, the fact that for all other treatments a robust effect was found limits the potential of this alternative. Furthermore, when one considers all of the data analyzed together the only condition that shows a statistical significant difference from yields achieved using conventional practices is when all synthetic fertilizers, pesticides, and herbicides are immediately withdrawn and replaced with Organic approved alternatives. However, in all cases where either the rate or the inclusion of these three categories of synthetic inputs is decreased gradually or staggered, there is no statistically significant difference in the yields achieved compared to conventional growing practices. These findings have direct implications in the manner in which farmers should transition their land from conventional to Organic growing practices. Finally, it should also be noted that when the same model is used for each of the two time periods and the combined data, the qualitative pattern of results does not change relative to only comparing the optimal models (Tables 1.3, 1.5 & 1.6).

Furthermore, the results do not change qualitatively when one assumes alternative covariance structures (such as that

The second interesting finding from this analysis concerns the apparent importance of the level of SOC in affecting yields. This variable was included in the optimal models in all of the various ways of partitioning the dataset. The sign of this coefficient is consistent with agronomic research data showing a positive relationship between SOM and yields (Reeves, 1997). The coefficient on SOC was always statistically different from 0 (p-value < .05). This finding further supports the importance of increasing SOM and tilth to achieve high yields, regardless of whether one is pursuing conventional or Organic production systems.

Further exploring the relationship between total SOC and yields, the direct relationship between SOC and both overall yield as well as each individual crop yield was studied. These findings can be found in Figures 1.5-1.7. Focusing first on Figure 1.5 which shows the relationship between SOC and yield during the pre-Organic management period one can see that for all crops there is a positive relationship between yield and SOC. Furthermore, when one looks at the 95% confidence interval of the estimates for each crop individually one can see that the estimate is always greater than zero, strongly supporting the hypothesis that increasing SOM drives increases in yield. Focusing now on the Organic management period of the dataset (Figure 1.6), one can see the same trend as observed before on average. However, while the 95% confidence intervals of both soybeans and sweetpotatoes do overlap zero, when one considers all the crops combined together
the relationship between yields and SOC once again appears strong. Finally when one considers all of the data together (Figure 1.7) we once again observe a consistent strong relationship between yields and SOC regardless of crop considered.

Finally a principle components analysis (hereafter PCA) was conducted on the yield data. Given the fact that each crop has different ideal growing conditions, it seems likely that combining such data together would not be sound analytically. However, this ultimately is an empirical question and PCA analysis was used to quantify the strength of the various patterns contained within the yield dataset. Looking below at Table 1.7 one can see that in all cases the 1st principal component explains almost 50% of the total variance in the subsets of the data studied (~43%, ~50%, ~47% respectively). The results of this PCA analysis indicate that since there is one pattern of relationships in each of the yield data subsets that explains almost the majority of the variance, the normalization and concatenation procedure used in the present analysis to put the yields for each crop on equal footing was justified.

DISCUSSION AND CONCLUSIONS

In order to determine whether the order in which synthetic inputs are removed from use in a conventional agricultural production field being transitioned to Organic use, the above described experiment was conducted. This experiment found a consistent positive relationship between yield and initial SOC but did not find a difference in the yields from the conventional control condition and the treatment where synthetic fertilizer was removed in the year prior to the removal of synthetic herbicides and pesticides. Statistically significant differences were found though between the other treatments and the conventional control in at least some cases. These findings were robust against different ways of partitioning the data as well as assuming different types of covariance structures (i.e. assuming correlations amongst a single crop instead of across space; data not shown).

Both of these findings may have profound implications for the optimal manner in which producers can transition farmland from conventional to Organic usage while maintaining high yields. Additional research should be conducted to replicate these findings across additional regions, soil types, and climactic conditions. First focusing on the result that higher amounts of SOC lead to higher yields irrespective of controlling variables and experimental condition, this finding corroborates other evidence of the important link between SOM content and productive capacity (Rodale Institute, 2012; Reeves, 1997). Previous researchers have highlighted the importance of SOM in affecting overall soil health (Six et al, 2004), capacity to support biodiversity (Giller et al,
1997), and ability to mitigate drought stress (Rodale Institute, 2012; Bot & Benites, 2005) amongst others. It would be expected that the practices used in this experiment to increase SOC, such as the use of cover crops and the termination strategy employed (i.e. plowing under, mowing, rolling-crimping; Ashford & Reeves, 2003), would also help to improve yields. These changes are thought to enhance productive capacity of soils both by improving tilth with regards to texture (Schjønning et al, 2007; Shepherd, Harrison, & Webb, 2002), CEC (Loveland & Webb, 2003; Ouédraogo, Mando, & Zombré. 2001; Lal, 2006), water holding potential (Bot & Benites, 2005; Rodale Institute, 2012), buffering capacity (Loveland & Webb, 2003; Lal, 2006) and others and also by essentially filling out more completely different ecological niches to effect more efficient use of various nutrient fluxes through the soil. This finding directly argues that producers should take steps to foster the amount of SOC in their soils for the purpose of increasing yields over the long term. The benefits from this increase in SOM can benefit both conventional, Organic, and transitioning producers.

Focusing now on the second important result from the present analysis, findings indicate that the agronomically optimal way to transition land from conventional to Organic usage in order to limit the short term yield drop is by substituting organic matter additions for conventional fertilizers alongside use of cover crops prior to entering the full transition. After a period of at least one year (longer time periods may be more ideal but were not studied in the present experiment), synthetic pesticides and herbicides should then be discontinued and replaced with Organic approved alternatives. A likely explanation for this finding is that the increased amounts of biomatter being returned to the soil (which would causes increases in SOC) most likely had a beneficial impact; this is consistent with our primary hypothesis. Second, removing synthetic fertilizers and replacing them with Organic equivalents has less impact then discontinuing use of pesticides and herbicides on agroecosystems.

Removal of synthetic herbicides and replacement with increased amounts of cultivation have been documented to negatively influence soil tilth as well as soil biota. There exists research showing the negative effects on carabids, frequently used as indicators of overall biodiversity health and known to play important roles in the process of Biological Control. (Stinner & House, 1990; House & Rosario Alzugaray, 1989; Kromp, 1999; Bikhofer et al, 2008) These organisms are present at the research site used for this study (Balme, Orr, & Fox, 2010). Other research shows negative effects on other soil communities (Brust, Stinner, & McCartney, 1985; Witmer, Hough-Goldstein, & Pesek, 2003; Crowder et al, 2010). Removal of synthetic pesticides in this experiment would also be expected to greatly upset the underlying agroecosystems ecology because no Organic alternative
was used. Thus, in this case many ecological niches were suddenly changed/made available which most likely had negative impacts on ecosystem stability. Consistent with our secondary hypothesis, the finding that the only condition that experienced a yield difference (at the p = 10% level) relative to conventional production practices when one groups all of the data together was when all synthetic inputs were removed immediately. This condition would be expected to be the most disruptive to overall agroecosystem stability.

It is important to note that while this staggered withdrawal strategy will take at least one year longer to transition land from conventional to Organic usage relative to the removal of all synthetic inputs at the start of the transition period, the present analysis indicates that such a staggered withdrawal strategy will experience no yield loss relative to conventional usage over the whole of the rotation. This is an important point because the main financial obstacle producers must be able to overcome when transitioning land to Organic usage is the 3 year period of time where they typically experience a yield loss relative to previous production levels while at the same time they cannot receive the price premium paid for Organic production because the land has yet to be certified. It may typically be the case then that producers would be better off taking an additional year prior to being able to certify their production as Organic and be able to maintain equivalent production levels throughout the entire transition period.

An additional point that must be considered by prospective farmers looking to transition land from conventional to Organic usage is that the current experiment does not demonstrate one way or another what is the most economically advantageous option. While the results demonstrate an agronomic strategy that results in no experienced yield loss relative to conventional management strategies over the full course of the Organic transition period, this does not imply that such a strategy is the most economically profitable. This is because the present experiment did not consider such factors that are known to differ between conventional and Organic management systems including but not limited to the machinery used, the number of tractor passes required (with subsequent effects on fuel usage), difference in transportation costs, and the price premium received. Each producer thinking of transitioning farmland from conventional to Organic usage will need to consider their own unique economic situation before applying the agronomic insights found in this analysis.

It bears further consideration as to why the yield drop that is associated with transitioning land from conventional to Organic production was observed only marginally in the present experiment. We hypothesize that this has occurred because of methodological differences that
exist between the ways in which this analysis was implemented relative to others. Most experiments conducted analyses at the level of individual crops instead of at the level of a complete rotation (Brumfield, Adelaja, & Reiners, 1993; Dobbs & Smolik, 1997; Hanson et al, 1997; Clark et al, 1999; Maeder et al, 2002 Delbridge et al, 2011). Because it may be the case that different crops respond differentially to the withdrawal of various categories of synthetic inputs, it is not surprising that when one statistically analyzes the yields from multiple crops simultaneously the traditional yield loss is not attributed to the treatment condition. In such an analysis the treatment would only be found to have a causal role if all crops showed a similar pattern of results. It is important to realize that most producers who are certified Organic or are considering doing so are at least somewhat diversified. Therefore, the manner in which this analysis was conducted is more akin to the ways in which Organic farms are typically operated; growers need to be concerned about yields across the whole of their rotations instead of within a specific crop to the exclusion of the others.

With regards to explaining the pattern of results in this experiment, it is most likely the case that there are other covariates that were not studied in the present analysis that would be able to causally explain the difference in yields. The other covariates most likely will relate to either soil tilth or biodiversity.

While the present results are consistent with the hypothesis that the yield loss typically observed when one transitions from conventional to Organic production is due to changes in the dynamics underlying soil chemical, physical, and biological properties that govern nutrient cycling, plant growth and development, and the biological control properties of the agroecosystem, the present analysis cannot confirm that this is the mode of action. It would be important to note what variables are causally important in this process so that targeted, cost effective methods may be developed and disseminated to assist farmers in producing in a consistently sustainable manner. Follow-up work should focus on integrating metrics of biodiversity change (both above and below ground) into the analysis. These metrics should represent both the number of species present within the agroecosystems but also changes in their relative dispersions. Furthermore, these metrics would hopefully represent biodiversity across many sizes of organisms, from the microbial to the macro-vertebrate/invertebrate levels, all of which are known to play roles in the process of Biological Control (Hoitinik & Boehm, 1999; Crowder et al, 2010). Other metrics to include would be ongoing measures of changes in soil fertility and tilth, soil physical properties such as water holding potential and CEC. By including this type of information in the analysis one would be able to determine which covariates can be most causally linked to changes in yields.
Several other outstanding questions germane to the current discussion have yet to be answered and future agronomic research work on the topic should attempt to address one or more of them. The first outstanding question is whether the present findings are robust to other crop rotations within the Coastal Plain of North Carolina or more broadly to other geographic regions and their respective crop rotations. The second outstanding question is whether there are additional covariates that are within the producer’s ability to affect which may prove to be important in understanding the dynamics that occur when land is transitioned from conventional to Organic usage. Perhaps other measurements of soil tilth, previous cropping history, specific agronomic practices, or other variables may prove to be more influential in driving consistently high yields. The third outstanding question is whether these findings are robust to any weather pattern or whether different transition strategies may be more optimal if expected weather patterns differ consistently but unpredictably from historical norms (such as with the pronounced drought periods that have been occurring with greater frequency and severity worldwide since the start of the new millennium; Dai, 2010). The fourth and final outstanding question is whether there are specific recommendations of how to transition land from conventional to Organic usage if specific products have been in use in a field. This may be particularly relevant in areas that have relied on either a single or a small number of chemicals to control some type of problem/agronomic issue. In cases where a small number of chemicals/products have been used repeatedly and extensively, it is most likely the case that the ecosystem there has adapted to their presence. The immediate withdrawal of these products may have deleterious consequences that are greater in magnitude than the removal of other chemicals/products in the same general category (i.e. fertilizers, herbicides, and pesticides). Many of these questions would be most adequately studied at the regional scale so that the research may be conducted that is as relevant and representative to in-field agronomic practices.

The presented analysis finds evidence that both the staggered removal of different types of synthetic inputs and the presence of increased amounts of SOM directly lead to increases in crop yield across a real world crop rotation used in the Coastal Plain of North Carolina. These findings have direct relevance to producers as they directly argue for a longer transition period in order to avoid yield losses over that time as well as more efforts to increase SOM levels within production fields to maintain historic production levels. Future work will expand this analysis to ensure the present finds are robust against a wider range of crop rotations, crops, and geographic regions.
Figure 1.1: Example Plot from Experiment
Figure 1.2: Yield Variables from Pre-Organic Management Period. This figure shows the histograms and associated Lilliefors test used to assess normality for each of the crops grown.

Figure 1.3: Yield Variables from Organic Management Period. This figure shows the histograms and associated Lilliefors test used to assess normality for each of the crops grown.
Figure 1.4: Histogram of Residuals from Optimal Model Fits via AIC. This figure shows the histograms and associated Lilliefors tests of the residuals associated with the regressions used to study the Pre-Organic (top) and Organic (middle) Management periods as well as all data combined together (bottom) in order to assess whether they are normally distributed.

Figure 1.5: Relationship between Baseline Levels of Organic Nitrogen and Yield (Pre-Organic Management Period). This figure shows the linear relationship and associated 95% confidence intervals between each of the studied crops (soybeans, sweet potatoes, wheat) and baseline levels of Organic Nitrogen.
Figure 1.6: Relationship between Baseline Levels of Organic Carbon and Yield (Organic Management Period). This figure shows the linear relationship and associated 95% confidence intervals between each of the studied crops (soybeans, sweet potatoes, cabbage, wheat) and baseline levels of Organic Carbon.

Figure 1.7: Relationship between Baseline Levels of Organic Carbon and Yield (All Data Combined). This figure shows the linear relationship and associated 95% confidence intervals between each of the studied crops (soybeans, sweet potatoes, cabbage, wheat) and baseline levels of Organic Carbon.
Table 1.1: Treatment Plan for Experiment

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<tr>
<th>Treatments</th>
<th>YEAR 1</th>
<th>YEAR 2</th>
<th>YEARS 3-6</th>
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<td>(+ F + H + P)</td>
<td>(+ F + H + P)</td>
</tr>
<tr>
<td>2 - Organic</td>
<td>(- F - H - P)</td>
<td>(- F - H - P)</td>
<td>(- F - H - P)</td>
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<tr>
<td>3 - Progressive</td>
<td>(- F + H + P)</td>
<td>(- F + H + P)</td>
<td>(- F - H - P)</td>
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<tr>
<td>4 - Progressive</td>
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<td>(+ F - H + P)</td>
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<tr>
<td>6 - Progressive</td>
<td>(GR)</td>
<td>(GR)</td>
<td>(F - H - P)</td>
</tr>
</tbody>
</table>

Notation used for treatment identification: [synthetic F (fertilizer), H (herbicide), P (pesticides, including insecticide and fungicide)]; - (without), + (with). GR (gradual reduction of all synthetic inputs, for example, banding vs. broadcasting. In the second year, only rescue chemical treatments were applied).

Table 1.2: Pre-Orgainc Management Period Regression Results - Optimal Model

<table>
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### Table 1.4: Combined Data Regression Results – Optimal Model

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REFERENCES


HOUSE, G. J., & ROSARIO ALZUGARAY, M. D. (1989-04-01T00:00:00). Influence of cover cropping and no-tillage practices on community composition of soil arthropods in a north carolina


This paper looks to provide an overview of the “Local Foods Movement” in North Carolina and conduct data analysis of both primary and secondary data of the potential economic impact of “Local Foods” on communities. The idea of Local Foods has steadily grown in popularity over the last decade (Martinez et al, 2010). Championed by the USDA’s “Know your Farmer, Know your Food,” campaign, this popular movement seeks to instigate social change by engaging consumers with the food and other agriculture products they consume. This engagement comes in the form of encouraging consumers to learn more about the environmental impacts of the ways in which these goods are produced, the health implications of eating various diets (Pollan, 2006), the economic impact of supporting locally owned businesses (Schuman, 2006) and others. In the past decade a large number of “Local Foods Initiatives” (hereafter LFI) have sprung up nationwide to both capitalize on this engagement though the novel market opportunities this movement has created and to further drive the movement forward by catalyzing further engagement (Delind, 2006). While the concept of Local Foods is broad, it is commonly defined as agricultural production that takes place within a certain geographic radius from the consumer. In different regions of the United States/World this geographic span is larger or smaller depending on a number of factors including agroclimatic variability, location of suitable farmland, location of suitable markets, available processing infrastructure, and many others. Some communities are able to define local as being produced within 50 miles, others use metrics such as “within the state.” Still others must define a definition of Local Foods based on their own unique geographies, demographics, and histories (Low et al, 1995). For the purpose of the present discussion for North Carolina, Local Foods will be defined as production/processing occurring within the state (Curtis, Creamer, & Thraves, 2010).

The Local Foods Movement has garnered popular support from varied segments of the population because of the wide range of societal issues it affects and is affected by (Low & Vogel, 2011). Environmentalists see Local Foods as a way to encourage individuals to care more for the environment and to take the time to understand the ecological impact of their dietary choices. Public health advocates see Local Foods as a way to encourage a healthier population by encouraging the consumption of more horticultural goods (i.e. fruits & vegetables). Economic
planners see Local Foods as a way to create industry, business, and entrepreneurship using resources already at hand. Agricultural advocates see Local Foods as a way to improve profitability for smaller size growers and help keep them and their land in production. Because the process of agriculture, from seed to table, touches so many other aspects of life, proponents see it as a wellspring from which to instigate change in these other domains (Kloppenburg et al, 1996).

**Goals of the Local Foods Movement: Promoting Rural Job Creation**

There has been a great deal of interest in the Local Foods movement being a catalyst for rural job creation. Proponents of this point of view highlight the growing interest nationwide amongst consumers having a connection with where their food comes from, health/environmental concerns regarding its production, issues of freshness and its impacts on health, the mode of agriculture that was used to produce it, and increased diversity of offerings (Follett, 2009). These individuals further argue that there is an unfulfilled and continually growing market demand that can be capitalized on by farmers. Furthermore, because these goods are often sold direct to the consumers, or with fewer supply chain transactions, farmers have the potential to earn increased margins relative to wholesale outlets for their production. Furthermore, a rise in demand for these local products may lead to wholesale outlets being willing to buy these goods at a premium relative to non-local equivalents providing farmers with an additional higher than typical margins marketing channel. These changes may allow smaller sized farms to provide adequate income to maintain a farming family. The unfulfilled consumer demand for Local Foods can be seen in the continual growth in the number of farmers markets, the amount of food reported to be sold direct to consumers (Census of Agriculture, 2014), and the trend for institutions and large supermarkets to be advertising local products and purchasing selectively from local growers. These efforts are often contrasted with state/county run initiatives for job growth which often depend on economic incentive packages to lure existing companies to new areas; the obvious problem with this approach is that this commonplace practice leads to the development of a market for companies to relocate, thus typically negating any net benefits that a community might experience from having a new business move in (Fasenfest et al, 1997). In many cases economic incentive packages may be more effectively applied to businesses already located locally and in need of capital to expand; this would be increase both demand for other services within the community and generate economic development from the ground up.
In addition, there are four additional and distinct arguments for the utility of the Local Foods movement to be an engine for rural job creation. The first is based upon the perceived ability for direct growth of the farming economy to drive growth in related local based value added industries. These industries could use locally grown products as their inputs thus increasing both demand for the raw agricultural goods produced locally as well as consumer demand for higher quality final products (USDA: Rural Development, 2015). The types of potential industries ranges tremendously but could be anything that enhances the Local Food infrastructure (i.e. slaughterhouses, grain mills, packing facilities, etc.) to a whole range of consumer outlets (i.e. butchers, bakers, and even beeswax candle stick makers).

The second argument is that many farms are currently operating at below their production capacity because of either a current inability to cover variable costs typically due to a lack of available credit or the potential of transitioning to higher value crops that local consumers want. This implies that relative to other industries which support could go towards (whether it be public or private financial support of some kind), agriculture could yield greater return on investment. This would occur because less of the support would need to go towards covering fixed costs or covering capital expenditures. Thus, an increased percentage of all support would be able to ultimately go towards reinvestment in the company/industry, potentially leading to faster rates of growth over medium length time periods. While it is not guaranteed that operators of agricultural businesses would be willing to reinvest into their operations/industries at rates higher than other business owners, the above mentioned characteristics of many agricultural operations would allow them to do so.

The third distinct argument is that producers may benefit from agricultural production, even when only engaging in it part time. In many places in the state, conducting small scale direct to consumer sales is one strategy by which households could increase their total income. In many rural places, households are able to expand production of their “market gardens” to large enough scale to allow for direct to consumer sales without encountering additional needs for land or capitalization. While the total possible revenue generated from these operations is limited, their production may help many households to make ends meet. As opposed to other industries which rely more exclusively on either full time or part time labor, the fluidity of agriculture with regards to being either a primary or secondary form of household income makes it a useful tool by which to potentially raise the average income of a large number of households a modest amount. The above argument assumes that individuals already have access to land; this is a reasonable assumption in
many rural areas. Many such places in North Carolina have growing issues with unemployment/poverty (US Census, 2010) and finding ways to increase household incomes even a small amount using already available resources may have a large aggregate impact.

The fourth argument is that growing demand for local food may encourage more individuals to become farmers creating additional employment from the grassroots up. These individuals, as entrepreneurs within communities, would create demand for goods and services from nearby businesses. These new farmers, whether engaged in production on a new farm or working on an already established one, will help keep money within the community because both their work and much of the goods/services they consume will be based within it; this will be largely due to the fact that agricultural items are bulky and tend to only ship cost effectively at very large scales.

Because of the profound interest in trying to develop this sector of the Local Foods economy, there is great interest in documenting potential economic gains. This is commonly done using Input-Output Analysis (hereafter I-O analysis); the IMPLAN database (MIG Inc.) is commonly used for this purpose although its validity without collection of extensive site specific data has been questioned (Lazarus, Platas, & Morse, 2003; Bonn & Harrington, 2008; Radtke, Detering, & Brokken, 1985; Hotvedt, Busby, & Jacob, 1988). IMPLAN attempts to mathematically represent the relationships between different industries within economic communities as small as individual zip codes; for this reason it is oftentimes used by Municipal and County governments for the purpose of forecasting economic impacts. In addition, other similar econometrics-based imputation methodologies have also been used. These analyses typically focus on one of two variables that are derived from the models, the economic multiplier associated with some industry and its total output (dollar value). These two variables represent two complementary ways in which businesses are intertwined with one another in communities. The economic multiplier represents the marginal impact of each dollar of revenue generated. Businesses/industries with higher economic multipliers do more business in the community with each dollar made; this has the effect of increasing the supply of money circulating through the economy. However, an industry can have a large economic multiplier but a small absolute impact because they are a relatively small share of the market space. For this reason it is important to consider both the economic multiplier and the total output when evaluating the results of these analyses. However, given the fact that Local Foods producers are typically not comparable to more traditional growers in term of size (either revenue or acreage), most economic studies of Local Foods have focused on the economic multiplier.
The argument for why Local Foods businesses would be expected to be associated with a higher than typical multiplier when compared to businesses of equivalent size in other industries is that the majority of their business partners would be based in the local community and thus be more likely to do business with relatively more individuals/businesses/entities nearby. It is thought that these enterprises would contribute relatively more per dollar of revenue than non-local counterparts because they would spread their purchases across a greater number of businesses (many local, some not), thus creating increased demand for both directly supporting services as well as those consumed by their employees. These supporting services include but are not limited to accountants, restaurants, entertainment, etc. This would result in an expected higher multiplier to be revealed from subsequent I-O analysis. While it is true that these products would generally cost more than conventional alternatives, it is thought that their production/consumption would have a “rising tide raises all boats” phenomena thus justifying their purchasing on solely economic grounds.

Underlying the importance of finding ways to leverage the agricultural economy to drive interrelated and non-farm sectors, previous work found that there is no significant relationship between a farmer’s quality of life and the scale of their operation (measured via income or acreage; Coughenour and Swanson 1992; Molnar 1985) but there is one with the opportunity for off farm employment (Hoppe et al, 2007). This is consistent with the fact that it is now estimated that over 90% of farm-household income comes from non-agriculture sources (Arbuckle & Kast, 2012). A farm household is defined as any operation that produces a sufficient amount to do more than $2000 in potential revenue.

In order for the argument presented above to work within a community and because of the expected higher average cost of Local Foods, it is important to note that the supporting populace must have either sufficient disposable income to adjust their purchasing behavior to purchase these locally produced items or a willingness to adjust their eating habits to consume seasonally available food as well as have a decreased intake of meats and value added products (both practices which lower food costs). The consensus of the current evidence is that when purchasing in season produce, prices of local goods can be equivalent in price to non-local alternatives but that this relationship breaks down when one considers meat or value added goods (Pirog & McCann, 2009; Renkow & Georgiade, 2011). Because there is great heterogeneity within the population as to whether households can effectively use locally produced horticultural goods in their home kitchens (Brown & Hermann, 2005) as well as whether people are willing to scale back their meat intake (Godfray et al, 2010), it remains uncertain as to whether a broad range of the population will be
willing to support the Local Foods movement. At the same time however, there is strong interest amongst the “Millenial” generation for locally produced goods; these individuals may show fundamentally different purchasing patterns than older generations (Jefferies, 2012). Further work should be conducted to stimulate demand across all consumer age ranges for local goods that can be produced in cost effective ways in order to create additional market opportunities for rural job creation. In addition, the potential for developing dedicated Local Foods aggregator industries (i.e. dedicated buyers of Local Foods from clusters of small farms) to allow small farms to capitalize on increased marketing economies of scale may allow rural communities to take advantage of agglomeration benefits that are known to exist in other sectors of the economy (Brasier et al, 2007). Furthermore, it is hoped that the emphasis on increasing demand for local goods, of which produce is the most cost effective for the average household to purchase regularly, will have indirect benefits on population health by encouraging the consumption of additional seasonally available produce (Ahern, Brown, & Dukas, 2011).

Goals of the Local Foods Movement: Promoting Mid-Sized Farms

Over the past several decades there have large declines in the number of midsized family farms in this country with a contemporaneous increase in both small and large farms (Lyson, Stevenson, & Welsh, 2008). This is important structural change for the wellbeing of rural communities in light of the Goldschmidt hypothesis. In the 1950’s Walter Goldschmidt hypothesized that agricultural communities that are dominated by mid-sized family farms over farms of an industrial scale would be socioeconomically healthier and their communities more vibrant (Goldschmidt, 1978; Lobao, 1990). Using the USDA small farm typology which was set in 1995, these are farms which have a gross revenue between $100,000 and $250,000 annually (Sommer et al, 1998). Note that in the updated USDA typology this category is now called Moderate-Sales Small Family Farms (Hoppes & MacDonald, 2013). This pattern of consolidation and loss of medium sized farms is frequently explained with reference to these farms being too small to take advantage of the commodities of scale enjoyed by larger farms while at the same time they are too large to support their volume of production and needs for capitalization through alternative marketing channels. Thus because of limited marketing opportunities these midsize growers are unable to use either traditional wholesale or direct to consumer marketing channels effectively. At the same time however, these midsize farms are the best situated to take advantage of growing demand of institutions (school boards, prisons, hospitals, park systems, etc.) purchasing Local Foods.
(Kirschenmann et al, 2008). This is because their larger scale of production will allow these institutions to work with fewer growers to source the requisite amount of goods making it more attractive for institutions to pursue this demand.

Given the fact that these farms are frequently unable to sell the full breadth of their production at alternative markets (farmer’s markets, CSA’s, etc.), the importance of these institutional buyers cannot be underestimated. It is important to note that the original reason the USDA drew a distinction between small/medium size farms and large farms at $250,000 was that was the amount they estimated a farm would need to generate in revenue in order to achieve an household income equal to the national median (Sommer et al, 1998). This amount, when you adjust for inflation and assume the same ratio between the prices received for commodities and the prices paid for the inputs, is now $381,000. Under the new typology this upper limit falls into the range of Large Scale Family Farms (Hoppes & MacDonald, 2013). The importance of these alternative markets, whether they be direct to consumer or selling to institutional buyers lies in farmers being able to receive a higher margin for their production. While the margins would be expected to be highest for direct to consumer sales, direct to institution sales often also result in higher margins relative to conventional wholesales. Given the fact that medium sized farms require far more of a time commitment to run and maintain compared to the average small farm, the opportunity for off farm income is decreased. Therefore, if the goal of the Local Foods movement is to promote the continued existence of farms of medium scale, there is a need for solution/remedies/avenues that allow farmers to maintain high enough margins that they are able to support a family with decreased reliance on off-farm sources of income relative to small family farms. This fact implies that for the Local Foods movement to be effective at promoting the continued existence of mid-sized family farms over the short term, it must either find ways to promote increased amounts of institutional buying, direct subsidy payments to these types of growers specifically, or alternative revenue streams for these farms such as agritourism or other forms of “multifunctional agriculture” activities which work within the time constrains of the producer and the supporting family (Smithers, Joseph, & Armstrong, 2005; Amsden et al, 2011). It should be noted that these “multifunctional” activities could be non-market outcomes which are
known to have community level impacts (such as pollution mitigation); research is being conducted to try and place a market value on these activities (Moon & Griffith, 2011).

One interesting point to note with regards to economic analyses that are comparing the relative benefits of having different composition of farms of varying scale while holding the size of the agricultural industry constant is that they take into account the year to year survivability rate of different sizes of farms (Morse & Guess-Murphy, 2001). This fact implies that farms that are more likely to continue operation year after year are given relatively more importance in the analyses because policy interventions that are geared towards them will have more of a lasting impact on average. Oftentimes when survivability is excluded from these analyses, the greater economic benefits fall on the side of small to mid-size family farms because of their increased use of labor at the expense of capital (Morse & Guess-Murphy, 2001). This finding implies that if the Local Foods movement were to be successful in improving the chance of survival of midsize farms from one year to the next, the macro-level economics view of what scale of agriculture is best for the economy will gradually swing to the side of small and medium farms.

Finally, it should be noted that there are expected positive environmental ramifications of improving the outlook of medium size family farms. It has been demonstrated time and time again that farms/stewards who believe that they will be farming the same land for a long period of time are less likely to use their lands in ways that degrade its long term potential to produce (Rosset, 2000). While this literature has often focused on issues of land tenure in developing countries, the same principle applies to domestic farms that are perennially on the edge of failing. Farmers who feel that every year may be their last will be willing to deplete their agricultural resource base (most commonly the soil) in order to ensure profitability in the current year. While this practice may prove to be problematic in subsequent growing seasons, the short term outlook most individuals take to dealing with their current problems causes them to discount this potential greatly (Rubenstein, 2003). This may further hurt the long term viability of this scale of agriculture.

Goals of the Local Foods Movement: Promoting Environmental Improvement

While there is not a single way that small to mid-size family farms operate, on average they tend to do so in a manner that is more sensitive to the environment (Altieri, 1998). This typically

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1 An example of innovative ways to improve the profitability of relevant farms in NC is the Market Based Conservation Initiative being employed by Fort Bragg to preserve farmland that directly impinge on their training missions (Market Based Conservation Initiative, 2014).
occurs due to both decreased reliance on mechanization and the associated need for agro-chemicals (Chappell, 2011) as well as the commonplace desire to maintain family traditions (Parker & Shaw, 2013) and keep the land in a good state for future generations (Parker, Shaw, & Richmond, 2008). Furthermore, it has been shown that small to midsize farms are often more efficient than large farms in both the amount of crops/goods produced per calorie of energy input (Kirner & Kratchovil, 2006; Netting, 1993) as well as per unit area when one allows for the production of polycultures (Carter, 1984; Barrett, 1996; Assuancao & Braido, 2007; Cornia, 1985; Feder, 1985; Oduol & Tsuji, 2005). This is frequently referred to as the “inverse relationship between farm size and output” and is a consequence of the increased reliance on hand labor as these practices are not conducive to mechanization. However, there has been some research arguing that these findings are essentially due to misspecification of econometric models that have omitted land quality as a variable (Lamb, 2003; Benjamin, 1995; Bhalla & Roy, 1988). These findings indicate that in face of declining agricultural resources (i.e. phosphorus; Dery & Anderson, 2007) it should be reconsidered what scale of agriculture is on average the most energy efficient way to produce.

One of the outstanding contemporary issues for modern agriculture concerns the rise of Confined Animal Feeding Operations (hereafter CAFOs) and their profound potential for affecting the environment negatively. Work by a large number of researchers has found both positive and negative aspects of their popularization. One consistent finding is that for the most part the surrounding community disproportionally bears the brunt of the negative consequences in the form of exposure to severe odors and decreased use value of property due to environmental contamination while the individual producer may garner some economic benefits (Bonanno & Constance, 2000). However, farmers participating in this production strategy oftentimes are seen as essentially “serfs” on their own land because of the stringent nature of the contract agreements that are placed upon them along with the demand that they maintain the requisite infrastructure without retaining ownership of the underlying process by which the animals are raised (Thu & Durrenberger, 1998). It should be noted however that there is some heterogeneity in the validity of this characterization; typically though, when CAFO producers are able to exert market force for their own wellbeing through cooperative action they do so at the further expense of the surrounding community by successfully defending their right to produce over the surrounding communities rights to a nuisance free living. (Ashwood, Diamond, & Thu, 2014). As will be discussed in the review of the Goldschmidt literature below, while there is not a consensus on whether or not the rise of CAFO’s has been an economic boon to communities, the evidence strongly indicates that
from a quality of life perspective it has a strong potential to be negative for the surrounding communities (Thu & Durrenberger, 1998).

A further point to consider when weighing the pros and cons of increased scale of agriculture (especially CAFOs) and the intersection of economics and the environment is the potential for environmental calamity. This was seen in the aftermath of Hurricane Floyd (1999) in which a large amount of the Coastal Plain of NC was inundated with floodwaters. In some areas of the state these waters reached to more than 15 feet in height. Eastern NC is home to the state’s hog CAFO industry, with many of these facilities lying in the path of these floodwaters. Due to lax environmental regulations set forth by the North Carolina Department of the Environment and Natural Resources on the processing of the waste from these operations, these floodwaters caused the discharge of millions of gallons of hog waste into the areas rivers, lakes, and estuaries with profound effects on aquatic life (Bales, 2003). Furthermore, GIS analysis has since found that the populations at risk from receiving these manure contaminated floodwaters are disproportionally African American and poor, frequently relying on well water for daily consumption (Wing, Freedman, & Band, 2002). In addition, it has been shown that these contaminated flood waters have the potential to pollute the soil with fecal related diseases, raising the possibility for the poisoning of groundwater these wells draw from (Casteel, Sobsey, & Mueller, 2006). Finally, there was a documented increase in the rise of respiratory and gastrointestinal diseases one month after the storm, consistent with water based fecal pollution (CDC, 2000). While an economic impact analysis of this contaminated flooding has not been conducted independent of general impact analyses, the documented large increase in discharged nitrogen and pesticides into the Pamlico Sound was certainly not beneficial to normal environmental functioning (Bales, 2003) or human health. These types of potentially calamitous economic impacts are not included when calculating the expected economic benefits of supporting different scales of agriculture through I-O analysis and similar econometric methodologies.

Goals of the Local Foods Movement: Farmland Preservation

One of the outstanding issues in many areas, especially those at the intersection of urban and rural living, is the issue of farmland preservation. Over the last 70 years almost half of American farmland has been lost (Census of Agriculture, 2014), normally converted to some other land use as opposed to being allowed to remain idle. In some cases this led to highly erodible land being removed from production (Napier & Napier, 1991), but also commonly good agriculturally land was
converted to either urban/residential land use; these practices contribute to the phenomenon of urban sprawl (Livanis, 2006). This pattern of development is seen as a growing problem by both agricultural advocates and urban planners who are concerned about the increased costs of providing services to those living farther away from urban areas (Carruthers & Gudmnunder, 2003). In some urban areas, this has led to the use of land use restriction easements (sometimes voluntary) that prevent the redevelopment of agricultural land. In some places in North America this has led to a sharp boundary between the edge of an urban area and the beginning of the surrounding countryside (Condon et al, 2010).

It is important to note the intersection between preserving farmland, improving rural livelihoods, and the Local Foods movement. In the United States, the original mission of the Soil Conservation Society was both to address issues of soil erosion as well as limiting urban sprawl (Bunce, 1998). Furthermore, the European Union as well as Norway and Japan have intrinsically tied together their agricultural policies and rural development policies because of the perceived link between them (OECD, 2009). This has led to subsidization schemes that reward smaller growers more per unit of output, preferential buying programs, quotas, and other market intervention strategies meant to improve rural livelihoods. In Norway in particular there is the stated goal of keeping the countryside populated by finding ways for these citizens to make a commensurate income with urban areas. This is done to decrease potential pressures on urban growth that would occur if these individuals were to leave the countryside (Flaten, 2002). In the context of the United States, while federal agricultural policy has typically not taken so direct a hand in improving rural quality of life, the Local Foods movement actively seeks ways to do so as there is a growing awareness of the consequences of losing the heart blood of rural areas (Carr & Kefalas, 2009). By finding ways of generating increased demand for locally produced agricultural goods, the Local Foods movement hopes to simultaneously address issues of farmland preservation and rural quality of life.

Goldschmidt Hypothesis

As described above, proponents of the Local Food Movement have emphasized it’s potential to address a range of societal problems. These include but are not limited to rural unemployment, environmental degradation due to conventional farming and the associated losses of biodiversity (Follett, 2009; Chappell et al, 2011), developing markets which are well suited for medium sized farms (Stevenson et al, 2011), restoring rural communities and decreasing the demand for
increasing amounts of urban sprawl, (Lyson, 2014; Martinez, 2010; Delin, 2006), and improving the cohesiveness, resiliency, and vitality of communities (Kloppenburg Jr et al, 1996; Hultine et al 2007; Lee & Thomas, 2010). While the logic of how LFIs can simultaneously tackle many of these societal problems simultaneously will be discussed at length below, the common thread is that these initiatives bring resources (i.e. money, expertise, labor, etc.) to communities that would not otherwise have them. The logic then goes that by leveraging these resources communities can create the societal and community structures that further attract more resources. Some of these community structures are a politically engaged citizenry, socially intertwined communities, locally owned businesses, a trusted police force, and many others. Many of these community/societal structures that are common across “vibrant” communities (Putnam, 2000) were noticed by Walter Goldschmidt during his seminal work looking at how the manner in which agriculture is conducted in a community can profoundly impact society (Goldschmidt, 1978).

Walter Goldschmidt’s seminal work has become known as the Goldschmidt Hypothesis (Lobao & Meyer, 2001). In the 1950’s Goldschmidt hypothesized that agricultural communities that are dominated by mid-sized family farms over farms of an industrial scale would be socioeconomically healthier and their communities more vibrant (Goldschmidt, 1978; Lobao, 1990). In this work he conducted case studies on two California agricultural communities which were highly similar to one another except for the average scale of agriculture between the two (Goldschmidt, 1978). This work was commissioned by the USDA in order to better understand the impact of agricultural industrialization on family farms; previous work conducted in the 1930’s had raised the issue that inequality had the potential to influence farming communities negatively (Tetreau, 1938). Therefore the USDA wanted to inform their policy decisions for the betterment of the agricultural community. In Goldschmidt’s study, one of the studied communities was dominated by “mid-sized”, family farms while the other was dominated by a form of agriculture much more industrial in nature. Goldschmidt found that in general, the community dominated by family farms was more cohesive, the populace had a better quality of life, and the community overall was healthier/more vibrant. While this work has been highly influential on later researchers, it has been criticized for failing to control for some differences that existed between the two communities. For example, Goldschmidt assigned the fact that the communities differed with regard to the amount of hired labor as a consequence of the scale of farming instead of treating that as a possible predictor of community wellbeing (Hayes & Olmstead, 1984; Gilles & Dalecki, 1988).
Since the public release of Goldschmidt’s work in the late 1970’s, a number of researchers have investigated the robustness of his findings over a range of differing situations. Many of these findings have been extensively summarized in a number of reviews (Lobao, 1990, Lobao & Meyer, 2001; Lobao & Stofferahn, 2008) and so a brief summary of the findings is given here. In general, there has been more evidence found in favor of the Goldschmidt hypothesis than has been found against it or is inconclusive across a wide range of employed methodologies. First I focus on the studies that found consistently negative relationships between the scale of agricultural and community wellbeing.

Using a variety of linear programming/linear regression analysis at the county level, a number of researchers have found that larger amounts of industrial farming (including CAFO agriculture) are associated with poorer quality of public services (Fujimoto, 1977), increased amounts of energy usage (Buttel, Lancelle & Lee, 1988), increased reliance on public support and decreases in income (Durrenberger & Thu, 1996, Crowley & Roscigno, 2004; Lyson & Welsh, 2005), declines in physical and mental health of citizens (Lyson et al, 2001), declines in the amounts of agricultural inputs purchased locally (Chism & Levins, 1994; Foltz et al, 2002), increases in the amount of children at risk for a variety of socioeconomic problems (Peters, 2002), increases in issues of environmental injustice (Wilson et al, 2002), decreases in the growth rate of per capita income (Deller, 2003), and overall declines in general community wellbeing (MacCannell 1998, Lyson, 2001). Employing case study type analysis, researchers have found detrimental connections between increased scale of agriculture (including CAFOs) and community inequality (Goldschmidt, 1978), mental wellbeing (Schiffman, 1998), and overall declines in general community wellbeing (Small Farm Viability Project, 1977; DeLind, 1998; Constance and Tunistra, 2005, McMillan & Schulman, 2005; Donham et al, 2007). Employing survey based research, researchers have found detrimental connections between increased scale of agriculture (including CAFOs) and farmer and agricultural worker involvement with the surrounding community (Martinson et al, 1976; Smithers et al, 2004; Jackson-Smith & Gillespie, 2005), declines in citizen health (Wing & Wolf, 2000), and overall declines in general community wellbeing (Rodefeld, 1974).

Grouping together all three types of study methodologies, there have been several works that found positive effects of the scale of agriculture on various measures of community well-being. These works found a beneficial relationship between the scale of agriculture (including CAFO’s) and the amount of energy used in agriculture (Heaton & Brown, 1982), increases in income (van Es et al, 1988; Barnes & Blevins, 1992), the amounts of agricultural inputs purchased locally (Foltz & Zueli,
2005), and a lack of evidence for overall changes for the worse in the general community wellbeing (Green, 1985; Buttel et al, 1988; Lobao & Schulman, 1991, Irwin et al, 1999). Frequently, these studies differed from earlier studies that looked at similar issues by controlling for additional variables that were found to be endogenous. In the case of Barnes & Blevins (1992) it has been questioned as to whether their methodology appropriately incorporated those shown to be previously ignored endogenous variables (Lobao, Schulman, & Swanson, 1993).

More common than research finding no support for the Goldschmidt hypothesis are works that found mixed support depending on circumstance. Oftentimes these papers would find certain measures of quality of life or standard of living would be higher in agricultural communities dominated by family farms at the expense of other metrics; without a unified framework to put these difference on a commensurate scale it is difficult to know whether holistically were net goods/bads for society. Oftentimes the results of these studies indicated a tradeoff between declines in community income but decreases in overall food costs (Heady & Sonka, 1974), increases in net income or property value but also increases in income inequality alongside the negative societal changes that typically accompany such shifts (Marousek, 1979; Skees & Swanson, 1988; Lobao, 1990), less non-agricultural economic transactions and negative population growth with no effect on income (Flora & Flora, 1988), tradeoffs between the effects of more hired labor and larger agricultural scale holding the other constant (Gilles & Dalecki, 1988), tradeoffs between economic benefits to local communities and the state economy (Henry et al, 1987), benefits to producers at the expense of communities (Ashwood, Diamond, & Thu, 2014), and differential effects on producers at different stages of their careers (Wright et al, 2001). Other results have shown that the effects of scale are mediated by other controlled but interconnected factors such as the strength of civic institutions and the vitality of the middle class (Lyson, Torres, & Welsh, 2001).

It has remained an open question for the past several decades as to whether communities dominated by small or large farming operations are more sustainable with regards to long-term viability (Goldschmidt, 1978). A major reason why this question has yet to be resolved in any type of satisfactory way is that the majority of relevant research has focused on the short-term implications of planning decisions while paying little attention to the longer-term effects. Because current trends suggest increased Local Foods may occur alongside enhanced environmental stewardship and the potential alleviation of certain societal issues (rising health care costs, high unemployment, etc.), all of which provide benefits to communities that are not included (or count against) traditional
measures of growth, further research on the implications of the Goldschmidt hypothesis remain as relevant today as when it was first introduced almost 50 years ago.

**Why Isn’t Local Foods the Dominant Form of Agriculture?**

The Local Foods movement has grown in popularity with both consumers and producers over the past decade and has been heralded as a powerful way to improve the economic viability of producers (and those subsequent in the supply chain), grow local economies to create jobs, promote farmland and environmental preservation/stewardship, address food-related chronic diseases like obesity and diabetes, and enhance food security (Curtis et al, 2010). At no time in recent history have so many different concerns motivated such a broad consumer base in support of agriculture; this is an important moment that could drive a broad shift towards sustainable agriculture systems if properly harnessed. Despite this interest, there exist many structural reasons why Local Foods is not the dominant mode of agricultural production from which people’s daily food is derived.

It is widely acknowledged both in and out of the agricultural community that there are a wide variety of reasons why it is advantageous to sell goods near the site they are produced (ability to grow better tasting varieties that do not store as well, decreased loss due to spoilage, decreased transportation costs, decreased storage costs, geographic constraints on the spread of food-borne diseases, etc.). Despite these obvious benefits there exists a great many structural constraints that prohibit many farmers from engaging in local sales. An extensive literature looking at what size of farms participate in locally oriented food systems versus those that cross regional lines consistently shows that a higher percentage of smaller farms are engaged in local sales compared to larger operations (Low & Vogel, 2011). As was described by one farmer that helped design this project, only certain sizes of farms can profitably engage in local sales (most commonly through direct marketing channels such as farmer’s markets and Community Supported Agricultural programs) because of the limited volume of goods that can move through such markets. This fact alone currently precludes many farmers who would otherwise be interested in selling to LFIs from doing so because they do not feel they will be able to generate sufficient revenue from such a business model given the size of their operation and their method of cultivation. However, if sufficient demand for Local Foods could be fostered broadly in the community, it may be possible for farms of greater size to participate in Local Foods production profitably.
Working in the opposite direction, other structural issues keeping LFIs from becoming larger volume players of the United States food supply are economic biases/disadvantages that exist against them. This can be seen in the systematic ways that agricultural subsidy programs such as “Crop Insurance” are administered; these programs are inherently biased towards operations that limit diversity both within a growing season because simultaneously only certain crops are covered and that often times insuring numerous crops require separate policies and across seasons because expected yields are based on historical averages for the same plot (ProAg, 2015). Furthermore, large volume purchasers have become accustomed to working with very large growers where single operations are able to supply large amounts of the desired good. These purchasers are reluctant to now embrace a large number of small sales partners because of the logistical complications that will ensue. It should be noted that more and more agricultural aggregator businesses (sometimes known as food hubs) are being started in order to facilitate small producers being able to sell collectively en masse to large volume purchasers; while these aggregator businesses face the same higher transaction costs from working with a larger number of smaller growers as other large volume purchasers, they are willing to bear these costs in order to bring a differentiated good to market. Finally, it should be noted that LFIs are rarely able to receive public support at the same rate that other more technologically oriented or centralized businesses are able to. For NC, this pattern of funding can be seen most clearly at the state level where many tax incentive programs have been used over the past decade to attract almost exclusively non LFI businesses. This is despite the fact that agriculture is still directly or indirectly responsible for 17% of the overall NC economy (NCDA, 2014). In times when agricultural ventures have received public subsidization at the state level, typically it was very large commercialized operations that were funded while smaller agricultural operations are not eligible for consideration (ThriveNC, 2015). Part of this bias may be due to the fact that it is far more methodologically unambiguous to predict the monetary impact of businesses on communities than the other ways they may impact quality of life, a la the Goldschmidt Hypothesis.

Local Foods Nationally

A number of well-known national organizations have begun to champion the cause of Local Foods over the past decade. In some cases this support may be idealistic and done so to further the movement while others may do so to capitalize on novel market opportunities created by increased consumer interest in locally produced foods. Many of these organizations are either part of or are
directly tied to the Federal Government. The largest single example of this is the United States Department of Agriculture. The USDA begun championing Local Foods approximately a decade ago (Martinez, 2010) and has done so for a variety of reasons. Reports published by the Economic Research Service (hereafter ERS) of the USDA have implicated LFIs with all of the potential benefits stated above including but not limited to rural development and entrepreneurship (Bagi & Reeder, 2012), improved environmental stewardship (Osteen et al, 2012), a means to provide markets to mid-sized farms (Low et al, 1995), and others. In addition to this Federal organization, on a base by base basis the US Military has begun to support Local Foods as a way to improve the health of those in and around the bases (Clayton, 2014). Because of the fact that many military installations are located in rural communities as well as that soldiers disproportionately hail from such places (Florida, 2010), the military has a vested interest in keeping these communities and their members healthy. Along these same lines the Military has also recently come out in support of preschool education (Mission Readiness, 2015) and combating childhood obesity (Mission Readiness, 2010); the Military sees the costs associated with contributing to such programs now as an investment in the health and wellbeing of the future fighting force. Finally, a number of impactful national organizations have come out in strong support for Local Foods. Some, like the American Farmland Trust do so for obvious reasons. Others, such as the Union of Concerned Scientists, do so for a number of subtler reasons that relate to many of the arguments stated above with regard to entrepreneurship and rural development (O’Hara, 2011).

Local Foods in NC

While a great deal of progress has been made on the national stage with regards to the creation of, support for, and interest in LFIs nationwide, North Carolina has been at the forefront of this movement. Blessed by a wide range of agroclimactic conditions and a typically mild winter, NC farmers are able to produce a wide range of goods demanded by consumers over much of the year. Furthermore, a citizenry that has consistently demonstrated an eagerness to support LFIs has led to an ever growing market share for Local Foods (Agricultural Census, 2014; Curtis, Creamer, & Thraves, 2010). This support for LFIs across the state has come about both through grassroots efforts and spearheaded by a number of organizations including the Carolina Farm Stewardship Association, the Rural Advancement Federation International, as well as the Appalachian Sustainable Agriculture Project. In addition, the movement has received public support and guidance through the activities of the Center for Environmental Farming Systems (hereafter CEFS), a collaboration
between the North Carolina Department of Agriculture, North Carolina State University, and North Carolina Agricultural and Technical University.

In 2008, CEFS launched the statewide initiative “Building a Local Food Economy in North Carolina, from Farm to Fork”. Using the expertise garnered from two decades of studying various production systems, CEFS launched the initiative to find ways to bolster the entire food system. The initiatives developed a comprehensive, action-oriented statewide guide to support LFIs (Curtis, Creamer & Thraves, 2010), a commitment from the NC Cooperative Extension to designate a Local Food Coordinator in every county, supporting a “10% Campaign”, where a collection of individuals, businesses, institutions, and agencies commit to spending 10% of their food dollar on Local Foods (nc10percent.com), and lobbying for legislation that established a North Carolina Sustainable Local Food Advisory Council. Furthermore, CEFS has also created the organization, NC CHOICES, to facilitate and support the niche meats industry.

One of the primary reasons that the Local Foods movement has gained such a foothold in North Carolina is that much of the agricultural landscape is still dominated by small scale producers and, furthermore, that much of the farming population (whether rural or urban) still has a connection to place and are interested in finding ways to foster rural livelihoods and development. Historically, the production of tobacco allowed small scale producers to consistently earn a livelihood. The fact that small scale producers could earn sufficient revenues from their tobacco production most likely prevented the same drive towards consolidation that was occurring around the country during the same time. However, as tobacco production waned and the government support system was phased out, many of these former tobacco producers have had to adapt (NC Geographer, 2002). In some areas of the state (Coastal Plain), this has led to large scale consolidation of farms as people have moved to other row crops (see Figure 2.12). In the words of tobacco researcher Blake Brown,

“Consolidation of growers, though, will be accelerated, so we will see fewer growers growing more tobacco. I do not think they will be huge growers. Rather, they will be middle-sized growers, probably 100 to 200 acre growers. This is the likely size range of a stable unit that will work well for companies to maintain the kind of quality they want. We will see increased specialization of tobacco farmers. We will not see the diversification on

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2 In the figure the green lines correspond to highways/interstates. The green circles indicate CAFO operations that have been granted a permit to spread solid waste as fertilizer in agricultural fields. This practice is not commonly done in the Mountains.
farms that we see now. The reason for this is that tobacco is a very management-intensive crop, and some farmers will specialize in tobacco production because that will be the most profitable thing for them to do. They will drop the other commodities that they grow currently because they have not been allowed to grow as much tobacco as they would like... We are going to see a lot of structural change, which I think is an outcome that surprises most folks.” (Blake Brown, NC Geographer 2002)

Mr. Brown’s predictions were largely accurate. Tobacco producers in the East are nowadays somewhat diversified (oftentimes growers will farm sweet potatoes and potentially a grain crop in addition to tobacco for example) but nothing like the diversification seen on historical small acreage holdings.

In other areas of the state (the Mountains and the Piedmont) the topography precludes the use of large scale machinery and thus acts as an impediment to farm consolidation. However, at the same time there is ever growing demand for development of agricultural land for residential, business, and infrastructure development leading to former tobacco growers who do not have sufficient acreage to produce lesser valued crops profitably having to decide between either developing their land or finding alternative crops to produce. Many of these growers are now attempting to break into the Local Foods market with its demand for high quality, valuable horticultural goods as a way to replace the profits that had formerly come from tobacco production. As these farms are typically of the size that the USDA would call “medium sized producers,” this trend of trying to become involved with LFIs is one way in which mid-scale producers are trying to increase their market share relative to very small and very large farms.

What is Needed to Move Local Foods Forward?

Given the involvement of Federal government and relevant organizations in fostering the Local Foods movement an outstanding question is how much financial support makes economic sense for the state to provide for its continuation, or how much support should be provided to encourage entrepreneurial efforts in this area. When one considers the short-term benefits of increased Local Foods the discussion is limited to the potential for increased farmgate revenue due to higher percentage of profits being retained as well as increased circulation of funds through the local economy increasing the available money supply (Schuman, 2003). However, when one expands their timeframe of interest to include long-term effects, a whole range of considerations that directly affect the long-term viability and sustainability of farming come under scrutiny. Will
increased amounts of Local Foods act indirectly to promote environmental stewardship? Will increasing amounts of Local Foods decrease the rate of farmland loss in areas in which the food is produced? Will increased amounts of Local Foods encourage healthier eating habits with commensurate improvements in citizen health and wellbeing? Will increased amounts of Local Foods serve to improve food security in disadvantaged areas? Will increased amounts of Local Foods lower the barriers to entry for new farmer’s looking to get started in farming? Could this process occur nearby urban areas and thus help to reduce the rate of encroachment of urban areas on the countryside? All of these considerations should play a direct role in determining the long-term worth of current planning decisions yet they commonly are not considered.

Arguably the single greatest impediment to Local Foods becoming a more frequent part of the average consumer’s diet is that it is viewed as more expensive (Pirog & McCann, 2009). This is even more of an issue than consumer demand for out of season produce as that demand can at least partially be satisfied by local production employing growing season extending technologies such as hoophouses and greenhouses. Some work has shown that Local Foods are not more expensive when one only considers in-season produce and certain other goods; on average however Local Foods is typically viewed as being more expensive than its alternatives (Renkow & Georgiad, 2011). This image problem is exacerbated by the fact that there has never been an extensive accounting of its long-term costs and benefits to the consumer, even when focuses solely on the economic domain. The reason this is a problem is that if consumers had a quantified framework with which they could understand how their Local Foods purchases affected themselves and their communities, they would better be able to more effectively and holistically compare Local Food products with alternatives. In order to address this problem of no quantified framework existing for understanding the economic benefits of Local Foods, the present study was undertaken.

Before moving forward, it is important to note that the work presented below focuses exclusively on better understanding the economic impact of Local Foods. This is in contrast to many of its touted benefits which are either not easily or consistently valued using economic methodologies. What is the value of cleaner rivers downstream from a stretch of farmland? What is the value of beautiful landscape? What is the value of an environment not polluted with the scent of industrial livestock operations? While there exists a number of economic methodologies to elicit the implied “value” of the answers to these questions such as Willingness to Pay / Willingness to Accept, Contingent Property Valuation, and others, additional research has shown that these methodologies fail to elicit consistent valuations across time when one focuses on highly abstract
Because of this well-known methodological limitation on finding a common metric to equally value these different traits, while they are fundamentally important to the research question at hand, they will be set aside for later work. This paper instead focuses on better characterizing the aggregate economic impact of Local Foods relative to its alternatives. By focusing solely on the economic impacts, we can focus discussions on the relative merits of Local Foods and its alternatives instead of discussing how those merits should be measured.

While the growth of Local Foods has been repeatedly implicated in being causally associated with positive economic changes to society, little work has succeeded in quantifying the potential impact. In other economic domains/industries such quantifications are typically done using the IMPLAN database (IMPLAN Group, 2014). IMPLAN (IMpact analysis for PLANning) is an economic database and software package produced by a company called MIG, Inc. This database contains the information used to conduct I-O analysis (described further in the Methods section) for regions down to the county level. IMPLAN is composed of industry specific economic data and regionally appropriate Social Accounting Matrices (hereafter SAM) information to derive both the expected direct and indirect effects of changes to the economy. The SAM information allows for the IMPLAN database to parcel out the anticipated effect of some economic change out to the level of the individual household. The information in IMPLAN is derived primarily through publically available federal information (such as the Agricultural Census), some field collection, and econometric interpolation. Because of the fact that much of this information is interpolated, there is much reason to believe that while it models well the forms of an industry that are most common (such as corn, soybean, tobacco, and cotton production in NC) it represents the less common forms, such as Local Foods, less well. In fact, IMPLAN recognizes this fault with their agriculture data and instead encourages users to substitute their own data whenever possible. “Since the agriculture data are, to a large extent, derived, analysts with local agriculture data are encouraged to use it when building their IMPLAN models” (IMPLAN, 2015). Because of this recognized shortcoming and the desire to be able to accurately measure the economic impact of Local Foods sales in NC, the present study was undertaken. Primary economic, demographic, and agricultural data were collected from across NC to be used in the adjustment of the IMPLAN model. In addition, the default IMPLAN data for NC was studied and adjusted to be made consistent with the findings of the most recent USDA Agricultural Census. Because of the much greater sampling coverage and density of the Agricultural Census, its estimates have greater reliability than those from the IMPLAN database. By undertaking both of these analysis methodologies in parallel it is possible to derive an understanding of the most cost
effective approach to facilitating such an analysis for other states/communities that are interested in replicating these efforts.

METHODS

This project employed a number of techniques and methodologies to collect and analyze both primary mail based survey data as well as secondary data derived from both IMPLAN and the Agricultural Census. As these phases of the data collection/analysis were largely independent of one another, they will be described separately.

Primary Data – Mail Survey Based Data Collection

One of the outstanding issues with regards to available data sets to be used in conducting regional economic impact analysis, whether it be for agriculture or other industries, is whether the data accurately reflect the nuances of the region it is mean to represent. Because much of the data in such data sets is derived and interpolated, it is possible that not all parts of the economy are equally well represented. This problem may be especially true for agriculture because of the fact that much of the data used in the interpolation is not reported below the state level (prices, wages, etc). In order to determine whether these datasets accurately reflect the current state of North Carolina agriculture, including those producing in Local Foods production, the following survey was conducted. This survey aimed to collect sufficient information to evaluate the accuracy of the IMPLAN database with regards to NC agriculture; the collected information consisted of agronomic, economic, and demographic data relevant to evaluating the accuracy of the IMPLAN database. Please see Appendix 2 for a copy of the survey instrument. Please note that the actual survey was formatted such that it was printed on landscape paper folded in half along its long axis creating a survey booklet.

Sampling Frame

In order to conduct a representative survey of farmers across the state given the resources available to the project, a stratified sampling approach was used. The state of North Carolina can be divided into three primary geographic regions (Mountains, Piedmont, and Coastal Plain) which differ in terms of their relevant agronomic characteristics. These characteristics include but are not limited to topography, soil type, climate, demographic patterns including population density, and other factors relevant for farming. There are established boundaries as to which counties fall into
each of the three geographic regions. Concurrently, all counties in North Carolina are assigned an economic tier status by the NC Department of Commerce which is updated on an annual basis. The tier designations used for this study are consistent with the 2013 rankings (NC Department of Commerce, 2013). This rating system currently has 3 tiers and is meant to represent the long term outlook for economic growth at the county level. Because of the fact that there is evidence to suggest that the success of the Local Foods movement in a given area may differ across both geographic region (i.e. in areas with higher population density or greater amounts of horticultural production) and economic tier status (i.e. in areas with greater disposable incomes per capita) it was decided to stratify the survey's sampling based on the interaction of Geographic Region and Economic Tier Status. A single county was chosen at random from each combination of traits so that 9 counties were selected in total. The selected counties are: Burke (I - Mountain), Transylvania (II - Mountains), Henderson (III – Mountains), Anson (I - Piedmont), Rowan (II – Piedmont), Chatham (III – Piedmont), Robeson (I – Coastal Plain), Wayne (II – Coastal Plain), Carteret (III – Coastal Plain).

While these counties were in no way selected based upon their relative agronomic output, they represent a diverse sampling of counties from across the state. The random selection of these counties allows the results of the survey to be generalized to the state as a whole for the purpose of subsequent analysis.

The sampling frame for each county was defined using contact lists maintained by the North Carolina Cooperative Extension Service, relevant non-profit organizations, and the participation lists of the Present Use Value Taxation Deferment Program. Under this program, North Carolina landowners may have a portion of their property taxes deferred for 3 years at which time the value is forgiven if the land is used in some type of agricultural/horticultural/forestland production program and several other minimum requirements are met. The Present Use Value program is administered at the county level and its records are in the public domain. While approximately 10% of each county's sampling frame was surveyed, the number of farmers that it represents within each county varies tremendously; Carteret County had the minimum sample size of 20 growers while Chatham County has the maximum sample size of 100). All data was cleaned to remove any duplicate landowners. We also eliminated any landowner who lived outside of the county being surveyed as we were interested in receiving data from those directly engaged with farming. With our selection methodology farmers of all acreages were equally likely to be selected. This was done primarily by screening the mailing address of individuals listed throughout the used databases. In certain counties extensive follow-up surveying has been required due to a high percentage of the
farmland being held by non-farmers or outside organizations. Subjects who returned their questionnaires were entered into a drawing with the recipient selecting a civic organization of their choosing to receive a $250 donation

**Survey Implementation**

The implementation of this survey data collection can be divided into two phases that differ with regards to the initial way we contacted potential participants. In both phases our methodology was based upon the Tailored Design Method (Dillman, 2009) although certain modifications were made in the 1st phase to facilitate unique aspects of this project. The Dillman method is rooted in social exchange theory, namely that people inherently feel a need to reciprocate a social act, even an unsolicited one. In order to encourage potential participants to respond to a mail based survey, the Dillman Method encourages a contact procedure that evokes the feeling of a social give-and-take with the hope that the participant will become more likely to respond, or reciprocate, to the survey. Both phases began with a short preletter being sent to potential participants (see sample letter in Appendix 1; please note that these letters had to be reformatted from their original form in order to be printed in this document. All contact information and signatures have also been removed from the presented versions). Also included in the contact passage was a “small token of thanks,” a “Support Local Foods” refrigerator magnet, as suggested in the Tailored Design Method. In the first phase of the survey, project personnel then attempted to meet with survey participants and deliver the survey materials directly. All available contact information was used including home address, mailing address, phone number, and email address. A second contact attempt would be made if the 1st had been unsuccessful. Project personnel used this meeting time to answer any questions participants had about the survey and to assure them of the confidentiality of the information. If project personnel were unable to meet with potential participants, the survey and cover letter were mailed to the listed mailing address.

In the 2nd phase of the study we adapted our methodology to be consistent with the standard Tailored Design Method. We changed our survey approach because of the slow speed at which we were able to meet with project participants due primarily to travel distance and in many cases not having a phone number or email address with which to arrange a meeting time. In contrast to before, the contact procedure for this project had 4 parts and closely followed the findings of the Dillman method (Tailored Design Method, TDM); we used the first contact opportunity to determine whether the participant self-identified as a farmer or identified another
individual as whom they rented their farmland to. Only those participants identified as farmers were contacted a second time. Consequently, we asked for relevant demographic information (age, sex, level of education, etc.) during our first contact opportunity in order to ensure the representativeness of our sample. We followed the same follow up contact procedure for non-respondents as described below. Different versions of this document were sent to participants depending on whether they were identified as part of the sampling frame through the Present Use Value Program or the contact lists of the project’s partnering organizations. An easily redeemable gift card of a small value ($5) was included in this mailing (VISA Gift Card; this is consistent with the findings of TDM).

The second contact opportunity was used to survey the participant for relevant economic information. Only participants who had previously been identified as farmers were surveyed in this step. In order to incentivize participation at this level of the survey, the survey package included an easily redeemable $50 gift card. The value of this card was consistent with the amount of time it required participants to fill out the survey in its entirety (~30 min; up to 2 hrs. has been reported). Participants who had not submitted a response were contacted with a follow up postcard 1 week after the original survey was submitted.

Parts 3 & 4 of the contact procedure were meant to deal with non-response errors. In parts 3 and 4 participants received a replacement questionnaire and cover letter, approximately 4 weeks and 7 weeks after the original mailings, respectively. The mailings in part 4 were individually printed and all addresses were handwritten, consistent with the Tailored Design Method. The wording in each mailing was made slightly different to increase their novelty, consistent with the Tailored Design Method. No additional gift cards were included at this stage of the contact procedure.

As stated above, because of the fact that our intended survey population and our sampling frame did not completely overlap, we broke the survey into two phases. The 1st phase identified individuals as either farmers or non-farmer farmland owners. This was done through both in person interviews and brief mail based questionnaires. The 2nd phase of the survey was only sent to farmers and was composed of the survey booklet shown in Appendix 2. For the surveying of Anson, Rowan, Carteret, Wayne, and Robeson counties phases 1 and 2 were combined and all materials were delivered to participants in person whenever possible. Only if repeated contact attempts were unsuccessful was the survey sent through the USPS. Our overall response rate for this phase of the sampling procedure was 52%.
For the surveying of Chatham, Burke, Henderson and Transylvania counties the survey was conducted entirely through the US postal service. During this phase of the surveying we broke the survey into two portions. The 1st portion asked if the individual was farming or owned the farmland. The 2nd portion, which was sent only to those that are actively farming, was the economic survey. Our response rate to the 1st portion was 45%. Our response rate to the 2nd portion was 29%. Our overall response rate across both methodologies was 44%. In total 99 surveys were received that were from the intended sampling frame. Some surveys contained missing data. Of the received surveys the Piedmont was overly represented and the Mountains underrepresented.

Quantitative Analysis of Survey Data

The collected survey data was analyzed quantitatively. The quantitative approach was taken in order to try and deduce statistical relationships between different traits of farms in North Carolina. We did this in order to produce a testable set of hypotheses with which to subject the IMPLAN database to test its veracity. For example, if the collected data were to indicate that over 80% of farm income in the Piedmont Region of NC came from cattle or dairy production, the IMPLAN database should also represent that fact within the statistical margin of error for the survey. In order to determine if an “identified pattern” in the survey data is meaningful, logistic regression techniques were used to evaluate whether certain patterns are statistically significant. Logistic regression is used when the dependent variable is categorical; for the present analysis we are interested if covariates significantly predict whether farms sell locally, what marketing channels they use, whether they practice Organic production techniques, and what commodities they produce. Ultimately the number of respondents to the survey limited the success of this analysis strategy and no significant findings were made using this technique.

In addition, the data was analyzed for the purpose of identifying both the commonalities and differences that exist across agriculture in North Carolina. This was done in order to make use of data that did not have sufficient sample size to be effectively used for the validation of the IMPLAN database but still strongly suggested certain patterns of agriculture structuring that should be further explored. As described earlier, the sampling frame for the survey used in this project was stratified along both geographic region and economic tier status of the counties. We hoped that sufficient sampling coverage would be had in each of the chosen counties to conduct analysis for each one separately. For much of the surveyed counties however, sufficient data was not collected to facilitate this level of analysis. Therefore the data was analyzed at higher levels of aggregation,
namely the geographic region. The major research hypothesis that was investigated was whether there was a difference in the relative degree to which farms that sell Local Foods purchase their own inputs preferentially from a larger number of businesses than those that do not sell locally; the number of businesses a farm buys from was used as a proxy for their “multiplier” in this analysis. We used comparisons against the Agricultural Census with regards to production categories, scale of operations, and operator demographics to determine whether our collected sample was representative of the population.

Analysis of IMPLAN and other Secondary Data

In addition to the analysis of the primary data collected by this project, relevant secondary data was also studied. This data came from both the IMPLAN database (MIG Inc.) as well as county-level data from the Agricultural Census. This analysis was implemented to evaluate the baseline I-O predictions of the IMPLAN database, to determine how those valuations change when the IMPLAN database is reconciled with the Agricultural Census, and then informed by the results of the survey as well.

The I-O analysis presented in this document primarily used the IMPLAN database. The goal of the analysis was to evaluate the economic value of direct to consumer sales of fruits and vegetables (specifically the vegetable/melon, fruits/nuts, and the ornamental horticulture/nursery sectors). We did this for an individual county that has a strong horticultural industry (Rowan), for a subset of counties that had previously been chosen through a stratified sample to be representative of North Carolina as a whole, and for the whole state. These counties used in the subset were Anson, Burke, Carteret, Chatham, Henderson, Robeson, Rowan, Transylvania, and Wayne; these correspond to the counties used surveyed in the primary data collection phase of this project. The horticultural sectors of the studied geographies are comprised of many of the types of products that are featured in the emerging Local Foods movement; expansion of production of these Local Foods products onto farmland currently producing other agricultural goods could lead to net regional employment and income gains.

The 2012 Census of Agriculture provides a fortuitous benchmark for measuring how well IMPLAN represents the value of both direct sales activity as well as the value of fruit and vegetable production for regional economies in NC. Because of how the agricultural sectors are grouped within IMPLAN, we included in our analysis all horticultural and nursery crop production. Given that the Local Foods movement is trying to reconnect consumers with producers of wholesome food
products, the value of Direct Sales is an appropriate measure of the effective size of the movement and can be viewed as a proxy for “Local Food” sales in the analysis. Direct sales comprise all sales made directly to consumers regardless of venue; examples of direct sales include but are not limited to sales at farmers markets, roadside stands, CSAs, direct to restaurant, etc). The greatest increases in direct sales in recent years nationally has been in the area of fruits and vegetable in local markets (correspondence with national advocates for Local Foods). Local Foods advocates argue that the economic justification for public support going to these type of agriculture is that by substituting locally produced farm products for goods supplied from outside of the community/region, the region boosts farm productivity, farming intensity, and enhances the linkages between agriculture and supporting industries causing the associated economic multiplier within the regional economy to increase. Thus, if Local Foods demands increase, there may be measurable positive economic impacts.

I-O models are used to produce estimates of the value of different industries to a region’s economy. Different types of agricultural production are considered different industries as it pertains to I-O models. I-O models are detailed accountings of all estimated inter-industrial transactions; they tell us how much is bought and how much is sold amongst all industries in a region. By modeling how different industries interdepend on the products other industries supply, we can try to predict how the whole economy would react to some kind of change. What would be the economic impact of demand for fruit and vegetables increasing 10%? What would be the economic impact of a new slaughter-facility if local producers of livestock had the animals processed/sold locally instead of sold to stockyards? The limitation of these models is that they assume all of the relationships in the economy stay the same over time, therefor they are of limited use in modeling changes over longer periods of time (Leontief, 1987). These models are populated with data that is highly localized; in the case of IMPLAN it is disaggregated through econometric methodologies down to the zip code level. Databases such as IMPLAN rely on benchmarked industrial survey data that is statistically more reliable at the state and national levels, thus the accuracy of these zip-code level interpolations is not always ideal. The agricultural components of I-O models is typically informed by annual survey data from the USDA, which are then benchmarked quinquennially by the Census of Agriculture.

Despite the efforts made to achieve accurate results with the disaggregation techniques used within IMPLAN, I-O models “out-of-the-box,” might not adequately portray regional agricultural activity. Therefore, when conducting I-O analyses, it is important to check the
interpolated data to make sure it adequately reflects the region of scrutiny. In the case of agriculture, the county level data contained in the Census of Agriculture can be used to fine-tune these databases to properly reflect production across different agricultural sectors. Accordingly, whenever necessary the I-O models used in the subsequent analyses have been adjusted to reflect basic regional production characteristics as of the 2012 Census of Agriculture.

I-O models produce an array of information for analysts. For our purposes there are four types of data and four levels of data comprising a typical I-O results table. The types of data are:

- Output: This is the value of agricultural/industrial productivity over the course of a year. It represents the worth of what was produced whether it was sold or not.
- Labor income: These are wage and salary payments to workers, including employer-provided benefits. Management payments to proprietors are also counted as labor income payments.
- Value added: Value added includes all labor income (mentioned above) plus payments to investors (dividends, interests, and rents), and indirect tax payments to governments. Value added is the equivalent of Gross Domestic Product (GDP) which is used to measure the magnitude of economy economic activity across counties, states, and the nation.
- Jobs: I-O models measure the annualized job value in different industries. Many industries have mostly full-time jobs, but many others have part-time and seasonal jobs. I-O models do not convert jobs into full-time equivalencies. As many people have more than one job, there are always more jobs in an economy than there are employed persons.

The levels of data are

- Direct values. This is the value of direct output from an industry.
- Indirect values. All direct firms require intermediate inputs into production. They must buy supplies, utilities, other agricultural or manufactured inputs, transportation, and services, just to name a few. The indirect and induced values comprise what is typically known as the “Multiplier Effect” in such analyses. They are frequently known as Type II multipliers.
- Induced values. When the workers in the direct industry (the farms) and those in the indirect industry (the supplying sectors) convert their labor incomes into household spending they induce a third round of economic activity. Induced values are sometimes called the household values. They are frequently known as Type III multipliers.
• Total values. The sum of direct, indirect, and induced activity constitutes the total economic effect that is being measured. In short it gives us the economic sums of the studied industry, its suppliers, and affected households.

RESULTS
Survey

Overall the data appears to be representative of the intended survey population (i.e. farmers in North Carolina). Using the 2012 Agricultural Census as a benchmark, our respondents were of older age (mean age of survey respondent is 63 years, Agricultural Census mean age is 57 years; t(38) = 3.686, p < .01), the expected racial composition (95% of survey respondents are white, 96% of NC farmers are white; $\chi(1, N = 42) = 0, p = 1$), and the expected gender (78% of survey respondents are male, 87% of NC farmers are male; $\chi(1, N = 42) = 0.194, p = .66$). Looking now at the agriculture diversity of the respondents, the mean and median acreage for the three geographic regions are 107/70 (Mountains), 262/110 (Piedmont), 375/180 (Coastal Plain). The mean and median acreage for the same geographic regions reported in the 2012 Agricultural Census as 91/65 (Mountains; t(7) = 0.3863, p =0.7107), 120/95 (Piedmont; t(16) = .1241, p = 0.9), and 437/356 (Coastal Plain; t(7) = -0.4038, p = .6984). Finally, we focus now on the county which had the highest absolute number of responses, Rowan County. In Rowan County the distribution of farms sizes which we received data from matches the distributions predicted from the Agricultural Census with regards to both farm size and gross revenue. We did not have an adequate number of responses in each country individually for this analysis to be meaningful for other counties.

In general the responses of the survey indicated that farming takes a wide range of forms across the state. Certain expected patterns can be seen in the data, the acreage of respondents is smallest in the Mountains and largest in the Coastal Plain. Operations in the Coastal Plain report being of both the largest acreage as well as having the greatest potential for large profit. The distribution of respondents’ acreage in the Coastal Plain is skewed to the right indicating a lack of midsize farms and higher than expected number of large farms. However the same relative percentage of very small farms persists there as elsewhere. The survey responses indicate that while farmer households can be of any income level, the majority of the time this income is primarily derived from off-farm sources. This conclusion was made by comparing the farm’s reported profit with reported household income. Overall, regardless of how one looks at the
collected survey data, our survey participants appears to have been drawn from the intended survey population randomly and without bias for certain types of agricultural operations.

Despite the success of the sampling methodology in achieving a representative sample of farmers across North Carolina, the overall number of respondents makes it difficult to use this data for the intended purpose of validating and amending the IMPLAN database. This precludes us from using the data to directly amend the IMPLAN database using the collected data. Despite not being able to use this data for the purpose of amending IMPLAN and evaluating its veracity by comparing it against real world data, we must instead focus on using the data to find either any structural differences that exist within NC agriculture along either geographic and socio-economic lines as well as to test any hypotheses that relate to the economic potential of the Local Foods movement by comparing between different subsets of the collected data.

One outstanding question in the ongoing debate about the potential benefits of Local Foods (these include economic, social, and environmental benefits) concerns whether farms that engage in Direct to Consumer Sales are associated with a higher economic multiplier than those that do not. Because this multiplier represents the number of other businesses a company is attached to, one would expect businesses that have dealings with many companies to be associated with a higher multiplier than businesses that deal with only a handful holding other variables constant (such as total revenue, number of employees, location, etc). Furthermore, as businesses do more and more business with fewer and fewer entities that are able to provide a wide range of services, these businesses become more likely to be based in other communities (i.e. “non-local”; buying hardware supplies at a relevant big box store whose headquarters are based elsewhere as opposed to purchasing it from the local hardware store) thus providing a second way in which the total value of the money in the economy is failing to be maximized. One of the interesting pieces of data that was collected in the current survey was a list of all the individuals/businesses/entities a given farm bought from or sold to in the past year. Analyzing this data found that for the state of North Carolina, farms that engage in Direct to Consumer Sales bought from statistically more entities (mean/median = 8.9167 / 7) than those that did not (mean/median = 5.1923 / 3; t(36) = 1.9263, p = .0620); a stronger effect was observed when limiting the analysis to farms that do below $256,000 in revenue per year (t(33) = 2.1803, p = .0365). This was also true for the Piedmont region specifically (D2C farms mean/median = 9.1250 / 7, Not D2C farms mean/median 4.1429 / 3; t(20) = 2.1233, p = .0474). While we cannot use the present data to corroborate the default IMPLAN Information, it does support the ongoing hypothesis in Local Food circles that Local Foods farms are
associated with a higher economic multiplier than farms that do not sell direct to consumers. Differences in the methodology used here relative to IMPLAN’s preclude us from hypothesizing with any amount of reasonable accuracy the true multiplier for these industries.

Another outstanding question in the Local Foods community that can be addressed with the present survey data concerns the current importance and future of mid-sized farms. Previous work by ERS has shown that midsize farms are the most endangered size of farm. However, previous work has also shown that larger farms are more consistently profitable and able to support the livelihood of a family. Given the fact that advocates of Local Foods encourage the creation and development of more local agriculture, a reasonable question to ask is what is the minimum acreage necessary to guarantee a profit be generated given that the appropriate care and attention is paid to the operation? This is an important question to answer in order to ensure that any public subsidization of Local Foods goes to operations that have a high chance of long term success. This is to ensure that the public investment will continue to have an impact over the long term. While it is possible that smaller producers would be able to achieve profitability reliably, the fact that it is statistically unlikely makes it difficult to predict the benefit from public subsidization over the long term. From the data collected in this survey, by ordering farms by managed acreage and then calculating the point at which 75% of farms that size and larger are profitable, it was found that ~100 acres is necessary for operations to reliably make some amount of profit. When you consider all of the different types of farms in the state (Data Not Shown). Below this acreage both the value of profits and revenues can vary tremendously across agricultural operations.

The final outstanding question the data collected from this survey can help answer is what size of farms are suitable for Direct to Consumer marketing. As mentioned immediately above, these types of questions are of importance because of the desire advocates for Local Foods have in encouraging further public subsidization of this agricultural sector. This subsidization could take the form of a number of mechanisms including but not limited to direct payments, incorporation into “Crop Insurance” programs (thus decreasing annual risk), increased use of Electronic Benefit Transfer payments (EBT; i.e. SNAP) at farmers markets (thus decreasing transaction costs) and many others. Amongst the respondents to this survey, farms up to 650 acres in size take part in Direct to Consumer Sales (Data Not Shown). This finding implies that expansion into the Local Foods sector is realistic for all but the largest farms in North Carolina; doing so may be an opportunity for them to increase profitability.
Overall the results of the survey indicate that agriculture takes many different forms across North Carolina. Consistent with the expected distributions of farm size, net revenue, and farm operator age, this survey found much that corroborates other agricultural surveys, insights from field experts, and anecdotal hearsay. This survey also found evidence that indirectly supports the claim that farms that conduct Direct to Consumer sales have an associated higher economic multiplier than farms that do not. This effect is due to the larger number of individuals/businesses/entities these D2C farms buy from and what this implies for the degree of interconnectedness between these farms relative to non D2C farms.

**IMPLAN Analysis**

In addition to the analysis of primary survey data described above, an analysis of secondary data was also conducted. This analysis used the IMPLAN database and was done to evaluate the economic value of direct to consumer farmer sales of fruit, vegetables, and other horticultural products. We focused this analysis on the following economic sectors within IMPLAN: vegetables/melons, fruits/nuts, and ornamental horticulture/nursery. In order to be consistent with the sampling frame of the survey we conducted, we conducted this analysis at both the state level as well as only considering the counties of Anson, Burke, Carteret, Chatham, Henderson, Robeson, Rowan, Transylvania, and Wayne. In addition we also studied Rowan county individually. The purpose of this analysis was to accurately project job impacts from changes in sales levels of fruit and vegetable sales as well as other horticultural industries.

The counties in the subset are quite diverse in agricultural structure, as can be seen in Figure 2.2. This figure shows both the mean and median farm sizes for each county as well as the group’s average and the average of the whole state. All comparative statistics are from the 2012 Census of Agriculture. There is strong divergence amongst the counties with Burke County posting the lowest average farm size of 71 acres, and Carteret the highest at 503 acres. The median farm size tells us the size of the 50th percentile farm as ordered from smallest to largest. The highest median value is in Anson County, and the lowest is in Henderson County. Taken together as averages weighted by the total amount of farmland at the county level, the mix of counties produced values that are nearly identical to the overall statewide values. Please note that while the group’s average farm size is the weighted average, the group’s median farm size is the simple average of the county median values.
Agricultural productivity (i.e. value/acre) and the value of produced crops varied widely across the subset of counties studied. Figure 2.3 displays the range of average sales per acre of harvested farmland for the studied counties for all types of crops. The studied set’s average of $943 is $40 less than the state average, but the individual counties range widely. Chatham County receipts were $415 an acre, on average, as compared to Henderson and Transylvania County with sales of $3,312 and $3,439 respectively. These two counties produced large sales volumes in the nursery and floriculture crops, which have high cropping intensity.

Figure 2.4 shows the amount of fruit and vegetable sales per acre of production that occurred in the studied counties in 2012. Statewide, farms with orchard crops averaged $6,600 in sales per acre. The range for this subset of counties was $3,120 per acre with Carteret posting the highest value of $14,200 per acre, and Chatham County the lowest at $1,190 per acre. Vegetable and melon sales were $3,480 per acre statewide and $3,370 for the region. Chatham County had the highest at $6,630 per acre, and Robeson County the largest $2,450 per acre.

Having worked through some of the inter-county variability, Table 2.1 presents selected summary comparisons of this nine county subset for the state of North Carolina. In all, this subset of counties is less dependent on orchard or vegetable sales than the state average. It has a slightly higher percentage of farms, however, engaged in direct sales, as well as a higher incidence of farms with orchard sales (even though, as shown in Figure 2.3 above, sales per acre is substantially less in the region).

Table 2.2 compares the state of North Carolina’s direct sales farms with the nation’s. Other than the data presented in Table 2.1, there is no data at the county level that is of comparable level of detail to compare it with either the state or the nation. The state to nation comparison, however, helps us understand whether North Carolina’s farmers differ meaningfully from the nation’s. We see immediately that more than three-fourths of farms with direct sales in both the U.S. and N.C. had fewer than $5,000 in sales, and that just 6 percent had sales greater than $25,000 per farm. Conversely, the immense market power of the larger operations is evident as they account for 63% of direct sales in N.C., and 69% for the U.S. Average sales per farm are, however, very similar in the two lower sales categories. For larger farms, N.C. farmers average 24% lower sales per operation than the national average.

The data in Table 2.2 are very telling regarding Local Foods production and distribution for the state as a whole. A very high fraction of the farmers engaged in direct sales activities are small with regards to sales and, by likely inference, in size. In contrast, high sales, and by inference larger
farms, dominate direct sales activity. Policy changes meant to impact LFI and encourage greater
amounts of Local Foods sales must acknowledge the production expertise and capacities of local
farms of various sizes. As displayed in Figure 2.2, the studied 9 county set as a whole resembled the
state in terms of average and median farm size. It is reasonable to assume that the region’s direct
sales distribution by farms and by sales levels are more or less similar to the state’s distribution.

Having described how the selected nine county subset is both similar to and different from
the state as a whole with regards to agriculture, we now turn to the first application of I-O modelling
analysis. We used data derived from the primary survey (see above) to apportion 90% of the sale
value of direct to consumer sales to the livestock sector and 10% to all other crops. This information
is not contained in the Agricultural Census. For the nine county subset, a disproportionate amount
of farm income is generated from livestock production versus crops, as Figure 2.5 clearly
demonstrates. More than two-thirds of farmer sales were from livestock, and just 3 percent came
from fruits and vegetable production. The category of “all other crops” in the figure include grains,
oilseeds, cotton, tobacco, nursery and horticulture crops as well as hay and other forage. It is
unlikely that there would be any direct to consumer sales of feed grains, oil seeds, cotton, and
tobacco so their contributions were not considered in the direct sales analysis. Hay products was
also excluded in order to preserve parsimony of the analysis methodology.

Table 2.3 displays the regional economic value of direct sales for this nine county subset.
Table 2.8 shows the same analysis conducted for the whole state. The analysis of the nine county
subset shows that to produce $5.64 million in direct to consumer sales, only 31 jobs were needed
making a total of $1,743,675 in labor income. These farms required another $755,614 in regionally
supplied inputs, the provision of which necessitated an additional 4.6 jobs making $167,767 in labor
income. When the direct jobs and the indirect jobs converted their labor incomes into household
spending, they induced $950,438 in additional regional output supporting 9.1 jobs making $279,577
in labor income. In all, the region’s direct sales are linked to $7.35 million in total regional output,$
$3.82 million in value added (or GDP), and $2.2 million in labor income going towards 44.5
jobholders.

Table 2.3 also lists multipliers for specific items. An output multiplier of 1.3 means that for
every $1 of direct sales, there is $.30 in economic activity being generated elsewhere in the regional
economy. The same logic applies to the value added multiplier (1.27), the labor income multiplier
(1.26), and the job multiplier (1.44).
The results of the statewide analysis are shown in Table 2.4. Assuming the same mix of direct sales as described above, statewide these sales supported $31.83 million in agricultural output which required nearly 169 positions earning $10.04 million in labor income. These direct sales further stimulated $11.6 million in indirect output from suppliers, which in turn required 49.5 jobs earning $2.48 million in labor income. When the direct and indirect workers converted their earnings into household spending, they induced $10.32 million in additional output and $3.42 million in labor income going towards 85.5 jobs. Combined, the direct sales contributed a total $53.72 million in statewide output and $27.7 million in value added processing. A total of $15.94 million went to labor income across nearly 304 jobholders.

Table 2.4 also contains a row of multipliers as was done in Table 2.3. These multipliers are substantially higher than those found in Table 2.3 where direct sales for our studied subset of counties were summarized. While it is possible that this discrepancy is due to fundamental differences between our studied nine county subset and the state, this is unlikely given the data received from the primary survey (data shown throughout chapter showing similarities between nine county subset and the state as a whole). The more likely reason is that in the statewide analysis there are fewer inputs and consumed goods being purchased from outside the region being studied (i.e. the state versus the nine county region previously used) than in the regional model. These leakages are one of the things that contributes to a lower multiplier. Therefore one would expect that with few exceptions statewide models will produce higher multipliers than regional models.

Table 2.5 displays the regional economic value of fruits and vegetables farmers’ sales. From an estimated output of $41.1 million, these regional farmers supported 675.5 jobs making a total of $22.11 million in labor income. The individuals in these jobs required $3.8 million in regionally supplied inputs supporting 62.5 more jobs. These additional jobs made $1.76 million in labor income. When labor incomes were converted into household spending, 113.4 more jobs making $3.5 million in labor income were supported. In all, fruit and vegetable farming in the region supported $56.7 million in total regional output, which yielded $42.4 million in value added value, of which $27.4 million was labor income going to a total of 851 jobholders.

Table 2.6 shows the same analysis as shown in Table 2.5 but at the state level. Across the state the fruit and vegetable sectors produced $536.85 million in output while supporting nearly 4,601 jobs. These jobs earned a total of $267.64 million in labor income. These growers further stimulated $89.55 million in output from the sectors supply inputs/processing. These businesses
paid a total of $85.4 million in labor income to 887 workers. The money made by these workers further stimulated $249.97 million in induced output. $82.96 million in labor income was paid across 2,072 jobs to produce this induced output. In total, the state’s fruit and vegetable farmers accounted for $876.4 million in statewide output, a further $633.86 million in value added, and $385.97 million in labor income paid across 7,570 jobholders. Given these values, if NC consumers were to increase their fruit/vegetable consumption to FDA recommended levels and source 10% of their produce from within the state, an additional 1,000 jobs, $500,000,000 in labor income, $840,000,000 in value added processing, and $1,100,000,000 in total output would be added to the state economy (Agricultural Census, 2012).

The region also supports a robust nursery, horticulture, and floriculture sector according to IMPLAN, and verified by the Census of Agriculture. Those values are found in Table 2.7. This sector of agriculture produced $89.6 million in output employing 801 jobholders. These individuals made a total of $49.1 million in labor income. This sector generated a total of $122.75 million in regional output and $81.2 million in value added (or GDP), of which $59.9 million was labor income paid to nearly 1,150 jobholders.

At the state level the greenhouse, nursery, and floriculture sector is much larger than the state’s vegetable and fruit production sector. In Table 2.8, this agriculture sector produced $720.7 million in direct output which required 7,058 jobs. These positions made $366.4 million in labor income. Furthermore, this direct output required another $132.53 million in inputs; to produce these inputs 1,244 jobs making $55.14 million in labor income were required. When workers converted their incomes into spending, they further induced $346.3 million in output and $114.91 million in labor income to another 2,869 jobholders. In total this sector contributed $1.2 billion to the state’s total output, a further $779.1 million in value added, and $536.4 million in labor income to nearly 11,199 jobholders.

The economic impact of the studied agricultural subsectors – direct sales, fruits/vegetables, and ornamental horticultural/nursery – are not mutually exclusive, so one can’t add them all together. One can sum together the tables for the fruits/vegetable economic impacts and the ornamental horticulture/nursery impacts (Table 2.5 and Table 2.7 as well as Table 2.6 and Table 2.8 respectively), but direct sales can come from any sector. However, another way of quantifying the overall potential worth of different economic activities for the purpose of directly comparing them for their ability to impact economic development is by looking at the amount of total, multiplied-through economic activity that is generated regionally per $1 million of a particular kind of sales.
Table 2.9 compares the total contributions per $1 million in output per category analyzed. Please note that not all of the subsectors of the agricultural economy is represented in this table, thus the “All Regional Ag Sectors” entry is not merely the average of all of the rows above. The key indicators are jobs, labor income, and value added/GDP. Net regional economic growth is best approximated using value added metric (i.e. GDP), this is the conventional manner in which economic activity is quantified by government accounts. Fruits and vegetables are estimated to produce the highest amount of regional value added per $1 million of initial output, resulting in a further impact of $1.031 million. That industry is followed by the greenhouse and nursery sector with an impact of $906,149. Direct sales estimates, which were derived in large part from the other two sectors as well as direct animal sales, produced $677,309 in value added per $1 million in output change. The jobs multiplier was also significantly higher in the fruits and vegetable sector owing in large part to the labor-intensity required for this type of farming.

In all, Table 2.9 provides a summary multiplier chart to display the income gains that may accumulate if Local Foods production is increased. For example, an additional $1 million in fruit and vegetable sales in the nine county subset has the potential of producing $1.03 million in regional value added above the value of sales. If the land and labor required to do that work were shifted away from other agricultural activity (or more likely from other crop production), there would be a net gain for the regional economy of $368,493 per $1 million in direct output shifts ($1,031,165 million minus $662,672). These kinds of shifts count as net regional economic gains if one of two primary conditions exist. The first is the typical Local Foods scenario where a local sale is made to substitute for fruits or vegetables that are imported from some other part of the U.S. The second occurs when productivity in a sector expands such that regional export sales grow. This could be the case where the region is able to expand sales to, say the rest of North Carolina or other mid-Atlantic consumers. In both scenarios, net regional economic output increases, and the regions overall fortunes improve. The table above provides an indication of the amount of both gross and net gains that are possible within different agricultural sectors relevant to Local Foods.

Finally, Table 2.10 shows the same summary as Table 2.9 but for the whole state. As is clearly evident, both the combined fruit and vegetable sector and the greenhouse, nursery, and floriculture sector produce much higher multipliers than the estimated direct sales and the estimated value for all agriculture combined.
Evaluation of Unmodified IMPLAN Data

One additional research question that was investigated was whether it is necessary to adjust the IMPLAN database to be consistent with the findings from the 2012 Agricultural Census. A review of the IMPLAN model for North Carolina reveals values that are at odds with the county level data from the 2012 Census of Agriculture. In the above presented results for the nine county subregion the IMPLAN model had been modified to align with the gross sales values and the estimated number of farmers producing both direct sales as well as fruits, melons, and vegetables found in the Agricultural Census. The IMPLAN data at the state level was sufficiently in agreement with the findings of the Agricultural Census to not warrant this procedure. This was determined by comparing the values of equivalent line items in both IMPLAN, the most recent Agricultural Census, and the BEA’s Farm Income and Expenses (SA45) database. In cases where the IMPLAN values differed by more than approximately 5% the values from the benchmark’s, the IMPLAN values were replaced. The remaining agricultural industry values in the IMPLAN database were sufficiently close to the Agricultural Census as to not warrant modification. The following pages show the results of using the unmodified IMPLAN data.

In Table 2.11 one can see the unmodified expected economic impacts of direct sales allocated to fruits/vegetables, ornamental horticulture/nursery crops, and to the livestock categories for the nine county subset. There is little difference between the unmodified IMPLAN data and the data brought in line with the Agricultural Census (Table 2.3). This is consistent with the earlier finding that the livestock sector is well represented in IMPLAN because the vast majority of agriculture production in the studied counties comes from livestock sales. The vegetable and fruit sector modifications to direct sales according to the Agricultural Census did not meaningfully change the estimated economic impact values.

Table 2.12 shows the expected economic impacts of fruit and vegetable sales across the nine county subset using the unmodified IMPLAN database. While the total number of direct jobs in the unmodified model did not differ significantly from the Agricultural Census (2.8 percent less), there was a strong difference in sales reported in the Agricultural Census compared to the output reported in the original IMPLAN database (23.3 percent less). This difference, once multiplied through the Input-Output model, produced an expected job impact that was 8.6% less than what the default values would have produced, labor incomes that were 25.5% less, value added processing that was 23.6% less, and total regional output that was 24% lower. Given that this portion of the IMPLAN database is the one most studied in Local Foods research, the finding that
this data is poorly represented in IMPLAN is extremely important. While it is the case that for North Carolina the IMPLAN database overestimates the economic value of Local Foods production, in other cases IMPLAN may underestimate it. Differences in the direction of the effect would stem from the econometric methodologies that are used to generate the IMPLAN data. It should also be noted, however, that these distortions are not evident at the statewide level. This issue appears to have the most impact as researchers look at smaller and more geographic regions in their I-O analyses.

Table 2.13 shows the expected economic impact from the region’s greenhouse, nursery, and floriculture sector using the unmodified IMPLAN database. In the analyses described above (corresponding to Table 2.3 through Table 2.10), the values for these industries had not been changed for the nine county subregion as they were already very close to the values contained in the Agricultural Census. Therefore, the numbers shown in Table 2.13 including the demonstrated multiplied-through economic impacts are hardly different. This finding underscores the value of only needing to make strategic modifications to the IMPLAN model; however it is difficult to know a priori what sectors are in need of modification. This findings of this study highlight the need to update IMPLAN sectors that correspond to forms of county-level production which do not have significant market share of the counties gross cash receipts from agriculture.

Because of the finding that the IMPLAN database appears to represent some geographic regions and some agricultural subsectors poorly (such as fruit and vegetable sales) while other are represented quite well (i.e. greenhouse, nursery, and floriculture), the predictions made for a single county (Rowan) were made using both the original data as well as data modified to agree with the 2012 Agricultural Census. In the case of Rowan County, it was found that the original IMPLAN data was not always in agreement with the findings from the 2012 Census of Agriculture. IMPLAN’s unmodified data shows $11.93 million of output in the vegetable and melon sector. However, for this to be the case each of the county’s 43 farms that reported vegetable or melon sales would have had to have made $18,075 in sales per acre on average across 660 acres in production. This value seems highly unlikely given that the statewide average is only $3,482 per acre. Furthermore, discrepancies were also found in the grains, oilseeds, and “other crops” subsector. However, the original IMPLAN data represented the livestock sector well.

Table 2.14 compares the predictions made by the IMPLAN model using both the unmodified data as well as data modified to agree with the Agricultural Census. This table shows the expected economic impact for each additional $1 million of direct output for direct sales, fruit/vegetable
sales, and greenhouse, nursery, and floriculture production sales using both datasets. The original data predicted fewer jobs would be created across all studied subsectors as well as more labor income and value added processing. As with the nine-county regional analysis, the largest found difference was with regards to vegetable and fruit production. This is also the subsector that matters the most to most Local Foods advocates. The modified data predicts 2.5 times as many jobs after all linkages are multiplied through the system alongside significantly lower labor income and value added processing amounts.

DISCUSSION AND CONCLUSION

The Local Foods movement has grown in popularity over the past decade. Proponents advocate for public financial support of the movement because of the large number of social ills Local Foods is thought to be able to impact for the better. Because these benefits are thought to cut across the economic, social, and environmental domains, quantifying a holistic and comprehensive impact of these changes is methodologically difficult. While these far reaching impacts are fundamentally important, their simultaneous consideration presents a methodological difficulty for it requires all impacts to be valued in a common way. In order to avoid this methodological consideration, we focused our attempt at valuation on the economic domain. As with all other economic industries, analyses meant to predict the economic impact of different changes to the agricultural economy and the value of Local Foods sales are most commonly conducted using the IMPLAN database, produced by MIG Inc. This database is commonly used because it disaggregates relevant data down to the zip code level. Thus, its spatial specificity makes it attractive for economic analysis that are interested in gauging potential impacts at the county level and smaller. However, there is reason to suspect that this dataset does not represent LFI ventures well and thus analyses that use this dataset may be biased against Local Foods from the beginning. In order to determine whether this is in fact a problem for the agricultural sector of North Carolina, a statewide survey of farmers was undertaken.

While this survey was intended to be used in testing the veracity of the IMPLAN database, inadequate sample size precludes us from doing so. The sampling frame had been stratified along two independent dimensions; while we received adequate sampling coverage for the state as a whole we did not consistently have sufficient coverage to analyze each of these strata independently. Because of this, we conducted additional analyses of the collected survey data in
order to test support for other theories/hypothesized that are commonly heard in discussions of Local Foods.

The results of these analyses speak to a number of important characterizations of NC agriculture today. First and foremost, NC agriculture today is highly diverse with a large range of farm sizes, values, profitability, and marketing/sales strategies. While there are certain structural differences that exist across geographic regions (such as average farm size increasing as one moves east), in general there were few types of agriculture that were exclusively concentration in one portion of the state. The exception to this is certain types of horticultural production located uniquely in the Mountains (such as with apples and Christmas trees). Secondly, farms of all but the highest values and acreages engage in Direct to Consumer Sales in NC based upon results from the statewide survey we conducted. Thirdly, the point at which NC farms start reliably being profitable is around 100 acres in size. While there are many examples of farms less than 100 acres in size that are regularly profitable, there are more farms of the same acreage that are not. These two findings are particularly important for proponents of the Local Foods movement to consider because of the outstanding issues with the ongoing loss of midsize farms and improving farm profitability.

An additional analysis was conducted to determine whether farms that sell directly to consumers buy their inputs from a greater range of businesses than those that do not. It has been hypothesized many times (Otto & Varner, 2003; Swenson, 2006; Sonntag, 2008; Hughes et al, 2008; Swenson, 2009; Henneberry et al, 2009; Swenson, 2011; Low & Vogel, 2011) that direct to consumer farms would be associated with a higher economic multiplier than comparable non direct to consumer farms. This effect would in essence be mediated by the degree to which each kind of farm is embedded in the social and economic fabric of the community. We found that farms that sell direct to consumers are statistically more likely to buy from a greater range of input suppliers than farms that do not.

Proponents of the Local Foods movement should consider the above finding carefully. Given that the economic multiplier of direct to consumer farms has been shown to be higher than far farms selling through wholesale channels, for communities to be able to harness these benefits their must continue to exist a sufficiently broad range of supporting businesses. In many industries, including agriculture, there has been a large scale drive towards consolidation and a smaller number of companies covering both a greater breadth and range of services. (Schuman, 2006). If these supporting industries were to stop operating, direct to consumer farms would not have the option of working with a larger number of smaller businesses. In addition to the analysis of the primary
survey data, we also studied secondary data from the IMPLAN database to evaluate the expected economic impact of changes to the NC agricultural industry. The analysis was run at the level of an individual county with a strong horticultural sector, the nine county subregion used in the survey, and the whole state. The analysis was also run using both data that had and not been reconciled with the 2012 Agricultural Census. The Agricultural Census has a much denser sampling coverage than IMPLAN’s, thus one should put greater stock in Agricultural Census estimates than the ones within IMPLAN. Comparing the results of both analyses found that different sectors of the agricultural economy are represented with varying degrees of accuracy in the IMPLAN data. In general, livestock production is represented fairly accurately while fruit/vegetable production is not. This is consistent with the fact that livestock production is a far larger portion of the NC agricultural economy and thus would be expected to be better represented in the database. Furthermore, as one would expect that the data becomes more unreliable as one moves to smaller geographic regions of study. This can be seen in the revealed discrepancies between the original and unmodified data when used to make predictions at the level of the subregion and the individual county relative to the whole state.

The original intention of collecting the survey data used in this project was to test the accuracy of the IMPLAN database to field data collected in NC, however we were unable to use the data for this purpose however due to a lower than necessary response rate. Because of this fact, we are unable to corroborate the accuracy of IMPLAN in representing the Local Foods movement directly; this is because local foods is most closely associated with fruit and vegetables sales which were shown to be represented poorly in this study. However, analysis of secondary data argues that it does not well represent this portion of the agricultural economy. Future work in this area should strive to better evaluate the current accuracy of the IMPLAN database to determine the degree to which it is effective at being used in forecasting the net economic impacts of changes to the agricultural economy.
Figure 2.1: Percentage Change of Number of Farms (1975 -2011). Figure shows the change relative to 1975 of the number of farms at the county level. Green lines are the major interstates highways. Green dots are the sites of registered CAFO operations.
Figure 2.2: Average and Median Farm Sizes, North Carolina and the Study Counties

Figure 2.3: Average Sales per Harvested Acre, North Carolina and the Study Counties
Figure 2.4: Average Per Acre Sales ($1,000), North Carolina and the Study Counties

Figure 2.5: Distribution of Farm Sales by Farm Product for the Study Counties
Figure 2.6: Statewide Distribution of Farm Sales by Farm Product
Table 2.1: Comparison of North Carolina to Nine-County Subset for Horticultural/Direct Sales

<table>
<thead>
<tr>
<th></th>
<th>North Carolina</th>
<th>Nine County Subset</th>
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<tbody>
<tr>
<td>Orchard and Vegetable Sales as Percentages of Total Sales</td>
<td>4.1%</td>
<td>2.8%</td>
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<tr>
<td>Direct Sales as Percentages of Total Sales</td>
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<td>0.4%</td>
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<tr>
<td>Direct Sales Farms as Percentages of Farms</td>
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<td>10.3%</td>
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<td>Vegetable Sales Farms as Percentages of Farms</td>
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<tr>
<td>Orchard Sales Farms as Percentages of Farms</td>
<td>4.3%</td>
<td>6.0%</td>
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Table 2.2: Selected Characteristics of Direct Sales Farms: North Carolina and the U.S.

<table>
<thead>
<tr>
<th>Annual Sales in 2012</th>
<th>Distribution of Farms</th>
<th>Distribution of Sales</th>
<th>Average Sales Per Farm</th>
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<td>N.C.</td>
</tr>
<tr>
<td>Fewer than $5,000</td>
<td>79%</td>
<td>76%</td>
<td>13%</td>
</tr>
<tr>
<td>$5,000 to $24,999</td>
<td>16%</td>
<td>18%</td>
<td>23%</td>
</tr>
<tr>
<td>More than $25,000</td>
<td>6%</td>
<td>6%</td>
<td>63%</td>
</tr>
</tbody>
</table>

Table 2.3: Estimated Regional Direct Sales Impacts

<table>
<thead>
<tr>
<th>Impact Type</th>
<th>Jobs</th>
<th>Labor Income</th>
<th>Value Added</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>30.8</td>
<td>$1,743,675</td>
<td>$3,015,084</td>
<td>$5,640,011</td>
</tr>
<tr>
<td>Indirect</td>
<td>4.6</td>
<td>$167,767</td>
<td>$257,700</td>
<td>$755,614</td>
</tr>
<tr>
<td>Induced</td>
<td>9.1</td>
<td>$279,577</td>
<td>$547,249</td>
<td>$950,438</td>
</tr>
<tr>
<td>Total</td>
<td>44.5</td>
<td>$2,191,019</td>
<td>$3,820,032</td>
<td>$7,346,063</td>
</tr>
</tbody>
</table>

Multiplier | 1.44 | 1.26 | 1.27 | 1.30 |
Table 2.4: Estimated Statewide Direct Sales Impacts

<table>
<thead>
<tr>
<th>Impact Type</th>
<th>Jobs</th>
<th>Labor Income</th>
<th>Value Added</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>168.8</td>
<td>$10,037,637</td>
<td>$17,647,344</td>
<td>$31,826,000</td>
</tr>
<tr>
<td>Indirect</td>
<td>49.5</td>
<td>$2,478,604</td>
<td>$4,096,170</td>
<td>$11,582,342</td>
</tr>
<tr>
<td>Induced</td>
<td>85.5</td>
<td>$3,423,361</td>
<td>$5,954,261</td>
<td>$10,315,266</td>
</tr>
<tr>
<td>Total</td>
<td>303.8</td>
<td>$15,939,603</td>
<td>$27,697,776</td>
<td>$53,723,608</td>
</tr>
<tr>
<td>Multiplier</td>
<td>1.80</td>
<td>1.59</td>
<td>1.57</td>
<td>1.69</td>
</tr>
</tbody>
</table>

Table 2.5: Estimated Regional Fruit and Vegetable Sales Impacts

<table>
<thead>
<tr>
<th>Impact Type</th>
<th>Jobs</th>
<th>Labor Income</th>
<th>Value Added</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>675.5</td>
<td>$22,111,007</td>
<td>$33,254,046</td>
<td>$41,084,000</td>
</tr>
<tr>
<td>Indirect</td>
<td>62.5</td>
<td>$1,755,581</td>
<td>$2,278,080</td>
<td>$3,773,612</td>
</tr>
<tr>
<td>Induced</td>
<td>113.4</td>
<td>$3,489,945</td>
<td>$6,832,251</td>
<td>$11,864,748</td>
</tr>
<tr>
<td>Total</td>
<td>851.4</td>
<td>$27,356,533</td>
<td>$42,364,377</td>
<td>$56,722,359</td>
</tr>
<tr>
<td>Multiplier</td>
<td>1.26</td>
<td>1.24</td>
<td>1.27</td>
<td>1.38</td>
</tr>
</tbody>
</table>

Table 2.6: Estimated Statewide Fruit and Vegetable Sales Impacts

<table>
<thead>
<tr>
<th>Impact Type</th>
<th>Jobs</th>
<th>Labor Income</th>
<th>Value Added</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>4,600.7</td>
<td>$267,638,745</td>
<td>$435,565,958</td>
<td>$536,853,648</td>
</tr>
<tr>
<td>Indirect</td>
<td>887.3</td>
<td>$35,368,766</td>
<td>$54,015,848</td>
<td>$89,551,942</td>
</tr>
<tr>
<td>Induced</td>
<td>2,072.1</td>
<td>$82,959,986</td>
<td>$144,284,390</td>
<td>$249,965,238</td>
</tr>
<tr>
<td>Total</td>
<td>7,560.2</td>
<td>$385,967,498</td>
<td>$633,866,196</td>
<td>$876,370,828</td>
</tr>
<tr>
<td>Multiplier</td>
<td>1.64</td>
<td>1.44</td>
<td>1.46</td>
<td>1.63</td>
</tr>
</tbody>
</table>

Table 2.7: Estimated Regional Greenhouse, Nursery, & Floriculture Sales Impacts

<table>
<thead>
<tr>
<th>Impact Type</th>
<th>Jobs</th>
<th>Labor Income</th>
<th>Value Added</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>801.1</td>
<td>$49,060,000</td>
<td>$62,002,799</td>
<td>$89,614,008</td>
</tr>
<tr>
<td>Indirect</td>
<td>100.4</td>
<td>$3,188,497</td>
<td>$4,245,379</td>
<td>$7,164,692</td>
</tr>
<tr>
<td>Induced</td>
<td>248.1</td>
<td>$7,638,251</td>
<td>$14,955,424</td>
<td>$25,968,740</td>
</tr>
<tr>
<td>Total</td>
<td>1,149.5</td>
<td>$59,886,748</td>
<td>$81,203,602</td>
<td>$122,747,440</td>
</tr>
<tr>
<td>Multiplier</td>
<td>1.43</td>
<td>1.22</td>
<td>1.31</td>
<td>1.37</td>
</tr>
</tbody>
</table>
Table 2.8: Estimated Statewide Greenhouse, Nursery, & Floriculture Sales Impacts

<table>
<thead>
<tr>
<th>Impact Type</th>
<th>Jobs</th>
<th>Labor Income</th>
<th>Value Added</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>7,085.1</td>
<td>$366,388,064</td>
<td>$498,642,958</td>
<td>$720,699,648</td>
</tr>
<tr>
<td>Indirect</td>
<td>1,244.2</td>
<td>$55,143,443</td>
<td>$80,517,487</td>
<td>$132,530,654</td>
</tr>
<tr>
<td>Induced</td>
<td>2,869.5</td>
<td>$114,909,256</td>
<td>$199,899,329</td>
<td>$346,288,634</td>
</tr>
<tr>
<td>Total</td>
<td>11,198.7</td>
<td>$536,440,764</td>
<td>$779,059,774</td>
<td>$1,199,518,935</td>
</tr>
<tr>
<td>Multiplier</td>
<td>1.58</td>
<td>1.46</td>
<td>1.56</td>
<td>1.66</td>
</tr>
</tbody>
</table>

Table 2.9: Total Economic Contributions Per $Million of Direct Output for County Subset

<table>
<thead>
<tr>
<th>Impact Sector</th>
<th>Jobs</th>
<th>Labor Income</th>
<th>Value Added</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Sales</td>
<td>7.9</td>
<td>$388,478</td>
<td>$677,309</td>
<td>$1,302,491</td>
</tr>
<tr>
<td>Fruit and Vegetable Sales</td>
<td>20.7</td>
<td>$665,868</td>
<td>$1,031,165</td>
<td>$1,380,644</td>
</tr>
<tr>
<td>Greenhouse, Nursery, &amp; Floriculture</td>
<td>12.8</td>
<td>$668,274</td>
<td>$906,149</td>
<td>$1,369,735</td>
</tr>
<tr>
<td>All Regional Ag Sectors</td>
<td>7.7</td>
<td>$384,330</td>
<td>$662,672</td>
<td>$1,330,168</td>
</tr>
</tbody>
</table>

Table 2.10: Total Statewide Economic Contributions Per $Million of Direct Output

<table>
<thead>
<tr>
<th>Impact Sector</th>
<th>Jobs</th>
<th>Labor Income</th>
<th>Value Added</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Sales</td>
<td>9.5</td>
<td>$500,836</td>
<td>$870,288</td>
<td>$1,688,041</td>
</tr>
<tr>
<td>Fruit and Vegetable Sales</td>
<td>14.1</td>
<td>$718,944</td>
<td>$1,180,706</td>
<td>$1,632,420</td>
</tr>
<tr>
<td>Greenhouse, Nursery, &amp; Floriculture</td>
<td>15.5</td>
<td>$744,333</td>
<td>$1,080,977</td>
<td>$1,664,381</td>
</tr>
<tr>
<td>All Statewide Ag Sectors</td>
<td>9.5</td>
<td>$508,573</td>
<td>$874,534</td>
<td>$1,714,567</td>
</tr>
</tbody>
</table>
Table 2.11: Estimated Regional Direct Sales Impacts (Unmodified IMPLAN)

<table>
<thead>
<tr>
<th>Impact Type</th>
<th>Jobs</th>
<th>Labor Income</th>
<th>Value Added</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>29.7</td>
<td>$1,811,920</td>
<td>$3,131,326</td>
<td>$5,585,534</td>
</tr>
<tr>
<td>Indirect</td>
<td>4.6</td>
<td>$173,923</td>
<td>$267,297</td>
<td>$772,785</td>
</tr>
<tr>
<td>Induced</td>
<td>9.1</td>
<td>$290,459</td>
<td>$568,543</td>
<td>$992,015</td>
</tr>
<tr>
<td>Total</td>
<td>43.4</td>
<td>$2,276,302</td>
<td>$3,967,167</td>
<td>$7,350,254</td>
</tr>
</tbody>
</table>

Multiplier 1.46 1.26 1.27 1.32

Table 2.12: Estimated Regional Fruit and Vegetable Sales Impacts (Unmodified IMPLAN)

<table>
<thead>
<tr>
<th>Impact Type</th>
<th>Jobs</th>
<th>Labor Income</th>
<th>Value Added</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>695.3</td>
<td>$29,666,679</td>
<td>$43,222,666</td>
<td>$53,601,234</td>
</tr>
<tr>
<td>Indirect</td>
<td>84.8</td>
<td>$2,384,533</td>
<td>$3,065,787</td>
<td>$5,075,922</td>
</tr>
<tr>
<td>Induced</td>
<td>152.2</td>
<td>$4,686,608</td>
<td>$9,175,033</td>
<td>$15,932,789</td>
</tr>
<tr>
<td>Total</td>
<td>932.3</td>
<td>$36,737,821</td>
<td>$55,463,485</td>
<td>$74,609,945</td>
</tr>
</tbody>
</table>

Multiplier 1.34 1.24 1.28 1.39

Table 2.13: Estimated Regional Greenhouse, Nursery, & Floricultural Sales Impacts (Unmodified IMPLAN)

<table>
<thead>
<tr>
<th>Impact Type</th>
<th>Jobs</th>
<th>Labor Income</th>
<th>Value Added</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>801.1</td>
<td>$49,060,323</td>
<td>$62,003,208</td>
<td>$89,614,600</td>
</tr>
<tr>
<td>Indirect</td>
<td>99.8</td>
<td>$3,175,957</td>
<td>$4,231,494</td>
<td>$7,144,085</td>
</tr>
<tr>
<td>Induced</td>
<td>248.0</td>
<td>$7,636,498</td>
<td>$14,951,840</td>
<td>$25,962,233</td>
</tr>
<tr>
<td>Total</td>
<td>1,148.9</td>
<td>$59,872,778</td>
<td>$81,186,542</td>
<td>$122,720,917</td>
</tr>
</tbody>
</table>

Multiplier 1.43 1.22 1.31 1.37
Table 2.14: Total Rowan County Economic Contributions Per $Million of Direct Output – Modified IMPLAN

<table>
<thead>
<tr>
<th></th>
<th>Jobs</th>
<th>Labor Income</th>
<th>Value Added</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rowan County Total Ag Sector</td>
<td>17.1</td>
<td>$325,687</td>
<td>$541,709</td>
<td>$1,239,736</td>
</tr>
<tr>
<td>Direct Sales (Primarily Cattle)</td>
<td>3.9</td>
<td>$122,243</td>
<td>$276,078</td>
<td>$1,136,761</td>
</tr>
<tr>
<td>Vegetable and Fruit Production</td>
<td>20.0</td>
<td>$426,568</td>
<td>$502,967</td>
<td>$1,372,954</td>
</tr>
</tbody>
</table>

Table 2.15: Total Rowan County Economic Contributions Per $Million of Direct Output – Unmodified IMPLAN

<table>
<thead>
<tr>
<th></th>
<th>Jobs</th>
<th>Labor Income</th>
<th>Value Added</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rowan County Total Ag Sector</td>
<td>15.7</td>
<td>$346,799</td>
<td>$549,871</td>
<td>$1,241,379</td>
</tr>
<tr>
<td>Direct Sales (Primarily Cattle)</td>
<td>3.7</td>
<td>$120,071</td>
<td>$274,258</td>
<td>$1,133,220</td>
</tr>
<tr>
<td>Vegetable and Fruit Production</td>
<td>7.6</td>
<td>$593,895</td>
<td>$728,896</td>
<td>$1,337,332</td>
</tr>
</tbody>
</table>


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A STUDY OF HISTORICAL AGRICULTURAL LAND USE CHANGE IN NORTH CAROLINA

INTRODUCTION

Over the past 60 years, over ½ of the farmland in North Carolina (~9,500,000 acres lost with ~8,414,000 still in production; Agricultural Census, 2014; Lilly, 1998) has moved out of farms and into other land uses. This has occurred heterogeneously throughout the state with the majority according in the eastern Coastal Plain (see Figure 3.1). These alternative land uses include but are not limited to development for residential or business use, use for newly built infrastructure (such as roads), conversion to forestland, or remaining idle but out of agriculture. This land being removed from agricultural use includes both regularly cultivated and lower-intensely managed farmland such as fallowed land, hay/pasture land, and agricultural forestland (NRCS, 2010). While other states within the country have also experienced a decline in agricultural acreage over this time, North Carolina is one of the leading states in terms of net percentage of 1950’s farmland now utilized for different land use (Agricultural Census, 2014). Within the state of North Carolina there is a growing interest in farmland preservation for a number of unique but interconnected reasons. These include maintaining the rural landscape and culture (American Farmland Trust, 2007), limiting the growth of the cost of public services by not allowing urban sprawl to continue unabated (Carruthers, 2003; Renkow, 2007), maintaining the current provision of ecosystem services (Cong et al, 2014), providing areas suitable for the training of the United States Armed Services (Market Based Conservation Initiative, 2014; Cumberland County, NC: Model Easement, 2014), keeping farmland in periurban areas in order to provision locally produced horticultural crops into the surrounding communities, (Condon, 2010) and potentially improving quality of life (QOL) within nearby communities (Goldschmidt, 1978). The issue of ongoing farmland loss has become more prominent in recent years largely due to the growth of the Local Foods movement (Low et al, 2015) and the associated rise in public awareness that has subsequently grown out of it (Martinez et al, 2010).

Neoclassical economic theory suggests that these changes in land use are tied to the expected net economic value of present and future use of that land for agriculture relative to other potential uses; these uses include but are not limited to development for industry, residential, or infrastructure (i.e. roads, utilities, etc). Sociological theories suggest that these changes may be occurring instead due to changes in demographics, community structure, community identity, declines in rural identity and associated rural emigrations, or a decline in support (either direct or
indirect) for agriculture in communities amongst others. While these changes are not straightforward to measure in a manner similar to economic variables, they can be operationalized through a number of ways that speak to tangible aspects of these changes in society. While it is important to note that every individual will have different beliefs about the appropriateness of different ways of operationalizing the measurement of each of these changes, many of the measured variables chosen for the analysis presented below were chosen because of consensus agreement that the represent some measure of the aforementioned changes. Please find a description of the variables used to operationalize the measurement of these changes in Appendix 5.

This paper will first outline the economic and sociological theories that have been proposed to explain why farmland loss occurs. Second, a brief overview of the pattern of farmland change from 1975-present in NC will be described. Thirdly a description of the categories of variables used to operationalize the equitable comparison amongst economic and sociological theories will be given, and fourthly the holistic socioeconomic analysis of this issue will be presented.

LITERATURE REVIEW OF ECONOMIC THEORY EXPLAINING FARMLAND LOSS

Given the economic importance of agricultural production historically, both in North Carolina (North Carolina Business History, 2007) and the rest of the United States, the field of agriculture broadly has received a great deal of attention in the academic literature (Carter, 1984; Henry et al, 1987; Morse & Guess-Murphy, 2001). Some early examples of the subdisciplines within the field of agriculture that have achieved attention in the literature are theoretical agricultural economics (Marousek, 1979; Cornia, 1985), agriculture as a tool of economic development (Feder, 1985; Deller, Gould & Jones, 2003, Bagi, 2012), and the impact of agriculture on community wellbeing (Goldschmidt, 1978) amongst many others. Across the planet, one of the growing issues of importance concerns the loss of farmland and the impact these land use changes have on surrounding communities both economically and socially. The issue of farmland loss has increasingly become a topic of concern amongst stakeholders in North Carolina, one of the leading states in terms of the percentage of farmland lost relative to 1970’s levels, for a variety of interconnected reasons.

A number of explanations have been proposed to explain the loss of farmland over the past half century. Economic theory postulates that what determines the chosen use of a piece of land is
based upon the expected net revenue stream of using that land for different purposes. These theories argue that land that has historically been used for agricultural production only continues to remain in production if there is no other activity that land can be transitioned to that would provide a larger net revenue stream. As with all amortized cash flows, future payments are discounted by some amount (i.e. the discount rate) that may be unique to each property owner (McConnell, 1983). Furthermore, economic theory also predicts that land remaining in agriculture will shift towards the production of crops and or livestock that offer greater net revenue streams to the farmer/property owner, conditional on the cost of the shift (Davis, 2014).

For scholars of neoclassical economic theory, one of the greatest economic drivers of farmland loss, especially in peri-urban areas, is proximity to urban/developed/to be developed areas (Plantinga, Lubowski & Stavins, 2002; Cavailhes & Wavresky, 2003). In the absence of development restrictions, agricultural land that is close to urban/developed/to-be-developed land will increase in value under the expectation that the land will ultimately be developed (Livanis et al, 2006). Given the increased commuting distance many US workers are willing to undertake relative to the past several decades (facilitated by the inexpensive cost of transportation today; Renkow, 2010) the area in which property values are influenced by future development potential is constantly growing; this is due to the expectation that workers will be willing to commute farther and farther distances for sought after employment. Furthermore, it has been shown that the greatest increases in property value due to future development occurs in regions with high aesthetic value (Bunce, 1998; McGranahan, 1999). This, as well as the concern of the cost of providing public services to a larger and more disperse population has led many rural communities to institute farmland preservation plans to find ways to keep privately owned farmland from being developed (for example the Agriculture and Community Development Services, 2009). In work conducted by the National Resources Conservation Service, it was found that between a third to half of newly developed land is derived from the conversion of farmland (cultivated land, non-cultivated, and pasture land) with the remainder mostly coming from the conversion of forestland (NRCS Inventory, 2010; Fuller, 1999; Nusser, Breidt & Fuller, 1998).

There are a number of other potential economic factors that may be able to explain some portion of farmland loss. One agronomic reason may be that the land is no longer useful for production because of excessive erosion (Lubowski et al, 2006) or compaction (Chan et al, 2006). This may lead to a farmer’s removing a piece of land from their holdings if the cost of maintaining the land are not exceeded by the returns from that parcel. Another potential cause of the loss of
farmland are people leaving farming either because of retirement (the current average age of farmer in the US is 59; Agricultural Census, 2014), insufficient real wage growth or farm failure (Stam & Dixon, 2004); however for this to explain the loss of farmland it would have to be the case that the land was not subsequently consolidated into other farms.

LITERATURE REVIEW OF SOCIOLOGICAL THEORY EXPLAINING CONNECTION BETWEEN AGRICULTURE AND COMMUNITY WELLBEING

In contrast to economic theories which postulate that people remain in agricultural production because it is a rational monetary decision based upon expected revenue streams, there is a large body of sociological work that suggests other driving forces are in play. Consistent with this view of the world is the realization that in the United States over 90% of farm household income comes from non-farm sources (Hoppe et al, 2007). Furthermore, looking at the distribution of farms by managed acreage, the two categories that are growing are small and large farms yet the average small farm loses money (Agricultural Census, 2014). The fact that small farms are growing in number despite being, on average, not profitable, suggest that there may be other reasons why people choose to engage in agricultural production. It is important to note that the tax benefits of engaging in farming are not sufficient to explain these patterns as many of these programs (such as the Present Use Value program in North Carolina which taxes land based upon its current agricultural production value as opposed to its “best” value which is typically based on a residential use) could still be gained by renting that land out to a farmer (Malme, 1993).

A great deal of sociological research has found that that people engage in agricultural production for a number of personal reasons included but not limited to family tradition (Parker, 2013), stewardship towards the land (Altieri, 1998), the desire to play a certain role in the community (Condon, 2010), or personal interest (Coughenour, 1992). Furthermore, an additional body of sociological research has found fairly consistent relationships between the vitality and average scale of the farm economy and the socio-economic health of predominately rural communities (Goldschmidt, 1978; for a review see Lobao & Stofferahn, 2008). These lines of research typically found that communities dominated by small to medium scale agriculture were social/economically/culturally the healthiest. However other research has found otherwise (Barnes & Blevins, 1992). More recent research on this topic has found that sometimes the strength of these relationships may be moderated by specific demographic (Green, 1985), socio-economic, (Lobao & Schulman, 1991), or social capital (Lyson, Torres & Welsh, 2001) reasons. In recent years, a great
deal of work has focused on the impacts of CAFO operations on surrounding communities; this work has most commonly found negative social impacts and mixed economic impacts with the surrounding community bearing most of the ill effects (Thu & Durrenburger, 1998; Donham et al, 2007).

For the most part, the lines of research cited above cannot distinguish whether it was the presence of small to medium scale farms or the relative “vitality” of the communities that drove the prosperity (or lack thereof) of the other (Skees & Swanson, 1988; Chism & Levins, 1994 Arbuckle & Kast, 2012). It is possible that synergistic relationships exist between communities and their agricultural industries that affect the prosperity of the other. The concept of “vitality” is similar to the concept of “social capital” (Putnam, 2010) and includes such community characteristics as strong interdependence amongst community members, attachment to the place or way of life, a strong array of supporting industries, a consumer base that appreciates this unique sector of the economy, and other related traits. It is thought that these types of traits help to moderate the impacts of negative events that occur at both the level of the individual and the community by establishing a strong support and safety network.

There also exists evidence that a strong agricultural economy may foster further growth within itself. These types of synergistic benefits are thought to be derived from a concentration of relevant and competing businesses/supporting industries. Within the field of economics this it typically referred to as agglomeration economies (Wheaton & Shishido, 1981). While these businesses may be competing, their combined presence has the effect of raising worker skill level, attracting talent to the area, attracting supporting businesses/industries to the area, decreasing relevant search and transaction costs and other benefits (Ottaviano & Puga, 1998; Tveteras & Battese, 2006). The combination of these benefits may outweigh the loss of business due to increased competition from individual firms. It has not been extensively studied whether agglomeration economies exist for farms and farmland (for recent examples see Dorosh & Thurlow, 2012; Dorosh & Thurlow, 2013). Work has shown that rural areas that exhibit “agglomeration economies” have higher rates of return on investments than other rural areas (Gabe, 2005).

HISTORY OF FARMLAND CHANGE IN NORTH CAROLINA

Since 1975 there has been a net loss of farmland in North Carolina although the pattern has been heterogeneous spatially (see Figure 3.2; Agricultural Census, 2014) as well as temporally (see Figures 3.3 through 3.6). All peri-urban areas have seen a decline in the amount of farmland.
Furthermore, much of the real economic growth in agriculture over this time period has occurred in areas with net losses of farmland and can be attributed to the growth of CAFO agriculture (black circles in figures\(^3\)).

Over this same time period there has been a net decline in the number of farms in North Carolina although the pattern of change has been heterogeneous across the state both spatially (see Figure 3.7 and Figure 3.8) and temporally (see Figures 3.9 through 3.12). These patterns have been more homogenous when viewed in percentage terms (Figure 3.8). Furthermore, it should be noted that these losses appear to have occurred irrespective of the distance to the nearest highway (green lines in figures). This pattern of results appears stronger when one focuses solely on areas with CAFO operations.

Focusing now on Figures 3.2 through 3.6, one can see that in those regions that had the greatest net amount of farmland gained or lost the pattern has been consistent over time. In other areas though this has not been the case. Furthermore, one can see that in the 1990s-2000s there was a net gain in farmland and a decline in the loss of farms around urban areas; it is hypothesized that these patterns are due to the growth of peri-urban agriculture and “Local Farming”. This hypothesis is consistent with the observed increases in both population density (data not shown) as well as inflation adjusted net earnings by place of residence (data not shown) over this same time period.

The analysis so far has found a consistent relationship between the decline in farmland and the loss of farms through the 1980’s and then a heterogeneous pattern in the time since then when one views the state as a whole. Changes in average farm size are consistent with these expectations both spatially and temporally (data not shown). One interesting point to note is that the gains in the number of farms since the 1990’s in the Central Piedmont and the far Western Mountains restored those regions to an average farm size consistent with 1975 levels. Unfortunately, publicly available data back to the 1970’s does not contain consistent information on median farm size. Therefore, it is impossible to estimate the change in the distribution of farms on a county basis over this time period. The constancy of farm size in the Piedmont and Mountains is likely tied to the fact that the topography does not allow for the use of large machinery, thus making it harder to achieve economies of scale with regards to row crop production.

\(^3\) This data is derived from public records of operations receiving waste discharge permits; these permits are only applicable in cases where the manure is used to fertilize nearby agricultural fields. This practice is not widely used in the Mountains.
Finally, to address the issue of farm specialization with regards to either row crop or livestock production over the past four decades, the change in the ratio of real receipts from Livestock Production to Crop Production and the change in the ratio of real receipts from Crop Production to Livestock Production were calculated. Once again, there exists heterogeneity across the state both spatially and temporally (data not shown). With regards to livestock specialization, these changes occurred most predominantly in areas of CAFO growth. With regards to row crop specialization, these changes occurred most predominately in areas with unique agronomic characteristics relative to the rest of the state (i.e. organic matter rich soils and a flat topography; NRCS, 2010). This shift towards specialization began in the 1970s and continued at a slow pace through the 1980’s. Further specialization did not occur in the 1990’s but dramatically increased pace at the turn of the century. These occurrences are consistent with a tighter credit market after the farm crises of the 1980’s which would have made financing the purchasing of the ever larger machinery needed to accomplish this shift difficult.

DESCRIPTION OF CONSIDERED VARIABLE CATEGORIES

In order to effect both an agnostic and holistic study of the drivers of farmland loss in NC, a range of variables was selected to be considered. Because of a first differencing procedure used across the dataset to create stationarity, all data had to be variant across time (i.e. no non-changing categorical variables). It was also decided that all data had to be measured at least every 5 years. All data that was sampled non-annually was interpolated to annual intervals using linear splines. Because of the variable selection methodology employed, it was unnecessary to limit our analysis to only a subset of the available data. Instead, as a wide a range of data was collected as possible in order to try and represent many different changes that occurred in society over the studied time interval. All data for which it was appropriate to do so were converted to log form to be used in measuring elasticities; this is standard practice in econometric analysis. Appendix 5 at the end of this document contains a full definition of each variable, the source from which the data was drawn, whether the variable was log transformed for the analysis, whether it was used in nominal or real terms (i.e. adjusting for inflation), which analyses it was specifically used for, and the hypothesis of its expected direction of the effect on the dependent variable

Agriculture

As this analysis is primarily a study of farmland loss, it is logical to include a number of variables that
speak to various aspects of both the ways in which agriculture is conducted as well as its economic impact. The ways in which farming can differ across the state include the relative amounts of row-crop versus livestock based operations, the relative scale of the operations, their degree of mechanization, the amount of and value of labor employed, the degree to which operators participate in Federally Subsidized Agriculture Support Programs and other. In addition, systematic changes to the Tobacco Industry and the associated price support system over the studied period may have driven changes in the amount of farmland. It is important to note that one variable that would be beneficial to include in the analysis but does not have sufficient temporal coverage for the state of NC (available data begins in 2008) is the price of farmland at the county level.

**Economics**

Neoclassical economic theory suggests that individuals engage in agricultural production because the expected net return on their labor/resources will be higher than other forms of employment. Because of the hypothesized relationship between the number of people engaged in agricultural production, the average scale of farming operations, and the incentive to bring additional land into production to achieve increased economies of scale, it is logical to include variables that measure changes in the nonfarm economy in this analysis.

**Infrastructure**

The profitability of agriculture is dependent on being able to bring produced goods to market. Increases in the amount of roads at the county level, which would decrease transport time and distances on average, would improve the profitability of agriculture by decreasing transportation costs. Because increases in the amount of roads at the county level is expected to improve the profitability of farming, one would expect increases in this variable to be associated with increasing amounts of farmland. This is because the increasing profitability would encourage farmers to bring more land into production to achieve greater returns and capitalize on greater economies of scale. On the other hand increasing amounts of infrastructure may be associated with increasing amounts of development which may negatively impact the amount of farmland.

**Industries Broken Down By Standard Industrial Classification (SIC) Code**

These variables all represent the value of the associated industry. Because the skills necessary for employment in some of these industries will overlap more so with the skillset involved with
agriculture, one would expect employment for some industries to be more substitutable for employment in agriculture. Therefore, one would expect increases in the size of some industries to be more closely related to changes in the number of people engaging in farming and indirectly the amount of farmland in production.

**Demographics**

Over time the farming population of North Carolina has become more homogenous in terms of race (Agricultural Census, 2014). Furthermore, in these same areas there has been an increase in population density which is not conducive to the practice of large scale agriculture. Because these changes have occurred contemporaneous with changes in the amount of farmland, it is possible that changes in the demographics at the county level have been systematically associated with changes in the amount of farmland.

**Social**

In many areas of the state that have traditionally been dependent on agriculture, there has been a great deal of urbanization alongside a contemporaneous increase in median household income and decline in indicators of poverty. Today the majority of the largest scale farming in NC takes place in areas of relatively high poverty and low Median Household Income. These areas also tend to be low in population density. Because of the potential that changes in the relative levels of poverty/household buying power may drive changes in the amount of farmland, variables that measure different nuances of changes in the socio-economic status at the county level were included.

**Ecological**

There is a great deal of agronomic evidence that the yields of agricultural operations are improved by greater amounts of biodiversity in the area (Altieri, 1999). This effect may be due to naturally occurring biodiversity’s ability to foster Integrated Pest Management, increased pollination services, increased soil microbial health, or a number of others. Because of this fact it is hypothesized that increasing amounts of Ecological Diversity at the county level will be associated with increased agricultural production. At the same time however, the fact that over the past several decades US agriculture has become more productive while in field biodiversity has declined may lead this analysis to reveal a positive relationship.
METHODS

In order to determine which changes in the socio-economics of counties within NC can be causally related to changes in the amount of farmland, an exploratory Bayesian based analysis was undertaken. The datasets used for this study are the Bureau of Economic Analyses Local Area Personal Income Accounts (a compilation of the economic statistics tracked by various branches of federal government; US Department of Commerce – Bureau of Economic Analysis, 2015) as well as subsets of the Census of Agriculture (Agricultural Census, 2014) the City/County Databooks (University of Virginia Library, 2000) as well as other relevant information such as historical agricultural market prices, the length of the state road infrastructure over time, and the USDA Commuting Zone designations (Parker, 2012); all of these are county level datasets which cover the entire nation. It should be noted that certain economic variables of interest (such as farmland value) are not included in the main analysis because the data is only available for a very small portion of the overall time period. Whenever possible abbreviated analysis were conducted with these variables to ensure their effects were consistent with theory/intuition.

\[ y_{i,t} = AR1 \times y_{i,t-1} + x_{i,t} \times B + n_i + e_{i,t} \] (equation 1.1)

Y is the Dependent Variable, i.e. \( \Delta \) Number of Farms

“i” corresponds to different counties

“t” corresponds to different time periods

AR1 is the strength of the autoregressive process

Where 0 < AR1 <1

x is a matrix of covariates

B is a vector of regression coefficients

\( e_{i,t} \sim n(0,\sigma^2) \) and \( \sigma^2 \geq 0 \)

\( n_i \) is a county level fixed effect

In this analysis we embedded an econometric analysis paradigm used in research conducted by the Federal Reserve (Judson & Owen, 1996) to study Dynamic Panel Data, modeled in the manner of equation 1.1 above. Dynamic Panel Data is repeated measures cross section data with lagged values of the DV used as a covariate; the coefficients of these lagged DV’s can be thought of as a measure of the inertia involved with changes in the dependent variable. A dynamic model was used to conduct the modeling (i.e. lagged values of the DV were used as predictive covariates) because of the anecdotal evidence that exists amongst rural sociologists that changes in rural communities
have a tendency to reinforce subsequent changes (i.e. there is no reversion to the mean). This type of modeling was embedded into an “adaptive shrinkage” variable selection tool (Hoti & Silanpaa, 2006) implemented through a combination of Matlab (Mathworks Inc.) and Winbugs/JAGS (Spiegelhalter et al, 2003; Plummer, 2003). Winbugs/JAGS are freely available software that are designed for easily implementable model fitting in a Gibbs Sampling Framework; Gibbs Sampling is a Markov Chain Monte Carlo analytical technique that is able to explore data spaces/models even if the analytical form of the likelihood function is intractable (Gelman & Hill, 2006). Because Gibbs Sampling algorithms are stochastic, multiple chains were run in parallel and convergence was assessed using the Gelman-Rubin Score (<1.1: Gelman & Hill, 2006). All presented results were generated using random but sensible starting values for the MCMC runs. Sensible starting values were chosen by running the analysis using Unity for all starting values, recording the range of converged values for each type of parameter, and then using that range to select a random starting value from the appropriate uniform distribution. All models presented converged within 1,000,000 iterations; presented results are based on an additional run of 25,000 iterations after convergence had been achieved.

In Bayesian analyses, once can incorporate “beliefs” about the importance/value of model coefficient into a function referred to as “the prior.” These beliefs can either be literal beliefs the experimenter has about the relevant coefficient or can be used as a tool to identify which variables should be included in the analyses through an exploration of the data; we focus our attention on the latter case. For this particular analyses, a prior (i.e. Jeffries Prior) for each variable was chosen so that it was most likely that the variable would not be included in the current analyses (Beta = 0) and at that the same time all other possible values of the coefficient would have small but equal probability of occurring. This type of prior has the effect of only setting a coefficient equal to a non-zero if the data shows good evidence for doing so. While there are a number of other variable selection tools that could have been implemented, this approach does not require any type of calibration and so will work with other analyses without modification of the underlying code (O’Hara & Silanpaa, 2009).

In order for the analyses to identify how changes in each variable were associated with changes in the amount of farmland, all variables for which it was appropriate to do so were first log transformed. Looking at the data in terms of percentage change instead of levels was chosen in order to better understand how the dynamic process of changes in society influence changes in this specific aspect of agriculture. Next, in accordance with the procedure of Judson & Owen (1996), all
data was first differenced to create stationarity (Wooldridge, 2010). All of these first-differenced variables were tested for a common unit root using a MW test (Maddala & Wu, 1999) and any variables showing non-stationarity were excluded from further analyses. Because of the fact that an AR1 process was used for the modeling solely because of computational limitations and not because of testing various lag lengths to find one that was optimal for the data, the MW test was allowed to specify any lag length in its determination of stationarity. All variables described in this paper were found to be stationary. The inclusion of an AR1 lagged first-differenced DV has the effect of correlating the error term of the regression with the current value of the DV, the lagged first-difference DV was instrumented with the lagged DV from 1 time period earlier. While fitting the model, stationarity was imposed by constraining the coefficient of the AR1 term to be between 0 and 1. All data was normalized through z-scoring prior to being used in the analyses.

In order to take as agnostic a view as possible as to what variables may be deemed most relevant to understanding changes in the amount of farmland, a hierarchical Bayesian analysis was implemented. In such an analyses, not only are the coefficients of the regression fitted (first tier), but the distributions from which those coefficients are drawn from as well (second tier). This second tier of parameters is frequently known as hyperparameters (Lunn, 2013; Gelman & Hill, 2006). In all cases, uninformative priors were used so that the data would be able to guide the exploratory analyses. Furthermore, because the counties of NC are thought to share similarities with those in either the same geographic region (NC can be divided into three primary geographic regions on an East-West axis, see Figure 3.1) or the same economic tier (a composite statistic calculated by the NC Department of Commerce that represents their projection of the counties long term economic growth rate; tier 3 counties have the strongest projection), the analyses fit separate variance parameters for each combination of geographicRegion x economicTier. Because farming is typically conducted in similar ways within each of the state’s geographic regions but not across them, separate coefficients were fit for each region. The variance and coefficient parameters were drawn from common distributions respectively allowing for the algorithm to share mutual information across the groups. The covariance matrix was modeled using a non-informed Wishart prior (Df = n+1). It should be noted that this use of hierarchical modeling does not violate the agnostic approach undertaken in the analysis. If the data were to indicate so, complete information would be shared across the groups (this is possible in Bayesian modeling because the fitted terms are drawn from common distributions) and effectively the values of the fitted coefficients would be the same for all groups. This does not constitute a loss of degrees of freedom as would be the case...
Finally, the best model for the data was determined via Deviance Information Criteria score (DIC); this is the Bayesian Equivalent to AIC and BIC (Lunn, 2013). Models that fit separate sets of regression coefficients for each combination of geographicRegion x economicTier consistently failed to converge when run with random starting values. This may be due to either insufficient running time for the model fitting to converge, inappropriate starting values, or independent patterns of relationships amongst the studied variables for each of the nine categories of counties. Test runs of 10-100 times longer burn in periods were run in attempts to achieve convergence with no success. Please find in Appendixes 3 and 4 at the end of this document the annotated Winbugs code used to run the above described model.

Tests of the results of the analyses revealed both serial correlation across the residuals and heteroscedacity across the cross-section as well as a small amount across time. The presence of the serial correlation indicates that there is most likely greater than an AR1 process at play; future work will require more powerful computational hardware to be able to run these more complex models. Heteroscedacity across the cross-section was accounted for by fitting separate variance components to each combination of economicTier x geographicRegion that was used for analyses (see Results). Heteroscedacity across time, while minimal, was accounted for by refitting a refined model and assuming the data was derived from a student t-distribution (dF = 6) instead of a normal distribution as had been done previously. Across all models tested, the results of assuming either normality or a fat-tailed student-t distribution did not affect the qualitative results of the analysis for variables that were common across both models. All presented figures show the results assuming student-t distributions. Furthermore, the results of this analysis are robust to using lagged versions of all covariates to predict the DV indicating that autoregressive processes are at play.

In order to both establish causal relationships between variables identified as important and farmland loss as well as to handle issues of endogeneity, this analysis employs the econometric technique known as instrumental variables (hereafter IV). The issue of endogeneity arises because of the potential that for some variables it may be ambiguous whether they drive changes in the amount of farmland or whether the direction of causation is reversed. An example variable would be the number of farms at the county level. IV techniques are now considered fundamental to the econometric approach and have been used extensively in the literature to date across a diverse range of fields (Buettner, 2001; for an example in epidemiology see Greenland, 2000; for sociology see Gangl, 2010). Because controlled experiments are rarely possible in real world economic
situations, the field of econometrics has developed these powerful tools to deduce the presence and direction of cause and effect. These methodological techniques have been demonstrated to be effective solutions for a number of problems in regression analysis such as omitted variable bias, endogeneity, and measurement error (Greene, 2003). The presence of these issues without accounting for them quantitatively may result in regression results that have biased parameter estimates; proper implementation of IV techniques will result in parameter estimates that are both unbiased and efficient. For the purpose of this analysis, the dependent variable was instrumented without using any autoregressive terms or associated instrumentation of that variable (see above); the instrumentation was done using traditional frequentist methodologies. The first stage results of instrumenting the number of farms is shown in Table 3.2.

For a variable to be a valid “instrument” for a problematic/endogenous covariate, it must fulfill two conditions. First, the instrument must be exogenous meaning that its values are uncorrelated with the error term of the model it is being used to instrument. Second, it must exert its effect on the dependent variable only through the problematic/endogenous covariate. Valid instruments are typically used to find unbiased and efficient parameter estimates through a two-stage least squared methodology. First, the problematic covariate is regressed on all exogenous covariates included the valid instrument. Second, the predicted values of the problematic covariate are used in a regression alongside the other exogenous variables to predict the dependent variable. These resulting parameter estimates are efficient and unbiased. Estimates of their standard errors must be adjusted to reflect the two-stage least squared approach taken. This argument can be extended to the cases of both multiple problematic/endogenous covariates and multiple instruments.

Because of these two conditions, whether a covariate exerts a causal effect on the dependent variable may also be deduced using an IV approach. Instead of using the IV approach to assuage a problematic covariate, the approach may instead be used to establish the causal path from the covariate being studied to the dependent variable. The process of first regressing the covariate being studied on the valid instrument and other exogenous variables can be seen as finding that portion of the covariate's variance that is explained through the exogenously determined instrument. Because this variance is exogenously determined, it fulfills the criteria to be considered “randomly assigned” in the statistical sense of the phrase. Because of this, the same arguments that are used to justify claims of causality in a randomly assigned experiment are applicable to cases of IV approaches (Angrist, Imbens, & Rubin, 1996).
RESULTS

In order to determine the primary drivers of farmland loss in NC from 1975 to the present, the analysis described above was conducted. The primary and most consistent finding of the analysis is that changes in the number of farms at the county level is the most closely associated with changes in the amount of farmland at the county level; the two having a direct relationship. This finding challenges conventionally held beliefs that changes in the number of farms leads to farm consolidation and farm growth with little effect on the amount of farmland. Because of differences in the temporal coverage of different variables across the dataset, it was not possible to include all of the considered variables in the most temporally extensive of the analyses. Because of this fact the results of the analyses will be presented first for the full period of study (1975 to 2011) and then will be presented for a shorter time period (1975 to 2000) using a wider range of economically oriented variables.

In the figures presented below, the variables that have been identified as being statistically different from 0 using the Bayesian Analog of the 95% Confidence Interval (known as the Credibility Interval) have been circled in yellow. Those variables that have an elasticity greater than an absolute value of 0.1 are circled in red. The values of the coefficients should be interpreted as “a 1% change in this variable leads to an X% change in the number of farms” when holding all other variables constant. Furthermore, the posterior probability of inclusion for each variable has been calculated and is presented within the tables below. As with all Bayesian statistics, these models results are stochastic and must be evaluated against all potential models (i.e. all combination of the studied variables being chosen for inclusion/exclusion). The posterior probability of inclusion value presented below represents the probability that the relevant variable is actually predictive of changes in the dependent variable. This value is on scale from 0 to 100% with 100% representing certainty that the variable is predictive of changes in the amount of farmland. A variable was considered as being included in the model during each stochastic run once convergence had been reached if the associated elasticity was sure to be greater than .1; this was the same threshold used to determine if a covariate was “important” to a particular model. The description of the results below will focus on these variable because we can be certain that for those models that included these variables, they had a non-negligible impact.

One can see the results of the analysis on the 1975-2011 using all relevant variables whose temporal coverage spanned the full time period in Figures 3.15 and Table 3.3 along with the diagnostics for the regression in Figure 3.16. These diagnostics plots show, from top to bottom, the
histogram of all model residuals, a simple whisker plot showing the 95% confidence intervals and the median for the residuals of the model grouped by year, and a box plot of the residual values grouped by the geographicRegion x economicTier designation. For the figures showing the results of the analysis, the results of all the variables used are displayed on a single user so the reader may have a sense of context for the strength of one variable’s association with the DV relative to another. For all associated tables however only these variables that were determined to be important using the above described criteria were included. The tables show the quantiles for the range of coefficients that had been fitted for the associated variable through the many runs of stochastic Gibbs Sampling algorithm once convergence had been reached; in Bayesian statistics the fitted coefficient for a covariate is determined by a summary statistic over a large number of stochastic trials. The “percentage included” column corresponds to the percentage of stochastic model fits where the fitted value of the relevant coefficient was sufficiently large to be designated “important” in the analysis. Because of the Bayesian variable selection tool used in this analysis, the standard procedure of model fitting, removing non-significant covariates, refitting, etc. was not followed. The diagnostics shown in Figure 3.16 demonstrate that the residuals are generally consistent with the assumed fat-tailed student-t distributed as well as the amount of heteroscedacity observed across both time as well as between the different groupings of Economic Tier and Geographic Region designations for each county is not excessive. While there is one year that stands out as different from the rest, the results of the analysis do not appear heavily skewed due to this discrepancy. As was mentioned previously, heteroscedacity amongst these different groupings was accounted for by fitting separate variance parameters to each group. Heteroscedacity across time is minimal.

Because the model that fit the data best allowed for different coefficients to be fit for each geographic region, for some variables their effects were unique to certain geographic regions. Looking at Figure 3.15 and Table 3.3 one can see that the most predictive variables for changes in the amount of farmland, for all geographic regions, are changes in the number of farms (direct relationship). This variable was used in at least 50% of the models explored in this analysis. For the Piedmont and the Coastal Plain changes in the amount of fertilizers/agricultural chemicals were important at least 34% of the time. In the Mountains, changes in the length of roads had a consistently important impact. This later finding is consistent with the topography of the Blue Ridge Mountains in which not having road access to sites of production would severely hamper one’s ability to bring goods to market. Furthermore, uniquely for the Coastal Plain, changes in the total
money paid to farm workers is consistently implicated (over 50% of models). Because this time period of study does not contain any variable on the number of people employed within agriculture, it is impossible to know whether this change is due to increasing wages, greater numbers of people employed, or both. Finally, in the Piedmont, changes in the number of infant deaths were selected as important in a small number of the models explored (~2.5%); the number of infant deaths while controlling for the birth rate is frequently used a measure of the health of a population in sociological research. It is important to acknowledge that this finding is robust to controlling for changes in yields as well as changes in the amount of road infrastructure at the county level which has been shown to affect agricultural profitability (Pinson-andersen & Shimokawa, 2006; Binswanger, Khandker & Rosenzweig, 1993).

Focusing now on the period between 1975-2000, we are able to include a great deal more variables that neoclassical economic theory suggests would be important drivers of changes in the amount of farmland. The analysis includes all of the previous variables as well as both measures of the change in the revenue attributed to other economic sectors (as defined by SIC Code), the labor pool associated with agriculture, and several other interesting variables. The results are located in Figure 3.17 and Table 3.4 with the diagnostics of the regression presented in Figure 3.18. It should be noted that relative to the previously described analysis the shorter time period resulted in fewer issues of heteroscedacity over the full panel. Residuals were still consistent with the assumed fat-tailed student-t distribution and there was still relatively little observed heteroscedacity across time.

Within this analysis, changes in the number of farms remains an important predictor of changes in the amount of farmland across all geographic regions. Focusing now on individual geographic regions, for the Coastal Plain a consistent predictor of decreases in the amount of farmland was increases in the amount of money paid to labor. Furthermore, as like the previous analysis, there appears to be important relationships with the amount of fertilizers/agricultural chemicals used in this region and growth in the amount of farmland. This same finding holds for the amount of imputed income; machine work/repair is included in this variable. This finding is consistent with the increased amounts of mechanization found in this part of the state; once again this pattern is robust to controlling for changes in yields. Finally, the previous analysis’ pattern of results with regards to labor expenses continues to hold true. Furthermore, changes in the number of farm workers is not an important predictor. This implies that increases in the amount of farmland in the Coastal Plain are dependent on having access to farm labor that makes less and less in real terms year after year.
For the Mountains, the only two variables that were reliably associated with changes in the amount of farmland are changes in the number of farms and changes in the value of crops held in inventory. Because of the fact that most farmers would be expected to make storage decisions based on current market prices and other relevant factors (i.e. storage capacity, future prices, etc.) , there is no clear relationship between changes in the amount of farmland and changes in this variable.

Finally, the results of the Piedmont region of NC share certain similarities with both the Mountains the Coastal Plain. It was found that growth in the number of people employed with agriculture leads to declines in the amount of farmland (~50% of models) but like the Coastal Plain, so was growth in the amount paid to these workers. There also appeared to be competition between the growth of the financial services industry and farmland (~58% of models tested). This is most likely due to the growth of Charlotte, the financial services capital of NC and the South more broadly, and it attracting labor away from agriculture and into this industry. In addition, it was found that an increasing percentage of the population with a high school education is positively associated with changes in the amount of farmland. In addition, the same relationship between growth in fertilizer/ag chemical use and farm acreage was observed in the Piedmont. This may reflect the drive towards consolidation which has been strongest in the southern part of the region. Finally, it was also found that increasing amounts of “All Other Production Expenses” are associated with increases in the amount of farmland. As this variable essentially measures non-typical agronomic/marketing strategies the changes in this variable can be thought to represent the diversity of ways that producers in the Piedmont earn income from their farms. It is not uncommon for farms in this region of the state to engage in related business such as lumber processing (see chapter 2 of this dissertation).

Furthermore, in contrast to the first presented analysis, during the study period between 1975-2000 we are able to use IV techniques to alleviate the endogeneity issues in the current analysis as well as to simultaneously establish a causal path between changes in the number of farms and changes in the amount of farmland. The endogeneity arises because it cannot be known a priori whether changes in the number of farms drives changes in the amount of farmland or vice versa. The first stage results of instrumenting “Number of Farms” with “Number of Farm Proprietors” using frequentist methodologies is shown in Table 3.1. For reference, a non-instrumented analysis of Number of Farms, conducted the same way as the other Bayesian analysis presented in this work, is shown in Figure 3.8 and Table 3.6. While this variable is not a perfect
instrument, it does possess many characteristics that make it a good candidate for this use. While it does not need to be the case a priori that changes in the number of farm proprietors would affect changes in the amount of farmland by mediating changes in the number of farms, a study of the relevant statistics in the Agricultural Census argues that it does in fact do so within NC. By comparing the total number of farm proprietors to the number of farms, the number of secondary/tertiary operators, and the number of farm operators that are kin to one another, approximately 4/5 of the farm operators in the state are expected to work on farm operations on which a family member owns the land. Scenarios in which an agricultural operation rents additional farmland already in use in response to the addition of a secondary/tertiary farm operator is irrelevant to the current discussion as the net amount of farmland remains constant. Furthermore, the growth of an individual farm due to the marriage/partnership of two operators that own farmland individually is also irrelevant. Thus we need only focus on cases where novel farmland is brought into production without the addition of secondary/tertiary operator. The majority of this new agricultural land is expected to have been previously used for forestry (NRCS, 2014). Given the history of agriculture in most of NC, one would expect that most operations would have converted their timber land suitable for agricultural production to cropland long ago. Any such conversion that occurred during the study period would show up as a net increase in agricultural land in the present study. These conversions would have occurred in response to both increased rates of mechanization and the higher rate of return on agricultural than forestry land. Therefore, one would expect that the majority of forestry land being converted into agricultural land today would occur in the context of the creation of new farms. By definition then the impact of changes in the number of farm proprietors would have on the amount of farmland would be mediated through changes in the number of farms. Finally, much of this forestry land was most likely previously used for and degraded by agricultural production (personal correspondence with agricultural experts across the state), thus precluding it from being an attractive investment for established and profitable agricultural operations outside of very specific situations. Thus for these reasons it is logical to conclude that the majority of the impact of changes in the number of farm proprietors would have on changes on the amount of farmland would be mediated by changes in the number of farms.

Finally, it is logical to consider changes in the number of farm proprietors as being exogenously determined in the current analysis. This is because of the easy availability of mechanization in modern agriculture; changes in the number of farm proprietors typically would not
impact the number of acres that could be managed on an established farm. While this is certainly not true for new farmers, they do not control a large percentage of NC acreage thus allowing us to focus on established operations. Exceptions to this situation would only arise in the advent of insufficient supply of skilled agricultural labor, farms already being heavily mechanized, or mechanization being unsuitable for the unique agronomic characteristics of certain operations. In most regions of NC this constellation of occurrences is unlikely to occur given the current average state of agriculture in each of these regions respectively (author’s personal correspondence with members of NCSU Crop Science, Horticultural Science, and Agricultural Economics Departments).

Given the fact that for both time periods the variable that was the most consistent predictor of changes in the amount of farmland at the county level is changes in the number of farms, the natural question to ask is what causes changes in the number of farms. A similar analysis to the one described above was conducted for predicting changes in the number of farms for both the 1975 to 2011 time period and the 1975 to 2000 time period. The latter analysis allows for the inclusion of a greater range of variables that may have economic consequence on the number of farms at the county level. The results of the 1975 to 2011 time period can be seen in Figure 3.19 and Table 3.5 with the diagnostics of the regression being presented in Figure 3.20. Regression diagnostics do not indicate any problems with the fit of the residuals or heteroscedacity. There were no variables that were identified as having an unambiguous effect on changes in the number of farms across all three geographic regions.

For the Mountains it was found that increasing amounts of fuel (i.e. petroleum products) and increasing median family income levels are associated with growth in the number of farms in ~50% of the considered models. Additional research will need to be conducted to explain the cause/effect relationship between increasing fuel use and increasing number of farms. The latter relationship is consistent with growth of both small farms and increased amounts of retirement age individuals relocating to the South-Western Mountains; these individuals often engage in “hobby farming” with land they have acquired. An additional finding is that increased amounts of money going towards the wages of farm workers is predictive of increasing numbers of farms; there was no found relationship between this variable and growth in the amount of farmland within the Mountains. Finally, it was found that increases in the price of cattle are associated with decreases in the number of farms. This may reflect producers’ desire to capitalize on increased economies of scale for livestock production by consolidating smaller operations together at times when they have greater net cash receipts and can thus afford to invest in additional, necessary equipment.
For the Piedmont region of NC, there were a number of variables of which changes were predictive of changes in the number of farms. A small amount of the time increases in the amount of family assistance being paid out at the county level was negatively associated with changes in the number of farms while increases in the amount of Miscellaneous Income received by farms was positively associated. This latter fact is consistent with the hypothesis put forward to explain the pattern of results in the analyses conducted above that farmers in the Piedmont use their farms as a basis for other businesses (such as lumber). Similar to the Mountains, increases in the amount paid to farm workers was positively associated with increasing number of farms. Another interesting findings for the Piedmont concerned changes in the demographics that predicted changes in the amount of farmland. It was found that increasing numbers of people being born within the county is associated with increasing numbers of farms. The simplest explanation of this finding that agrees with expert knowledge of demographic change within the farming community in the Piedmont of NC is that many of the area’s “new, young farmers” are part of young families. These families may choose this lifestyle for a number of reasons. The final finding from the analysis was the consistent and strong relationship between increasing amounts of people living in poverty and increasing number of farms. This finding implies that in the Piedmont agriculture may frequently serves as a fall back option for those that do not have other means of producing an income. This finding is unique relative to the two other geographic regions and may have important implications for public policy.

Finally, for the Coastal Plain of NC there were only two variables that were found to have an unambiguous relationship with changes in the number of farms. First, it was found that changes in the price of cattle was positively associated with changes in the number of farms. This finding implies that there is a supply of individuals in this portion of the state that are capable of starting cattle production (most likely on pasture) in periods of higher expected returns but do not otherwise farm; in times when cattle prices are low these farms move out of production and the number of farms declines. The second variable found as predictive was the amount of fuel used. Similar to the Mountains, increasing amounts of fuel used is associated with more farms. Given the fact that large amounts of farm consolidation and increasing amounts of mechanization are ongoing in the Coastal Plain, both of which are expected to increase fuel use and decrease the number of farms, additional research will need to be conducted to explain the found relationship.

In order to allow for a direct comparison between the results of this analysis looking at changes in the number of farms and the previous results looking at changes in the amount of
farmland, the number of farms analysis was repeated using the 1975 – 2000 study period. While none of the variables for this analysis were instrumented, shortening the interval of time considered allowed us to include a number of potentially important economic variables. The only variable found to be consistently important for predicting changes in the number of farms are changes in the amount of farm employment. Given that this variable was the only representation of changes in the number of farm proprietors (which must by definition change when a new farm is created), this finding is unsurprising.

This analysis and the one described immediately above (Number of Farms: 1975-2011) had similar results. Each of the different geographic regions had their own set of variables that were found to be predictive of changes in the number of farms. For the Mountains, some of the same variable as were implicated previously once again were so. Changes in the amount of fuel used were once again consistently found to be predictive of changes in the amount of farmland. Changes to median family income and farm wages were not though. In ~20% of the models explored there was a positive relationship between growth in the number of farms and growth of the retail economic sector; this growing sector may provide additional points of sale to consumers. Finally the same negative relationship between the price of cattle and the number of farms is once again found. For the Piedmont, many of the variables that were highlighted in the 1975-2011 analysis were no longer found to be predictive of changed in the number of farms in the present analysis. There was still found to be a consistent and positive relationship between increases in the number of families living in poverty and the number of farms but in addition there was also found to sometimes be (~20% of models) a positive relationship with tobacco acreage. This finding is consistent with many small farms sustaining themselves with the revenues generated from tobacco sales; as the subsidy program was phased out and these revenues fell many of these smaller farms may not have been able to sustain themselves. In addition, negative relationships were found fairly consistently (~50% and ~35% respectively) between changes in the price of milk and changes in the amount of livestock purchased with changes in the number of farms. The first finding may reflect a drive towards consolidation when prices are high and there is more disposable income for investment in capital. The latter finding may reflect the fact that many farms in the Piedmont are small scale livestock operations that rely on on-farm breeding to maintain livestock populations from one year to the next. Having to purchase livestock from off the farm may make these farms non-viable leading to the negative relationship. Finally, ~40% of the time growth in the services industry was found to be positively associated with growth in the number of farms. As production
agriculture related services would have been grouped under the Agriculture SIC Industry, this finding is most likely caused by the growth in Agritourism that is more and more frequently taking place on small acreage farms (Bagi, 2012). Finally the results for the Coastal Plain in the current analysis mirrored the previous results except that there was now a positive relationship between growth in forest coverage and the number of farms. As the vast majority of this land is or has been used for agriculture previously, it is reasonable to conclude that much of this reforestation is occurring on previously used farmland that has become too infertile for crop production. As large scale, mechanized operations would be less likely to convert a portion of their holdings to a land use that would preclude the use of their current machinery, reforestation is most likely being conducted on smaller scale operations that are looking to diversify their revenue stream.

In evaluating the results of the above described analyses, one point should be noted concerning the nature of the variable selection tool used. For all of the presented analysis, a number of variables that have both utility as predictors but also controls for other variables were included. Some examples of these variables are population, number of jobs, overall size of the farm and non-farm economies, etc. Many of the findings are made more interesting and explainable when the analysis is viewed in the manner of a typical regression such that each regression covariate represents the effect of some change while holding all of the other covariates constant. However, whether one can do this within a variable selection algorithm is ambiguous. The entire point of the algorithm used is to decide which variables, based on the available data, are most sensible to include in subsequent analyses. If a variable isn’t selected, can we still interpret the meaning of regression coefficients in the traditional way? Regardless of the answer to this philosophical question, a subset of the above described analyses was repeated in the following manner. For these “control variables,” instead of applying a prior that implied a “variable selection” component, a traditional non-informative normal prior (mean 0, variance 10,000) was used. This had the effect of forcing these variables into the final regression so that there would be no ambiguity as to the appropriate way of interpreting the covariates that were selected from the variable selection algorithm. This procedure did not qualitatively change the results (data not shown).

DISCUSSION AND CONCLUSIONS

Farmland preservation is an important issue for a number of diverse but complementary reasons. Traditional economic analyses employed to explain the ongoing loss of farmland, both
nationwide and in NC, have focused on the relative profitability of agricultural relative to non-agricultural businesses. In contrast to this general approach, the current agnostic exploratory analysis has found that these relative changes are not predictive of changes in the amount of farmland. Furthermore, changes in the number of farms has been found to be the best predictor of changes in the amount of farmland.

The rationale for conducting this analysis was to take an honest, unbiased, and open-minded look at the drivers of farmland gain and loss at the county level within North Carolina. Traditionally, many people have turned to economic theory to explain these changes. However, there exists both research from other fields of study as well as anecdotal evidence to suggest that economic theory may not capture all of the important drivers at play. The major contribution to the literature this research effort makes is to highlight a broader range of factors that future researchers should consider as they further study the drivers of farmland loss/gain. Because of various methodologies employed in the present study, such as log transforming all appropriate variables, standardizing, as well as viewing the fitted regression coefficient values in the light of the variable selection algorithm used, it is difficult to compare the results of this study vis-à-vis a traditional economic analysis.

The major finding of this analysis was that for the state of North Carolina, during the period from 1975-2011, the most consistent predictor of changes in the amount of farmland was changes in the number of farms. It is important to note that these two variables are not merely two sides of the same coin. Because of the potential for farm consolidation, the movements of these two variables need not be directly linked. This can be seen in the fact that farm consolidation has happened heterogeneously across the state with it being by far the most commonplace in the Coastal Plain of North Carolina. In addition, it is unlikely that changes in the number of farms is merely acting as a proxy for “urbanization” and other metrics that were not directly measured but are logically connected to changes in the number of farms. However, this explanation is unlikely given the fact that a number of variables that would be expected to be highly correlated with changes in the degree of urbanization (median income levels, % of population white, changes in non-agricultural industry revenue, etc) were not implicated in the analyses. Finally, the fact that variables representing alternative land uses (directly represented by the amount of road infrastructure and the amount of forestland and proxied by changes in the population) were rarely implicated in the analyses leaves unclear what land removed from agricultural production is now used for. The two most likely possibilities are that the land is now sitting idle (farmers looking to
limit their cultivated acreage would first remove the least fertile lands) or that there isn’t a consistent pattern into what these lands are converted into.

As was stated above, the contribution of this analysis is to demonstrate the range of societal changes for which there is evidence that there exists meaningful and unambiguous relationships between them and changes in the amount of farmland. While it is difficult to translate these changes and their effects into a single value metric, this analysis remains useful across a range of circumstances. For example, for policy makers at both the State and Federal levels, this research may prove to be a guide of how to avoid certain unintended consequences of policy changes by highlighting the interrelationships that do exist between changes in the amount of farmland and other factors. An example of this would be Federal Agricultural Subsidization Policy (i.e. “Crop Insurance”, crop support payments, subsidized infrastructure upgrades, etc.). While these policies do not by definition discriminate against small acreage farmers, they do so de facto because of various requirements for participation, the way subsidization is calculated, as well as essentially not rewarding diversified operations (which most small acreage producers are) by making their costs of participation effectively higher. If policy makers who are involved with the formation of these Agricultural Subsidization policies are also interested in preserving farmland within their districts, policies that discriminate in the described way actually work against these individuals’ dual interests. Regardless of the exact scenario imagined, the important point to take away from this analysis is that many decisions are not based on economic tradeoffs. These decisions may have unintended consequences because the decision maker does not appreciate how their world is interconnected. The value of analyses such as these, while not per se giving individuals a recipe book as to how to weigh various tradeoffs, does highlight which variables, societal changes, and interdependencies need to be full considered to understand the full ramifications of any decision. Further work that takes the result of analyses such as this as the starting point will need to be conducted to elucidate more precisely how one should appropriately value such tradeoffs.

In summary, the findings from the analysis described in this paper have profound implications for how people concerned with the issue of farmland preservation should view the issue of farm consolidation. On the surface, farm consolidation does not appear detrimental to maintaining farmland because farmland is initially maintained while the number of farms decreases. However these findings indicate that over time the loss in the number of farms will be associated with loss of farmland; consistent with these findings is the notion that supporters of farmland preservation should support the continued functioning of all farms in a given region in order to
maintain the current number of farms. Furthermore, these findings further indicate that in order to bring new land into agriculture, it will be far more effective to encourage the creation of additional farms than to simply buy from already existing, profitable farms in the same area as all of the variables that speak to issues of farm revenue (overall farm income, revenue generated from crop sales, revenue generated from livestock sales, amounts spent on a variety of inputs, and the amount received in government agricultural subsidies) had no impact on the amount of farmland. Further work should be done to scale up this analysis to the whole nation as well as to expand the analysis to take an even broader view of how changes in the amount of farmland at the county level may be tied to other types of demographic or socio-economic changes at the county level. In addition, this analysis tool can be used to holistically explore the interconnections between other aspects of society in an unbiased and atheoretical way.
Figure 3.1: Map of North Carolina Counties/Geographic Regions (Source: NCpedia)
Figure 3.2: Change in Farmland at County Level (1975-2011). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations.
Figure 3.3: Change in Farmland at County Level (1975-1985). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations.
Figure 3.4: Change in Farmland at County Level (1985-1995). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations.
Figure 3.5: Change in Farmland at County Level (1995-2005). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations.
Figure 3.6: Change in Farmland at County Level (2005-2011). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations.
Figure 3.7: Change in Number of Farms at County Level (1975-2011). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations.
Figure 3.8: Percentage Change in Number of Farms at County Level (1975-2011). Green lines are the state’s interstate highway system, green dots are the locations of registered CAFO operations.
Figure 3.9: Change in Number of Farms at County Level (1975-1985). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations.
Figure 3.10: Change in Number of Farms at County Level (1985-1995). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations.
Figure 3.11: Change in Number of Farms at County Level (1995-2005). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations.
Figure 3.12: Change in Number of Farms at County Level (2005-2011). Black lines are the state’s interstate highway system, black dots are the locations of registered CAFO operations.
Figure 3.13: Change in Tobacco Acreage (1975-2004: Tobacco Subsidies in Place). Black lines are the state’s interstate highway system.
Figure 3.14: Change in Tobacco Acreage (2004-2011: Tobacco Buyout). Black lines are the state’s interstate highway system.
Figure 3.15: Elasticity of Change for Farm Acreage by County (1975-2011). All Data first differenced. Autoregressive term included. Residuals fitted with student-t distribution (df = 6)
Figure 3.16: Regression Diagnostics – Change in Farm Acreage by County (1975-2011)
Figure 3.17: Elasticity of Change for Farm Acreage by County (1975-2000) – Number of Farms Variable Instrumented with Number of Farm Proprietors. All Data first differenced. Autoregressive term included. Residuals fitted with student-t distribution ($dF = 6$)
Figure 3.18: Regression Diagnostics – Change in Farm Acreage by County Instrumented with Changes in Number of Farms (1975-2000)
Figure 3.19: Elasticity of Change for Number of Farms by County (1975-2011). All Data first differenced. Autoregressive term included. Residuals fitted with student-t distribution (dF = 6)
Figure 3.20: Regression Diagnostics – Change in Number of Farms by County (1975-2011)
Figure 3.21: Elasticity of Change for Number of Farms by County (1975-2000). All Data first differenced. Autoregressive term included. Residuals fitted with student-t distribution (dF = 6)
Figure 3.22: Regression Diagnostics – Change in Number of Farms by County (1975-2000)
### Table 3.1: Variables Included in Bayesian Variable Selection Analysis

<table>
<thead>
<tr>
<th>Variable Name and Definition</th>
<th>Data Source</th>
<th>Converted from Nominal to Real</th>
<th>Variable Log Transformed</th>
<th>Combined with other Counties in Same Commuting Zone</th>
<th>Analyses Variables Used In</th>
</tr>
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<tbody>
<tr>
<td>Land in Farms</td>
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### Table 3.1 Continued

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Table 3.2: Instrumentation Results Number of Farms
Variables Highlighted Green Significant at 5% Level

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Table 3.3: Analysis Results for Predicting the Drivers of Changes in Land in Farms (1975 to 2011)

The variables, for a given geographic region, that always have a have non-zero positive influence/non-zero negative influence (95% Credibility Interval) have been shaded green/red. 50% Quantile = Median

Only consistently impactful variables shown

<table>
<thead>
<tr>
<th>Quantile</th>
<th>Mountains</th>
<th></th>
<th></th>
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<th>Piedmont</th>
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<th>Coastal Plain</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>5%</td>
<td>50%</td>
<td>95%</td>
<td>% Inc</td>
<td>5%</td>
<td>50%</td>
<td>95%</td>
<td>% Inc</td>
<td>5%</td>
<td>50%</td>
<td>95%</td>
<td>% Inc</td>
<td></td>
</tr>
<tr>
<td>Fertilizer and Lime Inc. Ag Chemicals Real</td>
<td>-0.054</td>
<td>0.018</td>
<td>0.100</td>
<td>0.049</td>
<td>0.013</td>
<td>0.082</td>
<td>0.151</td>
<td>0.339</td>
<td>0.006</td>
<td>0.108</td>
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<tr>
<td>Hired Farm Labor Expenses Real</td>
<td>-0.066</td>
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<td>0.094</td>
<td>0.040</td>
<td>-1.41</td>
<td>-1.58</td>
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<td>0.203</td>
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<td>-0.081</td>
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<tr>
<td>Farm Supplements to Wages and Salaries Real</td>
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<td>0.024</td>
<td>0.083</td>
<td>0.014</td>
<td>-0.040</td>
<td>0.029</td>
<td>0.094</td>
<td>0.036</td>
<td>0.021</td>
<td>0.106</td>
<td>0.184</td>
<td>0.544</td>
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<tr>
<td>Number of Farms</td>
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<td>0.143</td>
<td>0.247</td>
<td>0.752</td>
<td>0.105</td>
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<td>0.044</td>
<td>0.106</td>
<td>0.165</td>
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<tr>
<td>Num of Infant Deaths</td>
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<td>0.036</td>
<td>0.096</td>
<td>-0.092</td>
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<td>-0.008</td>
<td>0.027</td>
<td>-0.025</td>
<td>0.016</td>
<td>0.058</td>
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<td>Length of Roads</td>
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<td>0.026</td>
<td>-0.060</td>
<td>-0.002</td>
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Table 3.4: Analysis Results for Predicting the Drivers of Changes in Land In Farms – Number of Farms Instrumented (1975 to 2000)

The variables, for a given geographic region, that always have a non-zero positive influence/non-zero negative influence (95% Credibility Interval) have been shaded green/red. 50% Quantile = Median

Only consistently impactful variables shown

<table>
<thead>
<tr>
<th>Quantile</th>
<th>Mountains</th>
<th>Piedmont</th>
<th>Coastal Plain</th>
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<tbody>
<tr>
<td></td>
<td>5%</td>
<td>50%</td>
<td>95%</td>
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<td>CZ -Finance, Insurance, and Real Estate</td>
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<td>0.006</td>
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<td>Farm Employment</td>
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<td>Imputed and Misc Income Received Real</td>
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<td>All Other Production Expenses Real</td>
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<td>Value of Inventory Change Crops Real</td>
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<td>Number of Farms</td>
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<td>-0.039</td>
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Table 3.5: Analysis Results for Predicting the Drivers of Changes in Number of Farms (1975 to 2011)

The variables, for a given geographic region, that always have a non-zero positive influence/non-zero negative influence (95% Credibility Interval) have been shaded green/red. 50% Quantile = Median

<table>
<thead>
<tr>
<th>Quantile</th>
<th>Mountains</th>
<th>Piedmont</th>
<th>Coastal Plain</th>
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<td>Adjustment for Residence</td>
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<td>Real</td>
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<td>Imputed and Misc Income</td>
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<td>Received Real</td>
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<td>Petroleum Products</td>
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<td>Num of Infant Deaths</td>
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<td>Median Family Income Real</td>
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<td>Pct Families Low Income</td>
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<tr>
<td>Real</td>
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</tr>
<tr>
<td>Cattle Prices Real</td>
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Table 3.6: Analysis Results for Predicting the Drivers of Changes in Number of Farms (1975 to 2000)
The variables, for a given geographic region, that always have a have non-zero positive influence/non-zero negative influence (95% Credibility Interval) have been shaded green/red.  50% Quantile = Median

<table>
<thead>
<tr>
<th>Quantile</th>
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<th>Coastal Plain</th>
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<td>50%</td>
<td>95%</td>
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<tr>
<td>CZ -Retail Trade Real</td>
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<td>CZ -Services Real</td>
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<td>Farm Employment</td>
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<td>Livestock Purchased Real</td>
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<tr>
<td>Pct Families Low Income</td>
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<td>0.126</td>
</tr>
<tr>
<td>Forest Acreage</td>
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<td>Tobacco Acreage</td>
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REFERENCES


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Parker, J. S. (2013). Integrating culture and community into environmental policy: Community tradition and farm size in conservation decision making. *Agriculture and Human Values, 30*(2), 159-178.


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APPENDICES
Appendix 1

Preletter
Survey Cover Letter,
No Response Follow-up Letter

For Economic Survey of Farmers across NC
A few days from now you will receive a questionnaire for an important research project being conducted across North Carolina by the Center for Environmental Farming Systems. The Center for Environmental Farming systems is part of the NCDA&CS, NCSU, NCA&TSU, and the North Carolina Cooperative Extension Service.

Across North Carolina, there is growing interest in local agriculture as a way to improve on-farm profitability, grow new businesses and create jobs, preserve farmland, and raise consumer awareness about the importance of agriculture to the state. As the consumer interest in local agriculture has soared, there are many new additional direct and wholesale market opportunities; not only for small farmers, but also for mid-scale and large farms as big institutions, universities, grocery stores, retail markets, and even the military bases expand their business models to meet the growing demand. Despite these novel opportunities, many of the state’s farmers are not yet able to capitalize on this growing enthusiasm for local agriculture because they have not been able to sell into these new markets. The findings of this research will make it easier for more farmers to access these new markets and profit from this growing excitement about local agriculture.

The questionnaire concerns the economic situation agriculture currently faces across the state and where you and the idea of “local” currently fit into the bigger picture. The study is an important one that will help encourage the growth of these new local agricultural markets that will lead to more opportunities for you to sell the goods you are producing. All of your data will remain confidential; the Institutional Review Board of NCSU has approved this research.

Thank you both for your time and for considering participating in this effort. It is only with the help of people like you throughout the state that we can do this work. There will be a small token of our appreciation packaged with the questionnaire.

Sincerely,

NANCY CREAMER             JOHN O’SULLIVAN             RELEVANT DIRECTOR
Directors of the Center for Environmental Farming Systems       Coop. Ext. Director of County
Dear PARTICIPANT,

We, Nancy Creamer & John O’Sullivan, Co-Directors of the Center for Environmental Farming Systems (CEFS) and INSERT NAME, Director of the INSERT COUNTY County Cooperative Extension Service, are asking for your help. CEFS is a partnership of the North Carolina Department of Agriculture and Consumer Services, NC State University, and NC A&T State University and is dedicated to ensuring profitability for farmers and the long-term viability of agriculture in North Carolina. The focus of CEFS is not limited to just the production of farm products, but also includes other aspects of the food system from farm to fork including market development, infrastructure development, and raising consumer awareness about the importance of agriculture.

We are contacting you because we are conducting a study to determine the economic potential of local agriculture by evaluating the direct and indirect economic impacts of both it and agriculture more broadly on everyone in the value chain. Your name was selected from a random sample of agricultural operations across the state. The economic information we are collecting will help foster the growth of this segment of the economy and create opportunities of great value to you and to North Carolina.

We understand that you may have concern about sharing economic information about your operation. While this survey is voluntary, your response is extremely important. Information provided by respondents will remain completely confidential. We will never publish any information that can be linked back to your operation.

All surveys that are returned to us will be entered into a drawing for a $250 donation to be made to a community organization of the winner’s choosing. Even if you don’t operate an agriculture-based business and only own land used for agriculture, we ask that you please return the survey after following its instructions. All returned surveys will be entered into the drawing.

Our goal as directors of the CEFS and INSERT COUNTY County’s Cooperative Extension Office is to ensure the long-term strength of the North Carolina Agricultural Community. If you would like more information please contact us or the project coordinator, Drew Marticorena. Our contact information may be found on the next page. We would like to thank you both for your time in considering our request as well as for the job you do in keeping North Carolina strong.

Sincerely,

NANCY CREAMER    JOHN O’SULLIVAN    COOP EXT. DIRECTOR
SECURITY PROTOCOLS

Thank you for considering participating in the study. If you are inclined to participate in this effort but remain concerned about our security protocols we ask that you please contact us or the project coordinator, Drew Marticorena; all contact information may be found below. We will be able to discuss with you our exact security protocols as well as other issues involving data security. Furthermore, if you would like to speak in person with a representative of this project before you decide whether to participate, we can arrange for a member of the project’s staff to visit with you at the site of your operation at your convenience. In order to ensure the accuracy and completeness of this project, we will strive to do everything we can to alleviate people’s concerns.

We will never use information you give us to compare against tax or other business records. All identifying information will be removed from our records as soon as they are no longer needed for our analysis. Please know that while your participation in this project is subject to disclosure through the Freedom of Information Act until we are able to destroy this information, your “privileged or confidential commercial or financial information” can NEVER be disclosed through such requests. (US Security and Exchange Commissions FOIA Exemptions #4; http://www.sec.gov/foia/nfoia.htm)

Contact Information for Drew Marticorena
Cell Phone: XXX XXX XXXX
Email: xxxxxxxxxx@ncsu.edu

Contact Information for Nancy Creamer
Office Phone: XXX XXX XXXX
Email: xxxxxxxxx@ncsu.edu

Contact Information for John O’Sullivan
Office Phone: XXX XXX XXXX
Email: xxxxxxxx@ncat.edu
Dear PARTICIPANT,

In the past few weeks we mailed you a letter and a survey asking for your help to support North Carolina Agriculture. The information we hope you'll be willing to provide is necessary for the success of this research project. Please find enclosed a replacement survey.

We understand that you may have concern about sharing this information about you and your business. While this survey is voluntary, your response is extremely important. Information provided by respondents will remain completely confidential. We will never publish any information that can be linked back to you or your business.

If you have returned the survey please accept our sincere apologies for the confusion. If you have not yet but would be willing to do so, at your convenience please complete the included replacement survey. Thank you so much for helping us to find way to better support North Carolina Agriculture. If you would like more information please contact us or the project coordinator, Drew Marticorena. Our contact information may be found below. We would like to thank you both for your time in considering our request as well as for the job you do in keeping North Carolina agriculture strong.

Sincerely,

NANCY CREAMER  
JOHN O’SULLIVAN  
COOP EXT DIRECTOR

Contact Information for Drew Marticorena
Cell Phone: XXX XXX XXXX
Email: xxxxxxx@ncsu.edu

Contact Information for John O’Sullivan
Cell Phone: XXX XXX XXXX
Email: xxxxxxx@ncat.edu

Contact Information for Nancy Creamer
Cell Phone: XXX XXX XXXX
Email: xxxxxxx@ncsu.edu

Contact Information for Coop. Ext. Director
Cell Phone: XXX XXX XXXX
Email: xxxxxxx@ncsu.edu
SECURITY PROTOCOLS

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Contact Information for Drew Marticorena
   Cell Phone: XXX XXX XXXX
   Email: xxxxxxxx@ncsu.edu

Contact Information for Nancy Creamer
   Office Phone: XXX XXX XXXX
   Email: xxxxxxxx@ncsu.edu

Contact Information for John O’Sullivan
   Office Phone: XXX XXX XXXX
   Email: xxxxxxxx@ncat.edu
Appendix 2

Survey Instrument for Economic Survey of Farmers across NC
1. Your name: _______________________________________________________

2. Do you operate an agricultural business that uses the agricultural land you own or do you rent the land to another Individual/Business?
   □ I use the land for my own business
   □ I rent the land to: _____________________________________________

   Contact information for this Individual/Business: ______________________
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________

   IF YOU DO NOT PERSONALLY OPERATE AN AGRICULTURE BUSINESS, PLEASE SKIP AHEAD TO PAGE 22

3. Name of your business: ______________________________________________

4. In which county did the majority of your production take place within in 2012?
   ________________________________________________________________

5. What are the major commodities/livestock/goods you produced in 2012?
   ________________________________________________________________
   ________________________________________________________________

6. How many acres did you manage in 2012? (either owned or rented from someone else)
   ________________________________________________________________
7. How much of your farm’s money (revenue) was made selling direct (to consumers, to restaurants, to food hubs, to processors, etc) in 2012?

☐ 0%-9%  ☐ 10%-19%  ☐ 20%-29%  ☐ 30%-39%  ☐ 40%-49%

☐ 50%-59%  ☐ 60%-69%  ☐ 70%-79%  ☐ 80%-89%  ☐ 90%-99%

☐ 100%

PLEASE MARK ALL THAT APPLY

8. How did your business make money (revenue)?

☐ By operating a farm  ☐ By operating an Ag-Related business

9. What type of Ag-Related business did you manage (if applicable)?

☐ Farm Supply Store

PLEASE MARK ALL THAT APPLY

☐ Are you a farm supply store open to the public?

☐ Are you a wholesaler of Farm Inputs?

What goods did you sell?

☐ Fertilizer  ☐ Substrates  ☐ Seeds

☐ Livestock  ☐ Livestock Supplies  ☐ Hand Equipment

☐ Power Equipment  ☐ Equipment Parts  ☐ Building Supplies

☐ Pesticides  ☐ Herbicides  ☐ Other Chemicals

☐ Other: ______________________________________________________

☐ Aggregator/Distributor of Agricultural Products (reselling goods that you have purchased from another farm/operation)

What goods are being resold/redistributed? ____________________________

_________________________________________________________
☐ Processor

What are the final product(s) produced? ______________________________
____________________________________

From where did you get the raw materials for the processing?
☐ Your Own Farm          ☐ Another Farm         ☐ Both
☐ Other: ________________________________

Have you been contracted by another person/business to do this processing?
☐ Yes: If so, by whom:_________________________  ☐ No

☐ Direct Sales to/through

         PLEASE MARK ALL THAT APPLY

☐ Restaurant          ☐ Roadside Stand
☐ Farmer’s Market Stand  ☐ Agritourism
☐ CSA

☐ Other: ________________________________

____________________________________
In order to build an accurate understanding of the current impact agriculture has on North Carolina we need information about who is managing agricultural businesses, how many people are being employed, and the rate at which they are being paid at across the state.

THIS, AND ALL OTHER INFORMATION, WILL BE KEPT STRICTLY CONFIDENTIAL

10. What was your business annual net revenue in 2012?

Revenue is the income your business made without taking into account the costs of doing business (i.e. money that your business brings in)

☐ Less than $3,999  ☐ $4,000-$7,999  ☐ $8,000-$15,999
☐ $16,000-$31,999  ☐ $32,000-$63,999  ☐ $64,000-$127,999
☐ $128,000-$255,999  ☐ $256,000-$511,999  ☐ $512,000-$1,023,999
☐ $1,024,000-$2,047,999  ☐ Greater than $2,048,000

11. Business annual profit in 2012?

Profit is money your business made minus the cost of doing business (rent/mortgage on land, input costs, equipment costs, purchased services, all labor/salary costs.

EXCLUDE salary/wages paid to you and your immediate family members)

☐ I lost money  ☐ No profit  ☐ Less than $1,999
☐ $2,000-$3,999  ☐ $4,000-$7,999  ☐ $8,000-$15,999
☐ $16,000-$31,999  ☐ $32,000-$63,999  ☐ $64,000-$127,999
☐ $128,000-$255,999  ☐ Greater than $256,000
12. How many individuals do you employ in each season in your operation:
   
   Spring: ________________________________
   Summer: ______________________________
   Fall: _________________________________
   Winter: ______________________________

13. What is the average wage per hour paid to hired individuals who work on an hourly basis?
   
   Part Time: ______________________________
   Full Time: ______________________________
FROM WHOM DO YOU BUY GOODS AND SERVICES FOR YOUR BUSINESS?
PLEASE LIST THE INDIVIDUALS/BUSINESSES YOU BUY THE MOST FROM FIRST
On the attached page (pages 8-13), please list all individuals/businesses you **PURCHASED** goods or services from over the past calendar year (Jan 1, 2012 – December 31, 2012). Please list the Individuals/Businesses you do the MOST business with first. Please include the amount of rent/mortgage payments you pay on land. Consider goods to include all direct inputs to the production process (fertilizer, soil amendments, seed, livestock, feed fuels, utilities, etc) as well as any indirect inputs that are necessary (machinery, organizational supplies, building supplies, etc). Please consider services to include any agreement that was made (both formal, contractual, agreements as well as informal “handshake”

<table>
<thead>
<tr>
<th>Individual/Business Name</th>
<th>Goods/Services Bought</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rent/Mortgage on Land</td>
<td>All rent/mortgage payments you made in 2012 on land your business is operating on</td>
</tr>
<tr>
<td>1</td>
<td></td>
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<tr>
<td>2</td>
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<td>7</td>
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<tr>
<td>8</td>
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</tr>
</tbody>
</table>
Buy Goods or Services From

agreements) for some service to be performed by an individual/organization not employed by you (clearing land, timber harvests, processing/transporting livestock, lawyers, accountants, consultants, etc). Whenever possible, please also include information about where the individuals/businesses are located, what goods/services are being bought and sold, whether these purchases are wholesale/retail/direct, the total amount of business you do with that individual/business per year, and whether most of the business is done in a single portion of the year or evenly throughout. If the available space is not sufficient please request additional pages.

<table>
<thead>
<tr>
<th>County That Business is Located In</th>
<th>Total $ Value of Purchases in 2012</th>
<th>Do You Only Make These Purchases at One Time During the Year?</th>
<th>Are You Buying Wholesale/ Retail/Direct</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOT APPLICABLE</td>
<td>NOT APPLICABLE</td>
<td>NOT APPLICABLE</td>
<td>NOT APPLICABLE</td>
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</tbody>
</table>
WHOM DO YOU SELL GOODS AND SERVICES TO?

PLEASE LIST THE INDIVIDUALS/BUSINESSES YOU SELL THE MOST TO FIRST

IF YOU SELL DIRECT THROUGH A ROADSIDE STAND/ FARMERS MARKET BOOTH/ CSA, PLEASE LIST EACH AS SINGLE ITEM
On the attached page (pages 16-21), please list all individuals/businesses you SELL goods or services to over the past calendar year (Jan 1, 2012 - December 31, 2012). Please consider goods to include all products sold outside of your operation, regardless of whether you produced the product or are reselling it. Please only include goods/services sold outside of your operation. For example, if your farm produces hay, only include it here if it sold off farm; do not include hay if it is fed to your own livestock. Please consider services to include any agreement.

CONTINUED ON FACING PAGE

<table>
<thead>
<tr>
<th>Individual/Business Name</th>
<th>Goods/Services Sold</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DIRECT SALES THROUGH FARMER’S MARKET BOOTH</strong></td>
<td>VALUE OF ALL SALES THAT GO THROUGH A FARMER’S MARKET STALL YOU OPERATE</td>
</tr>
<tr>
<td><strong>DIRECT SALES THROUGH ROADSIDE STAND</strong></td>
<td>VALUE OF ALL SALES THAT GO THROUGH A ROADSIDE STAND YOU OPERATE</td>
</tr>
<tr>
<td><strong>DIRECT SALES THROUGH CSA</strong></td>
<td>VALUE OF ALL SALES THAT GO THROUGH A CSA PROGRAM YOU OPERATE</td>
</tr>
<tr>
<td><strong>AGRITOURISM</strong></td>
<td>VALUE OF ALL AGRITOURISM ACTIVITIES THAT ARE ASSOCIATED WITH YOUR AG OPERATION</td>
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</table>
Sell To or Provide Services For

you or your organization made – (both formal, contractual agreements as well as informal “handshake” agreements) to complete work not directly related to your own production (clearing land, timber harvests, processing/transporting livestock, consulting, etc). Whenever possible, please also include information about where the individual/business you are working with are located, what goods are being bought and sold, the total amount of business you do with this individual/business per year, and whether most of the business is done in a single portion of the year or evenly throughout. If your operation engages in agritourism activities please include the total amount of business as a single line item.

<table>
<thead>
<tr>
<th>County That Business is Located In</th>
<th>Total $ Value of Sales or Services Rendered in 2012</th>
<th>Do you only make these sales at one time during the year?</th>
<th>Are You Selling Wholesale/Retail/Direct</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIRECT</td>
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<td>DIRECT</td>
</tr>
</tbody>
</table>
In the last section we ask about your demographic information so that we have a better understanding of who is answering our survey. This is to ensure that the survey participants are representative of the state as a whole. Finally, we ask that you share information about your personal household income so that we can understand the degree to which agricultural business’ revenue/profits contributes to household wealth within the state.

14. Demographic Information:
   a. Year of Birth: ________________________________
   b. Sex:  [ ] Male  [ ] Female
   c. Your Race
      PLEASE MARK ALL THAT APPLY
      [ ] White  [ ] Asian
      [ ] American Indian or Alaska Native
      [ ] Black or African American
      [ ] Native Hawaiian or Other Pacific Islander
   d. Are you of Spanish, Hispanic, or Latin origin or background?
      [ ] NO  [ ] YES
   e. Country of Birth: ________________________________
      If United States – State of Birth: __________________
      If North Carolina – County of Birth: _________________
   f. Did you complete high school?  [ ] NO  [ ] YES
      If YES, Highest Educational Degree Attained: ____________
15. Did you live on your farm at any time during 2012?  □ NO  □ YES

15. Do you think part of your operation could be certified USDA Organic given current production practices?

□ NO  □ YES

IF YES: Approximately what percentage of your operation do you think could have been certified USDA Organic in 2012? ________

IF YES: What percentage of your operation was certified USDA Organic in 2012? ________________________________

16. What was your personal household annual income in 2012 (all members of your immediate family, all income sources before taxes)?

PLEASE CHOOSE ONE

□ Less than $10,000  □ $10,000-$14,999  □ $15,000-$24,999

□ $25,000-$34,999  □ $35,000-$49,999  □ $50,000-$74,999

□ $75,000-$99,999  □ $100,000-$149,999  □ Greater than $150,000
Thank you for your help with this study. We could not do this work without you.

Please contact any of the Project Coordinators with any question/concerns about this project.

Contact Information for Drew Marticorena
Cell Phone: XXX XXX XXXX
Email: xxxxxxxxxx@ncsu.edu

Contact Information for Nancy Creamer
Office Phone: XXX XXX XXXX
Email: xxxxxxxxx@ncsu.edu

Contact Information for John O’Sullivan
Office Phone: XXX XXX XXXX
Email: xxxxxxxx@ncat.edu

As part of this project we will be developing educational materials to be used with Cooperative Extension’s outreach efforts about local agriculture.

17. Would you be willing to be interviewed (1-2 hours) at your convenience and location of your choice to collect more in depth information related to the North Carolina Agricultural Economy?

☐ YES
☐ NO
Appendix 3

Winbugs Code Used For Bayesian Variable Selection Analysis
Grouped at Level of Geographic Region
WINBUGS CODE FOR REGRESSION COEFFICIENTS FITTED FOR EACH GEOGRAPHIC REGION

model {

#THE FIRST FOR LOOP STEPS THROUGH EACH OF THE COUNTIES USED IN THE ANALYSIS

for ( i in 1 : N ) {

#BECAUSE THE CODE BELOW NEVER ASSIGNS A VALUE TO THE 1ST COLUMN OF “muDif” WE MUST
#DO SO HERE. ZERO IS AN ARBITRARY ASSIGNMENT

    muDif[i, 1] <- 0

#THIS FOR LOOP STEPS THROUGH EACH OF THE TIME PERIODS INCLUDED IN THE ANALYSIS. THE
#REASON IT IS T-2 IS THAT T IS THE NUMBER OF PERIODS BEFORE FIRST DIFFERENCES ARE TAKEN.
#IN ORDER TO INSTRUMENT THE DATA WE ALSO NEED TO USE UP A SECOND TIME PERIOD

    for( j in 1 : T-2 ) {

    #WE FIT THE DV TO A STUDENT T DISTRIBUTION WITH 6 DFs TO ACCOUNT FOR DATA BEING NON-
    #NORMAL. EACH PAIR OF COMBINATIONS OF ECONOMIC TIER & GEOGRAPHIC REGION ARE
    #ASSIGNED THEIR OWN VARIANCE DRAWN FROM A COMMON DISTRIBUTION (tauC). THE
    #“indexMatrix[economicTier[i] , geographicRegion[i]]” CODE FRAGMENT USES THE CURRENT
    #COUNTIES’ ECONOMIC TIER AND GEOGRAPHIC REGION TO ACCESS A LOOKUP TABLE (indexMatrix)
    #FOR THE APPROPRIATE INDEX

    YDif1[i ,j+1]  ~ dt(muDif[i , j+1],   tauC[indexMatrix[economicTier[i],
geographicRegion[i]],][],6)

    #BECAUSE THE DATA IS 1ST DIFFERENCED THERE IS NO INTERCEPT TERM. EACH GEOGRAPHIC
    #REGION HAS ITS OWN VALUES FOR THE MODEL COEFFICIENTS, ALL DRAWN FROM A COMMON
    #MULTIVARIATE DISTRIBUTION THAT HAS A COVARIANCE MATRIX FITTED BY THE MODEL. (SEE
    #FINAL PORTION OF CODE). EACH PAIR OF COMBINATIONS OF ECONOMIC TIER & GEOGRAPHIC
    #REGION HAVE THEIR OWN VALUES FOR THE AR1 AUTOREGRESSIVE TERM DRAWN FROM A
    #COMMON DISTRIBUTION. THE “inprod” CODE FRAGMENT IS SHORTHAND NOTATION FOR
    #MULTIPLYING EACH REGRESSION COEFFICIENT (STORED IN THE VECTOR “alpha1” AND ACCESSED
    #BY THE SAME LOOKUP TABLE USED ABOVE) BY THE APPROPRIATE DATA VALUE FOR THE CURRENT
    #COUNTY AND TIME PERIOD. THE “muDifIV” VARIABLE IS THE RESULT OF THE FIRST STAGE OF THE
# TWO STAGE INSTRUMENTATION PROCEDURE USED IN THIS AR1 ANALYSIS. IN THIS PROCEDURE
# THE PREVIOUS TIME PERIOD’S DV VALUE (WHICH HAS BEEN 1ST DIFFERENCED) IS INSTRUMENTED
# WITH THE FIRST TIME PERIOD VALUE #USED TO CALCULATE THAT 1ST DIFFERENCE. THE SAME
# LOOKUP TABLE IS USED

```
muDif[i,j+1] <- inprod(alpha1[geographicRegion[i]],var1Dif[i,j+1]) +
muDifIV[i, j] * alphaAR1[indexMatrix[economicTier[i],
geographicRegion[i]]]
```

# THE FOLLOWING TWO PROGRAM LINES ARE USED TO CONDUCT THE INSTRUMENTATION USED IN
# THE ANALYSIS PROCEDURE.

```
YDif2[i, j] ~ dt(muDifIV[i, j], tauCDif[indexMatrix[economicTier[i],
geographicRegion[i]]],6)
```

# Y[i,j] IS USED TO INSTRUMENT YDIF[I, j +1].

```
muDifIV[i, j] <- inprod(alpha1Dif[geographicRegion[i]],var1Dif[i,j+1]) + Y[i ,
j] *
alphaAR1Dif[indexMatrix[economicTier[i],geographicRegion[ i]]]
```

# THIS CALCULATES THE RESIDUALS OF THE MODEL FIT TO BE USED IN EVALUATING CONVERGENCE
# OF THE MODEL

```
res[i,j] <- YDif1[i,j+1] - muDif[i,j+1]
```

```
}
```

# THIS FOR LOOP STEPS THROUGH EACH OF THE DIFFERENT REGRESSION COEFFICIENTS. FOR ALL
# CODE IN THIS SECTION THE REASON WHY EACH LINE IS REPEATED IS SO THAT DIFFERENT
# COEFFICIENTS ARE INDEPENDENTLY FITTED TO BOTH THE INSTRUMENTED EQUATION AND THE
# EQUATION USED TO CONDUCT THE INSTRUMENTATION.

```
for (z in 1 : numTerms) {

# THIS CHOOSES A VALUE AT RANDOM FROM A UNIFORM DISTRIBUTION BETWEEN -5 AND 5. THIS IS
```
# USED FOR THE BAYESIAN VARIABLE SELECTION. THIS IS TO BE USED TO CALCULATE THE VARIANCE 
# OF THE FITTED DISTRIBUTIONS FOR THE REGRESSION COEFFICIENTS (alpha1).

inTau[z] ~ dunif (-5, 5)

inTaulDif[z] ~ dunif (-5, 5)

# TO IMPLEMENT THE ADAPTIVE SHRINKAGE VARIABLE SELECTION ALGORITHM, THE ABOVE 
# SELECTED VALUES ARE SQUARED. WINBUGS PARAMETERIZES DISTRIBUTIONS IN TERMS OF 
# PRECISION (INVERSE OF VARIANCE).

TauM[z] <- exp(inTau[z])

TaulMDif[z] <- exp(inTaulDif[z])

# USING THE ADAPTIVE SHRINKAGE VARIABLE SELECTION ALGORITHM, THIS FITS THE VECTOR OF 
# MEANS THAT WILL BE USED FOR THE MULTIVARIATE DISTRIBUTION USED TO FIT THE ACTUAL 
# REGRESSION #COEFFICIENTS (alpha1)

alpha1C[z] ~ dnorm(alpha1Values[z], TauM[z])

alpha1CDif[z] ~ dnorm(alpha1DifValues[z], TauMDif[z])

}

# THIS FOR LOOP STEPS THROUGH EACH OF THE PAIRS OF COMBINATIONS OF ECONOMICTIER & 
# GEOGRAPHICREGION THAT ARE ACCESSED BY THE LOOKUP TABLE MENTIONED ABOVE

for (j in 1 : 9) {

# THIS FITS THE VALUES OF THE AR1 COEFFICIENTS FOR EACH COMBINATION OF ECONOMICTIER & 
# GEOGRAPHIC REGION. THESE ARE DRAWN FROM AN UNINFORMATIVE NORMAL DISTRIBUTION 
# WITH A VERY SMALL PRECISION (AND THUS LARGE VARIANCE)

alphaAR1[j] ~ dnorm(alphaAR1Value[j], 1.0E-6)[0.0,1.0]

alphaAR1Dif[j] ~ dnorm(alphaAR1DifValue[j], 1.0E-6)[0.0,1.0]

# THIS FITS THE VARIANCE USED TO FIT EACH COMBINATION OF ECONOMICTIER & 
# GEOGRAPHICREGION. THIS IS AN UNINFORMATIVE DISTRIBUTION AND WAS PARAMETERIZED IN 
# TERMS OF STANDARD DEVIATION FOR THE SAKE OF SIMPLICITY.
\[ \text{sigmatauC}[j] \sim \text{dunif}(0, 10) \]
\[ \text{sigmatauCDif}[j] \sim \text{dunif}(0, 10) \]

#BECAUSE WINBUGS PARAMETERIZES DISTRIBUTIONS IN TERMS OF PRECISION THE VALUES
#IMMEDIATELY ABOVE NEED TO BE CONVERTED TO PRECISIONS
\[
\text{tauC}[j] <- \text{pow}(\text{sigmatauC}[j], -2) \\
\text{tauCDif}[j] <- \text{pow}(\text{sigmatauCDif}[j], -2)
\]

} 

#THIS DRAWS THE VALUES OF THE REGRESSION COEFFICIENTS FOR EACH OF THE GEOGRAPHIC
#REGIONS. THE COVARIANCE MATRIX USED IS FITTED BY A WISHART DISTRIBUTION BELOW. EACH
#SET OF REGRESSION COEFFICIENTS ARE INDEPENDENT DRAWS FROM A COMMON DISTRIBUTION.
for (k in 1:3) {
    \[
    \text{alpha1}[k, 1:\text{numTerms}] \sim \text{dmnorm}(\text{alpha1C}[\cdot], \text{alphaTAU}[\cdot]) \\
    \text{alpha1Dif}[k, 1:\text{numTerms}] \sim \text{dmnorm}(\text{alpha1CDif}[\cdot], \text{alphaTAUDif}[\cdot])
    \]
}

#THIS DRAWS THE VALUES FROM A FITTED WISHART DISTRIBUTION FOR THE COVARIANCE MATRIX
#USED TO MODEL THE INTERACTIONS BETWEEN VARIOUS REGRESSION COEFFICIENTS. THIS IS AS
#UNINFORMATIVE A DISTRIBUTION AS IS POSSIBLE.
\[
\text{alphaTAU} \sim \text{dwish}(\text{W1}[\cdot, \cdot], \text{numTerms} + 1) \\
\text{alphaTAUDif} \sim \text{dwish}(\text{W2}[\cdot, \cdot], \text{numTerms} + 1)
\]
Appendix 4

Winbugs Code Used For Bayesian Variable Selection Analysis
Grouped at Level of Geographic Region and Economic Tier Status
WINBUGS CODE FOR REGRESSION COEFFICIENTS FITTED FOR EACH COMBINATION OF ECONOMIC TIER AND GEOGRAPHIC REGION

model {
	#THE FIRST FOR LOOP STEPS THROUGH EACH OF THE COUNTIES USED IN THE ANALYSIS
	for (i in 1 : N) {

		#BECAUSE THE CODE BELOW NEVER ASSIGNS A VALUE TO THE 1ST COLUMN OF “muDif” WE MUST
		#DO SO HERE. ZERO IS AN ARBITRARY ASSIGNMENT
		muDif[i, 1] <- 0

		#THIS FOR LOOP STEPS THROUGH EACH OF THE TIME PERIODS INCLUDED IN THE ANALYSIS. THE
		#REASON IT IS T-2 IS THAT T IS THE NUMBER OF PERIODS BEFORE FIRST DIFFERENCES ARE TAKEN.
		#IN ORDER TO INSTRUMENT THE DATA WE ALSO NEED TO USE UP A SECOND TIME PERIOD
		for (j in 1 : T-2) {

			#WE FIT THE DV TO A STUDENT T DISTRIBUTION WITH 6 DFs TO ACCOUNT FOR DATA BEING NON-
		#NORMAL. EACH PAIR OF COMBINATIONS OF ECONOMIC TIER & GEOGRAPHIC REGION ARE
		#ASSIGNED THEIR OWN VARIANCE DRAWN FROM A COMMON DISTRIBUTION (tauC). THE
		#“indexMatrix[economicTier[i] , geographicRegion[i]]” CODE FRAGMENT USES THE CURRENT
		#COUNTIES’ ECONOMIC TIER AND GEOGRAPHIC REGION TO ACCESS A LOOKUP TABLE (indexMatrix)
		#FOR THE APPROPRIATE INDEX
			YDif1[i, j+1] ~ dt(muDif[i, j+1], tauC[indexMatrix[economicTier[i] , geographicRegion[i]]], 6)

			#BECAUSE THE DATA IS 1ST DIFFERENCED THERE IS NO INTERCEPT TERM. EACH PAIR OF
		#COMBINATIONS OF ECONOMIC TIER & GEOGRAPHIC REGION HAVE THEIR OWN VALUES FOR THE
		#MODEL COEFFICIENTS, ALL DRAWN FROM A COMMON MULTIVARIATE DISTRIBUTUTION THAT HAS A
		#COVARIANCE MATRIX FITTED BY THE MODEL. (SEE FINAL PORTION OF CODE). EACH PAIR OF
		#COMBINATIONS OF ECONOMIC TIER & GEOGRAPHIC REGION HAVE THEIR OWN VALUES FOR THE
		#AR1 AUTOREGRESSIVE TERM DRAWN FROM A COMMON DISTRIBUTION. THE “inprod” CODE
		#FRAGMENT IS SHORTHAND NOTATION FOR MULTIPLYING EACH REGRESSION COEFFICIENT
		#(STORED IN THE VECTOR “alpha1” AND ACCESSED BY THE SAME LOOKUP TABLE USED ABOVE) BY
#THE APPROPRIATE DATA VALUE FOR THE CURRENT COUNTY AND TIME PERIOD. THE “muDifIV”
#VARIABLE IS THE RESULT OF THE FIRST STAGE OF THE TWO STAGE INSTRUMENTATION PROCEDURE
#USED IN THIS AR1 ANALYSIS. IN THIS PROCEDURE THE PREVIOUS TIME PERIOD’S DV VALUE
#(WHICH HAS BEEN 1ST DIFFERENCED) IS INSTRUMENTED WITH THE FIRST TIME PERIOD VALUE
#USED TO CALCULATE THAT 1ST DIFFERENCE. THE SAME LOOKUP TABLE IS USED

muDif[i,j+1] <- inprod(alpha1[indexMatrix[economicTier[i], geographicRegion[i]], ]
                        , var1Dif[i,j+1]) + muDifIV[i,j] *
                        alphaAR1[indexMatrix[economicTier[i], geographicRegion[i]]]

#THE FOLLOWING TWO PROGRAM LINES ARE USED TO CONDUCT THE INSTRUMENTATION USED IN
#THE ANALYSIS PROCEDURE.

YDif2[i,j] ~ dt(muDifIV[i,j], tauCDif[indexMatrix[economicTier[i],
                                       geographicRegion[i]]], 6)

#Y[i,j] IS USED TO INSTRUMENT YDIF[I, j +1].

muDifIV[i,j] <- inprod(alpha1Dif[indexMatrix[economicTier[i],geographicRegion[i]],
                               ], var1Dif[i,j+1]) + Y[i,j] * alphaAR1Dif[indexMatrix[economicTier[i],
                                                       geographicRegion[i]]]

#THIS CALCULATES THE RESIDUALS OF THE MODEL FIT TO BE USED IN EVALUATING CONVERGENCE
#OF THE MODEL

res[i,j] <- YDif1[i,j+1] - muDif[i,j+1]

}

}

#THIS FOR LOOP STEPS THROUGH EACH OF THE DIFFERENT REGRESSION COEFFICIENTS. FOR ALL
#CODE IN THIS SECTION THE REASON WHY EACH LINE IS REPEATED IS SO THAT DIFFERENT
#COEFFICIENTS ARE INDEPENDENTLY FITTED TO BOTH THE INSTRUMENTED EQUATION AND THE
#EQUATION USED TO CONDUCT THE INSTRUMENTATION.

for (z in 1 : numTerms) {

#THIS CHOOSES A VALUE AT RANDOM FROM A UNIFORM DISTRIBUTION BETWEEN -5 AND 5. THIS IS
#USED FOR THE BAYESIAN VARIABLE SELECTION. THIS IS TO BE USED TO CALCULATE THE VARIANCE
#OF THE FITTED DISTRIBUTIONS FOR THE REGRESSION COEFFICIENTS (alpha1).

\[
in\text{Tau}[z] \sim \text{dunif}(-5, 5)
\]

\[
in\text{TauDif}[z] \sim \text{dunif}(-5, 5)
\]

#TO IMPLEMENT THE ADAPTIVE SHRINKAGE VARIABLE SELECTION ALGORITHM, THE ABOVE
#SELECTED VALUES ARE SQUARED. WINBUGS PARAMETERIZES DISTRIBUTIONS IN TERMS OF
#PRECISION (INVERSE OF VARIANCE).

\[
\text{TauM}[z] \leftarrow \exp(in\text{Tau}[z])
\]

\[
\text{TauMDif}[z] \leftarrow \exp(in\text{TauDif}[z])
\]

#USING THE ADAPTIVE SHRINKAGE VARIABLE SELECTION ALGORITHM, THIS FITS THE VECTOR OF
#MEANS THAT WILL BE USED FOR THE MULTIVARIATE DISTRIBUTION USED TO FIT THE ACTUAL
#REGRESSION COEFFICIENTS (alpha1)

\[
\text{alpha1C}[z] \sim \text{dnorm}(\text{alphaValues}[z], \text{Tau}[z])
\]

\[
\text{alpha1CDif}[z] \sim \text{dnorm}(\text{alphaDifValues}[z], \text{TauDif}[z])
\]

}  

#THIS FOR LOOP STEPS THROUGH EACH OF THE PAIRS OF COMBINATIONS OF ECONOMIC &
#GEOGRAPHIC REGION THAT ARE ACCESSED BY THE LOOKUP TABLE MENTIONED ABOVE

for (j in 1 : 9) {

#THIS DRAWS THE VALUES OF THE REGRESSION COEFFICIENTS. THE COVARIANCE MATRIX USED IS
#FITTED BY A WISHART DISTRIBUTION BELOW. EACH SET OF REGRESSION COEFFICIENTS ARE
#INDEPENDENT DRAWS FROM A COMMON DISTRIBUTION.

\[
\text{alpha1}[j, 1:\text{numTerms}] \sim \text{dmnorm}(\text{alpha1C}[j], \text{alphaTAU}[,])
\]

\[
\text{alpha1Dif}[j, 1:\text{numTerms}] \sim \text{dmnorm}(\text{alpha1Dif}[j], \text{alphaTAUDif}[,])
\]

#THIS FITS THE VALUES OF THE AR1 COEFFICIENTS FOR EACH COMBINATION OF ECONOMIC &
#GEOGRAPHIC REGION. THESE ARE DRAWN FROM AN UNINFORMATIVE NORMAL DISTRIBUTION
#WITH A VERY SMALL PRECISION (AND THUS LARGE VARIANCE)
alphaAR1[j] ~ dnorm(alphaAR1Value[j], 1.0E-6)(0.0,1.0)

alphaAR1Dif[j] ~ dnorm(alphaAR1DifValue[j], 1.0E-6)(0.0,1.0)

#THIS FITS THE VARIANCE USED TO FIT EACH COMBINATION OF ECONOMIC TIER &
#GEOGRAPHIC REGION. THIS IS AN UNINFORMATIVE DISTRIBUTION AND WAS PARAMETERIZED IN
#TERMS OF STANDARD DEVIATION FOR THE SAKE OF SIMPLICITY.

sigmatauC[j] ~ dunif (0 , 10)

sigmatauCDif[j] ~ dunif (0 , 10)

#BECAUSE WINBUGS PARAMETERIZES DISTRIBUTIONS IN TERMS OF PRECISION THE VALUES
#IMMEDIATELY ABOVE NEED TO BE CONVERTED TO PRECISIONS

tauC[j] <- pow(sigmatauC[j], -2)

tauCDif[j] <- pow(sigmatauCDif[j], -2)

}

#THIS DRAWS THE VALUES FROM A FITTED WISHART DISTRIBUTION FOR THE COVARIANCE MATRIX
#USED TO MODEL THE INTERACTIONS BETWEEN VARIOUS REGRESSION COEFFICIENTS. THIS IS AS
#UNINFORMATIVE A DISTRIBUTION AS IS POSSIBLE.

alphaTAU [1:numTerms, 1:numTerms] ~ dwish(W1[,], numTerms+1)

alphaTAUDif[1:numTerms, 1:numTerms] ~ dwish(W2[,], numTerms+1)
Appendix 5

Definition of Variables Used in Bayesian Variable Selection Analysis and Associated Hypotheses
<table>
<thead>
<tr>
<th>Variable Name and Definition</th>
<th>Data Source</th>
<th>Converted from Nominal to Real</th>
<th>Variable Log Transformed</th>
<th>Combined with Same Commuting Zone Counties</th>
<th>Analyses Used In</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land in Farms</td>
<td>Ag Census</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>All</td>
</tr>
</tbody>
</table>

Total acreage of farmland within county. Includes all land within farms, not only farmland used in current production. Data interpolated to annual intervals using linear spline methods.

Nonfarm Personal Income is Personal Income minus Farm Income. Personal Income is the income that is received by all persons from all sources. It is calculated as the sum of wage and salary disbursements, supplements to wages and salaries, proprietors' income with inventory valuation and capital consumption adjustments, rental income of persons with capital consumption adjustment, personal dividend income, personal interest income, and personal current transfer receipts, less contributions for government social insurance. The personal income of an area is the income that is received by, or on behalf of, all the individuals who live in the area; therefore, the estimates of personal income are presented by the place of residence of the income recipients (REIS Definition).

Hypothesis: Given the fact that farmers can either choose to engage in agricultural production or make a living from pursuing non-agricultural employment or venture, one would expect that as nonfarm personal income increases at the county level (controlling for changes in population) farming would become a less attractive economic option. This fact would lead farmers to leave agriculture. While some of the land that had been in use by these farmers would be consolidated into other operations, at least some percentage would go out of production. Because of this it is hypothesized that increases in nonfarm personal income would be associated with decreases in the amount of farmland. The effect of this variable on the number of active farmers would be mitigated by personal lifestyle choices of the farmers.

Population REIS No Yes No All

BEA uses the Census Bureau's midyear population estimates. Except for college students and other seasonal populations, which are measured on April 1, the population for all years is
Hypothesis: As agriculture typically occurs in places with low population density, one would expect that increases in the population would be associated with declines in the amount of farmland. This occurs due to development of agricultural land for residential, business, and infrastructure use as well as other reasons. However, it may also be the case that smaller scales of farming are made more profitable by being closer to areas with growing populations (i.e. urban areas). This may be because urban areas often time have higher disposable incomes and so higher prices may be charged, transportation costs are reduced, or there is a greater presence of related and supporting industries in the area. Because of this fact it is unclear as to whether increases in the county level population would be associated with increases or decreases in the amount of farmland. No hypothesis is made for this variable.

**Earnings By Place of Work**

Earnings by place of work is the sum of Wage and Salary Disbursements, supplements to wages and salaries and proprietors' income. BEA presents earnings by place of work because it can be used in the analyses of regional economies as a proxy for the income that is generated from participation in current production (REIS Definition).

Hypothesis: The difference between this value and non-farm personal income represents the amount of income that crosses county borders. Higher values of earning by place of work relative to nonfarm personal income indicates that people commute into the county for work more so than the other way around. Thus Increases in Earnings by Place Work is expected to have the same relationship with changes in the amount of farmland as nonfarm personal income.

**Employer Contributions For Government Social Insurance**

These contributions, which are subtracted in the calculation of personal income as part of contributions for government social insurance, consist of employer payments under the following
Federal and state and local government programs: Social Security; hospital insurance (HI); unemployment insurance; railroad retirement; government employee retirement; pension benefit guaranty; veterans life insurance; publicly-administered workers' compensation; military employee programs (veterans life and military medical insurance); and temporary disability insurance. These contributions are excluded from personal income by definition, but as part of supplements to wages and salaries, are included in earnings by place of work (REIS Definition).

Hypothesis: Because of the heterogeneous composition of this variable, there is no strong prediction as to how changes in its value relates to changes in the amount of farmland. This variable was included because its data was available as part of the REIS dataset and it was identifiable in all analyses.

**Adjustment For Residence**

| REIS | Yes | Yes | No | All |

The adjustment for residence is the net flow of the net labor earnings of inter-area commuters. The state and county estimates of personal income are presented by the state and county of residence of the income recipients. However, the source data for most of the components of wage and salary disbursements, supplements to wages and salaries, and contributions for government social insurance are on a place-of-work basis. Consequently, a residence adjustment is made to convert the estimates based on these source data to a place-of-residence basis (REIS Definition).

Hypothesis: Negative values of this variable indicate people commute into the county. Because of this fact, decreases in Adjustment for Residence are expected to be associated with increases in the amount of farmland for the same reasons as stated for nonfarm personal income.

**Dividends, Interest, and Rent**

| REIS | Yes | Yes | No | All |

Personal dividend income, personal interest income, and rental income of persons with capital consumption adjustment are sometimes referred to as "investment income" or "property income. "Dividends: This component of personal income consists of the payments in cash or other assets, excluding the corporation's own stock, made by corporations located in the United States or abroad to persons who are U.S. residents. It excludes that portion of dividends paid by regulated
investment companies (mutual funds) related to capital gains distributions. Interest: This component of personal income is the interest income (monetary and imputed) of persons from all sources. Rent: Rental income is the net income of persons from the rental of real property except for the income of persons primarily engaged in the real estate business; the imputed net rental income of the owner-occupants of nonfarm dwellings; and the royalties received from patents, copyrights, and the right to natural resources (REIS Definition).

Hypothesis: As Dividends, Interest, and Rent represents income that should be considered a viable alternative to engaging in agricultural production, increases in this variable are expected to be associated with decreases in the amount of farmland for the same reasons as stated under non-farm personal income.

Wage and Salary Disbursements  REIS  Yes  Yes  No  All

Wage and salary disbursements consists of the monetary remuneration of employees, including corporate officers salaries and bonuses, commissions, pay-in-kind, incentive payments, and tips. It reflects the amount of payments disbursed, but not necessarily earned during the year. Wage and salary disbursements is measured before deductions, such as social security contributions and union dues. In recent years, stock options have become a point of discussion. Wage and salary disbursements includes stock options of nonqualified plans at the time that they have been exercised by the individual. Stock options are reported in wage and salary disbursements. The value that is included in wages is the difference between the exercise price and the price that the stock options were granted. For more information, see Carol Moylan's paper "Treatment of Employee Stock Options in the U.S. National Economic Accounts" (REIS Definition).

Hypothesis: Controlling for the number of wage and salary jobs, changes in this variable represent changes in the amount paid for non-agricultural labor. Because positive changes of this variable would be associated with non-agricultural employment becoming relatively more attractive in an economic sense, it is hypothesized that increases in Wage and Salary Disbursements would be associated with decreases in the amount of farmland for the same
reasons as stated above.

**Employer Contributions**

For Employee Pension and Insurance Funds

This component of personal income consists of employer payments to private and government employee retirement plans, private group health and life insurance plans, privately administered workers’ compensation plans, and supplemental unemployment benefit plans (REIS Definition).

Hypothesis: Controlling for the number of wage and salary jobs, increases in this variable would occur because of either more jobs becoming full time (which typically receive more benefits than part time employment) or a greater amount of benefits being associated with jobs. Regardless of the reason, increases in this variable would represent non-farm employment becoming a more attractive income source. Therefore, for the same reasons stated above, increases in Employer Contributions for Employee Pension and Insurance Funds is expected to be associated with decreases in the amount of farmland.

**Farm Proprietor’s Income**

Farm proprietors’ income consists of the income that is received by the sole proprietorships and the partnerships that operate farms. It excludes the income that is received by corporate farms (REIS Definition).

Hypothesis: It is reasonable to believe that as farm owners make additional revenue they will be incentivized to bring more land into production use in order to capitalize on economies of scale.

**Nonfarm Proprietor’s Income**

The BEA local area estimates of nonfarm self-employment consist of the number of sole proprietorships and the number of individual business partners not assumed to be limited partners. The nonfarm self-employment estimates resemble the wage and salary employment estimates in that both series measure jobs--as opposed to workers--on a full-time and part-time
basis. However, because of limitations in source data, two important measurement differences exist between the two sets of estimates. First, the self-employment estimates are largely on a place-of-residence basis rather than on the preferred place-of-work basis. Second, the self-employment estimates reflect the total number of sole proprietorships or partnerships active at any time during the year—as opposed to the annual average measure used for wage and salary employment (REIS Definition).

Hypothesis: Nonfarm Proprietors’ Income and Nonfarm Proprietor’s Employment are often used as proxies for the relative success and degree of entrepreneurship at the county level. Given the fact that increases in nonfarm proprietor’s income would imply a growing economy (and thus the creation of additional jobs or an increase in wages for current ones), it is hypothesized that increases in Nonfarm Proprietor’s Income would be associated with decreases in the amount of farmland. This would occur regardless of whether individuals are leaving farming to pursue their own non-farm businesses or are being employed by proprietors of non-farm businesses.

**Mining**

<table>
<thead>
<tr>
<th>Variable Name and Definition</th>
<th>Data Source</th>
<th>Converted from Nominal to Real</th>
<th>Variable Log Transformed</th>
<th>Combined with Same Commuting Zones</th>
<th>Used In Analyses Variables</th>
<th>Years Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining</td>
<td>REIS</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>1975-2000</td>
</tr>
</tbody>
</table>

The term "Mining" is used in both the SIC system and in NAICS, but it does not have the same definition in both systems. SIC definition: This SIC division includes all establishments primarily engaged in mining. The term mining is used in the broad sense to include the extraction of minerals occurring naturally: solids, such as coal and ores; liquids, such as crude petroleum; and gases such as natural gas. The term mining is also used in the broad sense to include quarrying, well operations, milling (e.g., crushing, screening, washing, flotation), and other preparation customarily done at the mine site, or as a part of mining activity. Exploration and development of mineral properties are included. Services performed on a contract or fee basis in the development or operation of mineral properties are classified separately but within this division. Establishments which have complete responsibility for operating mines, quarries, or oil and gas wells for others on a contract or fee basis are classified according to the product mined rather than as mineral services. NAICS definition: The Mining sector under NAICS comprises establishments that extract naturally occurring mineral solids, such as coal and ores; liquid minerals, such as crude petroleum;
and gases, such as natural gas. The term mining is used in the broad sense to include quarrying, well operations, beneficiating (e.g., crushing, screening, washing, and flotation), and other preparation customarily performed at the mine site, or as a part of mining activity. The Mining sector distinguishes two basic activities: mine operation and mining support activities. Mine operation includes establishments operating mines, quarries, or oil and gas wells on their own account or for others on a contract or fee basis. Mining support activities include establishments that perform exploration (except geophysical surveying) and/or other mining services on a contract or fee basis (except mine site preparation and construction of oil/gas pipelines; REIS Definition).

Hypothesis: Because the skillset of agriculture and mining has some overlap and there are not typically barriers to entry in mining with regards to specific scholastic education or certifications, agriculture and mining represent substitutable industries. Thus increasing amounts/value of mining are hypothesized to be associated with decreasing amount of farmland because some farmers will leave agriculture to pursue employment in the mining sector.

**Construction**

The term "Construction" is used in both the SIC system and in NAICS, but it does not have the same definition in both systems. SIC definition: This SIC division includes establishments primarily engaged in construction. The term construction includes new work, additions, alterations, reconstruction, installations, and repairs. Construction activities are generally administered or managed from a relatively fixed place of business, but the actual construction work is performed at one or more different sites. If a company has more than one relatively fixed place of business from which it undertakes or manages construction activities and for which separate data on the number of employees, payroll, receipts, and other establishment-type records are maintained, each such place of business is considered a separate construction establishment. Three broad types of construction activity are covered: (1) building construction by general contractors or by operative builders; (2) heavy construction other than building by general contractors and special trade contractors; and (3) construction activity by other special trade contractors. NAICS definition: The Construction (NAICS) sector comprises establishments primarily engaged in the construction of
buildings and other structures, heavy construction (except buildings), additions, alterations, reconstruction, installation, and maintenance and repairs. Establishments engaged in demolition or wrecking of buildings and other structures, clearing of building sites, and sale of materials from demolished structures are also included. This sector also includes those establishments engaged in blasting, test drilling, landfill, leveling, earthmoving, excavating, land drainage, and other land preparation. The industries within this sector have been defined on the basis of their unique production processes. As with all industries, the production processes are distinguished by their use of specialized human resources and specialized physical capital. Construction activities are generally administered or managed at a relatively fixed place of business, but the actual construction work is performed at one or more different project sites. In certain regional estimates this sector is divided into three subsectors of construction activities: (1) building construction and land subdivision and land development; (2) heavy construction (except buildings), such as highways, power plants, and pipelines; and (3) construction activity by special trade contractors (REIS Definition).

Hypothesis: Because the skillset of agriculture and construction has some overlap and there are not typically barriers to entry in construction with regards to specific scholastic education or certifications, agriculture and construction represent substitutable industries. Thus increasing amounts/value of construction are hypothesized to be associated with decreasing amounts of farmland because some farmers will agriculture to pursue employment in the construction sector.

Manufacturing  
REIS  Yes  Yes  Yes  1975-2000

The term "Manufacturing" is used in both the SIC system and in NAICS, but it does not have the same definition in both systems. SIC definition: The manufacturing SIC division includes establishments engaged in the mechanical or chemical transformation of materials or substances into new products. These establishments are usually described as plants, factories, or mills and characteristically use power driven machines and materials handling equipment. Establishments engaged in assembling component parts of manufactured products are also considered manufacturing if the new product is neither a structure nor other fixed improvement. Also included
is the blending of materials, such as lubricating oils, plastics resins, or liquors. NAICS definition: The Manufacturing NAICS sector comprises establishments engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products. The assembling of component parts of manufactured products is considered manufacturing, except in cases where the activity is appropriately classified in Sector 23, Construction. Establishments in the Manufacturing sector are often described as plants, factories, or mills and characteristically use power-driven machines and materials-handling equipment. However, establishments that transform materials or substances into new products by hand or in the worker's home and those engaged in selling to the general public products made on the same premises from which they are sold, such as bakeries, candy stores, and custom tailors, may also be included in this sector.

Manufacturing establishments may process materials or may contract with other establishments to process their materials for them. Both types of establishments are included in manufacturing (REIS Definition).

Hypothesis: Employment in manufacturing can have both low and high barriers to entry depending on the type of manufacturing being conducted. More and more manufacturing employment requires high skill level, certain types of scholastic education, and some number of certifications that may not overlap with agriculture. However, other types of agriculture may involve skillsets far more akin to typical agricultural practices (such as machining). At the same time though, changes in the amount of manufacturing which use agricultural goods as a raw ingredient will affect the overall profitability of agriculture. Because of these numerous different ways that agriculture and the manufacturing sector may interact one another, there is no hypothesis as to how changes in the value of Manufacturing will be associated with changes in the amount of farmland.

**Transportation and Public Utilities**

This SIC division includes establishments providing, to the general public or to other business enterprises, passenger and freight transportation, communications services, or electricity, gas,
steam, water or sanitary services. For many of the industries in this division, the establishments have activities, workers, and physical facilities distributed over an extensive geographic area. For this division, the establishment is represented by a relatively permanent office, shop, station, terminal, or warehouse, etc. that is either (1) directly responsible for supervising such activities or (2) the base from which personnel operate to carry out these activities. This division is referred to as "Transportation, Communications, Electric, Gas, and Sanitary Services" in the Standard Industrial Classification Manual (REIS Definition).

Hypothesis: Because the skillset of agriculture and transportation especially has many overlaps (i.e. the ability to effectively use large scale machinery) and there are not typically barriers to entry in transportation with regards to specific scholastic education or certifications (except for those many farmers would already have), agriculture and transportation represent substitutable industries. Thus increasing amounts/value of transportation are hypothesized to be associated with decreasing amounts of farmland because some farmers will agriculture to pursue employment in the transportation sector.

**Wholesale Trade**

The term "wholesale trade" is used in the SIC system and in NAICS, but it does not have the same definition in both systems. SIC definition: This SIC division includes establishments or places of business primarily engaged in selling merchandise to retailers; to industrial, commercial, institutional, farm, construction contractors, or professional business users; or to other wholesalers; or acting as agents or brokers in buying merchandise for or selling merchandise to such persons or companies. NAICS definition: The Wholesale Trade NAICS sector comprises establishments engaged in wholesaling merchandise, generally without transformation, and rendering services incidental to the sale of merchandise. The merchandise described in this sector includes the outputs of agriculture, mining, manufacturing, and certain information industries, such as publishing (REIS Definition).

Hypothesis: Because the wholesale trade sector includes sales to farming businesses, growth of
the Wholesale Trade sector may be associated with growth of the Agricultural Sector. For similar reasons to those stated above, growth in the agricultural sector is expected to be associated with increasing amounts of farmland. Thus it is hypothesized that increasing amounts of Wholesale trade would be associated with more land in farms.

**Retail Trade**

The term "retail trade" is used in the SIC system and in NAICS, but it does not have the same definition in both systems. SIC definition: This SIC division includes establishments engaged in selling merchandise for personal or household consumption and rendering services incidental to the sale of the goods. In general, retail establishments are classified by kind of business according to the principal lines of commodities sold (groceries, hardware, etc.), or the usual trade designation (drug store, cigar store, etc.). Some of the important characteristics of retail trade establishments are: the establishment is usually a place of business and is engaged in activities to attract the general public to buy; the establishment buys or receives merchandise as well as sells; the establishment may process its products, but such processing is incidental or subordinate to selling; the establishment is considered as retail in the trade; and the establishment sells to customers for personal or household use. Not all of these characteristics need be present and some are modified by trade practice. NAICS definition: The Retail Trade NAICS sector comprises establishments engaged in retailing merchandise, generally without transformation, and rendering services incidental to the sale of merchandise. The retailing process is the final step in the distribution of merchandise; retailers are, therefore, organized to sell merchandise in small quantities to the general public. This sector comprises two main types of retailers: store and nonstore retailers. 1. Store retailers operate fixed point-of-sale locations, located and designed to attract a high volume of walk-in customers. In general, retail stores have extensive displays of merchandise and use mass-media advertising to attract customers. They typically sell merchandise to the general public for personal or household consumption, but some also serve business and institutional clients. These include establishments, such as office supply stores, computer and software stores, building materials dealers, plumbing supply stores, and electrical supply stores. Catalog showrooms,
gasoline services stations, automotive dealers, and mobile home dealers are treated as store retailers. In addition to retailing merchandise, some types of store retailers are also engaged in the provision of after-sales services, such as repair and installation. For example, new automobile dealers, electronic and appliance stores, and musical instrument and supply stores often provide repair services. As a general rule, establishments engaged in retailing merchandise and providing after-sales services are classified in this sector. 2. Nonstore retailers, like store retailers, are organized to serve the general public, but their retailing methods differ. The establishments of this subsector reach customers and market merchandise with methods, such as the broadcasting of "infomercials," the broadcasting and publishing of direct-response advertising, the publishing of paper and electronic catalogs, door-to-door solicitation, in-home demonstration, selling from portable stalls (street vendors, except food), and distribution through vending machines. Establishments engaged in the direct sale (non store) of products, such as home heating oil dealers and home delivery newspaper routes are included here (REIS Definition).

Hypothesis: While this sector of the economy does include Grocers, it is difficult to establish a grounded hypothesis as to the relationship between agriculture and retail trade. This is because of the possibility that those goods sold in grocers and other establishments whose goods are derived from agricultural production may in fact be imported from outside NC (whether this means from another state inside of the US or internationally). Thus there potentially may be no relationship between changes in the value of Retail Trade and changes in the value of agriculture at the county level. Because of this there is no hypothesis as to the relationship between changes in the value of Retail Trade and changes in the amount of farmland at the county level.

Finance Insurance and Real Estate

This SIC division includes establishments operating primarily in the fields of finance, insurance, and real estate. Finance includes depository institutions, non-depository credit institutions, holding (but not predominantly operating) companies, other investment companies, brokers and dealers in securities and commodity contracts, and security and commodity exchanges. Insurance covers
<table>
<thead>
<tr>
<th>Variable Name and Definition</th>
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<th>Converted from Nominal to Real</th>
<th>Variable Log Transformed</th>
<th>Combined with Same Commuting Zone Counties</th>
<th>Used In Analyses Variables</th>
<th>Used In Variables</th>
<th>Analyses Variables</th>
</tr>
</thead>
</table>

carriers of all types of insurance, and insurance agents and brokers. Real estate includes owners, lessors, lessees, buyers, sellers, agents, and developers of real estate. Establishments primarily engaged in the construction of buildings for sale (operative builders) are classified in Construction, Industry 1531 (REIS Definition).

Hypothesis: Because the skillset of agriculture and these industries has little to no overlap and there are typically high barriers to entry with regards to specific scholastic education or certifications, agriculture and these sectors are not substitutable with regards to employment. Thus it is hypothesized that there will be no relationship between changes in the value of the Finance, Insurance, and Real Estate Industries and changes in the amount of farmland.

**Services**

This (SIC) division includes establishments primarily engaged in providing a wide variety of services for individuals, business and government establishments, and other organizations. Hotels and other lodging places; establishments providing personal, business, repair, and amusement services; health, legal, engineering, and other professional services; educational institutions; membership organizations, and other miscellaneous services, are included. Establishments which provide specialized services closely allied to activities covered in other divisions are classified in such divisions (REIS Definition).

Hypothesis: Because this industry is incredibly broad and scope and there is little expected overlap between the skillsets of agriculture and it, there is little reason to suspect there will be as strong relationship between changes in the value of Service and changes in agriculture. Thus there is no hypothesis as to how changes in the value of Services will relate to changes in the amount of farmland.

**Government and Government Enterprises**

In the national income and product accounts (NIPAs), gross domestic product and other major aggregates are presented in terms of three economic sectors: Business, households and
institutions, and general government. Government includes Federal civilian, military, and state and local. Government enterprises are government agencies that cover a substantial portion of their operating costs by selling goods and services to the public and that maintain separate accounts (REIS Definition).

Hypothesis: Because there is little expected overlap between the skillsets of agriculture and it, there is little reason to suspect there will be as strong relationship between changes in the value of Government and Government Enterprises and changes in agriculture. Thus there is no hypothesis as to how changes in the value of Government and Government Enterprises will relate to changes in the amount of farmland.

**Nonfarm Proprietors**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data Source</th>
<th>Converted from Nominal to Real</th>
<th>Combined with Same Commuting Zone Counties</th>
<th>Analyses Variables Used In</th>
</tr>
</thead>
<tbody>
<tr>
<td>REIS</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>1975-2000</td>
</tr>
</tbody>
</table>

**Employment**

The BEA local area estimates of nonfarm self-employment consist of the number of sole proprietorships and the number of individual business partners not assumed to be limited partners. The nonfarm self-employment estimates resemble the wage and salary employment estimates in that both series measure jobs—as opposed to workers—on a full-time and part-time basis. However, because of limitations in source data, two important measurement differences exist between the two sets of estimates. First, the self-employment estimates are largely on a place-of-residence basis rather than on the preferred place-of-work basis. Second, the self-employment estimates reflect the total number of sole proprietorships or partnerships active at any time during the year—as opposed to the annual average measure used for wage and salary employment (REIS Definition).

Hypothesis: Increases in this variable would most typically reflect the creation of new businesses which would be expected to over time create additional jobs and grow the economy. This growth in the nonfarm economy would be expected to make alternatives to farming more attractive. Thus increases in nonfarm proprietor’s employment is hypothesized to be associated with decreases in the amount of farmland.
<table>
<thead>
<tr>
<th>Variable Name and Definition</th>
<th>Data Source</th>
<th>Converted from Nominal to Real</th>
<th>Variable Log Transformed</th>
<th>Combined with Same Commuting Zone Counties</th>
<th>Used In Analyses Variables</th>
<th>Used In Variables</th>
<th>Used In Analyses</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm Employment</td>
<td>REIS</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>1975-2000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private Nonfarm Employment</td>
<td>REIS</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>1975-2000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retirement and Other Benefits</td>
<td>REIS</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>All</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Farm employment is the number of workers engaged in the direct production of agricultural commodities, either livestock or crops; whether as a sole proprietor, partner, or hired laborer (REIS Definition).

Hypothesis: One would expect that increases in the overall amount of farmland would be associated with greater amounts of employed labor. It is possible though that large increases in the amount of farmland may drive increased mechanization which may substitute for employed labor.

Private nonfarm employment is the sum of Wage and Salary Employment and Nonfarm proprietors’ employment, excluding government employment (REIS Definition).

Hypothesis: Because this analysis included both Wage and Salary Employment and Nonfarm Proprietor’s Employment, changes in this variable represent changes in the amount of government employment. As increasing amounts of government employment represents additional employment opportunities outside of agriculture for farmers, it is hypothesized that increases in Private Nonfarm Employment would be associated with decreases in the amount of farmland.

Total transfer payments excluding unemployment insurance benefit payments and income maintenance benefits. Retirement and other consists of retirement and disability insurance benefit payments, medical benefits, veterans benefit payments, federal education and training benefits, other government payments to individuals, government payments to nonprofit institutions, and business payments. (REIS Definition)

Hypothesis: This variable was included because its data was available as part of the REIS dataset and it was identifiable in all analyses. There is no hypothesis as to how it relates to changes in the amount of farmland.
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<tbody>
<tr>
<td>Number of Wage And Salary Jobs</td>
<td>REIS</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>All</td>
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</tbody>
</table>

Wage and salary employment, also referred to as wage and salary jobs, measures the average annual number of full-time and part-time jobs in each area by place-of-work. All jobs for which wages and salaries are paid are counted. Full-time and part-time jobs are counted with equal weight. Jury and witness service, as well as paid employment of prisoners, are not counted as wage and salary employment; the payments for these activities are classified as "other labor income" in the personal income measure. Corporate directorships are counted as self-employment.

Hypothesis: This metric combines together full time and part time positions. Controlling for population changes, changes in the Number of Wage and Salary Jobs represent increases in the availability of employment outside of agriculture for farmers. Thus, for the same reasons as above, it is hypothesized that increases in the Number of Wage and Salary Jobs would be associated with decreases in the amount of farmland. However, given the fact that this analysis also includes the Value of Wage and Salary Disbursements, increases in this variable may be associated with more part time employment and thus could have the opposite effect on the amount of farmland.

Value of Wage and Salary Disbursements  
REIS  Yes  Yes  Yes  All

Wage and salary disbursements consists of the monetary remuneration of employees, including corporate officers salaries and bonuses, commissions, pay-in-kind, incentive payments, and tips. It reflects the amount of payments disbursed, but not necessarily earned during the year. Wage and salary disbursements is measured before deductions, such as social security contributions and union dues. In recent years, stock options have become a point of discussion. Wage and salary disbursements includes stock options of nonqualified plans at the time that they have been exercised by the individual. Stock options are reported in wage and salary disbursements. The value that is included in wages is the difference between the exercise price and the price that the stock options were granted. For more information, see Carol Moylan's paper "Treatment of Employee Stock Options in the U.S. National Economic Accounts".
Hypothesis: Controlling for the number of wage and salary jobs, increases in this variable would be associated with increasing wages. These increasing wages would make non-farm employment more attractive relative to agriculture. Thus increases in the Value of Wage and Salary disbursements is hypothesized to be associated with decreases in the amount of farmland.

**Old Age Survivors and Disability Insurance OASDI Benefits**

These benefits, popularly known as social security, consist mainly of monthly benefits received by retired and disabled workers, dependents, and survivors and lump-sum payments received by survivors. The state estimates are based on annual tabulations of payments from the Social Security Administration (SSA). The county estimates are based on SSA tabulations of the amount of monthly benefits paid to those in current-payment status on December 31 by county of residence of the beneficiaries (REIS Definition).

Hypothesis: Given the fact that that Social Security payments are made primarily to the elderly, increases of this variable are expected to be associated with an aging population. There is no strong hypothesis as to how an aging population would affect agriculture at the county level and thus the amount of farmland.

**Railroad Retirement and Disability Benefits**

These benefits are received by retired and disabled railroad employees and their survivors under the Federal program of retirement insurance for railroad employees, who are not covered by OASDI. The state and county estimates are based on tabulations of the benefits disbursed by the Railroad Retirement Board (REIS Definition).

Hypothesis: This variable was included because its data was available as part of the REIS dataset and it was identifiable in all analyses. There is no hypothesis as to how it relates to changes in the amount of farmland.
Worker's Compensation

Workers' compensation consist of the payments that are received by individuals with employment-related injuries and illnesses and by the survivors of individuals who died of employment-related causes. The payments are from both Federal and state government funds. The state estimates of the payments received from the Federal fund, which covers only Federal civilian employees, are based on payments data from the Department of Labor. Compensation payments to both public and private employees from state-administered workers' compensation funds consist of the payments received under exclusively state-administered workers' compensation insurance programs, the payments received under state-administered insurance programs that compete with private insurance programs, and the payments received under the state-administered programs for second-injury funds (REIS Definition).

Hypothesis: This variable was included because its data was available as part of the REIS dataset and it was identifiable in all analyses. There is no hypothesis as to how it relates to changes in the amount of farmland.

Other Government Retirement and Disability Insurance Benefits

Other government retirement and disability insurance benefits consist largely of temporary disability payments, Pension Benefit Guaranty payments, and black lung payments (REIS Definition).

Hypothesis: This variable was included because its data was available as part of the REIS dataset and it was identifiable in all analyses. There is no hypothesis as to how it relates to changes in the amount of farmland.

Medicare Benefits

These benefits are Federal Government payments made through intermediaries to beneficiaries for the care provided to individuals under the provisions of the Medicare program (REIS Definition).
Hypothesis: Because of the fact that Medicare payments are made disproportionately to people of low income (who may also be elderly) this variable is considered a proxy for changes in the distribution of health across the economic spectrum. There is no hypothesis as to how it relates to changes in the amount of farmland.

Military Medical Insurance  

Military medical insurance benefits consist of payments made under the TriCare Management Program, formerly called the Civilian Health and Medical Plan of the Uniformed Services program (CHAMPUS), for the medical care of dependents of active duty military personnel and of retired military personnel and their dependents at nonmilitary medical facilities (REIS Definition).

Hypothesis: This variable was included because its data was available as part of the REIS dataset and it was identifiable in all analyses. There is no hypothesis as to how it relates to changes in the amount of farmland.

Supplemental Security Income (SSI) Benefits

These benefits consist of the payments received by low-income persons who are aged, blind, or disabled from both the Federal and state governments (REIS Definition).

Hypothesis: This variable was included because its data was available as part of the REIS dataset and it was identifiable in all analyses. There is no hypothesis as to how it relates to changes in the amount of farmland.

Family Assistance

These benefits were payments to low-income families under the State administered Aid to Families with Dependent Children (AFDC) and emergency assistance programs that received Federal matching funds. During 1997, these programs were superseded by the Temporary Assistance to Needy Families (TANF) program. The state estimates through 1996 were based on
unpublished quarterly data for these payments from the Administration for Children and Families (ACF) of the Department of Health and Human Services. The state estimates for AFDC and emergency assistance for 1997 were based on ACF unpublished data for the Federal grants to the states for fiscal year 1997. These data were adjusted to reflect (1) the number of months during calendar year 1997 that the AFDC and emergency assistance programs were in operation in each state, and (2) the fund matching percentage that was required of each state. The state estimates of the TANF payments for 1997 through 2001 were based on fiscal year direct data from the ACF Web site (REIS Definition).

Hypothesis: Increases in the value of this variable are expected to be associated with increases in poverty and declines in the Median Household Income. As areas with higher rates of poverty and lower Median Household Incomes have historically been associated with areas of more agriculture (although this is primarily mediated by the fact that rural areas broadly speaking are characterized by these two facts) it is possible that increases in Family Assistance will be associated with increases in the amount of farmland. This may occur because, in some communities that are land rich, agriculture may act as a fallback option for individuals that have not been able to secure employment elsewhere. These individuals may bring idle land into production in order to try and achieve the greatest profit possible. Thus it is hypothesized that increases in the value of Family Assistance benefits will be associated with increasing amounts of farmland.

**Supplemental Nutrition Assistance Program (SNAP)**

These benefits are issued to qualifying low-income individuals in order to supplement their ability to purchase food. Eligibility is determined by the state authorities’ interpretation of Federal regulations; the U.S. Department of Agriculture (USDA) pays the cost of the assistance. The state and county estimates are based on county tabulations of the value of the distributed benefits from the Department of Agriculture (REIS Definition).

Hypothesis: Given the fact that increased amounts of SNAP payments are expected to occur
alongside increasing amounts of poverty, the same argument as made under Family Assistance applies here.

**Other Income Maintenance**

Other income maintenance benefits consist largely of general assistance; expenditures for food under the supplemental program for women, infants, and children; refugee assistance; foster home care and adoption assistance; earned income tax credits; and energy assistance (REIS Definition).

Hypothesis: Given the fact that increased amounts of these payments are expected to occur alongside increasing amounts of poverty, the same argument as made under Family Assistance applies here.

**State Unemployment Insurance Compensation**

State Unemployment Insurance Compensation consists mainly of payments received by individuals under state-administered unemployment insurance (UI) programs, but includes the special benefits authorized by Federal legislation for periods of high unemployment (REIS Definition).

Hypothesis: Given the fact that one would expect increases in the value of State Unemployment Benefits being paid out to be associated with increased rates of unemployment, it may be the case that increases of this variable may be associated with increasing amounts of agriculture. This may occur because if people who have left agriculture but still have access to the necessary land/capital are unable to find employment off of the farm, they may return to the farm in order to engage in agricultural production. If the land now being used had not been involved with agricultural production for some time, this would register as increasing amount of farmland. Thus it is hypothesized that increases in the State Unemployment Insurance Compensation will be associated with increasing amounts of farmland.
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<tbody>
<tr>
<td><strong>Unemployment Compensation</strong></td>
<td>REIS</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>All</td>
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</table>

**For Railroad Employees**

Unemployment compensation of railroad employees are benefits received by railroad workers who are unemployed because of sickness or because work is unavailable in the railroad industry and in related industries, such as carrier affiliates. This UI program is administered by the Railroad Retirement Board (RRB) under a Federal program that is applicable throughout the Nation. See Unemployment insurance compensation (REIS Definition).

Hypothesis: Given the fact that one would expect increases in the value of State Unemployment Benefits being paid out to be associated with increased rates of unemployment, it may be the case that increases of this variable may be associated with increasing amounts of agriculture. This may occur because if people who have left agriculture but still have access to the necessary land/capital are unable to find employment off of the farm, they may return to the farm in order to engage in agricultural production. If the land now being used had not been involved with agricultural production for some time, this would register as increasing amount of farmland. Thus it is hypothesized that increases in the State Unemployment Insurance Compensation will be associated with increasing amounts of farmland.

**Veteran's Benefits**

Combination of Unemployment Benefits for Veterans, Veteran's Pension and Disability Benefits, Veteran’s Readjustment Benefits, and Veteran's Life Insurance Benefits. Unemployment Benefits for Veterans - These benefits are received by unemployed veterans who have recently separated from military service and who are not eligible for military retirement benefits. The compensation is paid under a Federal program that is administered by the state employment security agencies. See Unemployment insurance compensation Veteran’s Pension and Disability Benefits - These benefits consist mainly of the payments that are received by veterans with service-connected disabilities and by the survivors of military personnel who died of service-connected causes. In addition, these benefits include the payments that are received by war veterans who are 65 years old or older,
who have nonservice-connected disabilities, who are permanently and totally disabled, and who meet specified income requirements. The state and county estimates are based on the data for these payments from the Department of Veterans Affairs (DVA) / Veteran's Readjustment Benefits: These benefits are the payments of the allowances for tuition and other educational costs that are received by veterans and by the spouses and the children of disabled and deceased veterans; and for automobiles, conveyances, and specially adapted housing for disabled veterans / Veteran's Life Insurance Benefits - These benefits consist of the payments received by the beneficiaries of veterans life insurance policies and the dividends received by the policyholders from the five veterans life insurance programs administered by the Department of Veterans Affairs (DVA). The state and county estimates are based on data for these benefits from the DVA (REIS Definition).

Hypothesis: This variable was included because its data was available as part of the REIS dataset and it was identifiable in all analyses. There is no hypothesis as to how it relates to changes in the amount of farmland.

**Education and Training**

| REIS | Yes | Yes | No | All |

These benefits consist of the payments to outstanding science students who receive National Science Foundation (NSF) grants, the subsistence payments to the cadets at the six state maritime academies, and the payments for all other Federal fellowships. Higher education student assistance: These benefits consist of the Federal payments, called Pell Grants, for an undergraduate education for students with low incomes. Job Corps payments&-; these benefits are primarily the allowances for living expenses received by economically disadvantaged individuals who are between the ages of 16 and 21 and who are enrolled in the designated vocational and educational training programs. These benefits also include the adjustment allowances received by trainees upon the successful completion of their training. Interest payments on guaranteed student loans&-; these payments are made by the Department of Education to commercial lending institutions on behalf of the individuals who receive low-interest, deferred-payment loans from these institutions in order to pay the expenses of higher education. State educational assistance:
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<tbody>
<tr>
<td>Analyses Variables Variables</td>
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These benefits consist of educational assistance provided by states to individuals for tuition and other educational expenses not including loans. The national and state estimates are based on data for state government expenditures for "other education assistance and subsidies" from the Census Bureau's annual State Government Finances (REIS Definition).

Hypothesis: Given the fact that increasing amounts of agricultural production tend to occur in areas with lower levels of education, it is likely the case that there is a negative relationship between increases in the amount of Education and Training Assistance and the value of agriculture. Thus it is hypothesized that increases in the value of Education and Training Assistance will be associated with decreases in the amount of farmland at the county level.

Other Transfer Receipts of Individuals from Governments

Other transfer receipts of individuals from governments consist largely of Bureau of Indian Affairs payments, education exchange payments, Alaska Permanent Fund dividend payments, compensation of survivors of public safety officers, compensation of victims of crime, disaster relief payments, compensation for Japanese internment, and other special payments to individual

Receipts from the Federal government: These payments consist mainly of the payments to private nonprofit hospitals for hospital construction and the payments to private educational institutions on behalf of the recipients of Federal fellowships, Pell grants, and other education and training programs (REIS Definition).

Hypothesis: This variable was included because its data was available as part of the REIS dataset and it was identifiable in all analyses. There is no hypothesis as to how it relates to changes in the amount of farmland.

Receipts from the Federal Government

These payments consist mainly of the payments to private nonprofit hospitals for hospital construction and the payments to private educational institutions on behalf of the recipients of
Federal fellowships, Pell grants, and other education and training programs (REIS Definition).

Hypothesis: This variable was included because its data was available as part of the REIS dataset and it was identifiable in all analyses. There is no hypothesis as to how it relates to changes in the amount of farmland.

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<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receipts from State and Local Governments</td>
<td>REIS</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>All</td>
<td></td>
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</table>

Receipts from state and local governments consist of state and local government payments to nonprofit institutions for education assistance and for employment and training (REIS Definition).

Hypothesis: This variable was included because its data was available as part of the REIS dataset and it was identifiable in all analyses. There is no hypothesis as to how it relates to changes in the amount of farmland.

| Receipts from Businesses | REIS | Yes | Yes | No | All | |

Receipts from businesses consists mainly of corporate gifts of money, securities, and real property to nonprofit institutions that serve individuals (REIS Definition).

Hypothesis: This variable was included because its data was available as part of the REIS dataset and it was identifiable in all analyses. There is no hypothesis as to how this variable is expected to relate to changes in the amount of farmland.

| Current Transfer Receipts of Individuals from Businesses | REIS | Yes | Yes | No | All | |

Current transfer receipts of individuals from businesses consist of personal injury liability payments to individuals other than employees (REIS Definition).

Hypothesis: This variable was included because its data was available as part of the REIS dataset and it was identifiable in all analyses. There is no hypothesis as to how this variable is expected to relate to changes in the amount of farmland.
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<tbody>
<tr>
<td><strong>Cash Receipts Livestock and Related Products</strong></td>
<td>REIS</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>All</td>
</tr>
<tr>
<td>Cash receipts from livestock and products is the value of gross revenues received from the marketings of livestock and livestock products during a given calendar year. This includes the marketing of meat animals such as cattle and calves, hogs and pigs, sheep and lambs; poultry and poultry products (including eggs); and dairy products. Also included is the marketing of horses, bees, animal aquaculture, and other miscellaneous animal species raised on agricultural operations. (REIS Definition)</td>
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<tr>
<td>Hypothesis: As most livestock operations are at least somewhat diversified into row crop production (in order to effectively and legally use the waste generated from the livestock production by using it as fertilizer) one would expect that increases in the total amount of livestock raised (and thus increased amounts of available fertilizer) would drive increased amounts of farmland. However, it may be the case that at the level of the individual farm livestock production (especially once is succeeds as certain scale) may substitute for row crop production. Because the same value of livestock can be produced on a much smaller parcel of land (using CAFO production techniques) than in typical row crop production this substitution may lead to a net loss of farmland.</td>
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</tr>
<tr>
<td><strong>Cash Receipts Crops</strong></td>
<td>REIS</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>All</td>
</tr>
<tr>
<td>Cash receipts from crops is the value of gross revenues received from the marketing of crop commodities during a given calendar year. Crop commodities include grains, such as corn, wheat, and soybeans; hay; vegetables; fruits and nuts; greenhouse and nursery products; tobacco; cotton; and other miscellaneous crops (REIS Definition).</td>
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<tr>
<td>Hypothesis: Since the revenue generated from row crop production is inherently tied to the use of farmland, one would expect that increases in the total revenue generated from crop sales would spur increased amounts of farmland.</td>
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<tr>
<td><strong>Government Payments</strong></td>
<td>REIS</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>All</td>
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</table>
Federal government payments to farmers are payments made to farm operators under several federal government farm subsidy programs during a given calendar year. These payments include deficiency payments under price support programs for specific commodities, disaster payments, conservation payments, and direct payments to farmers under federal appropriations legislation (REIS Definition).

Hypothesis: As these payments are treated as expected income sources by farmers and that they reward large agricultural operations over smaller ones. Increases in the amount of government payments would be expected to drive increased amounts of farmland. Furthermore, in years in which these government payments increase due to some natural calamity, it is likely that additional land would enter production agriculture because it will be temporarily priced lower than it otherwise would be.

**Imputed and Miscellaneous Income Received**

Imputed and miscellaneous income received consists of imputed income, such as value of home consumption, and other farm related income components, such as machine hire and custom work (REIS Definition).

Hypothesis: It is hypothesized that increases in the amount of imputed and miscellaneous income will be associated with lower revenues produced from farming. For reasons previously stated, decreases in revenues from farming are hypothesized to be associated with decreases in the amount of farmland.

**Feed Purchased**

Feed purchased are expenditures for the purchase of feed by all farms during a given calendar year. (REIS Definition)

Hypothesis: Increases in the amount of feed purchased are expected to be associated with increases in the amount of livestock production. The same hypothesis are made for feed.
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**Livestock Purchased**

Livestock purchased are expenditures for the purchase of livestock by all farms during a given calendar year (REIS Definition).

Hypothesis: Increases in the amount of livestock purchased are expected to be associated with increases in the amount of livestock production. The same hypothesis are made for livestock purchased as were made for increased in the cash receipts from livestock operations.

**Seed Purchased**

Seed purchased are expenditures for the purchase of seed by all farms during a given calendar year (REIS Definition).

Hypothesis: Increases in the amount of seed purchased are expected to be associated primarily with increases in the amount of row crop production. The same hypothesis are made for seed purchased as were made for increases in the cash receipts from crop operations.

**Fertilizer and Lime Including Ag Chemicals**

Fertilizer and lime are expenditures on fertilizer and lime by all farms during a given calendar year. After 1977, this estimate includes expenditures on agricultural chemicals (pesticides), as well (REIS Definition).

Hypothesis: Increases in the amount of fertilizer, lime and agricultural chemicals purchased are expected to be associated primarily with increases in the amount of row crop production. The same hypothesis are made for seed purchased as were made for increases in the cash receipts from crop operations.

**Petroleum Products Purchased**

Petroleum products purchased are expenditures for the purchase of petroleum products by all

purchased as were made for increased in the cash receipts from livestock operations.
farms during a given calendar year (REIS Definition).

Hypothesis: This is primarily for both increased amounts of mechanization in row crop production and increases in confinement animal livestock operations. As both of these changes in agriculture are expected to be associated with increases in the value of cash receipts from crops and livestock respectively, increases in petroleum products is expected to be associated with increases in the amount of farmland.

**Hired Farm labor Expenses**

Hired farm labor expenses are expenditures for hired labor by all farms during a given calendar year. It consists of hired workers' cash pay and perquisites, employers' contributions for social security and Medicare, and payments for contract labor, machine hire, and custom work (REIS Definition).

Hypothesis: Given the expected elastic supply of labor available for agriculture (at least with regard to seasonal work which is a major source of employment in modern agricultural operations) one would expect that changes in the amount of Hired Farm labor expenses would be associated primarily with changes in the amount of labor employed and less with changes in the wages paid. Because of this we expect increases in the amount of farm labor expenses to be associated with increases in the amount of farmland.

**All Other Production Expenses**

All other production expenses are expenditures not elsewhere classified incurred by all farms in the production of agricultural commodities during a given calendar year. It consists of repair and operation of machinery; depreciation, interest, rent, and taxes; and other miscellaneous expenses. For the years 1969-1977, this estimate includes expenditures on agricultural chemicals (pesticides), as well (REIS Definition).

Hypothesis: As this category of expenditures is expected to grow with the size of farming operation, it is hypothesized that increases in all other production expenses is expected to be
associated with increases in the amount of farmland for reasons stated above.

**Value of Inventory Change**  
REIS  Yes  Yes  No  All

**Livestock**

The value of inventory change for livestock is the estimated value of the net change in the farm inventories of livestock commodities that are held for sale during a given calendar year (REIS Definition).

Hypothesis: Because the inventory of livestock and associated goods would be expected to change more so due to fluctuations in market demand than changes in livestock output, there is not a prediction as to how changes in the value of livestock inventory would move relative to changes in the amount of farmland.

**Value of Inventory Change**  
REIS  Yes  Yes  No  All

**Crops**

The value of inventory change for crops is the estimated value of the net change in the farm inventories of crop commodities that are held for sale during a given calendar year (REIS Definition).

Hypothesis: Because the inventory of crops (most commonly grain crops and soybeans) would be expected to change more so due to fluctuations in market demand than changes in crop output, there is not a prediction as to how changes in the value of crop inventory would move relative to changes in the amount of farmland.

**Net Income of Corporate Farms**  
REIS  Yes  Yes  No  All

Net income of corporate farms refers to the net income of corporate farms arising from the current production of agricultural commodities. The estimates of farm cash receipts, other income, and production expenses include the income or loss from both privately owned and corporate farms. However, the income of corporate farms is not included in total net farm proprietors' income and is shown as a subtraction from total net farm income (REIS Definition).
Hypothesis: Because corporate agriculture typically occurs on large scales for both crop and livestock production, one would expect increases in the amount of net income for corporate farms to be associated with increases in the amount of farmland. This would occur so that these farms are better able to achieve increased economies of scale in their operations.

**Farm Supplements to Wages**

Farm supplements to wages and salaries consists of the contributions of farm employers to privately administered workmen’s compensation, pensions, and welfare plans; and of the contributions of farm employers for government social insurance (REIS Definition).

Hypothesis: Because one would expect only full time agricultural workers to receive these benefits, it is hypothesized that increases in the farm supplements to wages and salaries would be associated with increases in the amount of farmland for the same reasons as changes in Farm Employment.

**Number of Farms**

Number of Farms within the county. Data interpolated to annual intervals using linear splines

Hypothesis: Given the fact that both the average and median farm sizes have increased in NC over the past several decades, it is unclear as to whether increases in the number of farms would be associated with increases in the amount of farmland. This is because smaller operations would not be able to capitalize on increased economies of scale in the same way that large operations are and thus they would have less incentive to bring new land into production. However, the analysis presented below found a consistent and strong relationship between increases in the amount of farms and increases in the amount of farmland. In order to establish a causal relationship between these two variables using instrumental variable techniques (and handle the obvious endogeneity issue) this variable was instrumented using the variable Farm Proprietor’s employment and the
analysis was repeated. No qualitative changes in the results occurred from this instrumentation.

**Number of Live Births**  
City/County | No | Yes | No | All  
Databooks

Number of live births within the county. Data Interpolated to annual intervals using linear splines.

Hypothesis: In the subsequent analysis, the combination of this variable, number of deaths, and changes in the population within the county can be viewed as a measure of the rate of migration into the county. While it is the case that, when controlling for population changes, increasing birth rates are typically associated with lower income levels and that farming tends to be more prevalent in areas with lower income, there does not appear to be any causal path between the birth rate and changes in agriculture. Furthermore, in some areas of the state agriculture has become more prevalent in areas with higher income for reasons stated under the Population Variable.

**Number of Deaths**  
City/County | No | Yes | No | All  
Databooks

Number of deaths within the county. Data Interpolated to annual intervals using linear splines.

Hypothesis: See number of live births.

**Number of Infant Deaths**  
City/County | No | Yes | No | All  
Databooks

Number of deaths of children less than 1 year of age within the county. Data Interpolated to annual intervals using linear splines.

Hypothesis: This variable, when controlling for the number of live births in the county, as frequently used a proxy for the overall health of the population. There is no strong hypothesis as to how changes in the health of the population would affect agriculture at the county level and
thus the amount of farmland.

**Percentage of County Population that Self-Identifies as White**

Percentage of County residents that report their ethnicity as White. Allows for individuals to indicate multiple ethnicities. Data interpolated to annual intervals using linear splines.

Hypothesis: Given this fact one would expect that decreases in the Percentage of white individuals in the county would be associated with less agriculture and thus less farmland. However, if farming operators were to be raising mixed-race children, one would not expect the aforementioned pattern to hold. No prediction is made for changes in this variable.

**Percentage of the County Population with Highschool Diploma**

Percentage of County residents that have received a Highschool diploma or equivalent. Data interpolated to annual intervals using linear splines.

Hypothesis: Given the fact that some employment opportunities that are alternatives to agricultural production require certain amounts of schooling that may be in excess of a Highschool Diploma, one would individuals with less education to have less employment opportunities off of the farm. Therefore it is hypothesized that increases in the percentage of the population with a highschool diploma will be associated with declines of agriculture and therefore less farmland because they will be better candidates for employment off of the farm.

**Median Family Income**

Median Family Income
Hypothesis: For the same reasons as stated above for Family Assistance, it is hypothesized that increases in the Median Family Income will be associated with decreases in the amount of farmland.

**Percentage of Families Classified as Low Income**

Percentage of all households that fall below the most recent Federal Classification of the Poverty Threshold for a family of 4. Data interpolated to annual intervals using linear splines.

Hypothesis: For the same reasons as stated above for Family Assistance, it is hypothesized that increases in the Median Family Income will be associated with decreases in the amount of farmland.

**Simpson Index for Ecological Diversity**

Simpson Index calculated from historical Breeding Bird Survey Data. The diversity of bird populations are a known proxy measure for overall ecological health. For counties that had 1 or more routes in a given year the Simpson Index was an average of all routes. For counties that did not have a route in a given year the data was spatially interpolated using the nearest neighbor route relative to the centroid of that county.

Hypothesis: The reason this variable was included is that there is a great deal of agronomic evidence that the yields of agricultural operations are improved by greater amounts of biodiversity in the area (Altieri, 1999). This effect may be due to naturally occurring Integrated Pest Management, increased pollination services, increased soil microbial health, or a number of others. Because of this fact it is hypothesized that increasing amounts of Ecological Diversity at the county level will be associated with increased agricultural production. This hypothesis is assuming that ecological diversity causally impacts yields, not the other way around. This hypothesis is consistent with the way the various covariates are represented in the modeling. The increase in production while holding all inputs constant will increase profitability encouraging farmers to bring
additional land into production. Furthermore, it is also possible that if this additional land brought into production is managed in way that does not support ecological health, farmers may ultimately remove this land from production because they are unable to maintain the same level of production as they are no longer receiving the same degree of Ecosystem Services. This would occur alongside a decline in this variable.

**Length of Roads**

NCDOT  No   Yes   No   All

Sum of all roads within a county in a given year. All Roads, regardless of width, designation, or use are treated equally. Data derived from historical NC Department of Transportation Records.

Hypothesis: The profitability of agriculture is dependent on being able to bring produced goods to market. Increases in the amount of roads at the county level, which would decrease transport time and distances on average, would improve the profitability of agriculture by decreasing transportation costs. Because increases in the Length of Roads at the county level is expected to improve the profitability of farming, one would expect increases in this variable to be associated with increasing amounts of farmland. This is because the increasing profitability would encourage farmers to bring more land into production to achieve greater returns and capitalize on greater economies of scale. While it is possible that the increase in road infrastructure would come at the expense of some amount of farmland, a relatively small amount would need to be sacrificed in order to see decreased transportation costs. These decreased transportation costs would likely have a positive net effect on the amount of farmland, even taking in to account the need to develop some amount of farmland in the process.

**Amount of Forest Coverage**

US Forest  No   Yes   No   All  

Service

Total area within a county that is covered by forest as defined by the US Forest Service. Includes both forest areas intended for eventual logging and non. Data interpolated to annual intervals using linear splines.

Hypothesis: It is commonly thought that a great deal of land brought into agricultural production
for the first time was previously used as forestland. Thus it is hypothesized that decreases in the amount of forestland will be associated with increases in the amount of farmland.

**Total Cropland in Tobacco**

County’s total cropland devoted to tobacco production in a given year. Data interpolated to annual intervals using linear splines.

Hypothesis: This variable was included in the analysis to act as a proxy for changes in the Tobacco Quota system which was phased out during the period of time covered in this analysis. As this program essentially subsidized tobacco production by establishing a price floor, one would expect that decreases in the amount of tobacco acreage would lead to decreases in the amount of farmland. While this superficially appears to be a tautology, it is always possible that land that was used for tobacco production could have been shifted to growing other crops. However, on a per acre basis tobacco is far more profitable than most other commercial crops. Thus it is expected that at least in some cases losses of tobacco acreage would drive a subset of farms out of business. Thus for the reasons stated above for the “Number of Farms” variable there is no strong prediction as to changes in tobacco acreage would effect changes in the amount of farmland.

**Corn & Soybean Acreage**

Acreage of cropland devoted to corn or soybean production in a given year. Data interpolated to annual intervals using linear splines.

Hypothesis: As corn and soybeans are the canonical crops for large scale row crop production across all of North Carolina, increased amounts of acreage devoted to these two crops would be expected to be associated with increased average scale of agriculture. Thus it is expected that increased amounts of Corn & Soybean acreage would be associated with increased amounts of farmland for the same reasons as stated above.
### Commodity Prices

US average commodity prices for Corn, Soybeans, Wheat, Calves, Cattle, Hogs and Milk.

Hypothesis: Neoclassical economic theory makes strong predictions that the prices received for these goods will directly affect their level of production. Thus it is hypothesized that increases in commodity prices will be associated with increases in the amount of farmland so that greater profits may be generated both by increased revenues and achieving greater economies of scale.