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CAUSES AND TRENDS OF LAND CONVERSION: A STUDY OF URBANIZATION IN NORTH ALABAMA

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Selected Paper prepared for presentation at the
Southern Agricultural Economics Association's Annual Meetings
Orlando, Florida, February 5-8, 2006

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CAUSES AND TRENDS OF LAND CONVERSION: A STUDY OF URBANIZATION IN NORTH ALABAMA

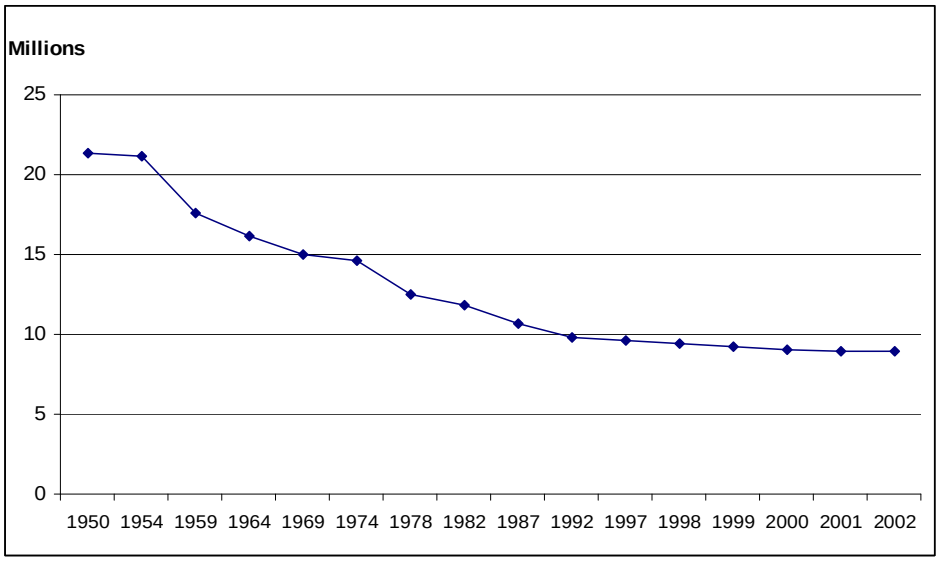
ABSTRACT

Alabama is experiencing significant pressure to convert agricultural land to urban uses. The dominant pattern of urbanization has been the conversion of agricultural land to residential and commercial uses. This paper examined regional, state, and local land use trends and developed a tool for identifying the determinants and impacts of past and proposed land use change in north Alabama using selected cities and towns in Madison County.

I. Introduction

Land use change is the result of complex interaction between the physical, socioeconomic, and legal setting within a geographical context. And that geographical context in itself is a complex spatial and temporal scale filled with uncertainty and error within virtually any description of land resources. In other words, any examination of land use is, by definition, imprecise and incomplete (Johnson, 2004). Also, there are many impacts resulting from conversion of farmland and certainly Alabama is experiencing most of them (Vanderberry, 2004). The state's landscape has changed recognizably since the middle of the last century. Farms no longer make up nearly two-thirds of the state's 32.5 million acres, as they did in 1950 with over 20 million acres (Figure 1).

Figure 1: Alabama Farmland Trend, 1950-2002

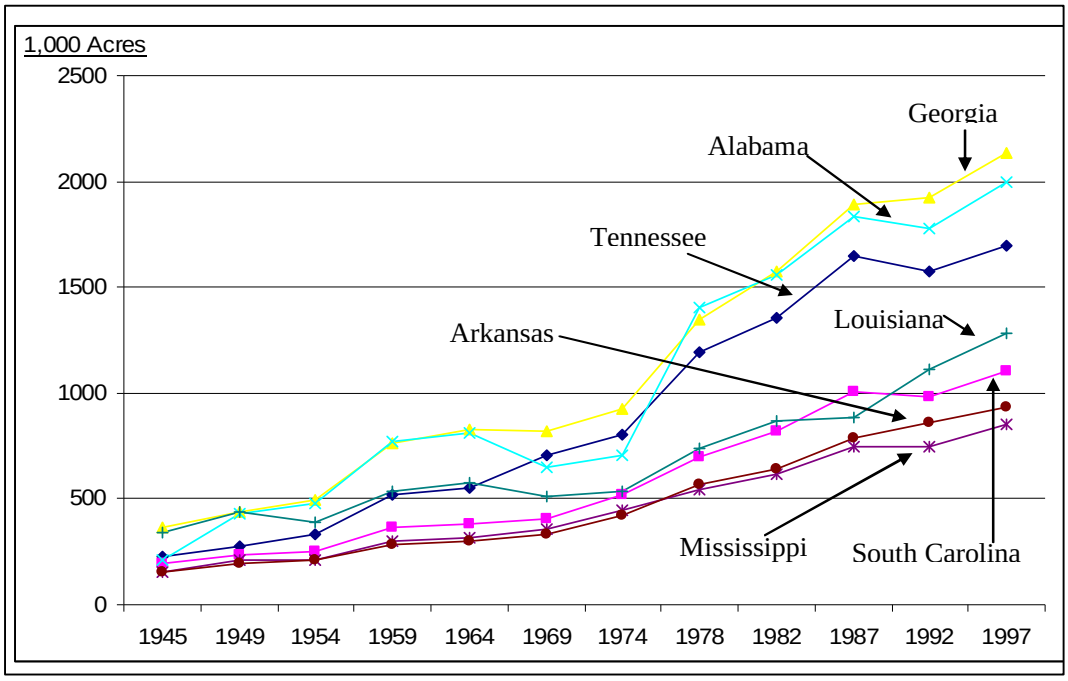


Source: Constructed by authors using data from NASS, Statistical Bulletin No. SB-991

Today, land in farms, which includes cropland, pastureland, rangeland, wooded land, farm ponds, and land around the farmstead, is less than 10 million acres (Figure 1) and comprises just over one-fourth of total land area in the state (Vanderberry, 2004).

This trend is not only common in Alabama. Other states in the south have seen declines in farm land as well; however, not quite as dramatic as in Alabama—the state ranks 12th in the nation among states with the most number of acres of newly developed land. In the south, Alabama is one of the states that have seen extensive urban landscapes growing at unprecedented rates (Figure 2). Across the region, the conversion of farmland to urban use has been identified to be the greatest threat to the long-term viability of the agricultural sector (Olson and Olson, 1999; Koontz, 2001; Rosenberger et al., 2002). The increasing demand for these non-agricultural land uses has fragmented the agricultural land base, and has driven up land values, as the "market value" for such non-agricultural land-use is normally significantly higher than the value of the land for agricultural production.

Figure 2: Trends in Urban Land, 1945-1997



Source: Constructed by authors using data from USDA National Resources Inventory

Given the data available to researchers however, the extent of change and the associated impacts are exceedingly difficult to track (dela Cruz, 2001; Olson and Olson, 1999; Koontz, 2001). This paper draws data primarily from the Census of Agriculture to examine the trends in land use across the state. This is done by first examining statewide trends and then estimate land use coefficients—computed as the change in urban land area as a ratio of change in population. The paper also examines the factors determining land conversion across cities and townships for one of the fastest growing county in north Alabama, Madison County. This is done by estimating an econometric model analyzing the relationships between developed land area and the various factors that are seen to be influencing the decision to convert agricultural land into development, especially residential development.

II. Related Studies

Farmland conversion issues have received considerable attention in literature. Ahn (2002) presented historical trends and future projections of forest, agricultural, and urban/other land uses for the South Central Region of the United States. Using an econometric land use model, the study investigated the relationship between the areas of land in alternative uses and economic and demographic factors influencing land use decisions. Land use determinants included are the net returns from different land uses, quality of land, and demographic variables like population density. Projections of future land use were generated using the model. The estimation results support the findings of earlier studies that net returns to alternative uses, demographic variables such as population density, and land quality are significant determinants of private land use

decisions. The projection results showed continued increases in urban/other land as a result of continued population growth in the region. The results suggested that land development is unlikely to significantly affect forestland in the South Central region over the next and the size of the forestland base will not be a factor limiting supplies of timber and other benefits from the forest.

A similar study by dela Cruz (2001) used an empirical model to estimate the determinants of land conversion. It assumed that an increase in built-up area will increase land conversion. The determinants included population, income, house value, lot size and agricultural rent. The results showed that land conversion increases with increased income and population and is not affected by changes in house value, lot size or agricultural income.

Another study found out that rural land converted to urban uses is directly related to increases in population in the South. Reynolds (2001) estimated land-use coefficients to provide a measure of the amount of land converted to urban uses per person added to the population base. The results indicate that from 1974 to 1987, two-thirds to three fourths of an acre of land was converted to urban uses for each person added to the population base. At this rate, about 12.6 million acres are expected to be converted to urban use in the South in the next two decades.

Kuminoff and Sumner (2001) examined both the numbers that measure farmland conversions and the related public perceptions about the causes and consequences of conversion. They used information from public opinion poll results, newspaper editorials, as well as public support for policies that promote farmland preservation. Results showed that farmland conversion is a serious issue in California and the

evidences presented revealed that its effects are more long term than immediate, more visible in particular localities than statewide, and involve more than direct agriculture-to-urban changes.

In 2005, an economic analysis of agricultural land conversion in the Southeast region (Nzaku and Bukenya, 2005) revealed that growth in population and employment over time has compromised with the agricultural sector on the use and allocation of land. Regional growth models as well as structural growth modeling techniques were used to understand the factors influencing the conversion of agricultural lands. Particularly, they found out that farmland conservation, home ownership, per capita taxes, employment expansion, and agricultural sales are significant determinants of farmland conversion.

Ramsy and Corty (1982) used ordinary least squares regression techniques to analyze the factors influencing the conversion process of prime agricultural lands to urban use. Aggregate census data for Louisiana urban population, urban family income, and prices per acre of farmland were used in the regression analysis. The results showed that change in urban population is a significant factor influencing agricultural land conversion.

III. Land Use Trends

More than half (55 percent) of Alabama's population resides in urban areas. As population increases, the need for land converted to housing and other urban uses increases. Federal land in Alabama totaled about 1 million acres in 1997 (3 percent). Non-federal land amounted to about 32 million acres (97 percent) of the state's total land area, mostly non-Federal rural land (86 percent) and non-Federal developed land (7

percent). Table 1 shows the land use distribution of non-federal rural land in Alabama. Most of Alabama's 29 million acres of non-federal rural land resides in forest land (73 percent), followed by pastureland (12 percent), cropland (10 percent), Conservation Reserve Program (CRP, 2 percent), range land (1 percent), and other rural land (2 percent). In the last 15 years, Alabama cropland has decreased to about 35 percent losing over 1.5 million acres. Although not considered a major threat to food production, urbanization and land use change results to the fragmentation of rural land including the loss of prime agricultural land. The decline in pastureland and range land between 1982 and 1997 was estimated at about 221,000 and 16,000 acres, respectively. To the contrary, forest and CRP land increased by about 302,300 and 521,900 acres in total area, respectively.

Table 2 presents the land area for prime farmland between 1982 and 1997. By definition, prime agricultural land is land of highest quality for food and fiber production (Ramsey and Corty, 1982). Alabama has lost about 955,000 (33 percent) acres of prime agricultural land from 1982 to 1997. All other types of rural land had an increase in surface area, although total rural land has lost 276,000 acres caused by lost of prime farmland. From 1992 to 1997 alone, cultivated cropland has decreased by about 190,000 acres.

Table 1. Land cover / use of non-federal rural land in Alabama, (data in 1,000 acres)

Year	Cropland	CRP land	Pastureland	Rangeland	Forest land	Other rural land	Total rural land
1982	4509.1	0.0	3747.0	83.2	20831.1	520.7	29691.1
1987	3994.4	207.9	3600.7	74.0	21104.8	503.3	29485.1
1992	3146.3	535.0	3752.8	73.9	21188.2	619.6	29315.8
1997	2,953.7	522.0	3528.2	73.6	21261.0	611.9	28950.4

Table 2. Prime farmland, by land cover/use (in 1000 acres)

Year	Cropland	CRP land	Pastureland	Rangeland	Forest land	Other rural land	Total rural land
1982	2902.1	0.0	1457.3	3.1	3010.0	158.4	7530.9
1987	2575.8	109.7	1490.5	4.3	3102.8	178.4	7461.5
1992	2080.9	306.9	1594.8	4.3	3174.0	236.7	7397.6
1997	1948.7	305.2	1505.9	3.1	3278.6	213.4	7254.9

Alabama is not exempted to issues related to land conversion and urbanization. From 1982 to 1997, the state had an increase of about 40 percent in developed land (Table 3). In the same period, rural land area lost more than 740,000 acres, most of which was converted into development (86 percent).

Table 3. Surface area of rural and developed land in Alabama (in 1000 acres)

Year	Developed	Rural	Total
1982	1616.6	29691.1	31307.7
1987	1807.2	29485.1	31292.3
1992	1937.0	29315.8	31252.8
1997	2252.3	28950.4	31202.7

IV. Estimation of Land Use Coefficients

To analyze land conversion rates, land-use coefficients in Alabama were estimated following a methodology adopted from Reynolds (2001). The coefficients were calculated between the years between 1982 and 1997. To better assess the trends in land conversion, the coefficients are estimated on a five year interval. The analyzed data are drawn from press releases and reports of the National Resources Inventory (NRI, 2005), and the Natural Resources Conservation Service (NRCS, 2005). The estimated coefficients represent the amount of additional land converted to urban use for each additional unit added to the population base.

Following Reynolds (2001), land use coefficients (μ) are computed as the change in urban land area divided by the change in population between two periods as follows:

$$\mu = \frac{(L_2 - L_1)}{Pop_2 - Pop_1} \quad (1)$$

where,

L_2 = urban land area in period 2 (acres);

L_1= urban land area in period 1 (acres);

Pop_2 = state population in period 2; and

Pop_1= state population in period 1.

The estimated urban land-use coefficients based on equation 1 are reported in Table 4. The results show the coefficient for the period between 1982 and 1987, as the highest, indicating that land conversion to urban uses was faster during this period than the later years. The estimated coefficient (2.12) for the period between 1982 and 1987 implies that for every additional person in the population base, 2.12 acres of rural land was converted to urban uses. Between the years 1987 and 1992, the rate of land conversion was 0.94 acres per additional person added to the population. This is more than a hundred percent decrease from the previous five years. In the years 1992 and 1997, the rate again increased to 1.44 acres per person added in the population. Overall, the rate of land conversion to urban uses in Alabama, between 1982 and 1997 is 1.44 acres per additional person in the population base. The coefficients are generally influenced by the change in urban area brought about by the change in land use, as population growth rate remained the same for the periods in consideration. The estimated rates (Table 4) are much higher in comparison to urban land-use coefficients in the South (0.686) and in the nation (0.690) (Reynolds, 2001).

Table 4. Land-use coefficients for urbanization in Alabama, 1982-1997

Year	Change in Urban Area (acres)	Change in Population	Land-use Coefficients (acres per person)
1982 - 1987	190,600	89,999	2.12
1987 - 1992	129,800	138,752	0.94
1992 - 1997	315,300	213,921	1.47
1982 - 1997	635,700	442,672	1.44

Based on the calculated coefficient (1.44 acres per person) for the 15-year period (1982 to 1997), forecasts of rural lands expected to be converted to urban uses were estimated (Table 5). These projections were calculated by multiplying the land-use coefficients by the change in population, as projected by the US Census for the years 2010 to 2030 on a five year interval. As shown in Table 5, the additional land projected for urban uses in 2030 was estimated at 106,777 acres. Altogether, this projection would bring the total land area converted to urbanization to 2,359,077 acres by the year 2030. This figure will represent 7.4 percent of the total Alabama land, from 7 percent in 1997. If all these conversions will come from agricultural land, urban land conversion will consume an additional 4 percent of land in farms in Alabama, reducing the agricultural land area to 2.8 million acres.

Table 5. Projections on urban land conversion in Alabama

Year	Projected Population	Change in Population	Converted Land (acres)
2010	4,596,330	-	-
2015	4,663,111	66,781	96,165
2020	4,728,915	65,804	94,758
2025	4,800,092	71,177	102,485
2030	4,874,243	74,151	106,777

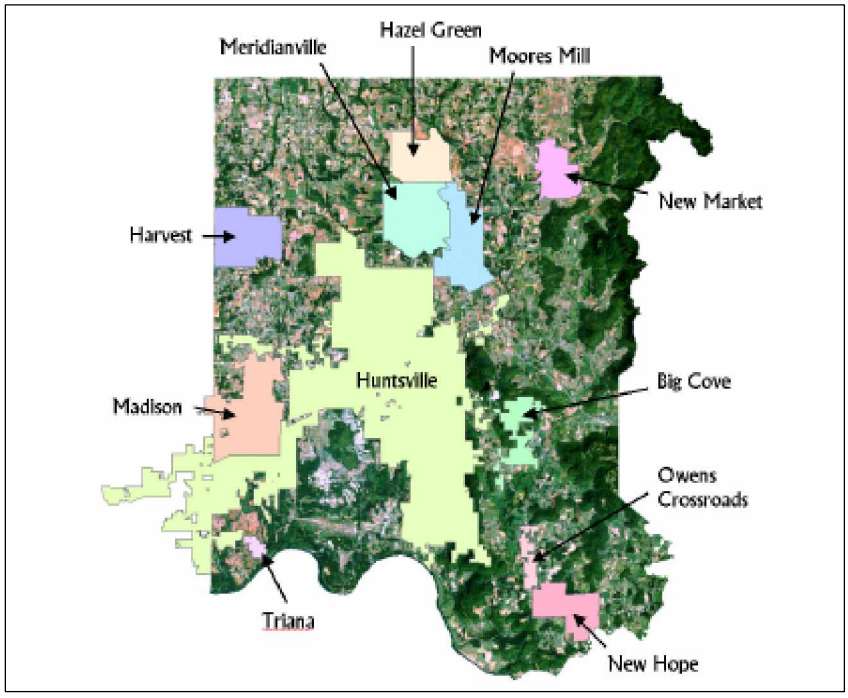
V. Causes of Land Conversion

This section examines the causes of land conversion across cities and towns in Madison County, Alabama. The developed land area data used for the empirical analysis were drawn from land use publications of National Space and Technology Center (Laymon, 2002). The Center produced several reports on land use land cover for Madison County covering the periods 1984, 1990 and 2000. On the other hand, demographic and housing information for city and town profiles for 1990 and 2000 were drawn from all-paces websites (ALLPLACES, 2005). To determine the factors affecting land development, a linear model was specified as follows:

$$Dev_{Land} = f\,[\text{education, income, unemployment rate, percentage of owner-occupied housing, percentage of rented housing, percentage of vacant housing, house age, house average value}] \quad (2)$$

The dependent variable Dev_{Land} is measured as the area of developed land in cities and towns in Madison County, Alabama (Figure 3). Overall, developed land data was obtained for eleven cities and towns in Madison County for two periods, 1990 and 2000. Data for the cities and towns was stacked for the two year periods, leading to twenty-two data points for the dependent variable. To free some degrees of freedom while at the same time utilizing the information from all the selected explanatory variables in equation 2, we used principal component analysis and reduced the number of explanatory variables to three composite factors: purchasing power, house ownership, and house value. Specifically, principal component analysis was used to seek a linear combination of variables such that the maximum variance was extracted from the explanatory variables listed in equation 2.

Figure 3: Map showing the location of cities and towns in Madison County



Source: Laymon, 2002.

The eigenvalues from the principal component analysis are presented in Tables 6 and 7 for purchasing power and house ownership and value, respectively. For purchasing power, four variables were examined and over 63 percent cumulative variance in the variables was explained. As shown in the Table 6, per capita income has the strongest performance with eigenvalue of 2.554.

Table 6. Principal Component Eigenvalues: Purchasing power

Purchasing Power Variables	**Eigenvalues**
Associate and bachelor's degree	0.944
Graduate or professional degree	0.424
Per capita income	2.554
Unemployment rate	0.079
Cumulative variance explained	63.84%

Table 7 presents the result of principal component analysis for house ownership and house value. Five input factors were used and two component factors were derived: house ownership and house value. The result shows that the final measure accounts for about 61 percent of the cumulative variance. The percentage of owner-occupied housing has the highest influence with eigenvalue of 3.034 followed by the percent of rented housing with eigenvalue of 1.121.

Table 7. Principal Component Eigenvalues: House ownership and house value

Factor Components	Eigenvalues
House ownership	
% owner-occupied	3.034
% rented	1.121
% vacant	0.504
Cumulative variance explained	60.67%
House value	
house median year built (house age)	0.342
owner-occupied house average value	6.38E-06

The empirical model examined the relationship between developed land area and three broad factors, hypothesized to influence developed land area; namely, purchasing power, house ownership, and house value. Purchasing power represents component factor for associate and bachelor's degree, graduate or professional degree, per capita income, and unemployment rate. House ownership and house value are two component factors which resulted by combining percentage of owner-occupied housing, percentage of rented housing, percentage of vacant housing, house median year built (a measure of house age), and owner-occupied house average value.

Thus, the estimated model examining the factors that influence the conversion of agricultural land to urban uses across cities and towns in Madison County, Alabama was specified as follows:

$$Dev_{Land} = f\,[\text{purchasing power, housing ownership, house value}] \quad (3)$$

where Dev_{Land} is the developed land area in hectares and purchasing power, housing ownership, house value are composite extracted factors from component analysis.

VII. Results

Table 8 presents the results of the regression analysis. As shown in the table, the variables tested in the model as determinants of land conversion are statistically significant at one percent level. The estimated R-square value (0.89) shows the strong explanatory power of the model. As expected, the coefficient for purchasing power, as a representative variable for average income and level of education, is positive. This is based on the hypothesis that increases in purchasing power result to increases in developed areas, given the assumption that housing is a normal good. This result is also consistent with previous studies on the factors affecting land conversion.

House ownership also has a positive relationship with developed land area. This shows that the increase in the proportion of owner-occupied housing has a direct relationship with the land conversion process. The relationship is found to be statistically significant.

Table 8. Regression Results of the Empirical Model

Variable	Coefficient	SE
Constant	4.152**	0.864
Purchasing power	3.775*	1.490
House ownership	4.860**	0.634
House value	-4.794**	1.376
R^2	0.895	

**, * Significant at 1% and 5% level, respectively

House value, which represents the market value of houses and a measure of conversion cost, has a negative correlation with developed land area and the relationship is statistically significant. This means that the increased cost in housing discourages the building of houses which translates to lesser land area being developed. Again, this empirical result is consistent with the hypothesis and the findings of previous studies.

Conclusions

Land-use coefficients for urbanization were estimated to measure the rate of land conversion and to analyze future land use changes. Land use coefficients were estimated for 15 years (1982 – 1997) at a five year interval. The rates were calculated per person added to the population base. The years 1982 and 1987 had the highest coefficient with 2.12 acres of land converted to urban use per person added to the population. Overall, the rate of land conversion for Alabama was 1.44 acres per person added to the population between 1982 and 1997. Based on this coefficient value, projections on urban land-use were estimated using the US Census' population projections. In 2030, an additional 106,777 acres was estimated to be converted to urban use.

The study also contributed to the efforts of determining the causes of land conversion, particularly in North Alabama. The results are generally consistent with theories and are generally in accordance with previous studies, except for the relationship between developed land area and house ownership. The factors tested (purchasing power, house ownership and house values) were found to be significant factors affecting the land conversion process. These findings can be useful in tracing the roots of the problem and can help policy makers in understanding the causes of land conversion to urban uses, as well as guiding them in evaluating and formulating strategies and procedures concerning

land conversion. It must be noted however, that though we pooled two time periods to increase the size of the data points, the sample size limits the generalization of our results. Future studies on land conversion issues would still be necessary to help in the efforts of identifying the causes of land conversion in the cities and townships in Alabama; and to test the effectiveness of zoning and other land use policies such as land taxes to ensure equitable land allocation.

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