

Land Cover and Socio-economic Characteristics in the Eight Counties of Alabama: A Spatial Analysis

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ABSTRACT

This study employed a clustering algorithm and a logistic regression analysis to examine the relationship between cropland and demographic attributes obtained at the census block group level. The result indicated that population density, African Americans, and poverty are significantly related with crop land use in the region.

Key words: land cover; remote sensing; logit; census; African-Americans

INTRODUCTION

The study of land use land cover has recently become an important subject in studying social and economic dynamics of the landscape (Fox, et al. 2003; Turner, et al, 1993). Land use land cover change (LULCC) involves the interaction of biophysical, social, ecological, and human behavioral attributes over time and space (Riebsame, et al. 1994; Turner and Gardner, 1992; Turner and Geoghegan, 2003). The role of humans in abandonment, conversion or intensification of current agricultural land use or/and reshaping or expanding forest patches for diverse human objectives can be noticed in many rural parts of the world (Geoghegan et al. 1998; Moran, et al. 2003; Schellas and Greenburg, 1996). These modifications at two levels: at the smaller scale, landowner's economic or environmental concerns and at the larger scale, corporate economic interests and public policy, shape decisions. (Fox, et al. 2003). The major concerns of the environmental researchers are on the long-term consequences of the LULCC in a

larger ecosystem such as in carbon sequestration, ecological diversity, land deterioration and fragmentation, water quality, and sustainability of the whole landscape (Turner et al., 1993; Turner, 1994; Riebsame, et al. 1994).

The recent land use land cover studies have investigated the causes and consequences of land use land cover change related to human population dynamics (changes in density, composition, and species), and changes in the indices of poverty and well-being (Gilles and Dalecki 1988; Wear and Bolstad, 1998). Differential impacts of land use land cover change involve land fragmentation or consolidation, degradation of agricultural productivity, decline or improvement in economic well-being, or changes in human population. For instance, the people who live in similar land use type may have differing socio-economic characteristics because their connections with places, institutions, and available resources are different (Turner et al. 1993). Studies of land use land cover changes help to locate areas that lag behind in economic development or areas facing deteriorating land resources. The identification and understanding of the dynamics underlying these local spatial characteristics establishes the linkage between poverty and land use land cover change. Studying the dynamics of LULCC in respect to the drivers of change such as human/household characteristics, institutions, and economic forces has been well-documented in recent research (Fox et al 2003). However, research linking land use land cover to poverty or well-being requires a complex research agenda and therefore requires further exploration of more diverse methodologies (Fox et al., 2003; Wear and Bolstad, 1998).

Since poverty emerges from both unequal and unavailable access to resources and services as well as differences in household characteristics and relationship with institutions, decisions-making criteria of people for changing or retaining their current land use is affected. In addition, resource institutions and market forces are the dominant agents in resource use and

management especially in the socio-economically vulnerable communities. As such their influence overshadows the landowners and defines the economic development possibilities in the communities.

With the advances in remote sensing and GIS techniques and the availability of data at a finer scale, LULCC change research has the potential to link the social context of land use with issues of poverty or well-being at different scales. Land use studies in under-developed countries have proven that studying social issues spatially helps in understanding the history and root causes of economic and social problems. Spatial studies conducted in the Amazon Basin (Moran et al, 2003), Mexico (Turner et al, 2003), and Vietnam (Fox et al, 2003) employed LULCC to elicit the causes and processes of deforestation and fragmentation, and their linkage to poverty and well-being.

This study investigated the relationship between land use land cover type and the demographic characteristics of the population in the black belt region of Alabama. The black-belt region, previously known as the cotton-belt, has undergone major changes in land cover and population characteristics. The vast areas of new pine plantation and fish ponds as well as the declining but still predominant African American populations make this region distinct from other parts of the state (Schellas and Zabawa, 2000). The majority of the lands in this region are owned by non-timber private forest owners who own 70 percent of the available forest (USDA, 1997). African Americans who make up 68% of the population in the region, own less than five percent of forestland. At the same time, the human development indices for these African American counties are well below the state and national average (Bukenya and Fraser, 2003). The current scenario in the black-belt region suggests that the abundance of natural resources may have both positive and negative socio-economic implications, creating both resource-

induced well-being and resource-dependence poverty. To understand these issues social science researchers need to apply current methodologies such as remote sensing, GIS, and qualitative analyses within a spatial and temporal context. In this study we attempt to apply spatial analysis techniques to understanding the relationship between land cover and quality of life.

OBJECTIVE OF THIS STUDY

In this study, we examined the relationship between the type of land use and the attribute of the people living in the landscape. There were two objectives: (1) to identify the type of land cover in the six watersheds of the southwest black region of Alabama, and (2) to examine the statistical relationship between the type of land cover and the demographic characteristics of the population living in the region. The two dominant land covers in the black-belt region (agriculture and forest) were analyzed. In the study we tested for significant statistical relationships between the demographic characteristics (population, income, race, education, poverty, etc) and land cover type. A combination of remote sensing, geographic information techniques, and binary logistic analysis was used to analyze data obtained from landsat 2000 ^{ETM} imagery, and the Census 2000 demographic information.

STUDY AREA

The study site (-86.4-88.4 degree East, 31.13 to 33 degree North) consists of eight counties (Dallas, Green, Hale, Lowndes, Marengo, Perry, Sumter, and Wilcox) located in the southwest part of Alabama (Figure 1). The area covers 6,479 square miles area. The region is known as ‘black-belt’ because of the predominant African American population and presence of the black calcareous soil. The total population of the region is about 150,000 of which 68% are

African Americans. The population density is 22 people per square mile. The mean elevation is 500 feet above the sea level and the landscape is mostly flat prairies. Warm and humid temperature prevails for more than seven months in most part of the region. The landscape is dominated by forest cover (65%), followed by pasture and crop land (USDA, 1997). The major forest tree species are loblolly, oak-pine, Oak-hickory, longleaf slash pine, and oak-gum cypress. The study area is mostly rural and population mostly depends on forest-based industry, agricultural, and livestock based activities are the major industrial employers.

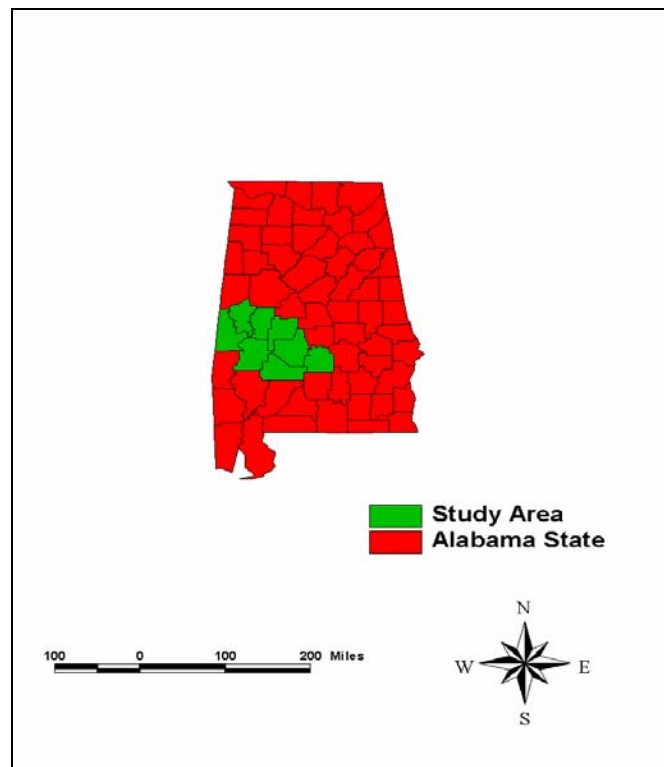


Figure 1: Study Area

DATA SOURCES AND DESCRIPTION

Landsat Enhanced Thematic Mapper (ETM) satellite image of 2000 was used to detect different land use types. The Landsat ^{ETM} data recorded in September 2000, was geo-referenced

to local UTM zone (WGS84 Datum), and was ortho-rectified and terrain corrected. The positional accuracy was +/- 50 meters Random Mean Square (RMS). The study area required three scenes (Path-row: 2038, 21-37, and 21-38) which were combined to create a mosaic of the study area. A vector layer of the UTM projected county boundary map was used to create a subset for the black-belt region for further image analysis.

Demographic data at the census block group level was obtained from the Census 2000 database. There were 161 block groups in the black belt region, but 22 urban block groups were removed from the analysis because these block groups did not contain any forest or croplands. Population, race, income, education, and poverty data was downloaded. Preliminary screening of the data indicated no missing values and outliers. Descriptive statistics indicate that the average cropland in a block group was about 14 square miles, forest land was about 26 square miles, and other type of land was about 1 square mile. Population density averaged 195 people per square mile, the percent African Americans was about 67%, and average number of people under poverty level in a block group was 288. Medium household income of whites was 2.48 times higher than African-Americans and whites had 2.93 times more bachelor degree than African Americans.

IMAGE PROCESSING

The Landsat ETM image was processed with ERDAS IMAGING 8.6 image processing software. Principle component analysis was utilized to reduce original six bands into three components. The new image provided a better view for image classification. The 2000 image was used to establish 15 classes based on the clustering algorithm in unsupervised classification using Anderson level 2 classification scheme (Jensen, 1996). The resolution of the data was 28.5

meters, so it was not possible to employ a higher level of classification (level III or IV) (Jensen, 1998). For this reason, both the low density and high density residential areas could not be clearly detected in the classified image. The 15 initial classes were regrouped into five major classes, which were: forest, agriculture, pasture, water, and other category (residential, commercial, transportation, and other type of land) (figure 2). The resulting image was 72% forestland, 13% pastureland, 10% agriculture land, 3.43% residential/commercial and other types of land, and 1.62% water bodies.

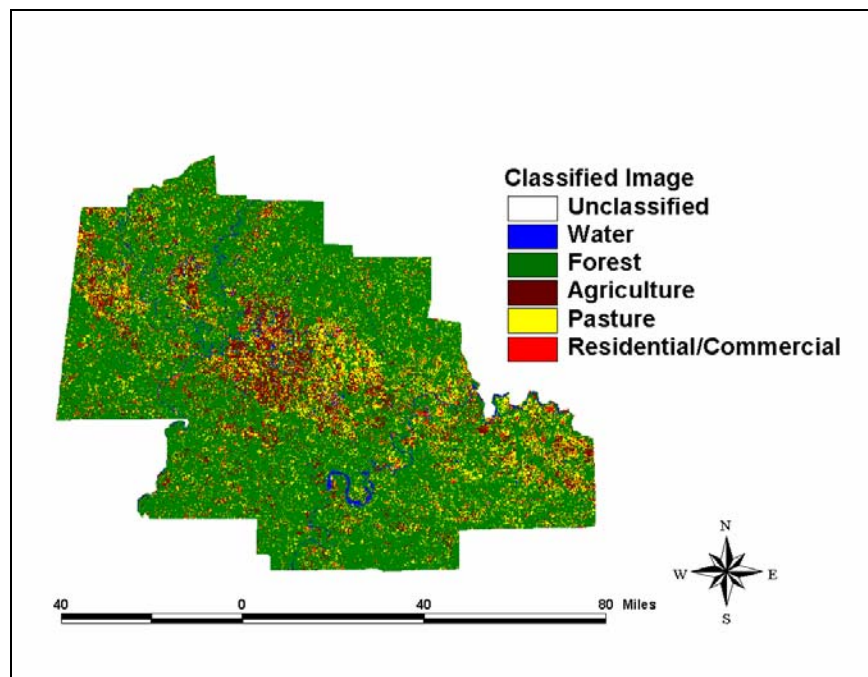


Figure 2. A Classified Map of the Black belt Region

LOGISTIC REGRESSION ANALYSIS

Logistic regression analysis was utilized to examine the relationship between type of land use and demographic characteristics of the study area. The mosaic of the classified raster subset was converted into a vector layer using ArcView. The new vector layer and the 2000 census

block group boundary layer of eight black-belt counties were then utilized to delineate areas covered by each land type in each block group. Block groups with over 50% of cropland were recoded into 1 and the other block groups with less than 50% of cropland were coded as '0'. This variable became the binary dependent variable in the logistic regression model.

Data for the independent variables were downloaded from the Census 2000 database. Five variables were selected to represent population, income, race, education, and poverty. Correlation analysis of the five variables disclosed no 'multicollinearity' effect. The five demographic independent variables: (1) population density for each block group, (2) percentage of blacks in each block group, (3) income poverty ratio less than 1, (4) the ratio of medium household income between whites and black for each block group, (5) the ratio of bachelor degree graduates between white and blacks for each block group. One hundred twelve block groups were utilized with SPSS version 10 software. The following logistic model (Gujrati, 1995) was specified:

$$L_i = \ln\left(\frac{P_i}{1 - P_i}\right) = Z_i = \beta_0 + \sum \beta_i X_i$$

Where L_i was the natural log of the odds of cropland in census block group i being greater than 50%, also called the logit, Z_i is a linear combination ($b_0 + b_1X_1 + b_2X_2 + b_3X_3 + \dots + b_nX_n$). P_i ranges between 0 and 1. If P_i represents the probability of cropland in census block group having greater than 50%, then $(1 - P_i)$ represents the probability of crop land being less than 50% in census block group.

RESULT INTERPRETATION

A significant Chi-square value (86.6, df 5, $P < .001$), a significant lowering of the -2loglikelihood value (44.97), and the high number of correctly classified census block groups

(88.5%) is evidence that the model was significant and provides a good explanation of the relationship between dependent and independent variables. Nagelkerke R square indicated that about 80% of the total variance in the dependent variable (cropland) was explained by the independent variables.

Table 1. Result of Logit Analysis

Variables	β Coef.	Std. Error	Wald Stat.	Sig. Level	Exp (β)
% black	-.063	.030	4.429	.035*	.939
Poverty	.011	.004	6.473	.011*	1.011
Income	.335	.396	.717	.397	1.398
Education	-.281	.196	2.055	.152	.755
Pop.density	-.078	.022	12.089	.001*	.925
Constant	4.80	2.422	3.926	.048	121.537

* Significant at 5% level

Population density, poverty ratio, and the percentage of African Americans were significant variables in the model (Table 1). The odds ratio indicates that a higher concentration of black population is less likely to have block groups with more than 50% being classified as cropland. For instance, a one percent increase in black population, the odds are decreased by a factor of .939. In case of population density, the result shows that the higher the population density, less likelihood of a census block group being classified as crop land. When one unit increases in the population density, the odds are decreased by .925. However, in case of the income poverty ratio, the relationship was positive showing that higher the income poverty ratio, the higher the likelihood of crop dominancy. The increase in the one unit poverty income ratio will increase the odds of cropland by a factor of 1.01. Based on the logistics analysis result, It

may be concluded that population density, poverty, and race have significant relationship with the crop cover other variables remaining constant. The result suggests that in the rural areas of these counties, i.e. away from the urban core, African Americans are more likely to concentrate in the forested areas and are better off than their farming counterparts. Until explicitly analyzed, it is fair to say that African Americans living in the forested areas have a higher well-being than those living in farming areas.

CONCLUSION

This analysis identified the type of land use in year 2000 in the eight watershed areas of the black-belt region of Alabama using image processing and GIS techniques. The result showed that forest land was dominant type followed by pasture and agricultural land. The second objective of the study was achieved by examining the statistical relationship between type of land use land cover and the demographic characteristics of the population. The result showed the significant relationship between land use type and population density, race, and poverty level. The result suggests that population density may be an important driving force in the clearing of forest or agricultural land, however, the nature of changes in the local and regional economies (e.g. housing development, logging, etc) which have not been examined in the model, may possess considerable effects on land use type.

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