Lynn Roche Phillips. AGRICULTURAL LAND USE PATTERNS IN THE SOUTHERN PIEDMONT: 1945 TO 1982. (Under the direction of Charles T. Ziehr) Department of Geography and Planning, June, 1985.

The Southern Piedmont has been an important agricultural region since its settlement in the early 1700s. Since that time, this area has undergone intense land use changes. The purpose of this study was to examine the changes in the agricultural land use within the study area from World War II to the present.

Cluster analysis was used to develop crop combination regions based on six field crops for three cross-sections in time. Two discriminant analyses were performed on the crop regions to provide additional information on their definitions. All crops, excluding soybeans, experienced dramatic acreage reductions during the study period, and a trend of declining farmland also existed. Most of the abandoned farmland was converted to pastureland or urban uses.

Several variables which described socio-economic conditions and agricultural practices were included in a discriminant analysis test to determine the factors which best differentiated the crop combination regions. It was found that variables which described agricultural specialization within an area were most important in explaining the regional cropping patterns.

The spatial structure of the crop combination regions suggests that former agricultural land use patterns (which included concentrations of

large cotton and tobacco acreages) still influence the landscape today. Although soybeans tended to dominate the cropping regions, the land use patterns that existed when cotton was "king" are currently expressed in the agricultural land use patterns of the 1980s.

AGRICULTURAL LAND USE PATTERNS
IN THE SOUTHERN PIEDMONT:
1945 TO 1982

A Thesis

Presented to

the Faculty of the Department of Geography and Planning

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of the Requirements for the Degree

Master of Arts in Geography

by

Lynn Roche Phillips

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CHAPTER 1

INTRODUCTION

Overview

The South was built on cotton. Haystead and Fite (1955) stated, "probably no crop, except the grape, has been eulogized so lushly and fanatically as cotton". Cotton was widely grown for use with slave labor as a cash crop chiefly because it could not be eaten. Corn fed the slaves and the South. Since Civil War times, these two crops, in many ways, have typified Southern Piedmont agriculture. Throughout the region, cash crops including cotton and tobacco, are grown with such food crops as corn and soybeans. Changes in the cropping patterns of this region reflect basic changes in the Southern Piedmont agricultural landscape.

The Southern Piedmont extends along the eastern periphery of the Appalachians through Virginia, North Carolina, South Carolina, Georgia and Alabama (Figure 1). It has been an area of intensive agricultural land use since its settlement by European colonists in the early 1700s (Trimble 1974). Several recent trends have significant potential to alter cropland patterns in the Southern Piedmont. Factors such as increased scale of landholdings, urbanization, and industrial growth have had impacts on the location of farming activities (Fite 1980). Metropolitan areas such as Atlanta, Richmond, Raleigh/Durham, Charlotte, and Columbia are located within this region. These cities, like many other urban areas in the Sunbelt, have experienced phenomenal growth

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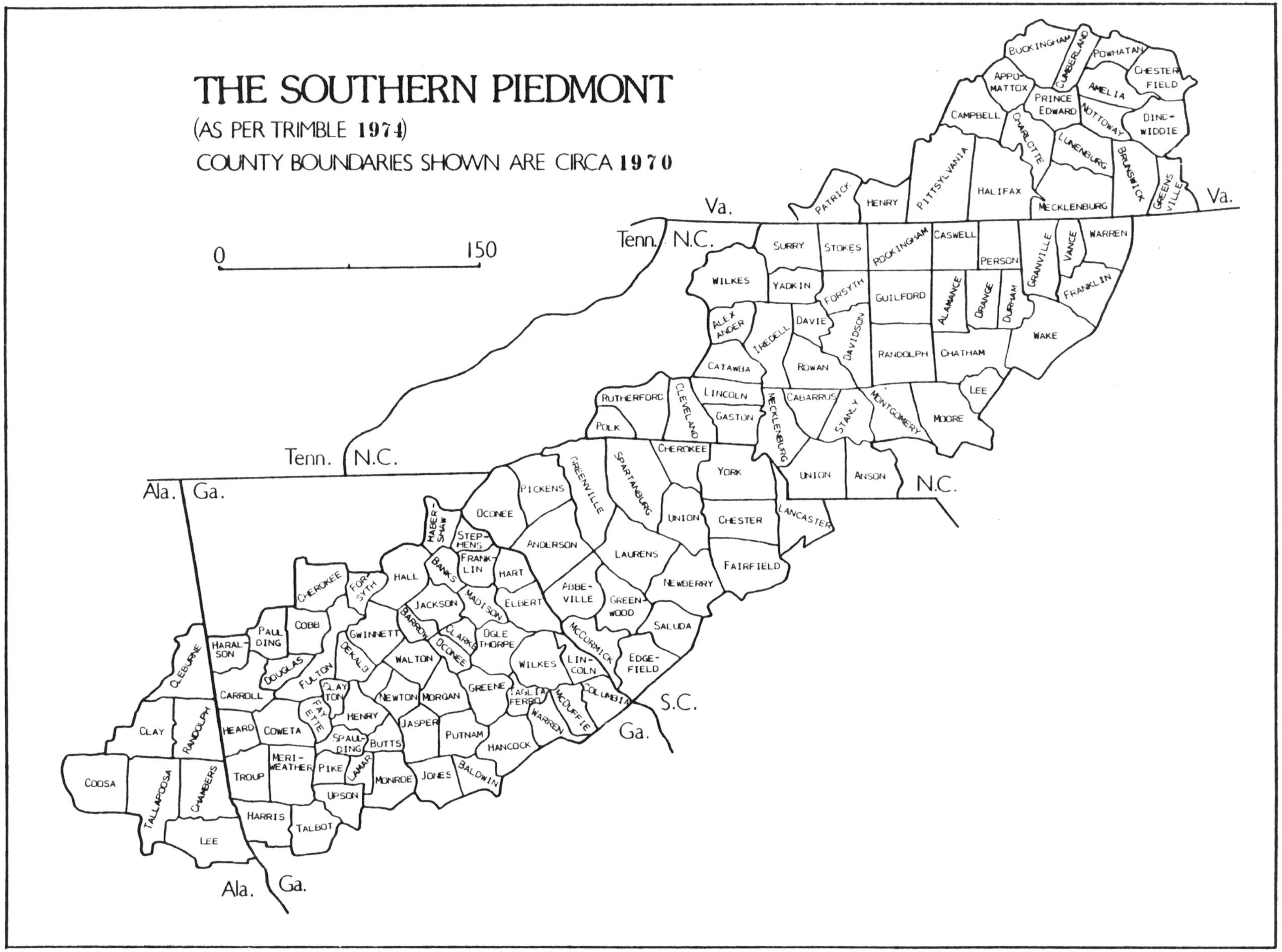
Figure 1 The Study Area



within the 1970s. These recent economic development pressures have had implications on land use patterns as competition for land has progressively increased (PCA 1983). Urban sprawl is a common problem facing land use planners. Agriculture in the region has undergone change in response to this pressure.

Several recent occurrences could alter Southern Piedmont cropping patterns. Cotton production has been declining for several decades (See Baker 1918; Prunty, et al. 1972; Hart 1977) and the tobacco industry is rapidly losing its strength. The 1985 tobacco quotas, for example, represent the smallest acreage since the federal tobacco program began. As a result, farmers are glutting the real estate market with abandoned cropland. In contrast, the use of soybeans as an industrial and food crop has grown in worldwide importance.

National policies have sparked drastic changes in farming practices. Influential members of the 98th Congress have stated that 1985 will be a critical year for agricultural policy. Amendments such as the 1985 Farm Bill are likely to bring about adjustments in the agricultural geography of the region.

Changes in agricultural commodity markets are also likely to produce changes in the cropping patterns. In North Carolina, for example, when prices for small grains recently rose, more soybeans were double-cropped with small grains.

Regional land use patterns may be expressed in the geography of crop combination regions. Crop combinations, for the purpose of this research, are two or more crops which, for physiologic, economic or social reasons, are cultivated together within the same region. The crops may be double-cropped or grown complementary to each other. Crop combinations may vary spatially and temporally, depending upon a variety of factors.

Research Problem

The purpose of this research was to investigate the types of crop combination patterns that existed within the Southern Piedmont from 1945 to 1982. Trends in the changing crop regions and areal associations among the crops were emphasized. This study attempted to identify factors important in defining these land use patterns.

The role of non-agricultural factors in shaping agricultural geography was also examined. Different crops are perceived to be cultivated under different social/environmental conditions. Cotton is probably the best example of this. Cotton is commonly thought of as being grown in large quantities on Southern plantations where labor is cheap and plentiful. Patterns of Southern cotton production have been specifically related to demographic and labor factors (Hart 1977). It was the intent of this research to identify the relative importance of various agricultural, land use, and socio-economic trends in helping to determine crop combination regions.

Several factors were considered which affect agricultural production patterns. Available labor, as stated above, is often a factor in determining the types of crops which are grown together. Another agent influential to farming practices is urbanization. Von Thunen's location theory is based on the effect of urbanization on cropping patterns. By examining the quantities of land in farms, this research studied the effects of encroaching urbanization on the amount of agriculture and the crop combination patterns within the region. It also sought to identify current trends in agricultural production and examine the effects of current trends on defining cropping patterns within the study area. The variables used to reflect these factors will be described in the next chapter.

Objectives

There are three major objectives assigned to this research. They include: 1) the identification of crop combinations for each study year, 2) the definition of regions based on the crop combinations for 1945, 1964, and 1982, and 3) the description and analysis of the changes within the regions over time.

The first objective involves identifying the relationships among the crop variables. This step defines the spatial associations among the crops. The second objective, defining crop combination regions, involves identifying and grouping the counties which have similar cropping patterns. After the cropping patterns and subsequent regions have been established, the final objective seeks to identify factors which may have been instrumental in creating these regions. It is safe to assume that social, economic, and behaviorial forces were influential in developing cropping practices during the study period. These factors are likely to vary spatially and temporally. This research sought to identify which factors, from a predefined set, were most influential in differentiating between cropping regions during 1945, 1964, and 1982.

Hypotheses

The research hypotheses address the two basic questions to be answered in this study. These questions are:

a) What are the changes in the crop associations (which subsequently define regions) within the study period? and,

b) what factors were instrumental in defining the crop combination regions?

There are two hypotheses which address the former of the questions answered by this study.

Hypothesis 1:

The first hypothesis speculates that specialty crops (such as cotton, peanuts and tobacco) will become less important and wheat and soybeans will assume greater importance in defining crop associations and regions. This will occur in reaction to the documented decline in the cotton and tobacco industries and the subsequent efforts in crop diversification. It will be in response to the trend of larger, more highly mechanized farms.

Hypothesis 2:

It is expected that the regions (identified by cluster analysis) will become more vague through time. They will more closely resemble a mosaic of smaller, non-contiguous regions rather than a set of larger, neatly-defined, contiguous regions. This is expected to occur in response to the decline of specialty crops and the urban growth that has occurred in the region within the study period.

Hypothesis 3:

With respect to the factors influential in defining crop combination regions, it is anticipated that manufacturing employment, population density, and non-white population will not be significant in defining the regions. The regions will be explained by variables which describe agricultural practices. Regional labor and population density will assume less importance. Farm size, amount of acres harvested and land in farms are more likely to influence regions than the above factors.

Justification and Previous Research

Examination of these land use changes is easily justified. A knowledge of the spatial and temporal changes in farming patterns is critical for regional planning and formulation of agricultural policy. It will provide insight into the effects of development in the region.

The spatial variation in cropping practices has implications for environmental issues. Soil conservationists may benefit from information on the location of changing cropping patterns. Knowledge of cropping patterns is critical to determining soil erosion rates (Trimble 1974). By converting corn, tobacco, and soybean acreage to small grains, for example, a Piedmont farmer reduces average soil loss by about two thirds (Healy and Sojka 1985). On a larger scale, it is anticipated that this study will provide insight into the changing cropping patterns and importance of farms in the Southern Piedmont.

This study differs from previous work done in agricultural geography. Though this region has been studied by geographers and agricultural scientists (see Hart 1978; 1980; Prunty 1952; 1970; Anderson 1973; Trimble 1974), no research has been conducted on the crop combinations of the region. The above studies were principally delineations of crop regions and qualitative assessments of temporal changes in crop geography.

Two of the foundations for this research were Trimble's (1974) work and a study by Weaver (1954) in the mid-1950's. Weaver's work identified the crop combination regions for selected areas in the Midwest. This research, now dated, is an impractical solution to the crop combination identification problem. The methods for determining regions were exhaustive and involved subjectivity. Weaver's product was 36 crop combination regions which were too numerous for other applications (Hoag 1969). Also, Weaver did not investigate underlying implications for the cropping patterns found. His work was mainly an attempt to show how maps of agricultural regions are oversimplified.

Trimble addressed the relationship between agricultural regions and erosion rates within the Southern Piedmont from 1700 to 1970. Although Trimble was able to link agricultural land use with high erosion in the region, his results with respect to crop regions were general and left room for ambiguity. In particular, his methodology was weak for delineating agricultural regions.

The present study differed from the above research in several ways. The methodology used for defining crop combination regions was entirely objective, as opposed to Weaver's partially subjective methods and Trimble's unspecified methods. This study was able to take advantage of highly sophisticated techniques for data analysis and defining regions that were not widely available in the earlier studies. Unlike those studies, the present work was specifically geared toward defining and explaining crop regions that will be useful for planning, agricultural, and conservation studies.

The Study Area

The Southern Piedmont (Figure 1) is located in the southern portion of the Appalachians. This area encompasses 59,000 square miles (37,640,000 square acres) or approximately 2.0 percent of the country. It is a highly dissected plateau lying between the Blue Ridge Mountains to the west and the Atlantic Coastal Plain to the east. The Piedmont extends through five states, including the hilly areas of southwestern Virginia, North and South Carolina, Georgia and parts of Alabama. A total of 136 counties are found within this area.

The physical geography of the Southern Piedmont has been described by Austin (1965), Trimble (1974), Pirkle and Yoho (1977), and Haystead and Fite (1955). The following discussion of the regional physiography has been taken from these and several other sources.

The Southern Piedmont is a region of hilly to gently rolling topography. Elevation ranges from an average of 300 feet near the Coastal Plain to an average of 1,000 feet toward the Blue Ridge. This dissected plateau is underlain mostly by schists, gniesses and granites and by some basic crystalline rocks, sandstones, and slates (Austin 1965).

The climate of the area is moderate with an average annual temperature of 57 to 65 degrees Farenheit. There are approximately 200 to 250 frost-free days, decreasing from north to south. Elevation, however, plays an important role in determining the amount of frost-free days. There is adequate rainfall for many types of crop production. Precipitation averages 45 to 55 inches and is evenly distributed throughout the year.

Soils are highly dissected and rich in oxides which foster a reddish color. Erosion has reduced most of the soils to clay-sized particles. Red-yellow ultisols and alfisols of the Cecil, Appling, Durham, and Madison series dominate the landscape. These soils were formed mainly on acid igneous rocks. Other series such as Alamance, Goldston, Georgeville, Herndon, produced from slate, are the second most commonly found soil type. The reddish-brown laterites, such as the Mecklenburg and Davidson soils are on uplands underlain by basic igneous rocks. Some coastal plain soil types can be found in some of the easternmost reaches of the study area.

Soils in this region are some of the most highly eroded in the United States. Much of the Piedmont has been stripped of topsoil. Gullying and dissection of the upper horizons have occurred at such a degree as to render the land unsuitable for agriculture in certain areas (Trimble 1974). Maximum soil erosion has occurred in the southeastern portion of South Carolina and Georgia. The eastern Piedmont of North Carolina has experienced the least amount of erosion in the region as a whole. Areas depleted of good soils have been converted to pasture land. Few crops are able to tolerate the nutrient-poor soils of the region.

In 1965, the region was described as a cash crop area (Austin 1965). Cotton was the major crop although tobacco was important in the northern one-third. Since that time, cotton production has fallen and the tobacco industry is undergoing major negative changes. Peanut production has traditionally been popular in Georgia and North Carolina. Because erosion has caused much land to be taken out of cultivation (Healy and Sojka 1985), forests and pastureland have become widespread. Approximately three-fifths of the area is in forest, but mostly in farm woodlots. A few large areas are in national forests and other large holdings by timber companies. The Southern Piedmont is experiencing many land use changes.

CHAPTER 2

METHODOLOGY

Overview

In this section, a general overview of the steps taken to collect and analyze the data is given. After collection of data from the U.S. Census of Agriculture and other sources, a three step statistical analysis was performed. First, cluster analysis was used to define crop regions. Second, a discriminant analysis was used to determine which crops were most important in determining regional differences. Finally, a second discriminant analysis was performed to assess the utility of several socio-economic and agricultural variables in discriminating among the regions.

Data on acreages of six field crops in 136 Southern Piedmont counties were entered into a cluster analysis. The analysis produced discrete regions (also referred to as clusters or groups) based on cropping patterns for each of three study years (1945, 1964, and 1982). Five regions were delineated for each study year.

Two stepwise discriminant tests were used to interpret the regions defined by the cluster analysis. The first analysis was helpful in determining the "meaning" of each cluster. The regions defined by cluster analysis served as dependent variables and the crops were entered into the discriminant model as independent variables. Stepwise discriminant analysis was chosen to determine which crops were most useful in distinguishing the clusters. The results of this step were interpreted with the help of commodity price trends during the study period.

The second discriminant analysis introduced several socio-economic and agricultural variables (also referred to as discriminating variables) as independent variables. Stepwise analysis was used to provide information on which of the discriminating variables were most influential in defining the differences between clusters (regions). The results of this step were interpreted statistically and in the context of a literature review on national farming trends.

Variables: The Crops

The major field crops of the region were used in this research. They included soybeans, peanuts, corn, wheat, tobacco, and cotton. Acreages for the field crops were gathered from the 1945, 1964, and 1982 US Censuses of Agriculture at the county level. The research interest was in post-war agricultural trends, therefore 1945, the final year of the war, was appropriate. The subsequent years represented dates when agricultural censuses were available. The counties within the study area served as observations.

Since the study included three cross-sections in time spanning 40 years, slight differences occurred in the variables available in the census. Categories for which crop data were collected were not identical for each of the study years. For example, in 1945, peanuts were listed as "picked or threshed". In 1982, no such category existed. "Peanuts harvested for nuts" was the category which appeared to be the most appropriate for use. The variables which best represented the data needed and most similar between the study years were used.

It is logical that larger counties have greater amounts of cropland by virtue of the size of county itself. In order to avoid a bias toward larger counties, raw acreages of data were not used in the analyses. Instead, the crops were expressed as proportions of total acres harvested in each county. The data value for each crop represented the proportion of each crop from all acres harvested. This provided a method to "standardize" the crop statistics.

All data collected were in acres. Acreages were preferred to pounds or some other production unit to maintain a level of control in the research. Production levels would tend to be higher in areas better suited to individual crops, thus producing biased data. Acres provided a better measure of quantities grown in each crop.

The 1945 soybean value, which was listed in bushels, had to be adjusted to acres. It was recomputed to acres (for each state in the study region) by dividing the statewide average of harvested bushels per acre into the bushels harvested per county. Although the traditional skewedness inherent to using a mean value existed, this provided the most reasonable measure of soybean acreage harvested for each observation.

The census categories for the crops, by year, included:

1945

Peanuts picked or threshed

Soybeans harvested for beans (in bushels)

Cotton harvested

Tobacco harvested (all types)

Corn harvested for grain

Wheat threshed or combined

1964

Peanuts harvested for picking and threshing

Soybeans harvested for beans

Cotton harvested

Tobacco harvested

Corn harvested for grain

Wheat harvested

1982

Peanuts harvested for nuts

Soybeans harvested for beans

Cotton harvested

Tobacco harvested

Corn harvested for grain or seed

Wheat for grain

Other Variables

The second discriminant analysis contained several other variables to serve as discriminating variables. These were computed from agricultural variables including the number of farms (FMS) in each county, number of harvested acres (ACRES) per county, all land in farms (LIF), and county size. These data, unlike the crop variables, were consistently available in the Census of Agriculture for each study year.

Certain conditions in the study area may have been influential in defining the regions where individual crops were grown together. It is understood that social and economic factors influence agricultural practices. Additional variables included in the second discriminant analysis were data on social and economic conditions within the region. Total population (POP) and percentage of non-white population (NWPOP) were taken from the 1940, 1960, and 1980 Censuses of Population. The 1947, 1967, and 1977 Censuses of Manufactures provided a variable on employment in manufacturing (EMP).

In order to avoid a bias toward larger counties, it was necessary to recalculate some of the above variables to account for the effects of county size. Additional variables were calculated from the existing data. The computations and subsequent names of the adjusted and newly created variables were:

LIF1=LIF/SIZE Proportion of county in farmland. This variable measures agricultural specialization within the study counties.

ACRES1=ACRES/SIZE Proportion of county in harvested acres. ACRES1 is another measure of agricultural specialization, but examines only harvested farmland in each county.

EMP1=EMP/POP Proportion of total population employed in manufacturing. EMP1 is a measure of industrial development in the county.

FMS1=ACRES/FMS Average acres harvested per farm. This indicates relative number of acres harvested per farm in the county.

FMS2=LIF/FMS Average size of farm. FMS2 measures the average size of farms within the county.

ACLIF=ACRES/LIF Proportion of farmland harvested. This is a measure of what proportion of farmland is harvested. The rest of this farmland is in pastures and forests.

POP1=POP/SIZE   Population density (persons/acre). POP1 measures the concentration of population within the study counties.

FMS1 and FMS2 will help to establish if crop associations are related to farm size. EMP1 and ACRES1 describe the economic climate of the county and the percentage of land devoted to agricultural use. LIF1 and ACLIF also measure the amount of area devoted to uses other than agricultural. By examining their converses, these variables explain the urban development occurring in the county. EMP1 (proportion of employment in manufacturing) and NWPOP (proportion of non-white residents) describe labor availability for agriculture and industry within the county.

Average market prices for the crops were gathered from the Agricultural Statistics. These values are the average price received by farmers throughout the U.S. for the study year. Prices were deflated to 1967 dollars using the Producer Price Index. The index was available from the Survey of Current Business for years 1946 through 1983.

Statistical Techniques

Two statistical techniques, cluster analysis and discriminant analysis, were employed in this study. The following section briefly describes each method and its application to the research problem.

Cluster Analysis

Cluster analysis is a technique which seeks to mathematically group data into constituent groups. It was used to organize the crop data into regions. The purpose of cluster analysis is to place objects into groups or clusters suggested by the data (not predefined) such that objects in a given cluster tend to be similar to each other and dissimilar to objects in other clusters (Barr, et al. 1982). This technique, like factor analysis, is useful for data reduction and also to search for meaningful relationships within data sets. This technique may be used to search for natural groupings within data, to simplify the description of a large set of multivariate data, as well as other reasons.

Fisher (1936) first applied the technique. Since that time, its use has been widely received in a variety of disciplines. Geographic applications have included King (1967) and Mather (1972).

Distance in space is the framework for cluster analysis and a variety of other statistical techniques. It must be remembered that distance, in numerical analyses, refers to distance between points in an x-dimensional abstract space when x is equal to the number of variables in the mathematical model. It should not be perceived as ground distance.

Cluster analysis is performed on the basis of Euclidean distances computed from one or more quantitative variables. Initially, a set of points (cluster seeds) is randomly selected as temporary means of the clusters. Each observation is assigned to the nearest seed to form temporary clusters. This sequence, with the cluster mean updated to accomodate the cluster members, is reiterated until all observations have been grouped with their nearest seed or until no further changes in the clusters occur. Distance between points in space is the operating criterion for the grouping algorithm. The main purpose of the technique is to place similar observations in the same groups while making the groups as dissimilar as possible.

It is beyond the scope of this research to describe in detail the mathematical derivations in cluster analysis. Everitt (1980) offers an excellent introduction to the technique as well as provides a discussion of the mathematics behind the technique. A recent publication by Aldenderfer and Blashfield (1985) thoroughly explains the analysis and Kachigan (1982) describes the theoretical framework of the technique.

Hartigan's (1975) and MacQueen's (1967) algorithms are the basis for the Statistical Analysis Systems (SAS) procedure, FASTCLUS, the technique chosen for the analysis. FASTCLUS differs from other SAS clustering techniques in that it mathematically assigns observations into non-overlapping clusters (Barr, et al. 1982).

A substantial problem in performing cluster analysis is deciding on the optimal number of clusters in the data. The literature does not suggest a satisfactory method of determining the number of groups. Beale (1969) offers an F statistic which determines if the results could be improved by using some smaller set of clusters. Calinski and Harabasz (1971) suggest the use of an exhausive equation to determine whether the number of clusters is adequate, but both of these methods are useful only where the clusters are approximately spherical in shape (Everitt 1980). Most references recommend the determination of number of clusters a priori, based on some intimate knowledge of the data.

Five disjoint (non-overlapping) clusters were chosen for this study. The reasons for this were two-fold: after examining the possibilities of crops grown in combination with each other, five groups seemed to best describe the agricultural patterns of the Southern Piedmont. Several trial cluster runs produced at least four distinct major regions and several peripheral clusters with two or three observations as members. It seemed that five clusters would account for the four natural clusters within the data and the fifth cluster would include any outlier observations. Two orthogonal rotations were applied to the data to maximize cluster contiguity.

Discriminant Analysis

Discriminant analysis is a procedure used to statistically distinguish between two or more predetermined groups of observations with respect to several variables simultaneously (Klecka 1981). This technique was employed following the definition of regions by cluster analysis to determine which discriminating variables were most influential in distinguishing between the regions associated with the clusters. Two discriminant tests were run: the first analysis entered the crops into the model and the second test used the other variables as independent variables.

The benefits from using this technique are the same as for regression analysis. Discriminant analysis is essentially an adaptation of the regression analysis technique, designed specifically for situations in which the criterion variable is qualitative in nature rather than quantitative (Kachigan 1982). The primary difference is that discriminant analysis treats the dependent variable as being measured at the nominal level (i.e., groups) (Klecka 1981). The discriminant model produced by the analysis allows an observation to be classified according to a criterion variable (in this case, the cluster regions) on the basis of the values of the discriminating variables.

Discriminant analysis, like cluster analysis, is widely used in many disciplines. Fisher (1936), a physical anthropologist and biologist, is credited with pioneering the technique. It has been widely used in political science. Applications in geography have been outlined by King (1970) and have included research by Bucklin (1967), Berry (1965), King (1967), McCluskey (1980), and others.

Discriminant analysis is most widely used in two research situations: analysis and classification. The classification application allows observations with unknown memberships to be assigned into groups with known memberships. Cluster analysis differs from discriminant analysis in the respect that cluster technique begins with no known group memberships among the data. In discriminant analysis, group memberships are predefined. The classification situation is not used in this research, but discriminant analysis is used to interpret group memberships among the crop regions defined by cluster analysis.

This application of discriminant analysis involves interpretation of the ways in which groups differ. This allows one to be able to "discriminate" between groups on the basis of some set of characteristics, how well they differentiate and which characteristics are the most powerful discriminators (Nie, et al. 1975). It attempts to do this by forming one or more linear combinations of the discriminating variables, much the same way that variables are "combined" to forms principal components in principal components analysis.

It is beyond the scope of this research to define the mathematical derivations of the discriminant function. Anderson (1958) and Rao (1952) are considered the "classic" works on the procedure and Cooley and Lohnes (1971) provide adequate treatment on the mathematical sophistication involved.

STEPDISC, the SAS stepwise discriminant analysis procedure, was used for both discriminant tests. STEPDISC was used to determine the relative importance of the crops into the first discriminant analysis function. In the second analysis, STEPDISC was used to determine the contribution of the other variables to the discriminant function. A stepwise, forward elimination procedure was used. This process mathematically evaluates all variables simultaneously and continues to select the variables which explain the most variation in the dependent variable. Beginning with no variables in the model, each step enters the variable that contributes most to the discriminatory power of the model. This iteration continues until no more of the unselected variables meet the entry criterion as indicated by the significance level. In STEPDISC, this level is measured by Wilks' lambda, an information statistic used for significance tests (see Barr, et al. 1982; Nie, et al. 1975; and Klecka 1981).

CHAPTER 3

AGRICULTURAL TRENDS: 1945 to 1982

Overview

Farming in the study area underwent tremendous change during the study years. All crops experienced acreage reductions, except soybeans, which showed tremendous growth. Agricultural land use declined, indicating less regional dependence on farming.

The following section details changes in the research variables from 1945 to 1982. Some of the data were recalculated to account for inconsistencies. The statistics were standardized to ameliorate the effects of county size and total acres. Crop acreages were expressed as proportions of total acres harvested in each county. This prevented bias toward larger counties. The mean values of acres grown in each crop are also given where needed to shed light on the average amount of acres devoted to each crop in the study counties.

Crops

Government programs monitor the production of agricultural products in the study area. Cotton, tobacco, and peanuts are grown under national commodity control policies. The basic objective of these programs has been to maintain realistic prices for commodities produced by the farmer to insure that he remains a viable component of the economy (Fisher 1970). To avoid the problem of overproduction, the crop acreage allotment has been devised as a means of controlling the planted acreages of selected crops. Federal crop allotment programs have modified rural land use in the study area during the past several decades. The allotment program has an areal connotation and, therefore, is an influential component of the cropping patterns of the study region. In general, allotment programs tend to discourage monoculture of tobacco, peanuts, and cotton and to preserve relatively small acreages of these crops, typically grown in association with feed grains (Fisher 1970). They may also entirely discourage cultivation of crops. Changes in policy in the cotton allotment program since the 1960's have accelerated the relocation of cotton production from marginal to more optimal growing areas (Bailey 1978).

Several tables display the changes in the cropping patterns during the study period. Table 1 shows the percentage change in the acreages of crops (as proportions of the total acres harvested per county) from 1945 to 1964 and 1964 to 1982. The average number of acres in each crop in the study counties is shown in Figure 2. It graphically portrays the amount of acres harvested for each crop. This value is the average figure for all counties in the study area. The average price per crop from 1945 to 1982 and the average yield per acre by year are shown in Figure 3. Price and yield per acre determine, to a large part, what crops will be grown in the study area. Price is sensitive to numerous social and economic factors. It reflects trends and agricultural policies at the regional and national scales. These tables and graphs are reference for the following discussion of change in crop acreage during the study period.

The most dramatic change in Southern Piedmont cropping patterns was

PERCENT CHANGE IN CROPS AS PROPORTION OF

TOTAL HARVESTED ACREAGE

1945 - 64 and 1964 - 82

CROP	1945 - 64	1964 - 82
Peanuts	35.3	- 28.0
Soybeans	1764.0	608.4
Tobacco	11.4	- 18.8
Wheat	- 25.1	89.1
Corn	- 44.9	- 45.4
Cotton	- 23.6	- 94.6

Table 1

Average Number of Acres in Each Crop

in Study Counties

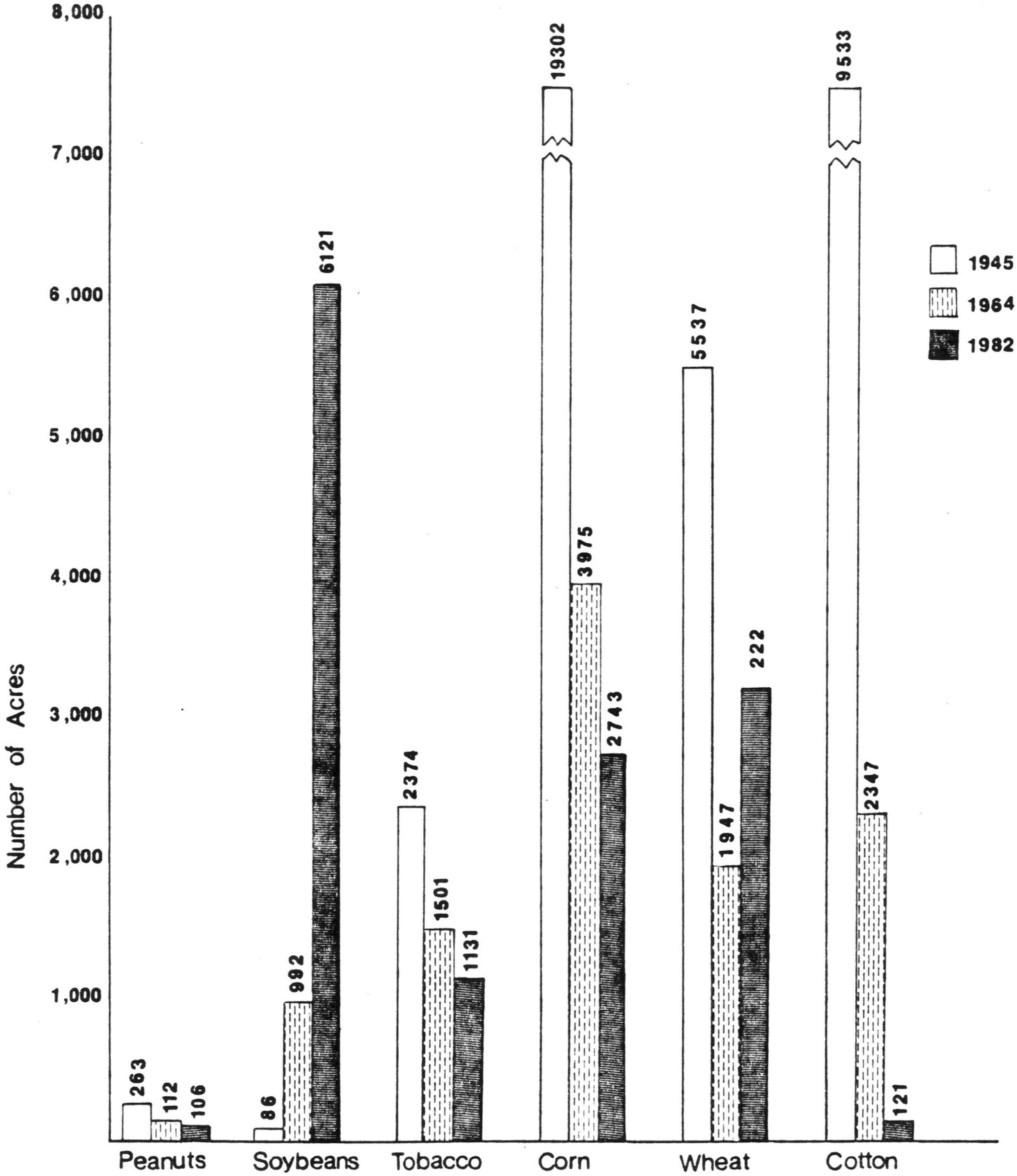


Figure 2

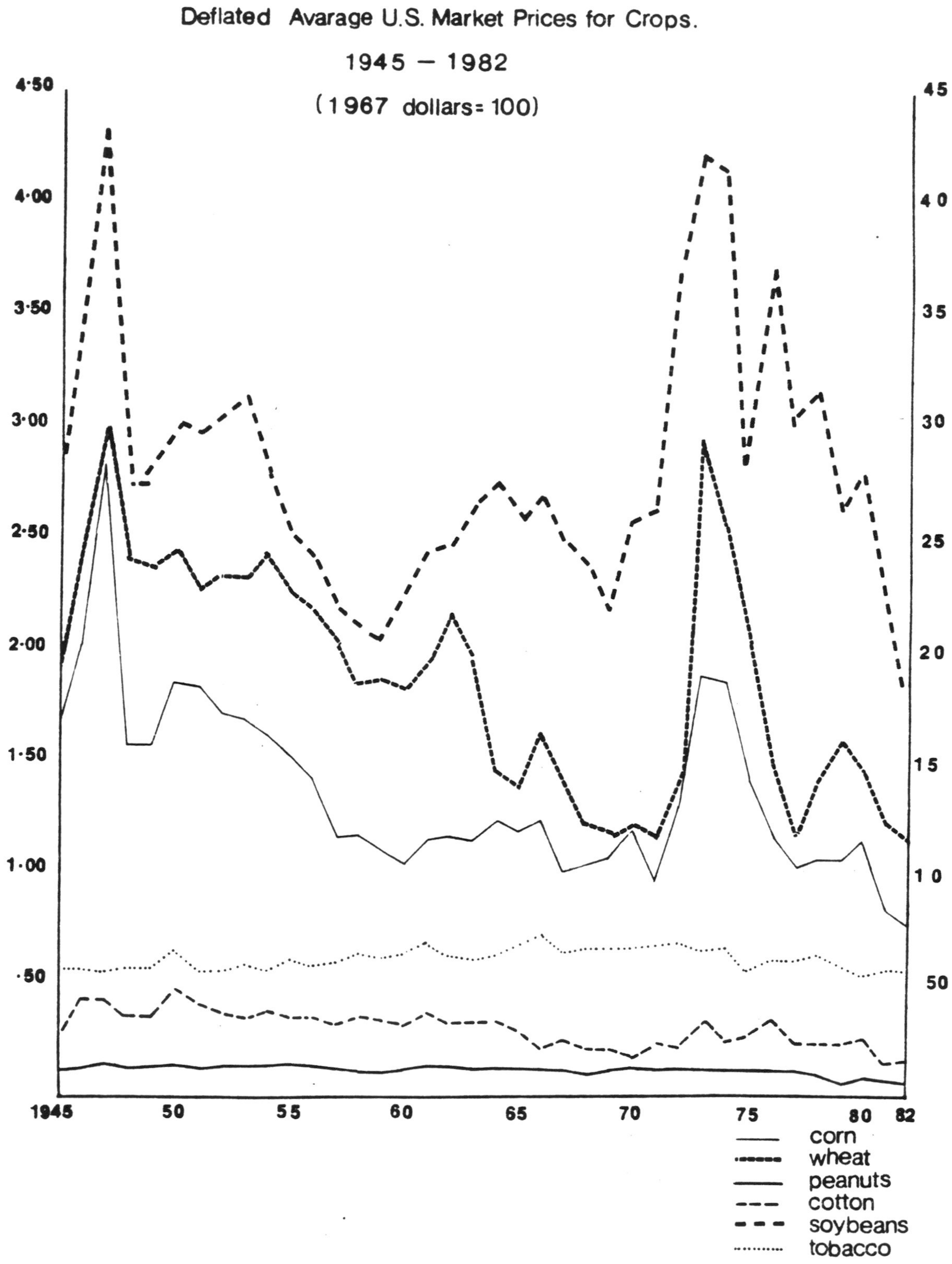

Deflated Avarage U.S. Market Prices for Crops.
1945 — 1982
(1967 dollars= 100)
4·50
4·00
3·50
3·00
2·50
2·00
1·50
1·00
·50
45
40
35
30
25
20
15
10
50
1945
50
55
60
65
70
75
80
82
corn
wheat
peanuts
cotton
soybeans
tobacco

Figure 3

AVERAGE YIELDS PER ACRE BY YEAR

AND STATE

CROP	AL	GA	NC	SC	VA	Mean
CORN (bu./acre)						
1945	17	13.4	25	16.5	33	21.0
1964	40	42	59	47	54	48.4
1982	55	50	77	58	90	52.0
SOYBEANS (bu./acre)						
1945	6.5	7.5	12.5	7	16	9.9
1964	23	20	25	23	20	22.2
1982	23	19	25	21	27	23.0
WHEAT (bu./acre)						
1945	15	13	14	13	16	14.2
1964	27	30	28	27	29	28.2
1982	44	43	39	35	44	41.0
PEANUTS (lbs./acre)						
1945	700	680	950	625	940	779
1964	1325	1710	2030	1450	2088	1721
1982	2715	2930	3175	2400	3150	2874
TOBACCO (lbs./acre)						
1945	838	1031	1109	1090	1117	1037
1964	1565	1919	2279	2170	2075	2002
1982	n/a	2200	2132	2168	2153	2163
COTTON (lbs./acre)						
1945	261	247	366	311	421	321
1964	467	488	490	519	462	485
1982	545	436	558	667	480	537

Figure 3
(continued)

an increase in soybean acreage. For example, in 1945, the average amount of soybeans harvested in the region was 86 acres per county. In 1964, this value had increased 11.5 times and by 1982, it had risen to 6,121 acres. This production rise is due to two important qualities of the crop. Soybeans are a hearty crop that can be adapted to a variety of growing conditions. This crop is quite versatile because it can be utilized in poultry and livestock feed in addition to being used as a source of oils for industrial use.

The rise in total acreage can be attributed chiefly to economic factors. During the study period, a favorable export market for soybeans opened (Siniard 1973). Demand for soybeans grew at a phenomenal rate, thereby escalating the price. This was probably the most influential component in this growing pattern. Soybean prices soared in 1946 and remained high throughout the study period. The price received for soybeans remained higher than for any other crop within the study period. Average yields per acre tripled in some states.

In addition to price incentives for soybean cultivation, government programs also played an important role. Subsidy programs reduced acreages of other crops competing for land use and soybeans were easily substituted for these acreages. The soybean seemed to be the crop alternative within an agricultural economy saddled with acreage allotments (Prunty 1970). This crop is under price support restrictions, but is not constrained by acreage allotments. Farmers were able to gain income from available land that could not be planted to other crops constrained by allotments. These conditions persist, and it is likely that soybean acreage will continue to rise. The increase in soybean production reflects the growing importance of the region's pastoral economy (Bederman 1970). Livestock has become an integral part of the agricultural economy of the region.

The data show that the peanut did not undergo as dramatic a change in cropping patterns as the soybean. Peanuts are not intensively grown within the study region due to soil restrictions. They are best suited to well-drained, light textured sandy loam soils with a moderately heavy clay subsoil (Anderson 1970).

At its peak, the average amount of peanuts grown per county was 263 acres. Compared to other field crops, this value is small. The number of acres planted in peanuts decreased from 1945 to 1964, but the proportion of harvested acres cultivated in peanuts increased during this time. This was also because the total acres of cropland harvested decreased. From 1964 to 1982, the proportion of harvested acres in peanuts declined nearly 30 percent. Figure 3 shows that during the study period, the price of peanuts did not fluctuate significantly, but yields quadrupled in some cases. Peanuts are produced under an allotment program which prompted a reduction in acreages (Anderson 1970). The decrease in peanut acreage is associated with large acreage increases of other crops. Peanuts were supplanted as a primary cash crop by another crop, soybeans.

Government control programs helped to promote erratic changes in tobacco acreage during the study period. Although tobacco prices remained stable, average acreages declined and yields rose to increase areal productivity. From 1945 to 1964, tobacco, as a proportion of all harvested acres in the study counties, rose 11.4 percent. An explanation may be that greater specialization in tobacco production existed among a smaller number of farms. Tobacco is regulated by acreage allotments and price supports as well as a pounds-per-acre ceiling. Regulatory constraints may have prevented some farmers from tobacco cultivation and which caused a greater concentration among a smaller, select group. The tobacco program was designed, in part, to keep small tobacco farmers from being forced out of business by large operators. Flue-cured tobacco, the major type grown in the study area, is more widely and economically produced on the Coastal Plain. Without the program, large operators on the Coastal Plain would likely have wrested most of the production away from the Southern Piedmont. For this reason, tobacco production, although in small amounts, has lingered. The program has served to maintain tobacco production in the Piedmont as of this date.

The data show that tobacco acreages declined from 1964 to 1982, which may coincide with several factors, including a decline in per capita demand. Between 1964 and 1982, research linking some forms of cancer, circulatory, and respiratory disease to smoking resulted in more stringent regulations on the advertising and sale of tobacco products. The per capita consumption of cigarettes fell four percent from 1968 to 1969 (Anderson 1970). Total consumption has also fallen in the last ten years (The Tobacco Institute 1985). Because of the continued decline in demand, import competition, and other factors such as budget cut-backs, the federal tobacco program is currently undergoing major changes. It is expected that tobacco production will continue to decline considerably in the future.

The grain crops also underwent major acreage losses during the study years. Wheat production declined from 1945 to 1964, but rose from 1964 to 1982. As a proportion of total acres harvested, wheat acreage nearly doubled from 1964 to 1982. Yields increased, but the price for wheat greatly fluctuated during the study period, which may have affected the cropping patterns. As with soybean production, increases in wheat production probably occurred largely as a result of allotment restrictions on other crops. Wheat and soybean cultivation probably occurred at the expense of less remunerative crops (Siniard 1973). Because the two crops are best suited to large acreages that facilitate harvesting by the same machinery, it is expected that they will be highly associated in the crop combination patterns.

Corn production declined significantly from 1945 to 1982. As a proportion of total harvested acres, corn acreage decreased 45 percent from 1945 to 1964 and another 45 percent from 1964 to 1982. Corn prices reflected this change, as prices fell considerably during the study period. Yields per acre tripled during this time. The decline in corn acreage is a product of the rise in soybean production. Corn was traditionally a major food crop in the South, but American dietary changes have taken great quantities out of production for human consumption. Corn was, at one time, a major component of the Southern diet. But most of the corn grown in this region is used to feed several head of livestock or a small poultry flock and is part of the subsistence farming so common in the area (Haystead and Fite 1955). Soybeans, to some extent, have replaced corn production in many areas. Soybeans have a high protein content and are commonly mixed with corn to feed livestock (Siniard 1973). Corn acreages have fallen off because it has become more economical to import Midwestern corn than to produce it in the Piedmont (Healy and Sojka 1985). The net effects of these factors have produced a decline in corn acreages.

Cotton acreage suffered a tremendous decline during the study period. Although the greatest acreage losses in cotton occurred around 1929, cotton was still an important crop in 1945 (Prunty and Aiken 1972). It was land intensive, but had high yields per acre. After 1945, cotton production declined significantly. From 1945 to 1964, cotton, as a proportion of the total harvested acres, fell almost 24 percent. Average acres grown in the study counties dropped from 9,533 to 2,347 acres. From 1964 to 1982, cotton acreage fell to an average of 121 acres per county, representing a 95 percent decline in the proportion of all harvested acres in the crop. The price received for cotton remained fairly stable during this time. Cotton acreage declines in the Southern Piedmont are consistent with the well-documented decreases in cotton production discussed by Prunty and Aiken (1972), Hart (1977, 1978), Fite (1955, 1985) and numerous others. Federal allotment programs, a decrease in labor supply and other concerns caused cotton production to move from this region to areas farther west. No other crop in the analysis showed such a marked loss in acreage.

In summation, Southern Piedmont agriculture between 1945 and 1982 was marked by several clear trends. There was a drastic decline in cotton production, accompanied by a dramatic increase in soybean production. There were less dramatic, though significant, declines in acreages of tobacco, corn, peanuts, and wheat. These declines were associated with a general decline in cropland in the Southern Piedmont.

Other Variables

The following section describes the changes in other variables of the analysis. This information is presented in a series of tables and graphs. Table 2 shows the percent change in the variables from 1945 to 1964 and 1964 to 1982. Figures 4a, b, and c illustrate the trends in several variables. The values given in the bar graphs represent the average county figure in the study area. The table and figures are sources for the following discussion of changes in the variables during the study period.

Agriculture in the Southern Piedmont is becoming increaingly less important in terms of absolute numbers. The average amount of land in farms per county (LIF) was 197,656 acres in 1945. In 1964, the average figure was 126,451 and it fell to 82,679 by 1982. The proportion of the county in farmland (LIF1) fell 35.7 percent from 1945 to 1964 and 34.6 percent from 1964 to 1982. In 1945, more than 71 percent of the area in the study counties was in farmland. By 1982, this dropped to less than 30 percent. The loss of land in farms has two implications: there are fewer farms in absolute numbers, and greater smounts of land are being converted to non-agricultural uses. The region has become more urbanized within the study period and farming areas have become less abundant.

The proportion of the county in harvested acres (ACRES1) fell 63 percent from 1945 to 1964, but remained stable from 1964 to 1982. The average amount of land harvested per county in 1945 was 20.9 percent.

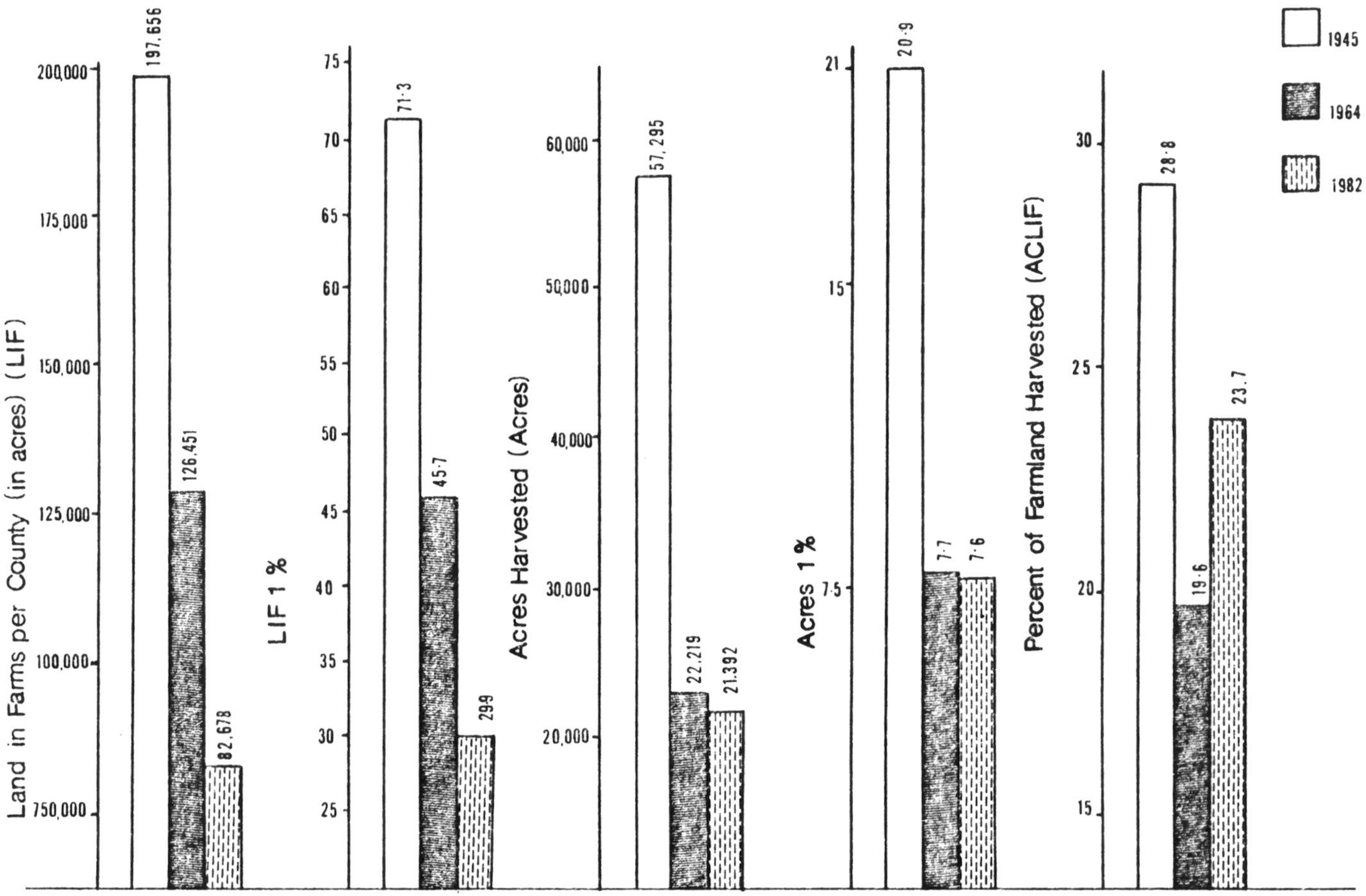
PERCENT CHANGE IN OTHER VARIABLES

DURING STUDY PERIOD

Variable	1945	1964	1982	Percent Change 45-64	64-82	45-82
LIF1 (Percent of county in farmland)	71.32	45.79	29.92	-35.7	-34.6	-58.0
ACRES1 (Percent of county in harvested acres)	20.99	07.76	07.69	-63.0	0.0	-63.0
FMS1 (Average acres harvested per farm)	25.30	22.45	40.45	-11.4	80.3	59.8
FMS2 (Average size of farm)	91.45	150.13	172.43	64.2	14.8	88.5
ACLIF (Percent of farmland harvested)	28.85	19.61	23.74	-32.0	21.0	-17.7
EMP1 (Percent of total population employed in manufacturing)	9.75	13.16	12.49	34.9	-5.1	28.1
POP1 (Persons per square acre)	1.17	1.53	2.31	31.2	50.7	97.4
NWPOP (Percent of non-white population)	33.19	30.21	26.95	-9.0	-10.9	-18.8

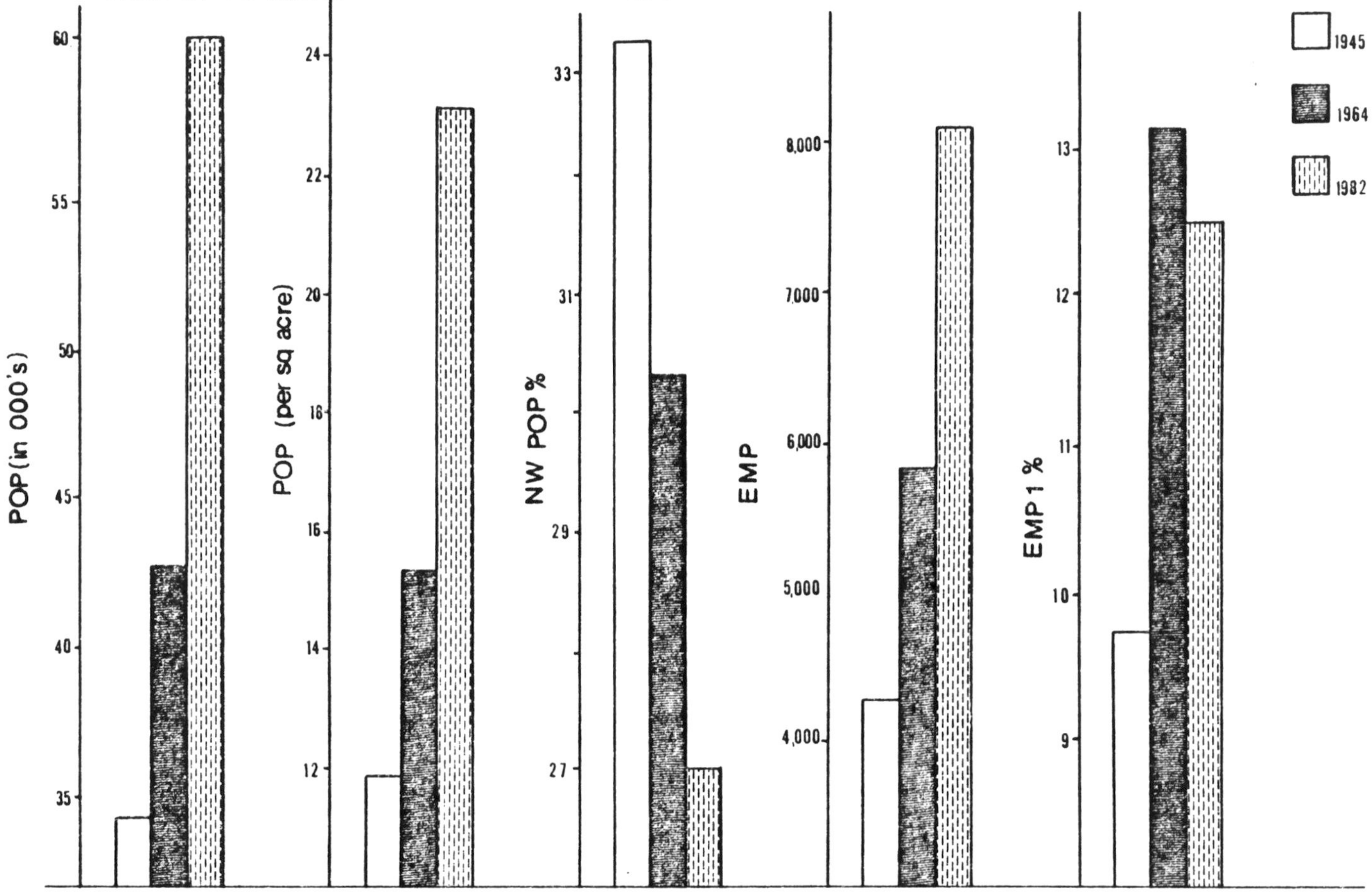
Table 2

Trends in Variables 1945–1982



Values compiled by author from U.S. Census data
Figure 4a

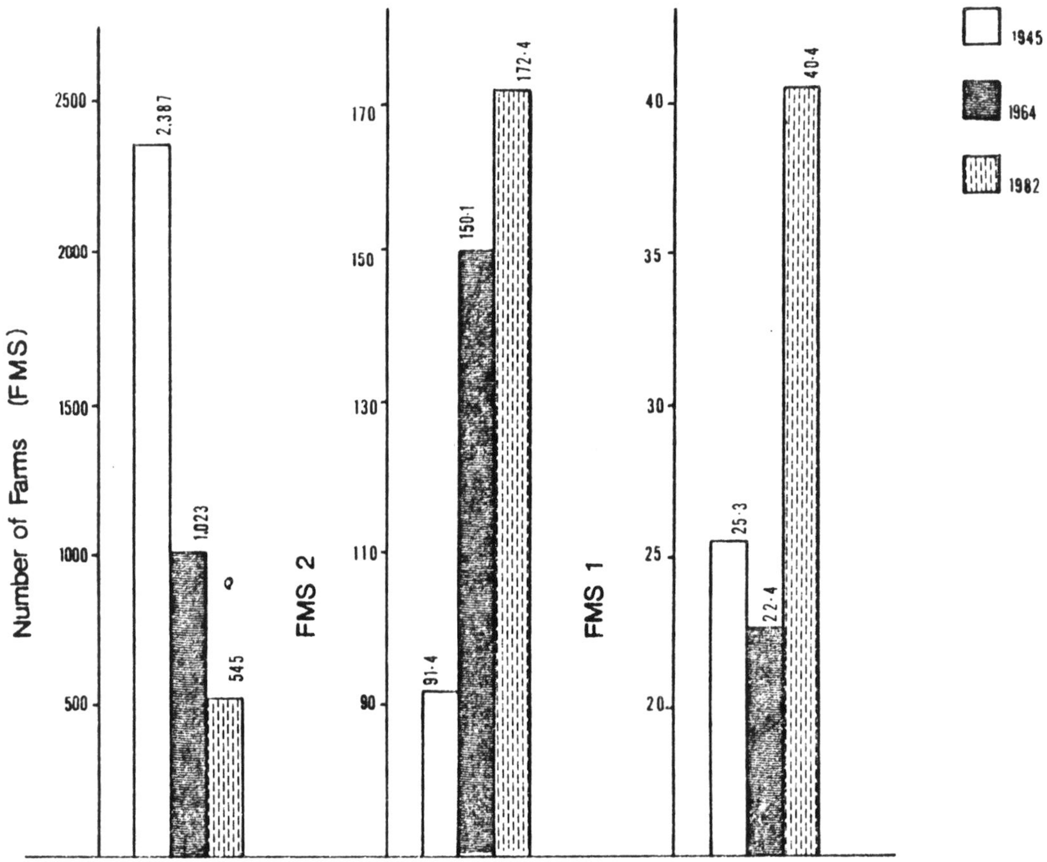
Trends in Variables 1945–1982 (continued)



Values compiled by author from U.S. Census data

Figure 4b

Trends in Variables 1945-1982 (continued)



Values compiled by author from U.S. Census data

Figure 4c

In 1964 and 1982, these figures were 7.7 and 7.6 percent respectively. The average number of harvested acres (ACRES), in absolute numbers was 57,295 in 1945. By 1982, this value fell to 21,392 acres. As fewer acres were harvested, more land was set aside for pasture.

To acquire a better understanding of the shifting agricultural importance of the region, it may be helpful to study the proportion of the farmland that was harvested cropland in the county (ACLIF). The (1 - x) value for this variable described the dominant land uses on the farms of the region. The converse indicated the proportion of farmland that may have been in pastureland or forested areas. Of the land in farms, 28.8 percent of the acreage was harvested in 1945. In 1964, only 19.6 percent was harvested, representing a 32 percent loss from 1945. From 1964 to 1982, the proportion of all farmland harvested rose to 23.7 percent. This implies a greater utilization of land use among farms and also that over 70 percent of the farms in this region are in pastures or forested lands.

The variables above describe the effect of the economic climate and changing land use trends on agricultural production in the region as a whole. These variables are inherently related to occurrences on the individual farm. The data on farms indicate that the absolute number of farms decreased, but average farm size increased. The average number of farms per county (FMS) was 2,387 in 1945, 1,023 in 1964, and dropped to 545 in 1982. Average farm size (FMS2) grew 64.2 and 14.8 percent repectively from 1945 to 1964 and 1964 to 1982. In absolute terms, the average farm size per county was 91.4 acres in 1945, 150.1 acres in 1964, and 172 acres in 1982. This decrease in farm number and increase in size is widely supported by the literature (PCA 1983; Prunty 1952; Hart 1976, 1980; Anderson 1973; Fite 1985).

Average farm utilization levels fluctuated during the study period. The average amount of acres harvested per farm (FMS1) fell 11.4 percent between 1945 and 1964, but increased 80.3 percent from 1964 to 1982. This variable differs from the proportion of the county in harvested acres in that it measures the absolute number of acres harvested on each farm. In 1945, an average of 25.3 acres were harvested from the average sized farm of 91.4 acres. This was 27.6 percent of the total farmland. In 1964, when the average size farm was 150 acres, only 22.4 acres were harvested, representing less than 15 percent of the total farmland. By 1982, this figure had risen again. On the average 172-acre farm, 23.4 percent of the total farmland, or 40.4 acres, were harvested. These figures reveal that crops were either grown more "intensively" in the early portion of the study period or possibly that less area became available for agricultural use. From 1945 to 1964, this area became less specialized in crop agriculture, promoting more acres to be put into pastureland (Bederman 1970). From 1964 to 1982, government subsidy programs were largely responsible for the increased yields per acre.

In general, other variables experienced significant change during the study period. The average population per county (POP) nearly doubled during the study period. In 1945, an average of 33,350 persons lived in each study county. By 1982, the average was 60,153 representing a population density (POP1) change of 1.17 persons to 2.31 persons per square acre. Most of this change occurred between 1964 and

1982. The average population density increased by more than 50 percent during this time.

The compostion of the population also changed. The proportion of non-whites (NWPOP) declined during the time period 1945 to 1982. In 1945, one-third of the total population was non-white. In 1964, this figure had fallen to 30.2 percent and by 1982, only 26.9 percent of the population was considered non-white.

Employment in manufacturing underwent various changes during the study period. The absolute number of persons employed in manufacturing (EMP) rose, but the percentage of population employed in manufacturing (EMP1) fluctuated. It rose almost 35 percent between 1945 and 1964, but fell five percent from 1964 to 1982. These changes are thought to be associated with an evolutionary process whereby the Southern Piedmont changed from a predominantly agricultual ecomomy to a more industial economy. Further changes were wrought as the industrial economy continued evolving into a more service-oriented economy. Therefore, the decline in manufacturing employment from 1964 to 1982 does not represent a re-emergence of agriculture, but the emergence of the tertiary sector. It also reflects a significant economic recession in 1981 and 1982.

Summary

In summary, during the study period, the Southern Piedmont became less dependent upon agriculture as an economic base. Nearly all crops, excluding soybeans, were grown on significantly less acreage. Despite yield per acre increases, production has declined. Soybeans served as a replacement for most crops that experienced acreage reductions.

The region saw fewer, but larger farms during the study period. Less area was devoted to farms, but more acres were harvested per farm. This implies that the region became less agriculturally-oriented, but the farms still in existence were more productive.

CHAPTER 4

CROP COMBINATION REGIONS

Overview

This chapter describes the results of the cluster analysis performed on the crop variables. The cluster analysis produced five crop combination regions in the study area. Discriminant analysis was performed on the data to determine the relative importance of the variables in explaining crop combination regions. The results from this analysis are also described.

Cluster Results

Cluster analysis was used to organize the study area into crop combination regions. It is a technique which mathematically combines data into constituent groups (see Chapter 2). This technique was used to define crop combination regions within the study area for 1945, 1964, and 1982. The purpose of cluster analysis is to place objects into groups or clusters suggested by the data such that objects in a given cluster tend to be similar to each other and dissimilar to objects in other clusters (Barr, et al. 1982). The cluster algorithm selected regions with the best internal homogeneity and extreme dissimilarity among regions.

Clustering was based on the crop variables. This produced five clusters, or crop combination regions. Five clusters were chosen because numerous test runs produced four distinct regions with several outlier counties (counties in a cluster alone). Test runs with more than five clusters simply produced more outliers. Five clusters best described the cropping patterns of the study area.

The crop combination regions for 1945, 1964, and 1982 are shown in Figure 5a, b, and c and their definitions are given in Table 3a, b, and c and Table 4a, b, and c. For each cluster, Tables 3a, b, and c show the average proportion of harvested acres in each crop. Tables 4a, b, and c summarize the characteristics of the clusters as related to the non-crop variables. Although the cluster analysis was based on the crops, these tables show average values for the other variables in the counties included in particular clusters. Standardized, as well as absolute, means are given. Standardization produces a mean of zero and one as the standard deviation. Figures that are standardized are valuable because they allow comparison between clusters. When all values have a mean of zero, comparison among the clusters can determine the relative amounts of crops grown in each cluster. It can be determined whether a particular cluster produces more or less than the average amount of acres in a certain crop by examining the sign of the value. Positive values indicate greater than "average" amounts grown for a particular crop, and a negative sign indicates less. The actual values given for each cluster are the proportions of all harvested acres in each crop. These figures may be better understood as percentages of the total amount of harvested acres within a particular cluster of counties.

A category for "other" crops was included in Table 3 to determine the relative importance of crops other than those row crops analyzed in the agricultural patterns of the study area. Other crops typically included forage crops like hay, oats, and alfalfa, as well as fruits, such as peaches. Hay, alfalfa, and oats are widely grown in the study area for use as a feed crop and also to mitigate erosion (Trimble 1974). For the purposes of this study, various clusters will be referred by name of the dominant crops grown included in this analysis. Because of the severe erosional problems in the Piedmont, most farmers grow a cover crop year round. It is recognized that while these crops are grown in small proportions, they do not reflect the overall cropping patterns of the study region.

1945 Cluster Definitions

The cluster analysis for 1945 produced four large clusters, or regions, plus a region with a single county as its member (Figure 5a). Clusters 2, 3, 4, and 5 contained 25, 54, 30, and 26 members respectively, but cluster 1 included only Greensville County, Virginia, located in the eastern portion of the Virginia study area. This county was isolated by the cluster algorithm due to its uniqueness among the counties. No other study county had similar agricultural patterns. This cluster was defined as the peanuts/corn/cotton combination region. Thirty-six percent of its harvested acres were in peanuts, 30 percent in corn, and 16.6 percent in cotton, and almost 12 percent of the harvested acres were in other crops. Soybeans, although still fairly insignificant as a major crop in the Southern Piedmont, were produced in this county. Nearly four times more soybeans were grown here than in any other county. Greensville County stood apart from the remaining

1945 Crop Combination Regions

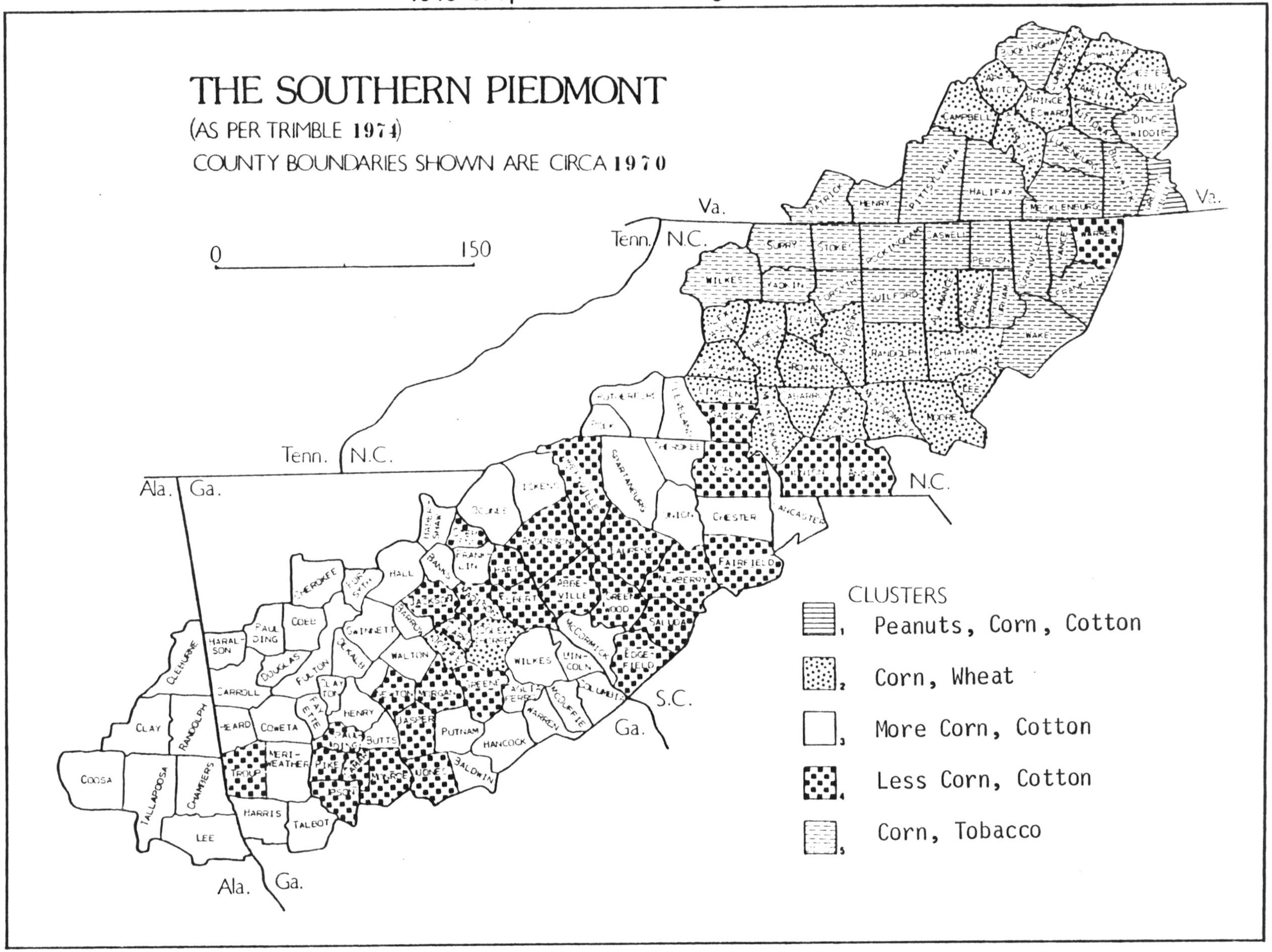


Figure 5a

CLUSTER DEFINITIONS:
PERCENTAGE OF TOTAL ACRES HARVESTED IN EACH CROP
Actual and Standardized Cluster Means

1945

Cluster Number / Crop	1 * Peanuts, Corn, Cotton		2 Corn, Wheat		3 More Corn, Cotton		4 Less Corn Cotton		5 Corn, Tobacco	
Peanuts	36.01	10.50	0.14	-0.15	0.40	-0.07	0.27	-0.11	0.73	0.02
Soybeans	1.03	3.62	0.28	0.49	0.09	-0.29	0.13	-0.14	0.20	0.15
Tobacco	2.66	-0.17	3.52	-0.05	0.00	-0.55	0.44	-0.49	16.54	1.77
Corn	30.72	-0.55	29.43	-0.71	41.53	0.74	29.52	-0.69	35.13	-0.02
Wheat	1.36	-1.13	18.53	1.51	4.31	-0.67	8.01	-0.10	9.49	0.11
Cotton	16.63	0.11	3.56	-1.00	24.53	0.78	19.90	0.39	2.18	-1.12
Other	11.59		44.54		29.14		41.73		35.73	

* Indicates cluster with one or two county membership

Table 3a

CLUSTER DEFINITIONS:
OTHER VARIABLES
Actual and Standardized Cluster Means

1945

Cluster Number	1 *		2		3		4		5	
Variable	Peanuts, Corn, Cotton		Corn, Wheat		More Corn, Cotton		Less Corn, Cotton		Corn, Tobacco	
LIF1	62.78	-0.77	71.77	0.02	70.10	-0.12	71.63	0.00	74.41	0.25
ACRES1	18.16	-0.36	20.56	-0.06	21.49	0.04	23.70	0.32	17.97	-0.39
FMS1	30.58	0.73	25.47	0.01	25.96	0.08	29.87	0.63	18.60	-0.95
FMS2	105.72	0.53	94.64	0.12	91.35	0.00	97.87	0.24	79.35	-0.43
ACLIF	28.93	0.00	27.89	-0.13	30.01	0.13	32.30	0.41	23.95	-0.61
EMP1	6.87	-0.38	11.31	0.20	8.01	-0.23	12.79	0.40	8.39	-0.18
POP1	7.72	-0.32	11.38	-0.03	11.36	-0.03	11.80	0.00	13.09	0.10
NWPOP	60.00	1.48	25.54	-0.42	33.04	0.00	38.68	0.30	33.36	0.01

* Indicates cluster with one or two county membership

Table 4a

counties in other ways, also. Table 3b shows that Cluster 1 had a larger than average non-white population (NWPOP). Its values for acres harvested per farm (FMS1) and farm size (FMS2) were above average, but it had a low proportion of land in farms (LIF1). In terms of its agricultural geography, Greensville County more closely resembles a Coastal Plain than a Piedmont county.

The corn/wheat region was cluster 2. Its members were located in the central and western portion of the North Carolina study area, the north-central section of the Virginia Piedmont and two outlier counties in Georgia. The cluster summary in Table 3a shows that counties of this region had lower percentages of acres for nearly all of the crops. Almost 45 percent of all harvested acres were in crops not included in this analysis. Corn was the most widely harvested crop in this region and wheat acreage comprised 18.5 percent of all acres harvested within the cluster. Table 4a shows that the percent of non-white population (NWPOP) was below average. The average for all clusters was 33.04 percent and cluster 2 had only 25 percent of its population as non-whites. The proportion of population employed in manufacturing (EMP1) was slightly above the mean. Cluster 2 had 11 percent of its population employed in manufacturing and the average for this year was around nine percent.

Cluster 3 and 4 were very similar in size, areal extent and definition. In terms of size, cluster 3 had 53 members and cluster 4 contained 30 counties. Their locations were similar in that both had members located within the southern tier of the study region. South Carolina, Georgia, and Alabama contributed most of the members, and three or four North Carolina counties were included. Although both clusters were generally located in the same area, the members of cluster 3 were "wrapped" around cluster 4. Counties belonging to cluster 4 formed the centroid for cluster 3. These two clusters also share a similar definition. They represent identical crop combinations, but differ in terms of the amount of each crop grown. Cotton and corn were grown together in these regions, but cluster 3, the outer ring of counties in the southern tier, had greater proportions of land in these crops indicating greater regional specialization in these crops. Corn production dominated 41.5 percent of the acres harvested and cotton was 24.5 percent. Other crops, which were probably hay and other forage crops, were harvested in approximately the same amount as cotton with 29.1 percent. In cluster 4, the inner counties, corn and cotton also dominated. Only 29.5 and 19.9 percent of all harvested acres were in corn and cotton, respectively. Cluster 4 grew the same crops, but fewer quantities than the previous region. Forty-one percent of all acres harvested were in other uses. Table 3a shows that except cotton, all other crops were grown in less than average levels indicated by the standardized values less than zero. Table 4a shows that no other variables stood out in distinguishing this region. Both clusters had near average values for the other variables in the analysis, but the inner counties (cluster 4) had higher average acres harvested per farm (FMS1). This represents a greater productivity level.

Cluster 5, located in North Carolina and Virginia, represented the corn/tobacco/wheat region. Corn occupied the most harvested acres in this cluster (35.1 percent) and tobacco acreage was 16.5 percent of all land in harvested acres. Wheat, the least prominent crop in the region, had only 9.5 percent of all harvested acres. This cluster had lower than average values for most other variables (see Table 4a). The proportion of farmland in harvested cropland (ACRES1), average acres harvested per farm (FMS1), and farm size (FMS2) all had negative standardized means, indicating less than average amounts for each variable. Farms in this cluster were smaller than average (79.3 acres) and probably had large amounts of land in forests since the land in farms was so scant (17.97 percent).

1964 Cluster Definitions

The 1964 crop combination regions are mapped in Figure 5b and summarized in Tables 3b and 4b. The following discussion describes the crop combination regions for 1964.

The peanut region, represented by Greensville County, VA, in the 1945 analysis, reappeared in the 1964 analysis, but with a different membership. Greensville County, VA, was included, as well as Dinwiddie, an adjacent Virginia county. In 1945, this cluster (cluster 2) represented the peanuts/corn/cotton region, but in 1964, it was the corn/peanuts/soybean region. During the 19 years between study years, peanuts became less important in this cluster. The mean peanut acreage was substantially lower than the previous study year. Corn remained essentially unchanged during this time. Again, this cluster was a major soybean producer compared to the other counties. Soybeans rose from slightly more than one percent of all acres harvested in 1945 to 18.5 percent. This year witnessed an increase in the amount of acres

1964 Crop Combination Regions

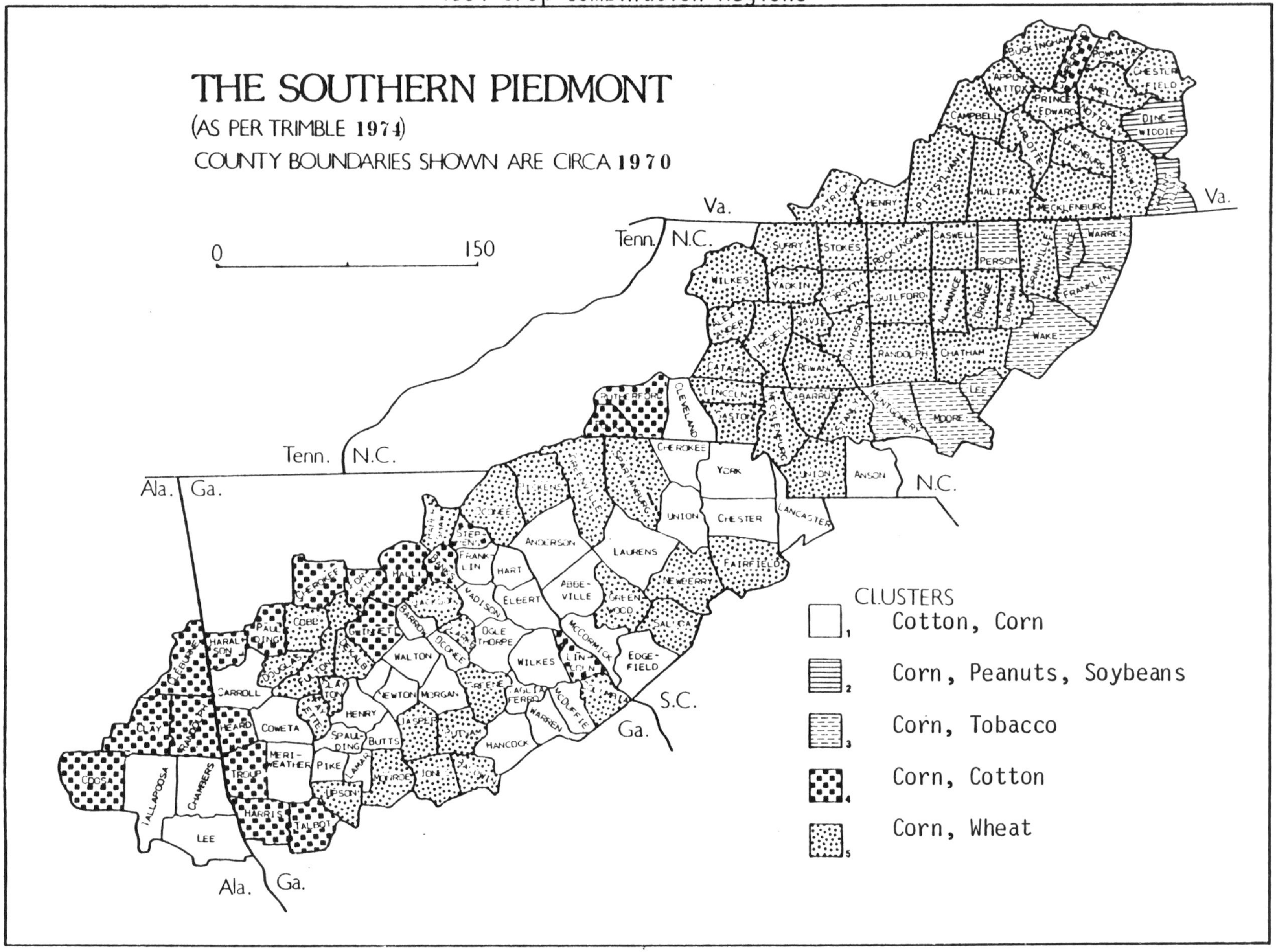


Figure 5 b

CLUSTER DEFINITIONS:
PERCENTAGE OF TOTAL ACRES HARVESTED IN EACH CROP

Actual and Standardized Cluster Means

1964

Cluster Number	1		2*		3		4		5	
Crop	Cotton, Corn		Corn, Peanuts, Soybeans		Corn, Tobacco		Corn, Cotton		Corn, Wheat	
Peanuts	0.03	-0.12	23.03	7.30	0.14	-0.09	0.15	-0.08	0.08	-0.10
Soybeans	1.80	-0.30	18.52	3.41	8.87	1.27	0.68	-0.55	3.51	0.70
Tobacco	0.02	-0.55	5.63	0.15	21.27	2.13	0.29	-0.51	5.90	0.19
Corn	14.75	-0.51	25.13	0.62	27.78	0.91	32.37	1.41	17.13	-0.25
Wheat	4.58	-0.33	3.93	-0.44	11.34	0.82	2.50	-0.68	8.23	0.29
Cotton	27.84	1.31	7.60	-0.33	13.79	0.17	8.78	-0.23	3.77	-0.64
Other	50.98		16.16		17.11		55.23		61.38	

* Indicates cluster with one or two county membership

Table 3b

CLUSTER DEFINITIONS:
OTHER VARIABLES
Actual and Standardized Cluster Means

1964

Cluster Number	1		2		3		4		5	
Variable	Cotton, Corn		Corn,* Peanuts, Soybeans		Corn, Tobacco		Corn, Cotton		Corn, Wheat	
LIF1	48.71	0.19	43.41	-0.15	61.27	1.05	37.43	-0.56	44.92	-0.05
ACRES1	7.70	-0.01	11.83	0.87	11.02	0.70	3.30	-0.96	8.59	0.17
FMS1	26.07	0.34	38.59	1.54	17.54	-0.48	12.08	-0.99	23.63	0.11
FMS2	174.48	0.32	143.11	-0.09	102.32	-0.63	143.00	-0.09	144.89	-0.06
ACLIF	15.47	-0.16	27.00	0.29	18.03	-0.06	8.82	-0.42	24.92	-0.20
EMP1	13.51	0.07	7.83	-1.11	9.35	-0.79	13.66	0.10	13.43	0.05
POP1	8.94	-0.29	7.56	-0.35	14.76	-0.02	7.77	-0.34	21.30	0.27
NWPOP	37.11	0.40	57.90	1.61	36.03	0.33	23.46	-0.39	26.99	-0.18

* Indicates cluster with one or two county membership

Table 4b

invested in other crops not included in this analysis. It rose from 11.5 to 16.1 percent of all harvested acres. The other variables in Table 4b describe the outstanding characteristics of the corn/peanut/soybeans region. These variables show that this region is strongly rural and agriculturally intensive. Employment in manufacturing (EMP1) had a standardized value of -1.11, indicating much lower than average industrial employment rates. Also, the non-white population (NWPOP) and average acres harvested per farm (FMS1) were substantially higher than the average in other clusters of that year. This supports the importance of agriculture in this crop combination region.

The 1945 cotton/corn regions in Georgia, South Carolina, and Alabama reappeared in the 1964 analysis. Similar to 1945, these clusters included much of the study area in Georgia, South Carolina, Alabama, and a few disjoint counties in North Carolina. The spatial patterns of these clusters remained unchanged: one cluster "wrapped" around the other, and both had memberships similar to the previous years. Again, the difference between these two regions was determined by the quantity grown in each crop. The "inside" cluster, cluster 1, was a cotton/corn region, and the "outside" counties, cluster 4, represented a corn/cotton region. In the internal region, cotton was clearly the dominant crop. Cultivation in cotton occupied 27.8 percent of all acres harvested and corn had only 14.7 percent of this land. In the other cluster, corn dominated with 32 percent and cotton was only 8.7 percent of the harvested acres. Cotton and corn were not the only crops grown in these two regions, however. Other crops such as hay and alfalfa comprised more than 50 percent of all harvested acres. The numerical value in other crops rose almost 40 percent from the previous study year. The increase in other crops supports the declining importance of cotton in these regions. Table 4b shows that the "outside" cluster, or the corn/cotton region, had below average values for nearly all of the other variables. The amount of acres harvested in these clusters was very low. The amount of cropland harvested in each county, ACRES1, and the amount of cropland harvested on the farms, FMS1, were 38 and 12 percent for the two clusters. This was very low compared to the other clusters in this study year. The "outside" cluster had lower values for the amount of land in farms (LIF1) and the amount of harvested farmland (ACLIF). The "inside" group of counties had higher values for the amount of acres harvested per farm, FMS1, and average farm size, FMS2. Average farm size in the interior cluster was 174 acres compared to 143 acres in the outside counties. The average amount of acres harvested per farm was 26 acres in the interior cluster and 12 acres in the outside region. Although these clusters contained large farms, relatively little cropland was harvested.

The North Carolina-Virginia corn/tobacco region was represented in cluster 3. Its eight members were located in a linear strip along the eastern portion of the North Carolina Piedmont. This cluster had more acreage in tobacco than its 1945 equivalent. Almost 22 percent of the harvested acres were in tobacco, and 27.4 percent were in corn, but wheat and cotton were also grown in this region. Cotton acreage was above average, as well as wheat production. Only 17 percent of the harvested acres was in other crops like hay and alfalfa. Acreage productivity was high in this region, as it had significantly high values for LIF1, percent of county in farmland, and ACRES1, percent of county in harvested acres. FMS2, average farm size, and EMP1, percent of the population employed in manufacturing, were significantly lower than the other regions.

The corn and wheat region, cluster 5, included 69 counties, or more than 50 percent of all the study area. Its members were scattered in every state except Alabama, with no distinct spatial pattern. Although corn and wheat were most commonly grown in this region, these two crops did not dominate all cropland. More than 61 percent of all acres harvested were in other crops, such as forage crops or fruits. Corn production was 19.1 percent of all acres harvested and wheat comprised 8.2 percent. This cluster had near average values for all of the other variables in the analysis, but the population density, POP1, was higher than average.

1982 Cluster Definitions

The 1982 analysis produced four clusters that had similar county membership and one cluster that contained only one county. In this year, the outlier county differed from previous years. The spatial arrangement of the regions for this year were similar to the regions defined in 1945 and 1964, but the crops which defined the regions differed almost entirely. For the first time, cotton was no longer a major component of any region. Soybeans became the dominant crop of the study area, with every cluster showing significant amounts of this crop in cultivation. Soybeans and wheat appeared as the most frequent crop

1982 Crop Combination Regions

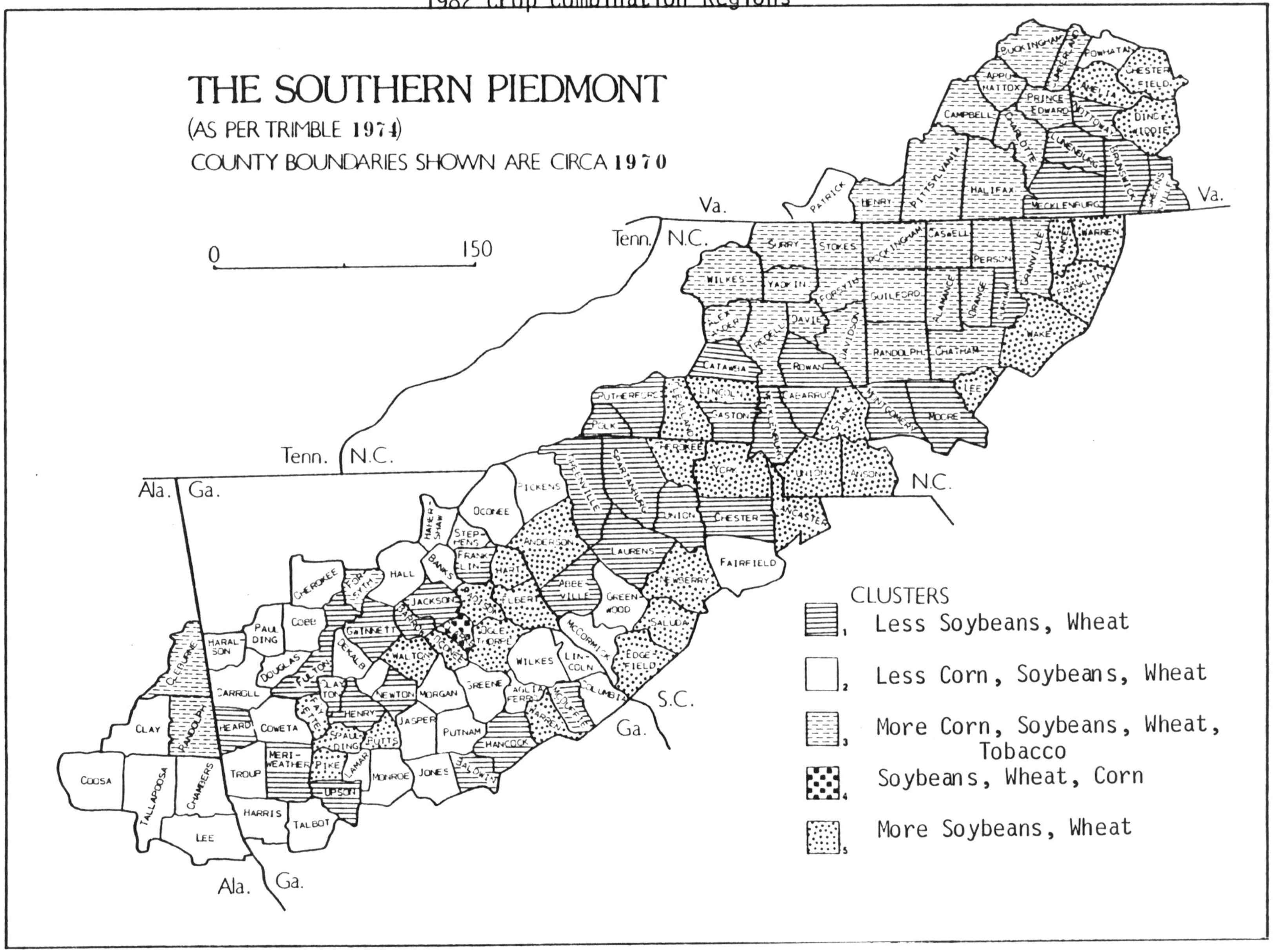


Figure 5c

CLUSTER DEFINITIONS:
PERCENTAGE OF TOTAL ACRES HARVESTED IN EACH CROP
Actual and Standardized Cluster Means

1982

Cluster Number	1		2		3		4 *		5	
Crop	Less Soybeans, Wheat		Less Corn, Soybeans, Wheat		More Corn, Soybeans, Wheat, Tobacco		Soybeans Wheat, Corn		More Soybeans, Wheat	
Peanuts	0.94	0.22	0.0	-0.10	0.0	-0.10	0.0	-0.10	0.24	-0.02
Soybeans	27.50	0.80	4.76	-2.81	13.12	-1.48	44.96	3.58	44.23	3.47
Tobacco	1.94	-0.26	0.21	-0.55	9.73	1.02	0.0	-0.58	3.46	-0.01
Corn	9.27	-0.22	5.68	-0.83	20.35	1.64	13.33	8.91	7.19	-0.57
Wheat	12.59	0.03	4.47	-1.18	11.36	-0.14	42.15	4.50	20.59	1.24
Cotton	0.47	-0.04	1.26	0.20	0.01	-0.19	0.00	-0.19	0.65	0.00
Other	47.29		83.62		45.43		0.00		23.64	

* Indicates cluster with one or two county membership

Table 3c

CLUSTER DEFINITIONS:
OTHER VARIABLES
Actual and Standardized Cluster Means

1982

Cluster Number	1		2		3		4 *		5	
Variable	Less Soybeans, Wheat		Less Corn, Soybeans, Wheat		More Corn, Soybeans, Wheat, Tobacco		Soybeans, Wheat, Corn		More Soybeans, Wheat	
LIF1	27.20	-0.23	22.09	-0.65	38.61	0.70	19.36	-0.87	33.87	0.31
ACRES1	6.79	-0.17	3.55	-0.75	9.56	0.32	7.79	0.00	11.62	0.69
FMS1	41.01	0.01	28.49	-0.46	33.20	-0.28	59.62	0.72	58.84	0.69
FMS2	170.94	0.00	185.82	0.22	142.67	-0.40	148.08	-0.30	178.83	0.12
ACLIF	24.14	0.01	14.61	-0.86	24.11	0.01	40.26	1.51	32.98	0.84
EMP1	15.22	0.36	10.70	-0.24	12.82	0.04	13.69	0.16	11.39	-0.14
POP1	32.74	0.25	23.50	0.00	18.79	-0.12	95.46	1.99	16.17	-0.20
NWPOP	26.49	0.00	27.20	0.04	22.48	-0.25	24.90	-0.10	29.31	0.17

* Indicates cluster with one or two county membership

Table 4c

combination and the differences between the regions were defined by the quantity grown in these crops.

One soybeans and wheat cluster, cluster 1, had members throughout the study area in every state except Alabama. Its members were arranged similarly to 1964's cluster 1. The region grew crops other than those in the analysis, as 47 percent of all acres harvested were in other crops. Soybeans and wheat were found to have 27.5 percent of all harvested acres in soybeans and 12.5 percent in wheat. Other crops were important in defining this cluster. Corn occupied 9.2 percent and tobacco production, although below the year's average, was nearly two percent of this cluster's cropland. The values for the other variables (see Table 4c) were average, except for EMP1, which was slightly above average.

Members of Cluster 2 were located along the periphery of the study area in Georgia, Alabama, South Carolina, and Virginia. Corn and soybeans, the most widely grown crops of the study in this cluster, covered less than 11 percent of all acres harvested. Wheat and cotton were also grown in scant amounts. These crops were not representative of this region, as "other" crops comprised over 83 percent of the region. The variables which described agricultural conditions, such as land in farms, acres harvested, and acres harvested per farm, were higher than average. This means that the farms were very productive. FMS2, or farm size, was greater than the mean, implying that the farms that do exist are larger than average.

Cluster 3 was a mixed crop area located in a contiguous group of counties in Virginia and North Carolina, with outliers in Georgia and

Alabama. Corn, soybeans, wheat, and tobacco were the dominant crops of this cluster, but other crops made up 45 percent of all acres harvested. Table 3c shows that corn was most widely grown (20.3 percent), and soybeans, wheat, and tobacco were distributed in similar proportions. This cluster had above average values for LIF1, percent of the cluster in farmland, and below average values for FMS2, farm size. The non-white population was slightly lower than the other clusters. The data support that the region was composed of many smaller farms.

Cluster 4 included only Clarke County, Georgia, an outlier during this year. It had extremely low values for LIF1, but POP1 and ACLIF were very high. Although it was defined as a soybeans/wheat/corn region, this information was misleading because of the small amount of land in farms. This county, the home of the University of Georgia, is a small, densely-populated county with a non-agricultural base. The amount of land in farms is fairly low.

Cluster 5, located in a north-to-south string of counties in every state except Alabama, probably best described the cropping patterns of the Southern Piedmont. It was a soybeans/wheat region. Located on the fringes of Cluster 1, another string of counties, it had many of Cluster 1's characteristics. These two clusters bore great similarities, but Cluster 5 produced greater quantities of each crop, except corn. Soybeans comprised 44.2 percent, wheat, 20.5 percent, and corn 7.1 percent of all acres harvested. Tobacco was an important crop in this cluster, and other crops comprised only 23.6 percent of the harvested acres. ACRES1, ACLIF, and FMS1 were significantly greater than average, thus indicating more agricultural activity.

Summary

In summary, the crop combination regions varied greatly from year to year. The most persistent of the regions was the North Carolina-Virginia tobacco producing region. In each study year, this region maintained a consistent membership which did not significantly vary spatially. The crops grown in association with tobacco did not vary greatly, either.

Probably the most important changes in the regions were the decrease in cotton cultivation and the switch from growing cotton to growing soybeans. Cotton production nearly vanished from the landscape, and soybean production rapidly filled most of the gaps. Nearly every cotton-producing cluster from 1945 and 1964 either made a clean switch to soybeans as the major crop or was taken out of cropland all together. Former cotton land was abandoned to scrubby woodland which can and will be reconverted when farmland is needed (Hart 1980).

Another major change in the crop combination regions was the tremendous decrease in the land in farms in the study area. In 1945, all counties had at least 70 percent of their land in farms, with a large proportion harvested. By 1964, the average percentage of land in farms fell to 47 percent and, in 1982, it was 28 percent. Some of this land was purchased by paper companies and planted in loblolly pines while other areas were converted to pastureland (Hart 1980). The rapid decline in farmland has two implications: 1) fewer farms are in existence than in the past (documented in the previous chapters) and, 2) greater amounts of "built-up" or urban-related land uses have developed in the area excluding forest and pasture land changes. The data indicate that the Southern Piedmont has experienced major changes in the amount of land in urban uses.

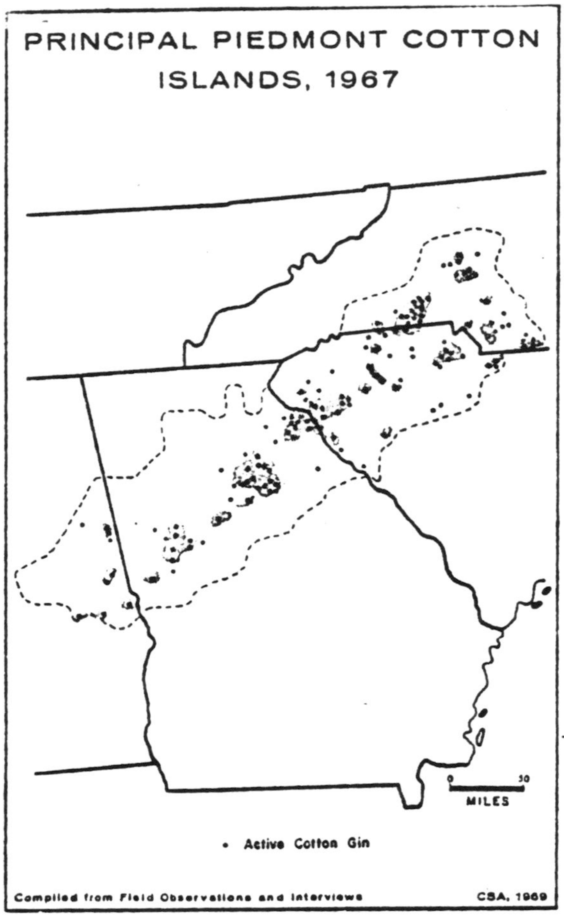
Spatial Structure of Crop Combination Regions

Identifying, mapping, and describing crop combination regions may not be adequate to reveal the spatial structure of Piedmont agriculture. Underlying patterns were present during the study years which were responsible for the formation of the crop combination regions. These were socio-economic factors, land use factors, or a combination of both. The patterns of the crop combination regions are discussed in the following paragraphs.

An undefined boundary, present in the crop combination maps for all study years, divided the study area into two distinct agricultural regions. The dividing line was approximately located at the southern North Carolina border with the southernmost North Carolina counties in the southerly region with South Carolina, Georgia, and Alabama. The dividing line distinguished the "northern" crop combinations of North Carolina and Virginia from those located to the south. Crop combinations were different upon crossing this line. Tobacco defined the crop combinations to the north and cotton was responsible for defining the crop combinations to the south of the line (except in 1982 when soybean production replaced cotton). The line just north of the North Carolina state border served as a natural boundary between cotton and tobacco cultivation.

None of the clusters were neat, coherent regions. Most were constructed of counties that were non-contiguous. Cluster members for most crop combination regions were located sporadically throughout the study area. Often two or three contiguous counties were grouped together into the same region. Only two crop combination regions had all members adjacent to or within close proximity to each other. In 1945 and 1964, clusters 4 and 1, the corn and cotton clusters, had counties strung together in a north to south band (Figure 5). They represented a cotton region which coincided with Prunty's (1972) location of cotton islands in the Southern Piedmont (Figure 6). The North Carolina-Virginia tobacco crop combination region, persistent in each year, was consistently cohesive. Each study year, it included approximately one-third of the study counties in the northern region. Although the crop combinations changed slightly between study years, the spatial boundaries of this region persisted. All other regions had members located in non-contiguous counties, and often in distant places.

The region of greatest cotton production, located in the upper Piedmont of Georgia and South Carolina, experienced a recurring phenomenon. In 1964 and 1945, the most intensive cotton cultivation counties (clusters 3 and 4, respectively) were encircled by a band of progressively less intensive cotton producing counties. The outer counties (cluster 4 in both years) had less cotton in cultivation, which may denote an areal transition from cotton as a major crop in this region. These counties may have been, at one time, major producers of the fiber, but as widespread cultivation of the crop decreased, they began to switch to another crop, or were taken out of agricultural production entirely.



Taken from Prunty, Merle C., Jr., and Aiken, Charles S. 1972. The Demise of the Piedmont Cotton Region. Annals of the Association of American Geographers 62: 291.

Figure 6

Discriminant Results

The crops which dominate each region, or cluster, may not necessarily be the most important crops for distinguishing between clusters. In 1945, for example, corn was a major component of several clusters. Because all clusters had significant acreages of corn, however, and corn as a percentage of all harvested acres did not vary greatly between clusters, this crop has a limited utility for defining the geographic pattern. The results of the stepwise discriminant analysis can be used to determine which crops are most important for distinguishing between clusters.

The application of discriminant analysis involves interpretation of the ways in which groups differ. It is a procedure used to statistically distinguish between two or more predetermined groups of observations with respect to several variables simultaneously (Klecka 1981). The crops and other variables were entered into two separate stepwise discriminant tests which determined the variables in each set that best distinguished between the clusters. Stepwise discriminant analysis, beginning with no variables, enters the variable which contributes most to the discriminatory power of the model. After the effects of that variable are removed from the model, a similar procedure takes place with the remaining variables. This continues until all the independent variables no longer meet the entry criterion set by the F statistic. The results from both runs are in Tables 5a and b.

In 1945 and 1964, the crop which best served to differentiate between regions was peanuts. It accounted for more than 80 percent of the variation between clusters in these two study years. The

SELECTED STATISTICS FOR RESULTS OF DISCRIMINANT ANALYSIS:

CROPS

YEAR	VARIABLE ENTERED	NUMBER IN	PARTIAL R**2	F STATISTIC	WILK$' LAMBDA	% VARIANCE EXPLAINED	CUMULATIVE VARIANCE
	NUTS1	1	0.8324	162.679	0.167580	83.24	83.34
	TOB1	2	0.7919	123.684	0.034871	13.27	96.51
1945	WHE1	3	0.6133	51.147	0.013484	2.14	98.65
	COTT1	4	0.5543	39.798	0.006010	0.74	99.39
	CORN1	5	0.3764	19.162	0.003748	0.22	99.62
	BEANS1	6	0.0659	2.223	0.003500	0.39	99.66
	NUTS1	1	0.8018	132.459	0.198233	80.18	80.18
	COTT1	2	0.7083	78.905	0.057830	14.03	94.21
1964	CORN1	3	0.4418	25.528	0.032278	2.55	96.76
	TOB1	4	0.4397	25.109	0.018087	1.42	98.18
	BEANS1	5	0.1557	5.855	0.015271	0.28	98.46
	BEANS1	1	0.8600	201.146	0.140019	86.00	86.00
1982	CORN1	2	0.6379	57.264	0.050695	8.93	94.93
	WHE1	3	0.2182	8.999	0.039635	1.10	96.03
	TOB1	4	0.1935	7.676	0.031967	0.76	96.79

Table 5a

SELECTED STATISTICS FOR RESULTS OF DISCRIMINANT ANALYSIS:

OTHER VARIABLES

YEAR	VARIABLE ENTERED	NUMBER IN	PARTIAL R**2	F STATISTIC	WILKS' LAMBDA	% VARIANCE EXPLAINED	CUMULATIVE VARIANCE
	FMS1	1	0.2754	12.350	0.724632	27.54	27.54
	NWPOP	2	0.1101	3.999	0.644850	7.97	35.51
1945	LIF1	3	0.1091	3.917	0.574522	7.03	42.54
	EMP1	4	0.0841	2.915	0.526213	4.83	47.37
	ACLIF	5	0.0742	2.525	0.487163	3.90	51.27
	FMS2	6	0.0827	2.816	0.446896	4.02	55.29
	FMS1	1	0.2355	10.090	0.764471	23.55	23.55
	ACRES1	2	0.1487	5.678	0.650774	11.86	34.91
	NWPOP	3	0.1347	5.019	0.563130	8.76	43.67
1964	POP1	4	0.0914	3.217	0.511682	5.14	48.81
	EMP1	5	0.0667	2.270	0.477544	3.41	52.22
	LIF1	6	0.0556	1.853	0.451016	2.65	54.87
	FMS2	7	0.1142	4.029	0.399509	5.15	60.02
	ACLIF	8	0.0932	3.184	0.362292	3.72	63.74
	ACLIF	1	0.4020	21.683	0.597962	40.20	40.20
	LIF1	2	0.2074	8.374	0.473937	12.40	52.60
1982	ACRES1	3	0.2178	8.841	0.370712	10.32	62.92
	FMS1	4	0.1053	3.706	0.332687	3.90	66.82
	EMP1	5	0.0643	2.149	0.310345	2.13	68.95
	POP1	6	0.0558	1.833	0.293021	1.73	70.68

FMS1 = Average Acres Harvested per Farm
FMS2 = Average Farm Size
LIF1 = Percent of County in Farmland
ACRES1 = Percent of County in Harvested Acres
ACLIF = Percent of Farmland Harvested
EMP1 = Percent Employed in Manufacturing
POP1 = Persons per Square Acre
NWPOP = Percent Non-white population

Table 5b

explanation lies in the outlier one and two county crop combination regions in Virginia. Because of their nonconformity to the remainder of the study area, the outlier counties skewed the results of this analysis. Since peanuts appeared as the best discriminating variable in the 1945 and 1964 analyses, the counties which represented peanut production probably should have been excluded from the study area. Greensville and Dindwiddie Counties, the outliers, more closely resembled counties of the Coastal Plain than Southern Piedmont. They were probably not representative of the remaining study area.

In 1945, after peanuts, the second most important discriminator between clusters was tobacco. The R squared value shows that it accounted for 79 percent of the variation between clusters after the effect of the best discriminator, peanuts, was removed from the equation. Alone, this variable accounted for 13.27 percent of the total variance between clusters. Wheat was entered third into the analysis, but it explained only 2.14 percent of the variance. These three crops cumulatively accounted for 98.65 percent of the variation in the clusters. The remaining variables contributed very little to the overall variation between clusters. The order of selection of variables is significant. Tobacco may have been important in distinguishing clusters in the north from clusters in the south. This is further supported by examining the clusters for the study years. In 1945, clusters 2 and 5 were located north of the tobacco/cotton dividing line near the southern border of North Carolina. In 1964, clusters 3 and 2 had tobacco acreages and in 1982, cluster 3 was the tobacco region. All of these clusters were located north of the southernmost tier of counties in North Carolina. None of the regions located south of this boundary had more than three percent harvested land in tobacco.

After peanuts, cotton was the most important variable for distinquishing between clusters in the analysis for 1964. Seventy percent of the variation in the clusters was explained by cotton after the effects of the peanuts variable was removed. By itself, cotton explained 14.03 percent of the total variation between clusters. Corn and tobacco were selected next, and their contributions to the overall variance between clusters was less than four percent. Although soybeans were selected, their utility in discriminating between clusters was limited. These five variables explained 98.46 percent of the variation between clusters. Cotton was a powerful discriminator because of its ability to divide the region in half, with the northern counties specializing in tobacco and the southern counties specializing in cotton. In 1945, clusters 3 and 4 (located in the southern tier) were major cotton producers and in 1964, cluster 1, also located below the southermost tier of North Carolina counties, produced the largest amount of cotton for the study year. All of these clusters were located south of the tobacco/cotton boundary and none of the clusters located north of this line had significant acreages of cotton.

In 1982, only four crops met the 1.0 F-level criteria for inclusion in the discriminant model. Soybeans were chosen as the best discriminating variable in the analysis, accounting for 86 percent of the variation between clusters. Corn was the next most important variable, with 8.93 percent of the variation explained by it. There was a significant decrease in the amount of variation explained by the last two variables, wheat and tobacco. Wheat could only account for 1.10 percent and tobacco, 0.76 percent of the total variation between clusters. The four variables accounted for 96.79 percent of the variation between clusters. The selection of soybeans was meaningful. Although not as easily visible in 1982 because of the extensive amounts of soybeans cultivated in nearly all areas of the study region, a regional division existed which was similar to previous years. In this case, the cluster which had the fewest acres in soybeans was located entirely above the tobacco/cotton dividing line. The clusters which had the largest concentrations of soybeans had 50 percent or more of their memberships located south of this line. This supports that soybeans were important in helping to define the aforementioned regional boundary.

Although the crops discussed above helped distinguish between the clusters, there may also be underlying factors which were active in distinguishing between clusters. The non-crop variables were introduced to another discriminant analysis to determine their relative importance in explaining crop combination regions in the study area. These variables were not included in the previous discriminant analysis because their value would have been masked by the importance of the crops. Since the clusters were originally defined by the crops, the crops would have been entered first into the stepwise discriminant function. This would have provided a false account of the explanation of the crop combination regions.

All of the variables entered into the stepwise discriminant process were related to agricultural activity. None of the variables in the discriminant function dealt with the population or industrialization of the study area. Most described the quantity of harvested cropland in the regions, which indicated the relative importance of agriculture in the area.

Although stepwise discriminant analysis will always select variables regardless of their explanatory quality provided a satisfactory F-level, none of the variables in this analysis were exceptionally good at distinguishing between clusters. All had very low partial R squared values and the Wilks' lambda levels remained relatively high. Partial R squared levels can be interpreted as stepwise coefficients of determination with a value between zero and one. The closer the value is to one, the better the explanatory power of the variable. Wilks' lambda is used to test for the statistical significance of discriminating information not already accounted for by the earlier functions. Lambda is an inverse measure of the residual discriminating power in the original variables which has not yet been removed by the discriminant functions (Klecka 1975). It is a value between zero and one. Values of lambda which are near zero denote high discrimination between clusters. As lambda increases toward one, it reports progressively less discrimination. Since it is an inverse measure, lower values are preferred.

The value of the non-crop variables in discriminating between clusters was limited. In 1945, six variables explained only 55.29 percent of the total variation between clusters. The stepwise discriminant analysis selected FMS1, the amount of cropland per farm, as the variable which best distinguished between clusters, yet it explained only 27.5 percent of the variation between regions. In descending importance, NWPOP (proportion of non-whites) and LIF1 (proportion of county in farmland) contributed significantly less to the analysis. Collectively, these two variables contributed 15 percent of the variation between clusters. Although qualified to be included in the analysis by their F-levels, EMP1 (manufacturing employment), ACLIF (percent of farmland harvested), and FMS2 (average farm size), contributed little to the overall variation between clusters. All of the above were relatively weak explanatory variables as shown by the Wilks' lambda. After all eligible variables entered the equation, lambda was only 0.44, meaning poor explanatory value for the variation in the discriminant function.

The discriminant function for the following study year had weaker explanatory power. Only 63.74 percent of the variation between clusters was explained. Again in 1964, FMS1 (average harvested cropland per farm) was chosen first as best able to distinguish between clusters. Over 23 percent of the variation was explained by this variable. ACRES1 (proportion of county in harvested cropland), NWPOP and POP1 (population density) were successively important in their ability to discriminate between clusters. A total of eight variables were included into the model which were relatively poor discriminators. Lambda was 0.36, meaning that a lot of information was not explained by the variables.

Six variables accounted for 70.68 percent of the variation between clusters in the 1982 analysis. The proportion of farmland harvested (ACLIF) was selected first. It explained 40 percent of the variation in the clusters. LIF1 (percent of county in farmland) and ACRES1 (percent of county in harvested cropland) were entered into the second and third steps. These three variables accounted for almost 63 percent of the variation between clusters. The remaining three variables explained very little. The analysis for this year was the most explanatory for the entire study period. The Wilks' lambda for this analysis was 0.29. This indicates that this model, although not exceptionally good, was the best overall explanatory model. The variables in this year's analysis were best at discriminating among clusters.

Summary

The two discriminant models demonstrated important points about crop regionalization in the Southern Piedmont. In the first analysis which used crops as variables, the crops which formed the boundary between the southern and northern crop regions for each year were most important in defining the regions. Excluding peanuts because of their special circumstances, the crops were, chronologically as per study year, tobacco, cotton, and soybeans. In the second analysis, the model showed that the relative importance of agriculture in the study counties was critical in explaining the crop combination regions. This can be related to the amount of urbanization in the study area. A county with a strong agricultural economy is probably not highly urbanized. Further, in a county, the importance of agricultural intensity in defining clusters can also be supported by the Pearson's correlation coefficients for the crops and the other variables in the study years (Tables 6a, b, and c). Absolute values less than 0.17 were statistically insignificant at the 0.05 level. Correlations can be negative or positive and are interpreted as values between zero and one. A correlation between variables should be high (0.50 or better) before it is significant in practical terms. Although few strong correlations existed at all between the variables, the strongest correlations occurred between the crops and the variables which defined agricultural intensity (LIF1, ACRES1, FMS1, and ACLIF). These variables represented various characteristics of harvested cropland in the study counties.

A negative correlation indicates that as one value rises, the other falls. Statistically significant negative correlations between the harvested cropland variables (see above) and the crops meant that in agriculturally intensive areas, certain crops are less likely to be grown. For example, in 1945 and 1964, corn is characteristically not widely grown in areas with an urban emphasis. These counties tended to produce other crops. Few other negative correlations existed between variables.

PEARSON'S CORRELATION COEFFICIENTS BETWEEN VARIABLES

1945

	NUTS1	BEANS1	TOB1	CORN1	WHE1	COTT1	LIF1	ACRES1	FMS1	FMS2	ACLIF	EMP1	NWPOP	POP1
NUTS1	1.00	.39	0.0	0.0	-.14	-.02	-.13	-.11	.07	.15	-.07	-.03	.23	-.06
BEANS1	.39	1.00	.12	-.05	.08	-.28	-.14	-.21	-.15	.08	-.22	-.04	.10	-.03
TOB1	0.0	.12	1.00	-.06	.17	-.58	.21	-.16	-.44	-.18	-.29	-.12	.03	0.0
CORN1	0.0	-.05	-.06	1.00	-.61	.10	-.29	-.45	-.28	.12	-.43	-.18	-.07	-.07
WHE1	-.14	.08	.17	-.61	1.00	-.40	.25	.24	-.03	-.19	.18	.18	-.28	.09
COTT1	-.02	-.28	-.58	.10	-.40	1.00	.12	.42	.39	-.04	.49	-.07	.09	-.08
LIF1	-.13	-.14	.21	-.29	.25	.12	1.00	.72	.18	-.27	.45	-.07	-.15	-.01
ACRES1	-.11	-.21	-.16	-.45	.24	.42	.72	1.00	.43	-.45	.93	.07	-.22	.17
FMS1	.07	-.15	-.44	-.28	-.03	.39	.18	.43	1.00	.48	.47	-.05	.43	-.16
FMS2	.15	.08	-.18	.12	-.19	-.04	-.27	-.45	.48	1.00	-.48	-.20	.66	-.40
ACLIF	-.07	-.22	-.29	-.43	.18	.49	.45	.93	.47	-.48	1.00	.13	-.21	-.27
EMP1	-.03	-.04	-.12	-.18	.18	-.07	-.07	.07	-.05	-.20	.13	1.00	-.27	.33
NWPOP	.23	.10	.02	-.07	-.28	.09	-.15	-.22	.43	.66	-.21	-.27	1.00	-.21
POP1	-.06	-.03	0.0	-.07	.09	-.08	-.01	.17	-.16	-.40	.27	.33	-.21	1.00

LIF1 = Percent of county in farmland
ACRES1 = Percent of county in harvested acres
FMS1 = Average acres harvested per farm
FMS2 = Average farm size

ACLIF = Percent of farmland harvested
EMP1 = Percent manufacturing employment
POP1 = Persons per square acre
NWPOP = Percent non-white population

Table 6a

PEARSON'S CORRELATION COEFFICIENTS BETWEEN VARIABLES

1964

	NUTS1	BEANS1	TOB1	CORN1	WHE1	COTT1	LIF1	ACRES1	FMS1	FMS2	ACLIF	EMP1	NWPOP	POP1
NUTS1	1.00	.34	0.0	.09	-.08	-.01	-.03	.11	.19	-.01	.07	-.11	.18	-.07
BEANS1	.34	1.00	.31	-.04	.27	-.15	-.01	.40	.27	-.28	.36	-.12	.09	-.01
TOB1	0.0	.31	1.00	.23	.44	-.36	.44	.34	-.17	-.35	.12	-.25	.05	-.01
CORN1	.09	-.04	.23	1.00	-.05	-.15	-.08	-.25	-.49	-.27	-.09	0.0	-.18	-.08
WHE1	-.08	.27	.44	-.05	1.00	-.29	.28	.54	.14	-.41	.35	.07	-.18	-.02
COTT1	-.01	-.15	-.36	-.15	-.29	1.00	.11	-.02	.24	.28	-.13	0.0	.31	-.17
LIF1	-.03	-.01	.44	-.08	.28	.11	1.00	.55	.16	.08	-.32	-.05	.07	-.25
ACRES1	.11	.40	.34	-.25	.54	-.02	.55	1.00	.58	-.32	.31	.04	-.06	-.03
FMS1	.19	.27	-.17	-.49	.14	.24	.16	.58	1.00	.34	.27	-.15	.35	-.07
FMS2	-.01	-.28	-.35	-.27	-.41	.28	.08	-.32	.34	1.00	-.36	-.21	.56	-.22
ACLIF	.07	.36	.12	-.09	.35	-.13	-.32	.31	.27	-.36	1.00	-.09	.07	-.02
EMP1	-.11	-.12	-.25	0.0	.07	0.0	-.05	.04	-.15	-.21	-.09	1.00	-.56	0.0
NWPOP	.18	.09	.05	-.18	-.10	.31	.07	-.06	.35	.56	.07	-.56	1.00	-.25
POP1	-.04	-.01	-.01	-.08	-.02	-.17	-.25	-.03	-.07	-.22	-.02	0.0	-.25	1.00

LIF1 = Percent of county in farmland
ACRES1 = Percent of county in harvested acres
FMS1 = Average acres harvested per farm
FMS2 = Average farm size

ACLIF = Percent of farmland harvested
EMP1 = Percent manufacturing employment
POP1 = Persons per square acre
NWPOP = Percent non-white population

Table 6b

PEARSON'S CORRELATION COEFFICIENTS BETWEEN VARIABLES

1982

	NUTS1	BEANS1	TOB1	CORN1	WHE1	COTT1	LIF1	ACRES1	FMS1	FMS2	ACLIF	EMP1	NWPOP	POP1
NUTS1	1.00	.09	-.02	.15	-.03	-.01	.08	.17	.41	.24	.17	-.17	.17	-.05
BEANS1	.09	1.00	.03	.16	.60	.02	.25	.50	.47	.01	.63	.14	.07	-.04
TOB1	-.02	.03	1.00	.30	.02	-.10	.44	.22	-.08	-.20	.08	0.0	.05	-.04
CORN1	.15	.01	.30	1.00	.07	-.11	.23	.30	.07	-.25	.31	.14	-.20	.06
WHE1	-.03	.60	.02	.07	1.00	-.09	.43	.49	.33	.05	.48	0.0	.04	-.12
COTT1	-.01	.02	-.10	-.11	-.09	1.00	-.05	-.06	-.01	.10	-.06	.10	0.0	-.03
LIF1	.08	.25	.44	.23	.43	-.05	1.00	.79	.39	.08	.46	.05	.03	-.35
ACRES1	.17	.50	.22	.30	.49	-.06	.79	1.00	.66	.01	.87	.11	-.03	-.15
FMS1	.41	.47	-.08	.07	.33	-.01	.39	.66	1.00	.57	.71	-.04	.37	-.22
FMS2	.24	.01	-.20	-.25	.05	.10	.08	.01	.57	1.00	-.06	-.17	.75	-.43
ACLIF	.17	.63	.08	.31	.48	-.06	.46	.87	.71	-.06	1.00	.17	-.09	.03
EMP1	-.17	.14	0.0	.14	0.0	.10	.05	.11	-.04	-.17	.17	1.00	-.17	-.01
NWPOP	.17	.07	.05	-.22	.04	0.0	.03	-.03	.37	.75	-.09	-.17	1.00	-.17
POP1	-.05	-.04	-.04	.06	-.12	-.03	-.35	-.15	-.22	-.43	.03	-.01	-.17	1.00

LIF1 = Percent of county in farmland
ACRES1 = Percent of county in harvested acres
FMS1 = Average acres harvested per farm
FMS2 = Average farm size

ACLIF = Percent of farmland harvested
EMP1 = Percent manufacturing employment
POP1 = Persons per square acre
NWPOP = Percent non-white population

Table 6c

CHAPTER 5

ANTECEDENT LAND USE: AN ALTERNATIVE EXPLANATION

Previous chapters have shown that agriculture in the Southern Piedmont has undergone tremendous change in less than 40 years since World War II. Increasing industrialization and urbanization have relegated agriculture to secondary economic importance within the country. Within the agricultural economy there have been dramatic changes: drastic declines in cotton and tobacco, reduction in corn, and the rise of the soybean. Crop regions within the Southern Piedmont have reflected these changes, with different crop combinations and changes in the crops which best define regional differences.

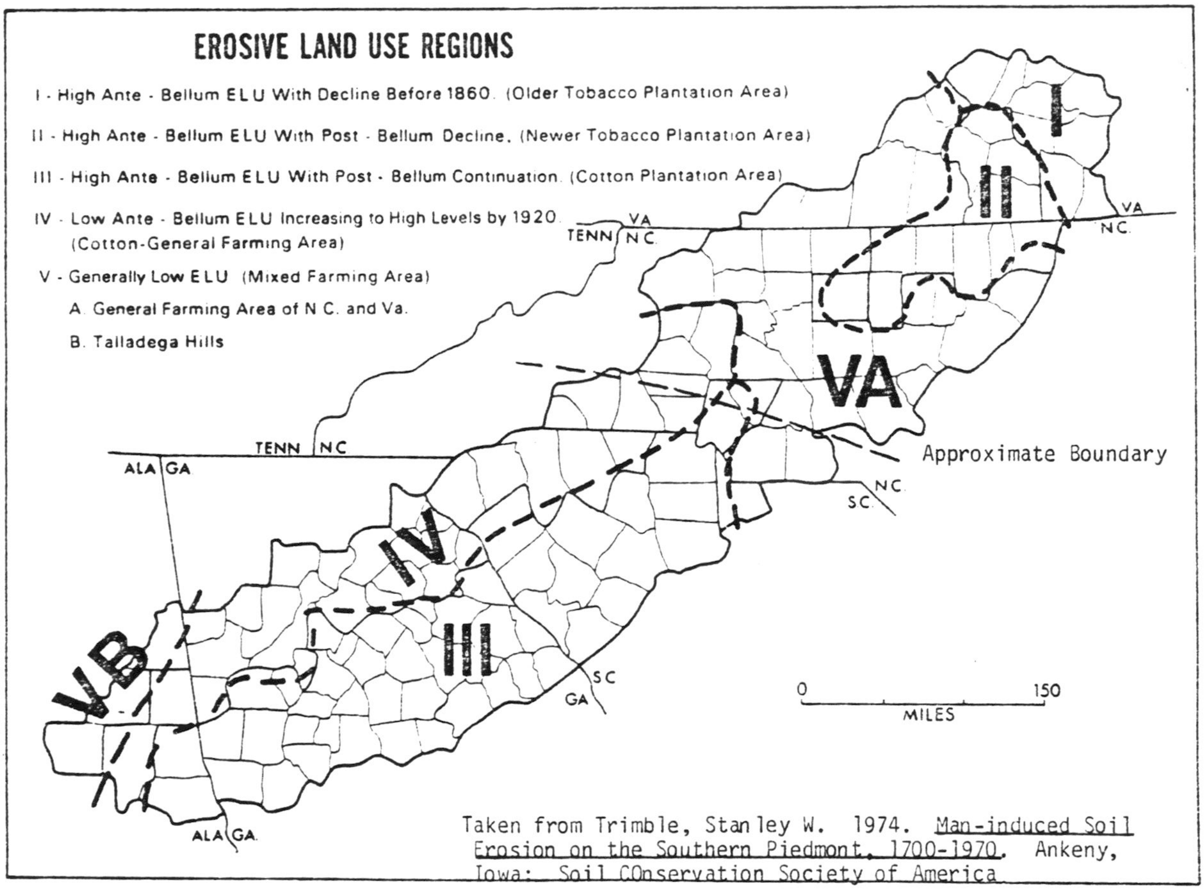
Yet, despite these changes, some regional trends within the Piedmont are remarkably persistent. In 1945, 1964, and 1982, there were pronounced differences between the southern tier of the study area (Alabama, Georgia, South Carolina, and the southernmost North Carolina counties) and the North Carolina-Virginia area. The southern tier was controlled by cotton-dominated crop combination regions and the northern regions were dominated by tobacco. It has been demonstrated that the northern North Carolina Piedmont and adjacent Virginia counties have been the most homogeneous and persistent of the crop combination regions. It has further been shown that demographic factors are not important in explaining these trends. The cropping trend is not easily explained by soil or landform factors, because the spatial variation of these features is dominated by a strong east-west gradient parallel to the Appalachian front, with no strong north-south trends (Trimble 1974).

It is suggested that antecedent land uses which bear little direct relationship to the crops grown in the 1980s are responsible for the regional trends. Trimble (1974) compared agricultural land use regions with erosion rates in the late 1800's and his agricultural regions are outlined on Figure 7. By comparing Figure 5 in Chapter 4 with Figure 7, it can be seen that the north-south boundary between crop regions seen in 1982, 1964, and 1945 is consistent with the boundary between the cotton-dominated and tobacco-dominated portions of the Piedmont as they existed in the 19th and early 20th centuries. In 1945, there is still evidence of a cotton/tobacco boundary, but the role of these crops in defining cropping patterns is far from completely dominating. In later years, the old cotton/tobacco boundary is still in evidence. Here, it does not define a boundary between cotton and tobacco growing regions, but a boundary between agricultural regions which grow other crops.

A cotton/tobacco boundary roughly coinciding with the persistent regional boundary identified in this study is also seen in the maps of Morgan (1978) and Prunty and Aiken (1972) in Figures 8 and 9. In the North Carolina Piedmont, tobacco production did not extend to the South Carolina border. Concentrations of tobacco existed farther north. Figure 9 shows that cotton cultivation only took place in the southern counties of North Carolina.

The land use patterns associated with cotton and tobacco production are quite different. In the Piedmont, especially, flue-cured tobacco tended to be grown on relatively small "yeoman" farms (Hart and Mather 1961). The typical Piedmont farmer grew an average of one-half to one

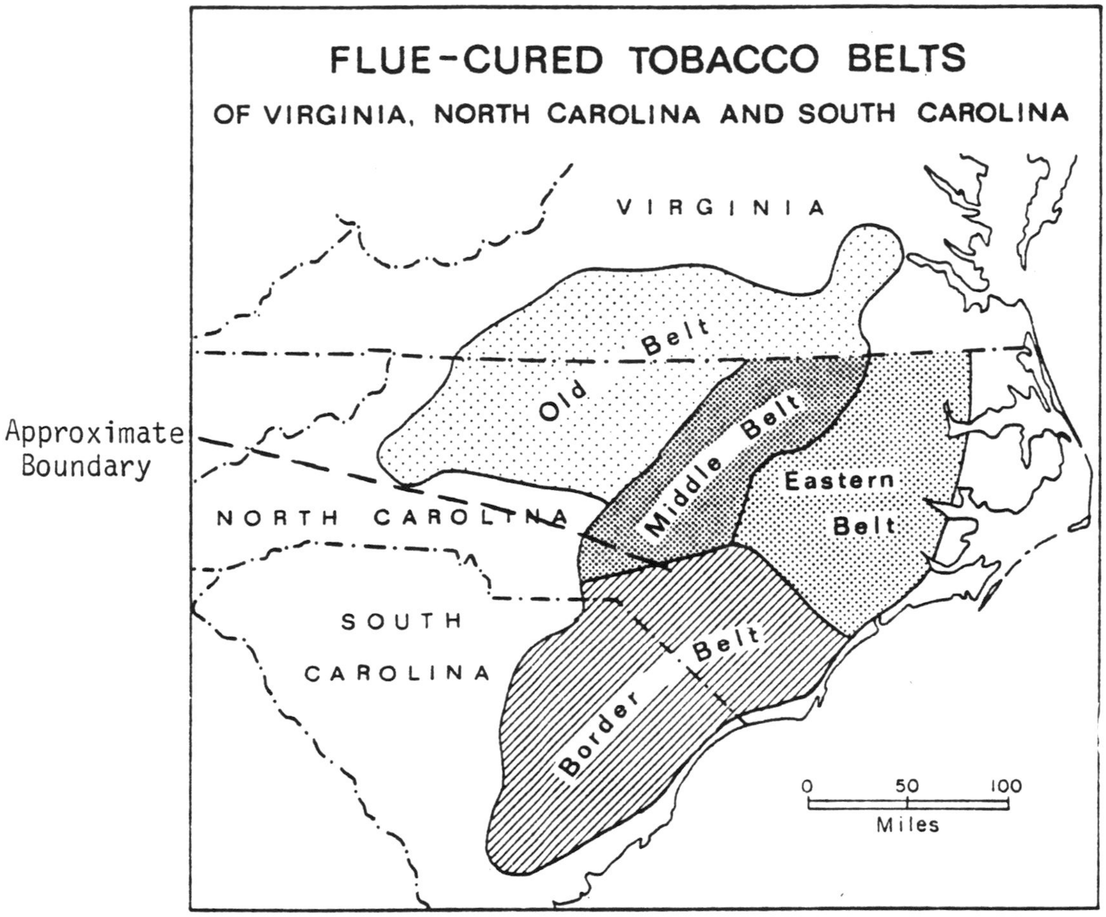
Cotton/Tobacco Boundary Compared to Trimble's (1974)
Erosive Land Use Agricultural Regions



Taken from Trimble, Stanley W. 1974. Man-induced Soil Erosion on the Southern Piedmont, 1700-1970. Ankeny, Iowa: Soil COnservation Society of America

Figure 7

Cotton/Tobacco Boundary Compared to
Morgan's (1978) Flue-Cured Tobacco Belt in the Study Area



Taken from Morgan, John C. 1978. The Ordering Pit: A Relict Feature of the Flue-Cured Tobacco Landscape. Southeastern Geographer XVIII: 102-114.

Figure 8

Cotton/Tobacco Boundary Compared to
Prunty and Aiken's (1972) Cotton Acreage in the Study Area

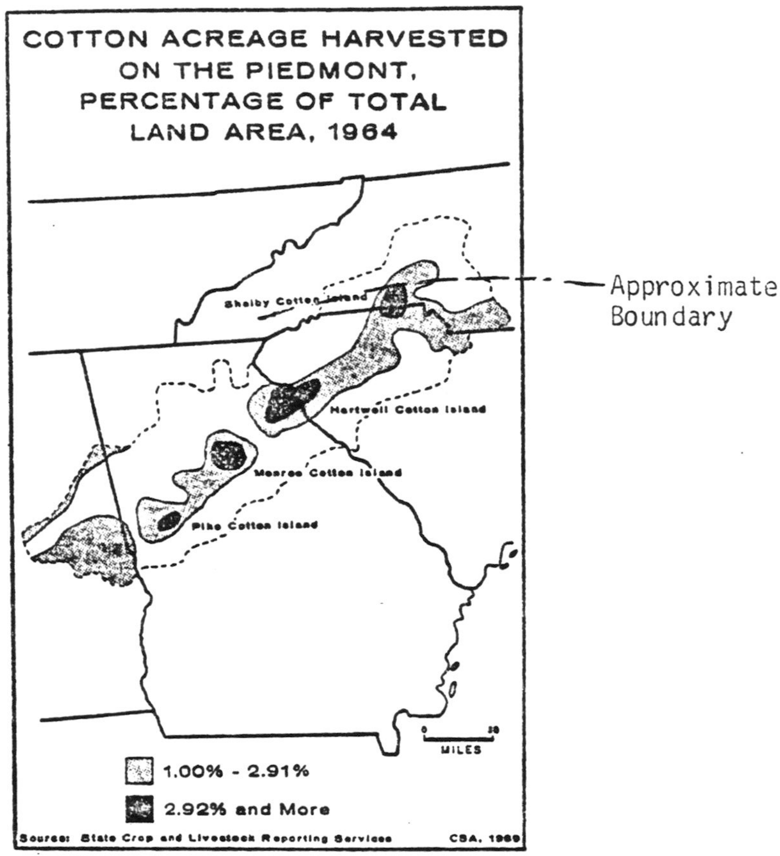


FIG. 9. Cotton acreage harvested on the Piedmont, 1964.

Taken from Prunty, Merle C. and Aiken, Charles S. 1972. The Demise of the Piedmont Cotton Region. Annals of the Association of American Geographers: 283-306.

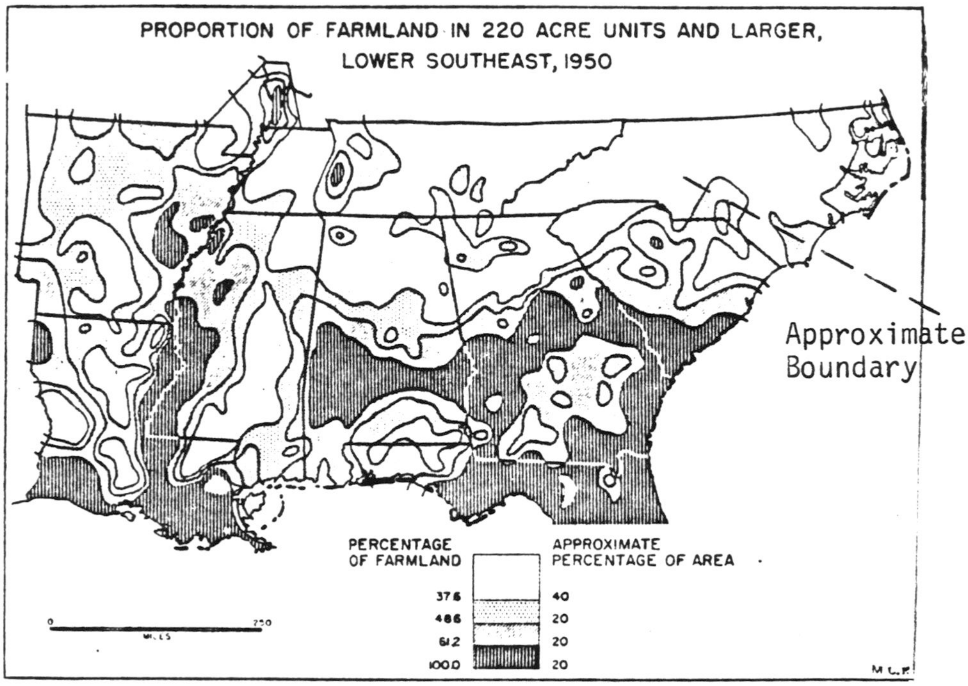
Figure 9

acre of tobacco (Haystead and Fite 1955). Today, Piedmont tobacco production is still limited to small acreages. The crop combination regions dominated by tobacco support this notion. These regions had the lowest values for the proportion of acres harvested in the counties (see Tables 3a,b, and c). Tobacco-dominated, compared to cotton-dominant clusters, also had significantly lower values for FMS2, average farm size (see Tables 4a, b, and c).

Cotton production was associated with larger landholdings, such as plantations, which tended to use more slave labor (Prunty 1955). Prunty and Aiken (1972) described a corollary between cotton production islands and the location of plantations. Prunty (1955) defined a plantation as a tract of at least 220 acres of farmland. Figure 10 shows that in 1950, the northernmost areal extent of plantations was coincident to the cotton/tobacco boundary described in this study. These land use patterns create regional differences in the scale of land ownership as well as in cropping patterns internal to the farm.

It is suggested, therefore, that the observed modern crop combination regions of the Southern Piedmont are the result of antecedent land use. Historic regions dominated by tobacco and cotton persist and are expressed in current crop geography, despite the dominance of different crops. The dominant process in this pattern is related to the tendency for soybeans to replace cotton (Siniard 1973), and to a lesser extent, the persistence of small tobacco farms in North Carolina. Though the distinction between Southern Piedmont agricultural regions in the 1980s is less clear than before, the cotton/tobacco boundary persists as a fuzzier, but existing boundary between regions

Cotton/Tobacco Boundary Compared to the
Northernmost Extent of Plantations



Taken from Prunty, Merle C., Jr. 1955. The Renaissance of the Southern Plantation. Geographical Review XLV: 462.

Figure 10

whose primary difference is related to soybeans. In the 1982 crop combination map, clusters 1, 2, and 5 were principally soybean clusters that were located south of the dividing line. As in 1945 and 1964 when cotton was dominant in this portion of the study area, the soybean-dominated clusters still have many of the characteristics of the cotton regions. The average farm size in these clusters is larger than the clusters to the north, as when cotton was dominant. The crop combinations have changed from cotton and corn to soybeans and wheat, but the land use patterns from the days of cotton production are still persistent.

This persistence is further supported by the data. In 1945, the northern region was characterized by clusters 2 and 5, excluding the outlier cluster. By calculating the mean farm size in the northern and southern sections, it can be shown that farms tended to be larger in the southern section. Clusters 2 and 5 had average farm sizes of 94.6 acres and 79.4 acres. This produces an overall combined mean of 87 acres. Clusters 3 and 4 were in the southern region. They had 91.3 and 143 acres as average farm sizes and a combined 117.1 acres. In 1964, cluster 3 and aproximately one-half of cluster 5 were north of the dividing line. Calculations show that the regions north of the boundary were composed of counties with smaller farms. The northern clusters had an average farm size of 123.6 acres and in the south, 154 acres was the mean. In 1982, the crop combinations were different, but this pattern was still apparent. The north was characterized by clusters 3, 1, and 5 which had 164.1 acres as the mean farm size. In the southern tier, farms were 178.5 acres on the average.

In all study years, farms tended to be larger in the southern portion of the study area. This coincides with historical land use practices, such as plantations. Although plantations are no longer visible landscape features, the land use practices which characterized them are still apparent. Farms still tend to be larger in the regions where plantations once existed. This tends to support the notion that current agricultural geography is strongly influenced by antecedent land use. The actual mechanisms by which historic land use affects modern cropping patterns are the tendency for soybeans to replace cotton and the persistence of flue-cured tobacco operations on farms now concentrating in soybeans.

CHAPTER 6

SUMMARY

Several conclusions can be drawn from the results of this study: 1) that agriculture is becoming a decreasingly important land use in the Southern Piedmont, 2) that the crop combinations of the study region have responded through change, and 3) that the land use patterns that exist today are continuations of cultivation patterns that existed when other crops dominated the agricultural landscape.

The agricultural geography of the study area is taking on new characteristics in light of encroaching urbanization and incremental abandonment of row crop agriculture on the Piedmont's highly erodible land. Crop farming is becoming of secondary importance as greater amounts of land are dedicated to pastures and forests. This is supported by the declining quantity of land in farms. Less land is being devoted to farms, and there are fewer farms. Those presently in existence are the largest ever and have the highest yields ever recorded. A concentration in field crop cultivation is diminishing and greater emphasis is being put on livestock, such as cattle and poultry. Forage crop cultivation is becoming increasingly abundant.

Most crops were grown in progressively smaller total acreages through the study period. Cotton acreages experienced the greatest decline, followed by corn. Corn production fell because of a combination of factors which caused a decreased local supply. The nation's dietary habits changed, as well as the need for corn as a forage crop. It became more economical to import corn from the Midwest than to grow it locally. Cotton production in the Southern Piedmont nearly vanished during the study period. It left the region for a number of reasons, including a shift from marginal to better adapted land and acreage restrictions. The rise in soybeans was mostly in response to price. Soybeans have been found to be a versatile crop worldwide, and this has been reflected in price.

The crop combinations changed through time. Cotton and corn were dominant in the southern tier, while tobacco, wheat, and corn were most common in the northern portion of the study area. When cotton left the agricultural landscape, soybeans replaced it as the dominant crop throughout much of the Piedmont. While tobacco acreages in 1982 were significantly lower than in previous years, tobacco was still a dominant factor in agricultural land use in the northern section of the study area. Soybeans, grown mostly in combination with wheat, were found in vast quantities throughout the study area in later years. Soybeans assumed a greater importance in defining crop associations and regions. This is in support of Hypothesis 1 in the Introductory chapter, which predicted that soybeans and grains would assume progressively greater importance in defining crop combination regions.

Hypothesis 2 suggested that the regions would become more vague through time. Only one region, the tobacco-dominated region of North Carolina and Virginia, was consistently cohesive. On a larger scale, however, the regions remained neatly defined. A distinct boundary existed between the regions which historically grew large quantities of cotton or tobacco. Although cotton production was dramatically reduced and soybeans became dominant, the land use patterns are similar to when cotton was "king". Soybean dominated crop combination regions can be found approximately where plantations once existed. While the regions do appear to be becoming more vague, they have hardly begun to disappear, and historic cropping patterns are remarkably persistent.

Cropping regions were best distinguished by the relative importance of agriculture in an area. The data suggest that agricultural specialization, within the counties and on the individual farms, was best able to explain the variance between the crop combination regions. Hypothesis 3 postulated that the demographic and economic variables would not be important in defining regions. While it was found that population and employment parameters apparently do not play an important role in distinguishing crop combination regions, the value of these parameters must not be underestimated. Such demographic variables are of extreme importance to the crop geography of the region. Population and employment characteristics weigh importantly in determining the relative position of agriculture in the regional economy. These variables do not appear to specifically determine the crop types grown in specific regions, but they define the importance of agriculture as an influential component in the regional economy.

Since it has been confirmed that agricultural production is becoming less important in the geography of the Southern Piedmont, it is recommended that additional studies be done in the future. Forage crops should be included in such an analysis as the regional economy becomes more pastoral. As tobacco continues losing its strength nationally due to erosion of support for the federal tobacco program and a national decline in demand for tobacco products (The Tobacco Institute 1985), it will become increasingly interesting to study the role of this crop in the rural landscape. It is expected that tobacco will lose importance in the study area to Coastal Plain areas to the east which are better suited to tobacco cultivation. Further research is needed to determine the effects of urbanization and agricultural trends on future agricultural endeavors in the Southern Piedmont. The Southern Piedmont may provide a model applicable to other regions undergoing transitions from agrarian economies and landscapes to urban and industrial economies and landscapes.

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