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Economic Factors Influencing Land Use Changes in the South-Central United States

Ralph J. Alig, Fred C. White,
and Brian C. Murray

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Ralph J. Alig, Research Forester
U.S. Department of Agriculture, Forest Service
Southeastern Forest Experiment Station
Research Triangle Park, North Carolina 27709

Fred C. White, Professor
Agricultural Economics Department
University of Georgia,
Athens, Georgia 30602

Brian C. Murray, Forester
U.S. Department of Agriculture, Forest Service
Southeastern Forest Experiment Station
Research Triangle Park,
North Carolina 27709

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ABSTRACT

Econometric models of land use change were estimated for two physiographic regions in the South-Central United States. Results are consistent with the economic hierarchy of land use, with population and personal income being significant explanatory variables. Findings regarding the importance of relative agricultural and forestry market-based incomes in influencing regional land use shifts suggest that farm programs play an important, but continually changing, role in land use change.

Keywords: Econometric analysis, acreage, forest land.

Private owners control over 90 percent of the land in the South. Their reallocation of land among uses such as forestry is influenced by factors related to production and consumption activities. Although area changes among major land uses are related through complex sets of interdependent linkages, understanding the dynamics of land use changes and the effects of government policies on land reallocation is important in planning for efficient resource utilization at the regional level. Long-term projections for any sector of the economy that is closely tied to the land, such as agriculture or forestry, must take into account competition for land from other sectors.

In the study described here, determinants of area changes for all major private uses of land were analyzed for the South-Central United States – Alabama, Arkansas, Louisiana, Mississippi, Oklahoma (eastern 18 counties), Tennessee, and Texas (eastern 66 counties). Effects on land reallocation from changes in expected relative land rents for alternative enterprises were estimated. This research study was designed to support forest resource supply analyses for the USDA Forest Service (1988) study of the prospective forest resource situation in the South.

Related Literature

Insights about variables affecting land use changes in the South can be gained from previous investigations, which have been conducted primarily from an agricultural perspective. Stoll and others (1984) estimated land use changes among cropland, pasture, and forest land for 13 Southern States. In a majority of cases, statistical coefficients on population and income were negative, indicating urbanizing pressures on pastureland and forest land. Overall, in 13 out of 16 cases, coefficients for substitute or competing land use variables were negative and statistically significant. In a similar study for Georgia, White and Fleming (1980) found correlations seemingly inconsistent with the hypothesis that incomes from land-based enterprises drive land use changes (e.g., negative coefficient for beef income in a pasture-acreage equation).

Alig (1986) estimated a set of land use/ownership equations for the three major physiographic regions – Coastal Plain, Piedmont, and Mountains – in the Southeastern United States (Florida, Georgia, North Carolina, South Carolina, and Virginia). Restrictions were imposed across equations so that the sum of statistical coefficients for each explanatory variable summed to zero to reflect the essentially fixed nature of the total land base. Population and personal income were major explanatory variables across the equations for major land uses, and were negatively correlated with changes in percentages of the land base occupied by agriculture and forestry. Increases in population and real personal income tend to intensify development pressure, with urbanization reducing forest area (Alig and Healy 1987). Variables reflecting government programs designed to improve soil conservation and encourage tree planting, such as the Soil Bank Program in the late 1950's and early 1960's, had significant positive coefficients in miscellaneous private forest equations and negative ones in crop and pasture/range equations.

Hardie's (1984) results suggest that timber has a comparative advantage on some high fertility sites in the South and that timber growing might become a competitive land use at the intensive margin of the region's farmland base. He also suggests that industrial owners of timberland may assign relatively lower discount rates to investments, such that industrial owners may find timberland to be an attractive investment under the same circumstances that nonindustrial landowners find it advantageous to disinvest.

An important finding from previous econometric analyses involving competing agricultural crops pertains to complications related to government intervention in associated markets. Lee and Helmberger (1985) review difficulties encountered in estimating acreage supply response (or annual planting) for major agricultural crops, noting that supply estimation is particularly difficult because farm programs tend to change every 3 to 5 years. This complicates supply estimation because relevant variables and structural parameters may change over time. Recent research has attempted to analyze aggregate supply response under "free market" and "farm program" regimes, including taking into account farm programs when modeling acreage response for nonprogram crops.

In contrast to the focus on annual planting in studies of agricultural acreage response, perennial crop supply response involves factors influencing both planting and removals, more similar to the area-change emphasis in our study. Perennial crop studies have estimated functions that relate the planting and removal to measures of past profitability, potential future production from existing acreage, and structural changes associated with market intervention programs (e.g., French and others 1985). Researchers investigating changes in aggregate forest area are not likely to have access to acreage data with the richness of detail (e.g., annual time series) available for many annual agricultural crops and perennial crops, such as peaches, but results from such studies regarding the importance of government programs provide useful insights when investigating forest area changes.

Conceptual Framework

Economic theory postulates that land will be devoted to the use that yields the greatest returns to the land resource. Returns to land are often expressed in terms of land rent—the portion of total returns that accrues to land after payment of total costs (Barlowe 1978). To determine the economically efficient allocation of land, demand functions for land as an input must be derived. Consider the case in which agricultural products such as crops, livestock, and forestry products are produced by independent technologies through the use of variable inputs and the fixed, allocable input of land. This production relationship for a particular landowner can be represented as:

$$q_i = f_i(X_i, a_i); \quad i = 1, 2, \ldots m \tag{1}$$

$$a_i + a_2 \ldots + a_m \leq \bar{a} \tag{2}$$

where

q_i = quantity of ith commodity,

X_i = the vector of variable input quantities, x_{kij}, used to produce the ith commodity,

a_i = the quantity of land allocated to the ith commodity, and

$\bar{a}$ = the total land area.

Profit from multiple uses, m, of a fixed quantity of land is described by the Lagrangian primal:

$$L = \sum_{i=1}^{m} p_i f_i \; (X_i, a_i) - \sum_{i=1}^{m} \sum_{j=1}^{n} r_j x_{ij} + \lambda \; (\bar{a} - \sum_{i=1}^{m} a_i) \tag{3}$$

where

p_i = the product price for the ith land-based product,

r_j = the purchase price of the jth input; j = 1, 2, ...n, and

x_{ij} = quantity of the jth variable input used in production of the ith commodity.

Assuming regularity conditions on Equation (3), optimum values for x_{ij}, a_i, and λ can be obtained from the first-order conditions. These solutions are a function of all product prices, variable input prices, and total quantity of available land (Shumway and others 1984). Optimum use of variable inputs is beyond the scope of this paper. Attention in this paper is focused on efficient allocation of land as determined by the first-order conditions from Equation (3):

$$a_j = h_j\,(P, R, \bar{a}) \qquad (4)$$

where

P = a vector of product prices and

R = a vector of input prices.

Since cash-flows for alternatives are often uneven, discounting is needed to account for the time value of money. Using the soil expectation approach, the expected net cash-flows for a particular land use are discounted and compared with any discounted cost outlays.

Model Specification

The basis for the structural model is derived from economic theory and Equation (4). The dependent variables are obtained by forming a ratio of acreage in each category to total acreage $\bar{a}$. The proportion of total acreage devoted to a particular land use is affected by variables representing expected land rent from all potential land uses:

$$\begin{aligned} a_1 / \bar{a} &= f_1(P, R) \\ a_2 / \bar{a} &= f_2(P, R) \\ &\;\;\vdots \\ a_m / \bar{a} &= f_m(P, R) \qquad (5) \end{aligned}$$

where m = number of land uses.

Four major uses of the land were considered in this study: crop agriculture, pasture agriculture, urban and developed uses, and forest. The private forest category was subdivided into three major ownership categories – farm forest, forest industry, and miscellaneous private – because of the distinctly different behaviors, and resultant differences in forest area trends (fig. 1), of these owner groups. Public land was included in a category of urban and other land because it comprises less than 10 percent of the land in the South and because public forest land seldom shifts to other categories. Therefore, six (m = 6) land use/ownership categories were included.

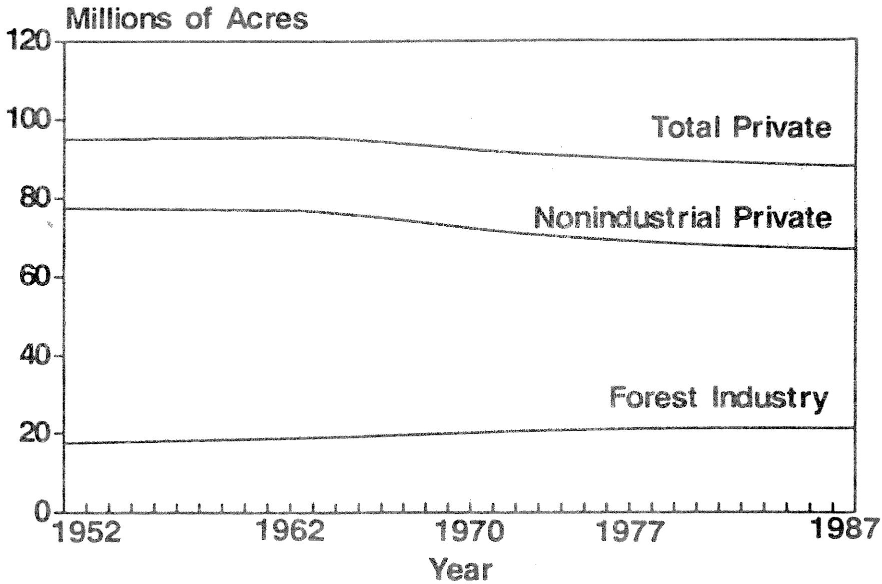

Figure 1.—Area trends for private timberland in the South-Central region, 1952-1987 (USDA Forest Service 1988).

Because the land base is fixed, and we are interested in how it is proportioned among competing uses, we selected the proportion devoted to a given use as the dependent variable. The share of the land base in a particular land use should be positively correlated with the ratio of expected real net income from that land use (serving as a proxy for land rent) to expected real net income from alternative uses. This formulation suggests that landowners are concerned with relative expected land-based incomes in reallocating acreage among competing uses and would not respond to a proportional change in all expected land use incomes. Thus, the response function is homogeneous of degree zero in use incomes.

A crucial step in the specification of regional land use models is securing independent variables that can be empirically evaluated. Because adequate series of historical land rent data (or land values for alternative uses) are not available, proxies were used such as real net income for land enterprises or other measures, such as population, which are thought to significantly influence land rent.

Given the complex set of interdependent linkages among major land uses indicated by the system of equations in (5), six categories of candidate explanatory variables were considered: (1) rural and urban population; (2) per-capita personal income; (3) relative land-based incomes from alternative enterprises; (4) risk measures; (5) income from processing of timber; and (6) government programs involving subsidies for tree planting.

Direct measures of land income are not available for urban and related developed uses. Therefore, urban and rural populations and per-capita income were used as proxies in the land use equations. Because developed land uses command the top of the economic hierarchy of land use, development pressures from increases in populations and incomes cause direct and indirect conversion of forest land. Clearing of forest for agriculture to replace agricultural acres that are developed would be an indirect conversion. Figure 2 illustrates the marked increases in population and personal income over the last several decades.

Time differences in production cycles between competing land uses complicate the analysis of factors that prompt shifts in land use. Major agricultural crops in the South, such as soybeans or corn, have production cycles equal to one growing season. In contrast, culture of a timber crop from seedlings requires at least several decades. The implications are that income expectations of the landowner for various land enterprises are quite different. Given the time differentials in

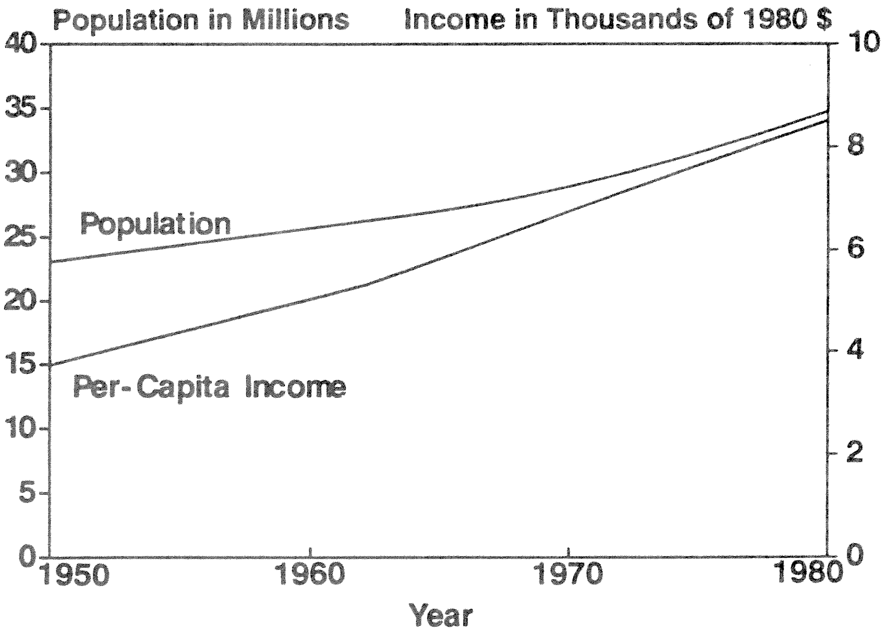

Figure 2.—Changes in population and per-capita personal income in the South-Central region, 1950-1980 (USDC, Bureau of the Census 1984).

production cycles, agriculture would likely be favored when the discount rate increases because of the relative reduction in the future value of timber products. A variable to reflect changes in real interest rates was tested, based on long-term interest rates.

Because expectations of landowners in aggregate cannot be observed, a major concern is specification of expectations and their dynamic nature. Based on the Nerlove (1958) model, partial-adjustment dynamic models in agriculture have attributed lags to technological and psychological inertia. Future expectations of land incomes formulated in the present study were conditioned by incomes obtained in the recent past. For example, a lagged 2-year moving average was used for timber income.

Little empirical research exists to guide the modeling of landowner perceptions of risk differentials for alternative land enterprises. One measure of the risk associated with land use is the deviation of actual returns from expected returns. Behrman (1968) specified a risk variable as a moving standard deviation of past prices. We used a similar approach by measuring risk on the basis of a moving standard deviation of returns per acre for selected land uses.

Property tax rates have often been hypothesized as contributing to the conversion of farmland to nonagricultural uses (Conklin and Lesher 1977) and of forest land to more intensive uses (Stier and Chang 1983). In addition, income taxes may impart differential impacts across land uses (Durst 1987; Murray 1987). Studies of the effects of taxation and differential assessment on land use have yielded mixed results. Stoll and others (1984) conclude that differential assessment for tax purposes in the South generally does not appear to have forestalled the conversion of eligible land to noneligible uses. Further, differential assessment practices vary markedly among Southern States.

Although the impacts of taxes on land uses have long been debated, empirical studies have not offered conclusive evidence of differential impacts across land uses. Tax-induced reductions in net income streams for a land use are compounded by property tax influences, but the net effect in a region is not known.

The effects of tax code changes embodied in the 1986 Tax Reform Act are too recent to allow empirical testing of associated impacts on land use shifts. Lofgren and others' (1986) study provides theoretical economic implications for changes in forest management intensity resulting from tax code changes. Lofgren and others (1986) used a utility maximization approach to analyze the effects of unequal taxing of income on a landowner's allocation of time among forestry, agricultural, and other activities. A relative increase in taxation for forestry-related income reduces optimal levels of timber management activity and long-term supply of roundwood from forest farmers. By varying assumptions for income targets and input substitutability, however, Lofgren and others (1986) derive a quite different result. If the landowner must produce a certain amount of income to satisfy some specific need, such as college tuition for an offspring, and labor devoted to nontimber activity cannot be varied, they derive a backward-bending supply curve for forest management activity. As the relative tax on forestry activity rises and the opportunity to shift labor to nontimber activity is heavily constrained, forestry activity must be increased to meet the individual's target income.

Area change for forest industry ownership is hypothesized to correlate with changes in capacity and expected returns from timber processing, related to costs of timber conversion, productivity trends, and demand for timber products. Concern for the availability of raw materials influences tactical and strategic planning, because industry draws heavily on noncaptive sources of timber. However, empirical investigation of such behavior is hampered by unavailability of a complete set of aggregate data.

Dummy variables were included to test for significant differences in land use among States in each physiographic region. Arkansas was singled out in the Coastal Plain region because of its northernmost

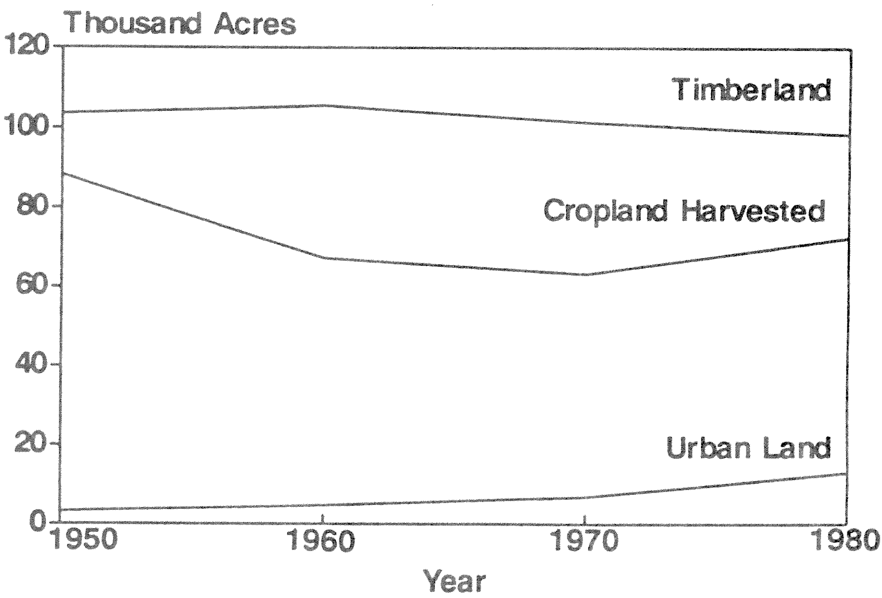

Figure 3. – Area trends for selected major uses of the land in the South-Central region, 1950-1980 (Frey and Hexem 1984; USDA Forest Service 1988).

location. Likewise, Tennessee was targeted because of its location at the northern edge of the Interior Highlands. Examination of the importance of certain attributes of land, such as location with respect to markets, geographic features, and other resources, was not feasible in this regional study.

Area in forest, sometimes viewed as a residual use, can be augmented by human factors, natural forces, or a combination of the two. For example, in the early twentieth century agricultural income per acre declined, crop fields were left unplanted, and many seeded naturally to loblolly pine. Trends in areas of cropland harvested and timberland have tended to move in opposite directions (fig. 3). Passive reversion of agricultural land to forest represents decisions by landowners in many cases to abandon crop fields because expected net returns were negative. This decision process has been complicated in later years by the availability of government programs that have supported agricultural incomes.

Government programs for agriculture have often focused on reducing crop acreage in order to reduce surpluses. One would therefore expect payments in programs for diverting land from agricultural production to be inversely related to crop acreage and to be directly related to targeted uses, such as forest.

Data and Variable Measurements

The seven Southern States chosen for model building contain approximately 180 million acres. About 85 percent of this area is in the Coastal Plain and Interior Highlands physiographic regions. The remainder is in the Lower Mississippi Alluvial Plain, often referred to as the "Delta." The Delta was omitted from our analysis because data on land use there were too limited.

According to periodic surveys by the regional Forest Inventory and Analysis (FIA) unit of the USDA Forest Service (Alig and others 1986), net changes in the areas of major land uses occur slowly at the regional level. Forests cover about 58 percent of the land in the South-Central region; a large majority of this forest arises from natural sources. Crops are the next largest use, occupying approximately 15 percent of the land. Pasture occupies about 13 percent, and urban and other uses occupy 14 percent. FIA surveys each State on a staggered 8- to 10-year cycle. The 7 States contain 35 survey units or sampling units, which are multicounty aggregations of from 3 million to 11 million acres. These surveys, in conjunction with periodic Census of Agriculture surveys by the U.S. Department of Commerce, Bureau of the Census, provided estimates of areas in the major land uses at either two or three dates from 1950 to 1985. Acreage estimates were transformed into percentages of a survey unit's total land area occupied by the six land uses/ownerships in a particular year.

For isolation of critical pairs of competing land uses, quotients of land incomes for alternative enterprises were used, based on ratios of output prices to input prices. For example, a ratio was formed from the index of prices received for soybeans and other crops and the index of prices paid for factors of production. Crop and livestock prices were derived from several sources, including annual issues by the U.S. Department of Agriculture on agricultural statistics and agricultural prices for each State. Timber income was computed with a 2-year moving average of weighted prices for southern pine sawtimber and pulpwood stumpage (Ulrich 1983).

Per-capita incomes and populations were obtained from the Census of Population (for example, U.S. Department of Commerce, Bureau of the Census 1984). Information on government programs was obtained from annual reports by State from the U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service. This information included government payments to farmers to establish tree cover under long-term programs such as the Soil Bank Program.

Estimation Procedure

Seemingly unrelated regression equations (SURE) were estimated to maximize efficiency gains in estimation, in view of the likely correlation of error terms across land use equations. Correlation among the error terms is inevitable because of the fixed total- land base, frequent transfers of land among uses/ownerships, and related patterns in the economic determinants.

Based on the structural model in Equation (5), the set of Equations in (6) can be viewed as reduced form equations in a system of demand and supply for land:

$$A_i = f(P, R), \quad i = 1, ..., 6 \qquad (6)$$

Relative prices of land, for which a complete set of data is not available, would not necessarily be a part of the vectors of variables P or R, but only those more fundamental variables that cause shifts in the demand and supply equations for land.

The fixed nature of the land base was reflected in estimation by imposing a series of restrictions. Because the size of each survey unit is essentially fixed, changes among the dependent variables are interdependent. An increase in the share of one use necessarily reduces the area of one or more other uses. Restricted SURE estimation satisfies the fixed land-base constraint that the sum of the coefficients of any explanatory variable across all land use equations is identically equal to zero, and that the intercept terms sum to one (Alig 1986).

Multivariate logit is an alternative to restricted SURE estimation. Both methods assure that predictions sum to desired totals, but the restricted SURE approach provides results that are easier to interpret. In it, each land use is represented in estimation, whereas in the multivariate approach, one equation is excluded and the estimated equations are in relative terms. Regression coefficients for exogenous variables in the multivariate regression approach indicate how each variable affects a land use relative to the land use excluded from estimation. The multivariate logit approach also requires use of the same set of independent variables in each equation, which precludes specifying the mix of variables individually for each land use.

Logarithmic transformations of the independent variables provide a concave functional form, posited for the relationship between the fraction of land in a particular use and expected land incomes. The concave functional form implies that as a greater percentage of the total land area is concentrated in a particular use, land rent differences between uses should tend to equalize.

The sets of equations for the two physiographic regions were also estimated by using first differences of the independent and dependent variables. The first difference for a particular variable is equal to the difference in its value between successive points of observation, t-(t-1). This alternative estimation was undertaken to test the sensitivity of results to alternative specifications.

Results

The SURE econometric results are presented in tables 1 and 2 by physiographic region. The first-difference results are given in tables 3 and 4. The following discussion refers to the first set of results, unless otherwise noted. Results for the two estimation sets are similar in general.

As in a nationwide study by Alig and Healy (1987), hypothesized signs for the significant coefficients for the income and population variables were obtained in most cases. For example, the significant coefficients for urban population are positive in the urban/other equation and negative in the forest ownership equations for the Interior Highlands. However, specific net effects of urban and rural population changes on the distribution of forest ownerships warrant further examination in future studies, particularly for the miscellaneous private class.

Table 1.—SURE estimation results for the Coastal Plain region[a]

Independent variable	Dependent variable					
	Crop	Pasture/ range	Urban/ other	Farm forest	Forest industry	Misc. private
Intercept	0.20* (6.71)	0.28* (5.76)	0.11* (3.38)	0.17* (4.86)	0.00 (0.09)	0.24* (4.93)
Crop-to-beef income ratio	−0.03* (−2.25)	0.03* (2.25)				
Timber-to-beef income ratio		−0.00 (−0.18)		0.00 (0.18)		
Timber-to-crop income ratio	−0.01 (−0.82)			0.01 (0.81)		
Per-capita personal income	−0.05* (−2.42)	0.02 (0.63)	0.08* (3.11)	−0.11* (−3.43)	0.03 (0.96)	0.02 (0.49)
Urban population	−0.01* (−2.06)	−0.02 (−1.43)	0.01 (1.26)	−0.04* (−4.25)	0.04* (3.24)	0.02 (1.08)
Rural population	0.08* (5.08)	0.10* (3.44)	0.02 (0.87)	0.03 (1.76)	−0.13* (−4.63)	−0.10* (−3.25)
Wood products income				−0.06 (−0.71)	0.08 (1.27)	−0.02 (−0.25)
Government forestry programs	0.01* (3.52)	−0.01* (−2.66)		0.02* (2.41)		−0.16 (−1.67)
Arkansas dummy	−0.02 (−1.14)	−0.07* (−2.06)	−0.02 (−0.85)	−0.04 (−1.70)	0.19* (6.24)	−0.04 (−1.13)

Weighted R^2 for the system equations = 0.61

Sample size, n = 42

[a] Numbers in parentheses below coefficients are *t*-statistics.

* Significantly different from zero at the 0.05 level.

Table 2.—SURE estimation results for the Interior Highlands region[a]

Independent variable	Dependent variable					
	Crop	Pasture/ range	Urban/ other	Farm forest	Forest industry	Misc. private
Intercept	0.08 (1.12)	0.28* (4.37)	0.18* (3.06)	0.20* (3.93)	−0.02 (−0.44)	0.28* (3.54)
Crop-to-beef income ratio	0.01 (0.34)	−0.01 (−0.34)				
Timber-to-beef income ratio		−0.03 (−1.39)		0.03 (1.36)		
Timber-to-crop income ratio	0.08* (5.00)			−0.08* (−4.90)		
Per-capita personal income	−0.00 (−0.07)	0.07 (1.48)	0.06 (1.28)	−0.16* (−4.35)	0.02 (0.57)	0.01 (0.22)
Urban population	0.03 (1.52)	0.01 (0.80)	0.05* (2.68)	−0.02* (−1.82)	0.00 (0.24)	−0.07* (−3.71)
Rural population	−0.04 (−0.98)	−0.01 (−0.22)	−0.06 (−1.41)	0.04 (1.40)	−0.05 (−1.75)	0.12* (2.69)
Wood products income				0.22 (1.74)	−0.02 (−0.29)	−0.20 (−1.63)
Government forestry programs	0.01* (1.84)	−0.03* (−4.23)		0.02* (2.21)		0.00 (0.06)
Tennessee dummy	0.12* (3.90)	−0.03 (−1.02)	−0.04 (−1.31)	−0.02 (−0.74)	−0.01 (−0.45)	−0.03 (−1.16)

Weighted R^2 for the system equations = 0.54

Sample size, n = 33

[a] Numbers in parentheses below coefficients are *t*-statistics.

* Significantly different from zero at the 0.05 level.

Table 3.—SURE estimation results for first-differences equations for the Coastal Plain region[a]

Independent variable	Dependent variable					
	Crop	Pasture/ range	Urban/ other	Farm forest	Forest industry	Misc. private
Crop-to-beef income ratio	−0.001 (−0.09)	0.001 (0.09)				
Timber-to-beef income ratio		−0.002 (−0.20)		0.002 (0.19)		
Timber-to-crop income ratio	−0.008 (−0.79)			0.008 (0.78)		
Per-capita personal income	0.010 (1.26)	−0.029* (−2.60)	0.009 (0.57)	−0.019 (−1.69)	0.019* (2.91)	0.009 (0.35)
Urban population	−0.136* (−3.45)	0.106* (2.65)	0.140* (2.11)	−0.074 (−1.64)	−0.031 (−1.16)	−0.005 (−0.05)
Rural population	0.095* (2.80)	−0.003 (−0.07)	−0.023 (−0.32)	0.040 (1.03)	−0.016 (−0.57)	−0.093 (−0.86)
Wood products income				−0.006 (−0.08)	0.069* (1.79)	−0.063 (−0.66)
Government forestry Programs	0.008* (2.58)	−0.010* (−2.40)		0.005 (0.95)		−0.003 (−0.62)
Arkansas dummy	0.004 (0.32)	0.020 (1.20)	0.005 (0.17)	−0.014 (−0.88)	0.019 (1.62)	−0.034 (−0.76)

Weighted R^2 for the system equations = 0.74

Sample size, n = 28

[a] Numbers in parentheses below coefficients are _t_-statistics.

* Significantly different from zero at the 0.05 level.

Table 4.—SURE estimation results for first-differences equations for the Interior Highlands region[a]

Independent variable	Dependent variable					
	Crop	Pasture/ range	Urban/ other	Farm forest	Forest industry	Misc. private
Crop-to-beef income ratio	0.019 (0.87)	-0.019 (-0.87)				
Timber-to-beef income ratio		-0.003 (-0.20)		0.003 (0.19)		
Timber-to-crop income ratio	0.013 (1.08)			-0.013 (-1.04)		
Per-capita personal income	0.016 (0.94)	-0.021 (-1.03)	0.009 (0.80)	-0.009 (-0.51)	0.004 (0.66)	0.001 (0.08)
Urban population	-0.073 (-1.25)	0.129 (1.53)	0.095* (1.79)	-0.147* (-3.02)	0.008 (0.31)	-0.012 (-0.19)
Rural population	0.113* (2.05)	-0.249* (-3.15)	0.090 (1.61)	0.001 (0.02)	0.008 (0.26)	0.038 (0.55)
Wood products income				-0.341 (-1.58)	0.062 (1.18)	0.279 (1.37)
Government forestry programs	-0.004 (-0.78)	0.015* (1.86)		-0.024* (-2.28)		0.014 (1.28)
Tennessee dummy	-0.002 (-0.11)	0.009 (0.35)	0.010 (0.64)	0.050* (2.20)	-0.004 (-0.54)	-0.063* (-2.63)

Weighted R^2 for the system equations = 0.61

Sample size, n = 22

[a] Numbers in parentheses below coefficients are t-statistics.

* Significantly different from zero at the 0.05 level.

Hypotheses about relative income variables were rejected. For example, we expected the coefficient for the ratio of timber-to-crop income to be negative in the crop equation when there was net movement of cropland to timberland. In fact, when this coefficient was significant, it was positive in the Interior Highlands region, contrary to the hypothesized relationship. Results for other measures related to land-based incomes were similar. Variables representing landowner risk, using moving averages of standard deviations of land income returns, and interest rates were not significant in preliminary testing.

Several factors make modeling interdependencies among rural land use classes difficult. First, impacts of government commodity programs are irregular and difficult to track. Second, pasture may act as a buffer between cropland and forest conversions. Although a substantial amount of cropland is grazed, this acreage is not reflected in available regional land use data. In addition, part of the difficulty in constructing appropriate proxies of expected land rent is representing the formulation of income expectations of landowners.

The influence of government programs on land use shifts in the South is reflected by the statistical results. Results suggest that government conservation programs have caused agricultural land to be diverted to forest land (primarily pine plantation) on farms in both physiographic regions.

Results for the first-differences equations are similar to those of the equations with the untransformed variables. The weighted R^2 values are slightly higher for the systems of first-differences equations. Most of the coefficients on the land use income variables had the expected signs, but were generally not statistically significant. Several of the associated coefficients for other independent variables are insignificant or have wrong signs, similar to the other sets of equations.

In general, results for the hypothesized land use relationships were mixed. Results for the urban and developed use classes, which are at the top of the economic hierarchy, appear to be the most consistent with the hypotheses. Results are less congruous for the less intensive land uses. The results support the hypothesis that changes in rural land uses are driven largely by demand forces outside the agricultural and forestry sectors, consistent with the economic hierarchy for land uses.

Results for the pasture/range equations appear to be the least consistent with the hypothesized relationships. In large part, historical data for this land use class reflect a residual land classification that may not be truly reflective of use. A contributing factor may be cycles in beef production, where inelastic demand for beef in conjunction with supply shifts (due to land use shifts) would cause price to fall, which could then cause income to fall. Additional complications include the use of feed grains in livestock production and use of croplands and forest for grazing when expected livestock incomes rise.

Our results generally are consistent with those of related studies. Lack of significance for proxies representing relative land rent, product prices, or related explanatory variables is consistent with Alig's (1986) findings for the Coastal Plain and Piedmont physiographic regions in the Southeastern United States, Parks' findings for North Carolina,[1] White and Fleming's (1980) for Georgia, and Carlen and Lofgren's (1988) for Sweden. Statistically significant effects of urban population and personal income on land use are likewise consistent with Alig's (1986) findings and with the national-level equations estimated by Alig and Healy (1987). The results are also consistent with other studies (such as Pope 1985) that indicate "consumptive demand" for rural land is a major determinant of land values and therefore of land use shifts.

The failure to detect effects of expected relative incomes from agriculture and forestry enterprises on use shifts suggests a need for additional research. Notable differences between forest and cropland enterprises are the heterogeneous nature of the land management goals of forest owners and the timing of land use incomes. Numerous studies of forest owners have attempted to isolate characteristics that correlate highly with investments in forestry. In general, nonindustrial owners of forest demonstrate highly inelastic supply responses.[2] Forests often are passively managed, major management decisions (e.g., harvest) may be prompted by a change in ownership, and forest incomes tend to be lumpy and periodic. In addition, management actions such as harvesting of trees may predispose some forested tracts to land use conversion.

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[1] Parks, Peter J. 1986. The influence of economic and demographic factors on forest land use decisions. Berkeley, CA: University of California. 88 pp. Unpublished Ph.D. dissertation.

[2] Royer, Jack. 1987. Use and effects of the reforestation tax incentives and cost sharing in the South. Durham, NC: Duke University. 33 pp.

Recent Changes in Land Use Outlook

Analysis of the prospective reallocation of land among uses in the South requires consideration of recent governmental actions that could not be analyzed in the regression phase of our study. The 1985 Farm Act, with its Conservation Reserve provisions, has considerable implications for forestry. Moulton and Dicks (1987) state that the Conservation Reserve Program is expected to become the largest tree planting program in the nation's history. The Tax Reform Act of 1986 (TRA) has relevant impacts on financial returns to crop, livestock, and timber investments. We will focus on the decisions of "other private" landowners, all forest owners except public agencies and companies with wood-processing facilities. This class of owner controls about two-thirds of the forest in the South-Central region (USDA Forest Service 1988).

The Conservation Reserve Program (CRP) of the 1985 Farm Act could stimulate planting of more than 4 million acres of erodible cropland to pine trees over the next decade. That area would equal approximately three-fifths of the existing nonindustrial area in southern pine plantations. Timber products from these plantations will not begin to be marketed until after the turn of the century, but at that time impacts on prices for stumpage and wood products could be significant (USDA Forest Service 1988). Currently, the full extent of landowner participation in the CRP is in doubt, but our regression results suggest that farmers are receptive to such programs, given the attractive subsidy rates (up to 50 percent of plantation establishment costs).

With respect to the TRA, Durst's (1987) results indicate that cropland investments are improved somewhat by the tax revisions and that livestock (hog) returns are virtually unaffected. After-tax profit for the hypothetical cropland investment appears to have improved by approximately 5 percent after implementation of the new law. The livestock investment has decreased in value by about 1 percent. These relatively small changes in profitability are not likely to have large effects on use of agricultural land. Consequently, we focus on the potential impact of the tax changes on timber investments.

Murray (1987) analyzed the effects on individual taxpayers of timber-related provisions in the 1986 Tax Reform Act for a hypothetical investment in loblolly pine reforestation in the South. Murray found an average decrease in financial returns of 33 percent under the new law due to: (1) elimination of the capital gains tax exclusion for timber sale income, (2) reduced value of annual expense deductions resulting from the lowering of tax rates on ordinary income, (3) timber sale revenue being taxed at a higher marginal rate than most ordinary income, and (4) elimination of income averaging in reporting sporadic income.

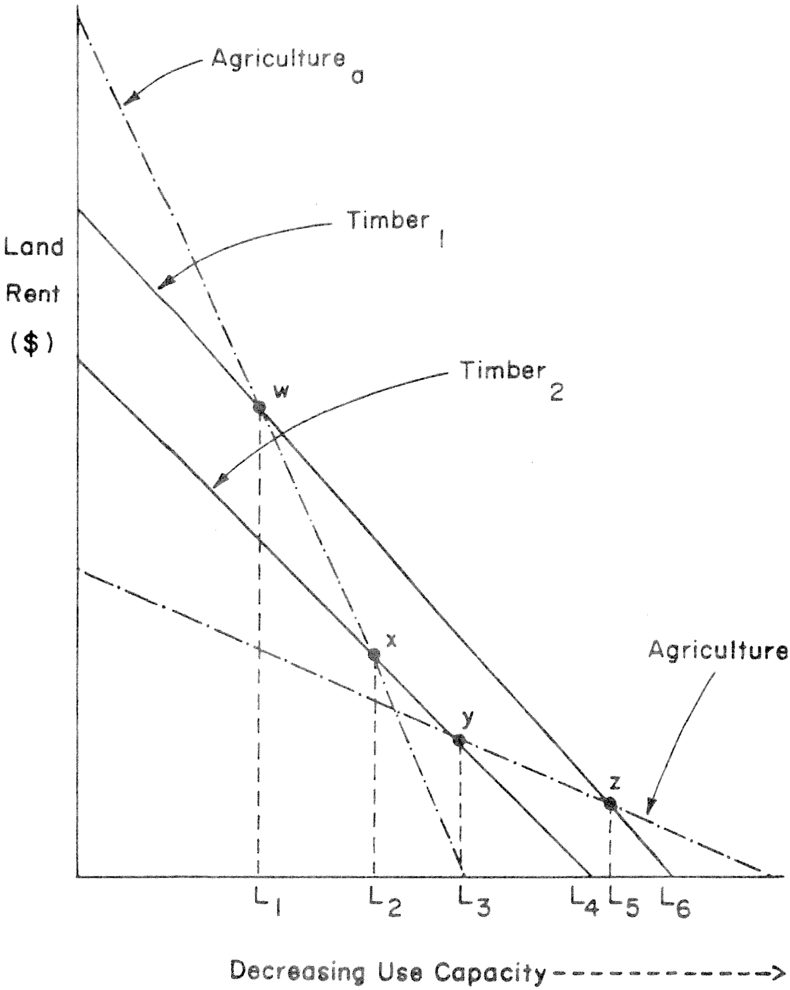

Figure 4. – Comparative land rents and the transfer of land between timber and agriculture as a result of tax code changes.

The margin of transference between timber and agriculture prior to TRA is represented by point W in figure 4 for assumption *a* (agriculture outcompetes timber on higher quality sites) and point Z for assumption *b* (timber outcompetes agriculture on higher quality sites). Timber returns are substantially reduced by the Tax Reform Act, while agriculture returns remain virtually unchanged. The effect on timber returns is reflected by the inward shift of the rent curve. As a result, the competitive status of timber investments worsens. The transfer of land from timber to agricultural uses is (L_2- L_1) under agriculture assumption a or (L_5 - L_3) under assumption b. The inward shift of the timber rent triangle (fig. 4) forces the extensive margin from point L_6 to L_4, resulting in a timberland loss of (L_6 - L_4).

Murray's (1987) analysis indicates that the extensive margin shifts inward and that the land rent triangle shift is biased percentagewise toward the extensive margin (fig. 4). Reforestation investments near the extensive margin receive a relatively larger percentage reduction in expected financial returns due to the TRA than do investments well within the margin. Murray concludes that marginal investments are taxed relatively higher than high-return plantation investments, further discouraging timber production from these lands.

The likely net impact of the CRP and TRA on changes in forest area in the South is difficult to predict at this time. Guidelines and procedures for these recent institutional changes have not been fully developed, and landowner responses to these complex and dynamic institutional developments are uncertain. Over the next few decades, we expect the 1985 Farm Act to have greater impact on land use than the TRA. We base this expectation on a direct causal link between the CRP and conversion to timber, as compared with an ill-defined link between prospective changes in after-tax timber income and forest conversion. Substantial forest acreage will continue to be converted to urban and developed uses (Alig and Healy 1987), and the future course of agriculture will have an important, but uncertain, impact on forest area changes.

Conclusions

Because the amounts of land devoted to various uses are interdependent, forest area change is notably influenced by macroeconomics and demography, consistent with the economic hierarchy of land use. The area in urban use grows with population and affluence. Changes in personal income also appear to have altered patterns of forest ownership. Much farm forest has transferred to other private nonindustrial owners, in part because of the demand for landownership fueled by personal income increases.

Impacts of technological change on land-based incomes and land use need further study, but some effects are obvious. Improvements in the per-acre production of crops and declining exports in recent years have lessened the area of land needed for food production. As a result, real prices of agricultural crops have declined, dampening incentives for planting crops. Similar situations in the past have led to conversion of cropland to forest in the South, and we believe that the same thing will happen again. The CRP of the 1985 Farm Bill is likely to speed that process.

The impacts of the 1986 Tax Reform Act on future land reallocation are much more difficult to predict. It is important not only to analyze direct effects of tax changes on timber investments but also to evaluate impacts on other uses in direct competition with timberland on the land base. Murray's (1987) and Durst's (1987) findings separately suggest that recent changes in income tax laws adversely affect the returns to timber investments relative to investments in other land-based activities. Evaluating tax impacts on land use shifts is complicated by the absence of definitive empirical tests of land use theory. One major gap is the lack of empirical findings supporting the hypothesis that differences in expected land incomes guide landowner behavior.

Owners compare land use alternatives on highly subjective scales. Theoretically, this subjective valuation results in choice of the land use with the highest utility for each landowner. In part because of data limitations, analysts have had great difficulties in empirically based studies in incorporating the influences of nonmarket values in land use decisions. Conservation, protection, and preservation are highly valued by some owners. The lack of statistical significance of market-based variables in our study supports the need for indepth investigation of nonmarket influences in regard to landowner behavior.

Efficient allocation of land among competing uses requires dynamic adjustments that do not take place as smoothly in the real world as they do in some models. There often are lags in adjustment and imperfections in land and capital markets. Mobility of resources in shifting among land use enterprises is hindered by rigidities related to investments in farm machinery and preferences for an agrarian lifestyle. Finally, landowners often may not have sufficient information readily available with which to fully understand the comparative advantages of competing land uses.

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Economic factors influencing land use changes in the South-Central United States. Res. Pap. SE-272. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 1988. 23 pp.

Econometric models of land use change were estimated for two physiographic regions in the South-Central United States. Results are consistent with the economic hierarchy of land use, with population and personal income being significant explanatory variables. Findings regarding the importance of relative agricultural and forestry market-based incomes in influencing regional land use shifts suggest that farm programs play an important, but continually changing, role in land use change.

Keywords: Econometric analysis, acreage, forest land.

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