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Historical Trends and Projections of Land Use for the South-Central United States

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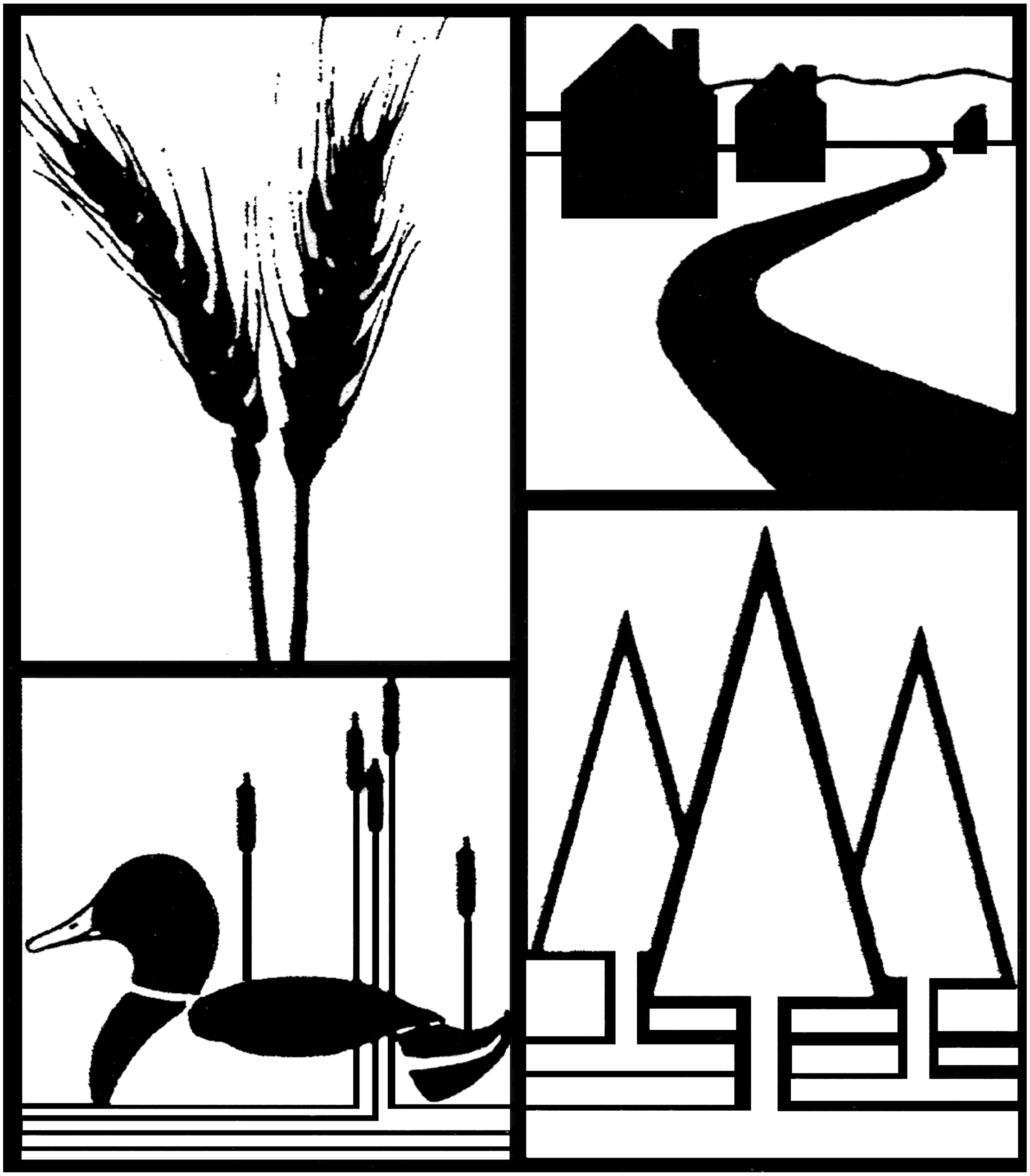

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Abstract

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This report presents historical trends and future projections of forest, agricultural, and urban and other land uses for the South-Central United States. A land use share model is used to investigate the relation between the areas of land in alternative uses and economic and demographic factors influencing land use decisions. Two different versions of the empirical model are estimated, depending on the stumpage price series used to calculate net returns from forest land: model 1 uses sawtimber prices and model 2 uses pulpwood price series. This leads to two sets of land use projections. We found that landowners are more responsive to changes in pulpwood prices than to those in sawtimber prices. The fitted econometric models were used to generate projections of future land use to 2050, given the projections on population and assuming 0.5-percent annual stumpage price increases. Although there were differences in magnitudes of changes, both sets of projections showed the same general trends of land use allocations over the next 50 years. The category urban and other land continuously increases owing to population growth, and timberland expands owing to assumed stumpage price increases. Agricultural land declines to compensate for the amount of increases of timberland and urban and other land.

Keywords: Land use, Resource Planning Act assessment, projections (forest area), land rents.

Summary

This paper presents historical trends and future projections of forest, agricultural, and urban and other land uses for the South-Central United States, which includes Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, and Texas. In 1992, agricultural, timber, urban, and other land uses comprised, respectively, 28, 56, 4, and 12 percent of the total land in the South-Central region. Agricultural land area (crop and pasture land combined) decreased by 1.9 million acres from 1964 to 1992, and timberland decreased by almost 5.0 million acres during the 1960s and 1970s but subsequently began to increase. Urban land has increased steadily (by 4.6 million acres since 1964) to meet increasing demands for residential, commercial, and other developed uses by the growing population of the South-Central region.

Long-term forest area projections are an important component of the Resource Planning Act (RPA; 1974) assessments and other forest policy analyses. We applied a standard econometric land use share model to the South-Central region, and used the fitted models to generate long-term projections of future land use. We constructed a panel data set, which covers both time series observations from 1964 to 1992 and cross-sectional observations by counties in the region. Data were gathered from various sources, including Forest Inventory and Analysis (FIA), Census of Agriculture, and Population and Housing Census. Using the constructed panel data, we estimated the relation between the area of land in alternative uses and economic and demographic factors hypothesized to influence land use decisions. Determinants of land use included the net returns to land in different uses, land quality, and demographic variables such as population density.

Two versions of the empirical model were estimated depending on which stumpage price series was used to calculate net returns from timberland. Sawtimber prices were used in model 1 and pulpwood prices in model 2. All other explanatory variables remained the same across the two models. These two alternative specifications of model permitted us to examine which stumpage price series might explain historical land use patterns better and which might be more appropriate for long-term projections.

We found that the dependent variables, defined as the ratio of agricultural to forest land and the ratio of urban and other land to forest land, were more responsive to changes in pulpwood prices than to changes in sawtimber prices. The magnitudes of coefficient estimates of other explanatory variables, however, were very similar across the two models. The explanatory powers of the two models, judged by adjusted R-squared statistics, were quite similar (0.74 for agricultural to forest equations and 0.44 for urban and other to forest equations in both models), which made it difficult to conclude which is more appropriate for long-term projections.

The estimation results supported the theoretical and empirical results of earlier studies. We found that rural land use patterns are determined by relative economic rents and land quality. The results also confirmed the previous finding that population and distance to city play important roles in explaining the share of urban and other land use. In most cases, the estimated coefficients were significantly different from zero at the 5-percent significance level.

We augmented the standard land use share model by incorporating fixed effects for cross-sectional observations measured by a set of FIA survey-unit dummy variables. Because FIA data provide only a few time-series observations, our panel data are limited in the time dimension; however, they are rich in the cross-sectional dimension

because states in the region have many counties. For long-term projections, it is important to adequately control for variations in the spatial dimension so that limited information on land use decisions over time can be used to estimate the temporal relation of interest. The FIA dummy variables in the models are expected to control the differences across FIA survey units, thus allowing other explanatory variables to capture the temporal relations over time.

Two sets of land use projections to 2050 were produced based on the parameter estimates from model 1 and model 2 and given projected increases in real stumpage prices and population. We assumed 0.5-percent annual increases in real stumpage prices based on historical trends of stumpage prices over the past 20 years. Population projections for the region were from the U.S. Department of Commerce (1995). The first set of projections (scenario 1 and 2) was based on the estimates of model 1. Scenario 1 included only population change, and scenario 2 included both population and sawtimber price changes. The second set of projections (scenario 3 and 4) was based on the estimates of model 2. Scenario 3 contains only population change, and scenario 4 incorporates both population and pulpwood price changes.

Scenarios 1 and 3 (counting for population change only) provide similar projections of future land use. The projected allocation to urban and other land, due to the population growth, represents a continued increase from 32.9 million acres in 1992 to 35.2 million acres by 2050 with scenario 1, and to 35.4 million acres with scenario 3. Comparing the two scenarios, increases in urban and other land were slightly greater with the estimates of model 2 (using pulpwood prices) than model 1 (using sawtimber prices). The private timberland and agricultural land decreased over the projection period to compensate for the increases in urban and other land. Results from both scenarios showed that more forest land is converted to urban and other land than to agricultural land.

Once we included stumpage price changes as a part of the scenarios along with population change (scenarios 2 and 4), however, the projection results provided different views of the future amounts of land use areas. Although both scenarios showed the same general trend of land use allocations over the projection period, the magnitudes of changes, especially in forest land, were different. The expansion of forest land in the next 50 years with pulpwood price increases is projected to be almost 10 times larger than those with sawtimber price increases. Area of forest land in model 2 increased by 4.703 million acres from 1992 to 2050, and area of forest land increased in model 1 by 0.478 million acres. This significant difference in projections seems to be attributable to the larger coefficient estimate for pulpwood forest rents than that for sawtimber forest rents.

Urban and other land continuously increased with population growth in both scenarios. Results from scenario 2 showed that the urban and other land increases by 1.96 million acres to 2050 and by 2.58 million acres with scenario 4, indicating that projections in model 2 generate slightly larger increases in urban and other land than in model 1. The agricultural land declined to compensate for the amount of increases of timberland and urban and other land.

Along with generating projections of future land use areas for the South-Central region, this exercise investigated which stumpage price series–sawtimber or pulpwood–is more appropriate to use in model development for subsequent long-term projections. A conclusion is difficult to reach based on the results of this study, because explanatory

powers of both models are almost identical and both sets of projections provided the same general trends of future land allocations. Although forest land projections with pulpwood price series presented notably higher numbers than with sawtimber price series, the absolute magnitudes of increases in forest land with pulpwood price increases (4.703 million acres for the next 50 years) can be viewed as plausible. One might argue that the projected increases in area of forest land with sawtimber prices were too small. A contribution of this exercise is an empirical finding that landowners are more sensitive to pulpwood price series than sawtimber price series. However, which price series is better suited for use in developing long-term forest land projections needs further investigations, including consideration of landowners' decision processes and the characteristics of timber production in the region of interest. For the South, this also should include investigation of the contributing influence of agricultural rents as they influence landowner decision processes and the development of consistent long-term agricultural price projections.

Contents

Introduction

The Resource Planning Act (RPA) of 1974 and the Soil and Water Resources Conservation Act of 1977 require the U.S. Department of Agriculture (USDA) to develop programs to conserve, protect, and enhance forest, soil, and water resources for sustained use. To serve this purpose, the USDA Forest Service conducts periodic assessments of the nation's forest resources (e.g., USDA Forest Service 1981). A key element of the RPA assessment is its long-term projections of forest land area, because changes in forest land area determine the future availability of timber supply, wildlife habitat, and other benefits provided by forests. For early assessments, forest area projections were based on expert opinion (Wall 1981); beginning with the 1989 assessment, however, this approach was replaced with econometric methods. During the 1980s, econometric analyses of land use were conducted for the Southeast (Alig 1986), South-Central (Alig et al. 1988), West (Parks 1986), North-Central (Plantinga et al. 1989), and Northeast (Howard and Lutz 1989) regions of the United States. For the current RPA assessment, econometric-based projections have been prepared for Maine (Plantinga et al. 1999), the Lake States region (Mauldin et al. 1999), and the Pacific Northwest west side (Kline and Alig 1999). The purpose of this report is to present projections for the South-Central region.

According to the definition of regions and subregions used for the RPA assessment, the U.S. South is composed of two subregions, the Southeast (Virginia, North Carolina, South Carolina, Georgia, and Florida) and the South-Central (Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, and Texas) (fig. 1). As a whole, the South includes roughly 24 percent of the land area of the United States and almost 40 percent of the nation's timberland (Powell et al. 1993). Considering the relative importance of forests in the region, credible long-term projections of future forest land area are crucial to estimating future timber supply.

To develop an econometric model of land use for the South-Central region, we used aggregate (county-level) data. Forest area observations were from Forest Inventory and Analysis (FIA) surveys conducted by the USDA Forest Service, and agricultural land area data were from the Census of Agriculture. Urban and other uses were treated as a residual category. The FIA inventories are conducted by state and historically have been completed about every 10 years. For most states in the South-Central region, three or four inventories have been completed since the 1960s.

We constructed a panel data for the region consisting of time-series and cross-sectional observations. Because only a few inventories are available over time, the panel is limited in the temporal dimension; however, the panel is rich in the cross-sectional dimension, because states in the region have many counties. Using these data to predict future forest area presents a particular challenge. Future land use projections involve land allocation decisions over a long-term horizon, but our panel data provides limited information on land use decisions over time. Accordingly, the econometric model must adequately control for differences across counties (i.e., variation in the spatial dimension) so that the limited information on land use decisions over time can be used to estimate the temporal relations of interest.

The basic approach used in this study was to estimate the relation between the area of land in forest, agricultural, and urban and other uses and the economic and demographic factors influencing land use decisions. Determinants of land use included the net returns to land in different uses, land quality, and demographic variables such as population density. Given projections of the land use determinants, the fitted econometric models were used to generate projections of land use to 2050.

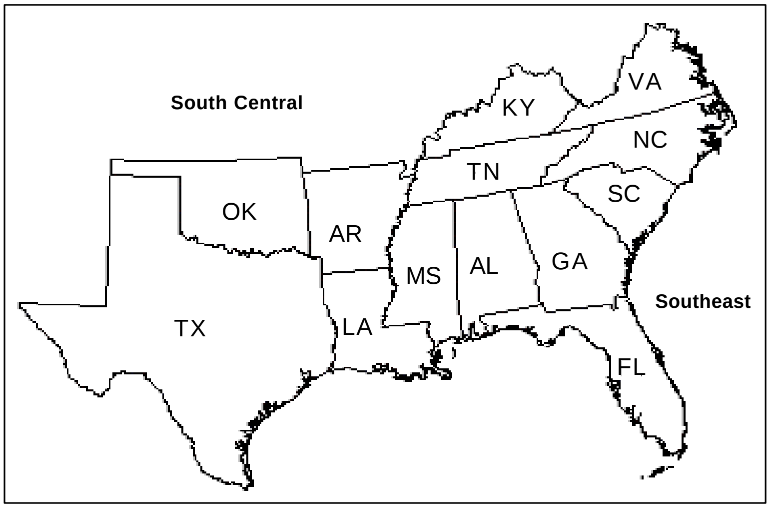

Figure 1—Subregions of the Southern United States for the Resources Planning Act assessment.

Historical Trends of Land Use and the Status of Timberland

Table 1 and figure 2 show the historical land use trends for the South-Central region. Only the eastern parts of Oklahoma (18 counties) and Texas (37 counties) are included because forest area is largely contained in the eastern parts of those states. In 1992, agricultural land (cropland and pastureland combined), timberland, urban land, and other land represented, respectively, 28, 56, 4, and 12 percent of the total land in the South-Central region. Since 1964, total cropland has increased by 1.3 million acres, and pastureland has declined by 3.2 million acres, for a net decrease of 1.9 million acres in agricultural land. Timberland decreased almost 5.0 million acres during the 1960s and 1970s but has increased subsequently. Overall, timberland area has declined by 2.4 million acres over the past 30 years.[1] Urban land has continually increased (by 4.6 million acres since the 1960s) to meet increasing demands for residential, commercial, and other developed uses that accompany population growth. “Other land” is defined as a residual category for the land in uses other than agriculture, forestry, and urban.[2] The area of the other land has declined by 2.6 million acres since the 1960s.

Most of the timberland in the South-Central region is privately owned (90 percent in 1992; table 2). While the total area of private timberland has remained stable over the past 40 years, ownership patterns within the private timberland category have shifted considerably. The proportions of timberland owned by forest industry, farmers, and other private owners have changed from 17, 42, and 41 percent in 1952 to 22, 20, and

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[1] Timberland in the region increased by 4.1 million acres between 1987 and 1997 according to recent forest survey estimates (USDA Forest Service 2000). A complete set of such data were not available when the present study was conducted. The data reflect recent land use shifts from agriculture to forestry that are related to changes in government programs, such as under the 1995 farm bill.

[2] “Other land” includes developed land not classified as urban land (e.g., suburban housing, farmsteads, rural transportation uses), wetlands, lands in transition between uses (e.g., cropland reverting to forest), and miscellaneous uses.

Table 1—Historical land use trends in the South-Central United States, 1964- 92[a]

Year	Crop[b]	Pasture[c]	Timber[d]	Urban[e]	Other[f]	Total
			Thousand acres			
1964	45,902	14,011	116,883	3,462	26,254	206,513
1969	52,640	13,039	115,479	4,171	20,016	205,344
1974	49,680	13,580	112,982	5,128	23,967	205,338
1978	52,288	11,853	111,844	5,944	23,409	205,338
1982	50,273	11,411	111,938	6,617	24,780	205,020
1987	47,425	11,706	112,128	7,279	26,482	205,020
1992	47,196	10,788	114,515	8,069	23,688	204,256
Net change from 1964	1,294	-3,223	-2,368	4,607	-2,567	
			Proportion			
1964	0.22	0.07	0.57	0.02	0.13	1.00
1969	0.26	0.06	0.56	0.02	0.10	1.00
1974	0.24	0.07	0.55	0.02	0.12	1.00
1978	0.25	0.06	0.54	0.03	0.11	1.00
1982	0.25	0.06	0.55	0.03	0.12	1.00
1987	0.23	0.06	0.55	0.04	0.13	1.00
1992	0.23	0.05	0.56	0.04	0.12	1.00

[a] Only the eastern parts of Oklahoma (18 counties) and Texas (37 counties) are included because forest area is largely contained in the eastern parts of these states.

[b] Cropland is defined as land from which crops were harvested or hay was cut; land in orchards, citrus groves, vineyards, and nurseries and greenhouses products; cropland used only for pasture or grazing; land in cover crops, legumes, and soil-improvement grasses; land on which all crops failed; land in cultivated summer fallow; and idle cropland. Data are from the census of agriculture.

[c] Pastureland is land used for pasture or grazing other than cropland or woodland pasture. Data are from the census of agriculture.

[d] Timberland is forest land capable of producing crops of industrial wood greater than 20 cubic feet per acre per year and not withdrawn from timber utilization. Data are from Powell et al. (1993) and linearly interpolated between agricultural census years.

[e] The definition of urban land is the area of places having 2,500 population or more. Data are from census of housing and population and linearly interpolated between agricultural census years.

[f] Other land is calculated as the area of land in uses other than crops, pasture, timberland, and urban.

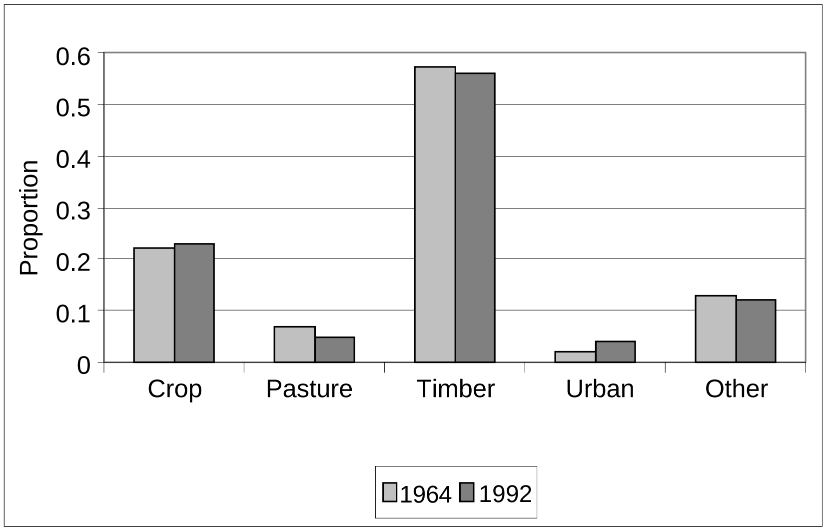

Figure 2—Historical changes in land use in the South-Central United States, 1964-92.

Table 2—Timberland in the South-Central United States, by ownership, 1952-92

Ownership	1952	1962	1977	1987	1992
	Thousand acres				
Federal	8,023	7,890	8,169	8,917	8,978
State	1,067	1,187	1,305	1,485	1,814
County and municipal	466	483	500	452	554
Total, public timberland	9,556	9,560	9,973	10,854	11,347
Forest industry	17,851	18,841	21,548	21,438	22,774
Farmer	44,187	36,873	29,573	28,157	21,041
Other private	43,885	52,389	50,718	51,679	59,354
Total, private timberland	105,923	108,103	101,839	101,274	103,168
All timberland	115,479	117,663	111,812	112,128	114,515

Source: Powell et al. 1993.

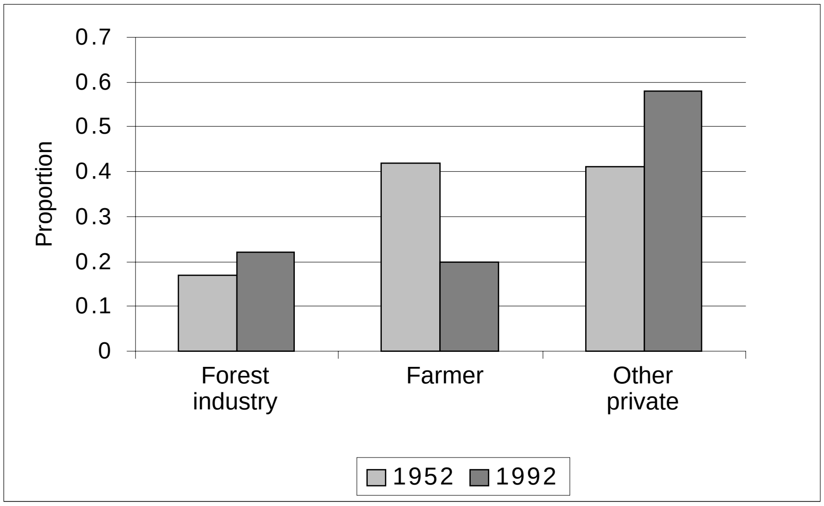

Figure 3—Changes in the ownership of private timberland in the South-Central United States, 1952-92.

58 percent in 1992, respectively (fig. 3). Farmer-owned timberland has shifted to either the forest industry or other private owners. Because forest industry timberland is managed intensively to produce timber and other forest products, the expansion of industry-owned timberland suggests that more and more timberland is being brought under intensive management practices in the region.

Hardwood forest types covered most of the forest land in the South-Central region in 1997 (USDA Forest Service 2000). Pine types covered about 24 percent of the region's forest land, the mixed oak-pine (predominantly hardwoods) type covered 16 percent, and hardwood types covered the remaining 60 percent. The hardwood types are those in upland and bottomland forest type classes. The softwood-producing forests contain the key pine plantation type; however, it covers less than one-seventh of the region's forest land base. The individual forest type covering the most area in the South-Central is the oak-hickory type (41 percent) followed by the loblolly-shortleaf pine type, (24 percent; table 3). The 1989 assessment (Alig and Wear 1992) projected that the conversion of natural pine stands to pine plantations would continue, along with conversion of some hardwood types to pine plantations.

Econometric Model

Land Use Share Model for Aggregate Data

The theoretical basis for our econometric model was rent maximization. Barlowe (1978) defines "land rent" as residual economic surplus; i.e., the total revenue less the total variable cost. The initial formulation of the concept of land rent is attributable to Ricardo (1817): "Rent is that portion of the produce of the earth, which is paid to the landlord for the use of the original and indestructible powers of the soils." Ricardo introduced the notion that land rent is a function of soil fertility or climate. Later, von Thunen (see Barlowe 1978) extended Ricardo's theory by adding location and transportation cost components to the model. Modern land use theory has been built on the early contributions of Ricardo and von Thunen and can be summarized as follows: Given a fixed land base, relative land rents are the key determinants of the allocation of land among competing uses. A recent addition to land use theory is the realization that heterogeneous land quality is crucial to determining the alternative uses of land. Studies by

Table 3—Timberland in the South-Central United States, by forest type, 1997

Forest type	Thousand acres	Proportion
Oak-hickory[a]	48,265	0.415
Loblolly-shortleaf pine[b]	27,528	0.237
Oak-pine[c]	18,451	0.159
Oak-gum-cypress[d]	16,202	0.139
Longleaf-slash pine[e]	3,147	0.027
Elm-ash-cotton-wood[f]	1,527	0.013
Other forest types	920	0.008
Nonstocked[g]	266	0.002
Total	116,306	1.000

[a] Forests in which upland oaks or hickories, singly or in combination, comprise a plurality of the stocking, except where pines comprise 25 to 49 percent, in which case the stand would be classified oak-pine. Common associates include yellow-poplar, elms, maples, and black walnut.

[b] Forest in which pines (except longleaf and slash pines) and eastern redcedar, singly or in combination, comprise a plurality of the stocking. Common associates include oaks, hickories, and gums.

[c] Forests in which hardwoods (usually upland oaks) comprise a plurality of the stocking, but in which softwoods, except cypress, comprise 25 to 49 percent of the stocking. Common associates include gums, hickories, and yellow-poplar.

[d] Bottomland forests in which tupelo, black-gum, sweet-gum, oaks, or southern cypress, singly or in combination, comprise a plurality of the stocking except where pines comprise 25 to 49 percent, in which case the stand would be classified oak-pine. Common associates include cotton-woods, willows, ashes, elms, hackberry, and maples.

[e] Forests in which longleaf or slash pines, singly or in combination, comprise a plurality of the stocking. Common associates include other southern pines, oaks, and gums.

[f] Forests in which elms, ashes, or cottonwood, singly or in combination, comprise a plurality of the stocking. Common associates include willow, sycamore, American beech, and maples.

[g] Timberland currently unoccupied by any live trees or seedlings; for example, recently clearcut areas.

Source: USDA Forest Service 2000.

Lichtenberg (1989) and Stavins and Jaffe (1990) demonstrate that existing aggregate land use allocations are strongly dependent on the characteristics of land. Importance of including land quality into a model for explaining current allocations has been proven through recent empirical analyses (Hardie and Parks 1997, Mauldin et al. 1999, Parks and Murray 1994, Plantinga et al. 1999, Wu and Segerson 1995).

A land use share model was used in the application of the data to the South-Central region. Following Ahn et al. (2000), the model was developed from the viewpoint of a landowner allocating a fixed amount of land to alternative uses. The solution to the landowner's optimization problem yielded an expression for the maximum discounted rents from each parcel of land. The profit expressions were incorporated into a second optimization problem to solve for the optimal shares of total land allocated to each use. The optimal share equations were aggregated to the county level to yield an econometric model that can be estimated with the available data. Optimal land use shares were expressed as a function of land rents and composite land quality measures.

Following the earlier authors (noted above), the optimal shares were specified as logistic functions of a linear combination of explanatory variables, X_{it}, and unknown parameters, β_k:

$$p_{ikt} = \frac{\exp(\beta_k^{'} X_{it})}{\sum_{s=1}^{3} \exp(\beta_s^{'} X_{it})} \cdot \qquad (1)$$

In equation (1), i indexes counties (i=1,2,…,I), k indexes land uses (k=1,…,K), and t indexes time. As noted above, the explanatory variables include county-level land rents and land quality measures. The logistic specification is used in many studies because it is a convenient way to constrain the shares to the unit interval.

As explained in Ahn et al. (2000), actual land use shares may differ from optimal land use shares owing to random factors such as weather. Thus, we may write the actual share of land allocated to use k, denoted y_{ikt}, as:

$$y_{ikt} = p_{ikt} + \varepsilon_{ikt} , \qquad (2)$$

where ε_{ikt} is an error term with zero mean. Substituting (1) into (2), and applying the transformation in chapter 19 of Judge et al. (1988), yields:

$$\ln(y_{ikt} / y_{i1t}) = \beta_k' X_{it} - \beta_1' \ X_{1t} + v_{kt} , \qquad (3)$$

where v_{kt} is a resulting error term.[3] In the estimation, we normalized the model with a forest share (y_{i1t}) equation. The model is identified if parameters are constrained by setting $\beta_1 = 0$ and can be consistently estimated with the ordinary least square procedure (OLS).

Data

The model in (3) was estimated by using OLS with pooled time-series and cross-sectional data. The panel data set for the South-Central region included 558 cross-sectional units (counties) and seven time points. The forest share, denoted , y_{ilt} was defined as the share of total land in private timberland in county i in time t. The small amount of forest land not meeting the timberland definition was excluded because timber yields are relatively low on these lands, thereby suggesting that their use is determined by factors other than net returns.[4] Public timberland was excluded for similar reasons. Observations for the 558 counties in the South-Central region were from FIA inventories conducted since the 1960s (table 4). At the state level, the forest share ranged from 48 percent in Kentucky to 69 percent in Alabama.

The agricultural share, y_{i2t}, was defined as the share of land in cropland and pasture. County-level observations were gathered from the census of agriculture for 1964, 1969, 1974, 1978, 1982, 1987, and 1992. In 1992, the agricultural land share ranged from 17 percent in Alabama to 41 percent in Kentucky. The share of land in urban and

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[3] Through the transformation, error terms in equation (3) become a function of parameters, indicating that heteroskedasticity is introduced in the covariance matrix of error terms. For technical details, refer to chapter 19 in Judge et al. (1988) and chapter 2 in Maddala (1983).

[4] The FIA definition of timberland is forest land that is producing, or capable of producing, more than 20 cubic feet per acre per year of industrial wood crops under natural conditions, that is not withdrawn from timber utilization, and that is not associated with urban or rural development (USDA Forest Service 2000).

Table 4—Forestry inventory analysis survey years in the South-Central United States, by state

State	Survey year
Alabama	1963, 1972, 1982, 1990
Arkansas	1969, 1978, 1988, 1995
Kentucky	1963, 1974, 1988
Louisiana	1963, 1974, 1984, 1991
Mississippi	1967, 1977, 1987, 1994
Oklahoma	1966, 1976, 1986, 1993
Tennessee	1961, 1971, 1980, 1989
Texas	1965, 1975, 1986, 1992

other uses, y_{i3t} , was defined as the share of total land in uses other than forestry and agriculture. This category includes developed land in urban, suburban, and rural areas and other unclassified land. Land in public forests and parks was excluded from total land area because these uses of land were assumed to be exogenously determined.

Because measurements of forest and agricultural land area were taken at different times, one of the data series had to be interpolated to produce a consistent set of observations. By examining the historical trends in land use in agricultural and forest land, we found that observed changes in agricultural land have been greater–in absolute and percentage terms–than changes in forest area (table 5). Because forest area seems to fluctuate less than agricultural land area, we can interpolate forest area observations more accurately. Thus, we constructed a set of forest area observations corresponding to the agricultural census years.

Net returns from private timberland were measured as the present discounted value of the infinite stream of real timber revenues per acre.[5] Revenue streams were calculated separately for major forest types (planted pine, naturally regenerated pine, oak-pine, oak-hickory, and oak-gum-cypress) by using type-specific timber yield curves, rotation lengths, and stumpage prices. We constructed two series of net returns, denoted fr_saw_{it} and fr_pulp_{it}, from sawtimber and pulpwood stumpage price series, respectively. Stumpage prices were from Timber-Mart South (TMS) for the period 1976-92. Net return series based on southern pulpwood and sawtimber prices were notably correlated, with a correlation coefficient of about 0.7. We included either sawtimber- or pulpwood-based net returns in the model, but not both because of multicollinearity concerns. We tested each net return series separately, as model 1 and model 2.

To calculate the sawtimber net returns, TMS pine sawtimber prices were used for planted and natural pine stands, and TMS mixed hardwood prices were used for oak-pine, oak-hickory, and oak-gum-cypress stands. To calculate pulpwood net returns, TMS pine pulpwood prices were used for planted and natural pine stands, and TMS hardwood pulpwood prices were used for oak-pine, oak-hickory, and oak-gum-cypress

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[5] Nominal net returns from forestry and agriculture were deflated by using the producer price index for all commodities (1982=100).

Table 5—Annual absolute and percentage changes in agricultural and private timberland area, South-Central United States, 1952-92

Year	Agri-culture[a]	Absolute change[b]	Percent change[b]	Timber-land[c]	Absolute change[b]	Percent change[b]
	- - - - - *Acres* - - - - -		*Percent*	- - - - - *Acres* - - - - -		*Percent*
1952		1,000		105,923		
1962				108,103	218	0.002
1964	59,913					
1969	65,679	1,153	0.019			
1974	63,260	-484	-0.007			
1977				101,839	-417	-0.004
1978	64,141	220	0.003			
1982	61,684	-614	-0.009			
1987	59,131	-510	-0.008	101,274	-57	-0.001
1992	57,984	-229	-0.004	103,168	379	0.004

[a] Agricultural land area is from the census of agriculture.

[b] All absolute and percentage changes are average annual changes between survey years.

[c] Private timberland is from Powell et al. (1993).

stands. Sawtimber and pulpwood stumpage price series for Louisiana (Howard 1997) were used to construct the price series of sawtimber and pulpwood for each state for the years prior to 1976.[6] It was assumed that landowners consider the average price over the preceding 3 years when forming expectations of future prices.

Yield curves were from Birdsey (1992), and rotation lengths corresponded to the Faustmann rotation for a 5-percent discount rate. Revenue streams also were discounted by using a 5-percent rate. Timber management costs were ignored because intensively managed timberlands remain a relatively small portion of the private timberland base in the South (Dubois et al. 1997, USDA Forest Service 1988). Finally, net returns for individual counties were calculated as a weighted average of type-specific net returns, where the weights were based on the forest-type composition of each county's timberland.

Agricultural net returns, ar_{it}, were measured as the real annual per-acre net returns (1982=100) from cropland and pastureland. Net returns for each county is a weighted average of revenues (price times yield) less variable production costs for major crops and pasture uses, where the weights correspond to crop and pasture shares of total agricultural land. Annual average crop prices were compiled from each state's agricultural statistics service, and yield data for each county and crop were obtained from the census of agriculture and the USDA Economic Research Service (ERS). Variable production costs equaled the total variable cash expenditures per acre, as reported in regional crop budget reports developed by ERS. It was assumed that farmers base their expectations of future net returns on the net returns of the prior year.

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[6] Starting with the 1976 observations for each state, we constructed a price series back to 1961 by assuming that annual percentage changes would be the same as those in the Louisiana series for this period.

In many empirical land use analyses, population measures are used to account for the allocation of land to nonrural uses (e.g., Hardie and Parks 1997, Wu and Segerson 1995). For our study, population density (total population divided by total land area in the county), pd_{it} , was used to explain the share of land devoted to urban and other uses. Total population for each county was taken from Bureau of the Census reports, and linear interpolation was used to estimate population in years between censuses. In addition to population density, a distance measure was introduced to explain the share of urban and other land. The rationale for the distance measure was the notion that land in rural counties close to a city (pop. $\geq$ 25,000) has more potential for conversion to developed uses than does land in counties farther away. The variable, $dist_i$, was calculated as the distance from the town located in the center of each county to the closest city with a population of more than 25,000.[7] For the distance calculation, the software package PC Miler was used.[8] The variable, $dist_i$, was not indexed by time because the distance measures remained the same over time.

Two land quality measures were included in the model: the average land capability class (LCC) rating (USDA 1973), lq_{1i} , and the percentage of total land in LCCs I and II, lq_{2i}. The LCC ratings were derived from county-level soil surveys and based on 12 soil characteristics (e.g., slope and permeability). Ratings range from I to VIII, where I is the most productive land and VIII is the least productive. Thus, a county with a higher value of lq_{1i} has lower quality land, on average. The variable lq_{2i} was included to account for the presence of highly productive land suitable for intensive agricultural uses. The ratings lq_{1i} and lq_{2i} were not indexed by time because land quality measures remain essentially constant over time.

In addition to the independent variables described above, we augmented the model by including a set of FIA survey unit dummy variables (*D*2 to *D*37) to capture cross-sectional variation in the dependent variable not accounted for by the other regressors. As mentioned earlier, we were concerned with measuring the temporal response to changes of independent variables and had to ensure that our model adequately controlled for spatial variation in the dependent variables (Ahn et al. 2000). A dummy variable, *D*1, was dropped from the model to avoid perfect multicollinearity with the overall constant term.

Estimation

From the model in equation (3), $\ln(y_2/y_1)$ and $\ln(y_3/y_1)$ were specified as linear functions of the independent variables described above and were estimated by using OLS procedures. It is well known that the logarithmic transformation introduces heteroskedasticity in error terms of the sort in equation (3). We used White's (1980) estimate of the covariance matrix, which allows for a general form of heteroskedasticity structure. Because the same set of independent variables was used in both equations,

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[7] Choosing 25,000 for the population is arbitrary. According to one of the definitions of urban land by the Bureau of the Census, an urban area is defined as an area having more than 2,500 in population, and a metropolitan area (MA) is defined as an area having more than 50,000 in population. We tried various cutoff numbers between 2,500 and 50,000 and reached the conclusion that a population of 25,000 is reasonable to use. There is not much supporting theory for choosing 25,000. However, it served our purpose well in that we wanted to include cities of reasonable size as well as metropolitan areas.

[8] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

there were no efficiency gains from estimating the equations as a system. Thus, the OLS estimator applied to each equation was identical to the seemingly unrelated regression (SUR) estimator. Two versions of the models were estimated: model 1 used the forest rent calculated from sawtimber prices (*fr_saw*), and model 2 used the forest rent calculated from pulpwood prices (*fr_pulp*).

Estimation Results

Model 1

The estimation results for model 1 are presented in table 6. Total differentiation of equation (3) indicated that the estimated coefficients measure the percentage of change in the share ratio for a one-unit change in the independent variable, all else equal. In the $1\text{n}(y_2/y_1)$ equation, the coefficients on forest and agricultural rents are negative and positive, respectively, as expected, and both are significantly different from zero at the 1-percent level. All else equal, a one-unit change in the forest rent (*fr_saw*) decreases the ratio of agricultural to forest land (y_2/y_1) by 0.1 percent. Higher forest rents are expected to increase the forest share and decrease the agricultural share, thereby decreasing (y_2/y_1). In contrast, a one-unit increase in agricultural rents (*ar*) tends to increase the share ratio by 0.3 percent, most likely by shifting land from forest to agriculture. The positive estimate of the coefficient on population density (*pd*) indicates that a higher population density tends to increase the ratio of agricultural to forest land; however, it is not significantly different from zero. The negative estimate of the coefficient on the distance measure (*dist*) suggests that a county located farther from a city tends to have a smaller ratio of agricultural to forest land; however, it is not statistically significant.

Both land quality variables were significantly different from zero at the 1-percent level. The estimated coefficient on lq_1 (the average LCC rating) was negative. A higher value of lq_1 indicated that a county has lower land quality on average, and this tends to correspond to a smaller share of agricultural land relative to forest land. Conversely, counties with a larger percentage of high-quality land (i.e., a larger value of lq_2) would be expected to have more agricultural land relative to forest, implying a positive coefficient on lq_2. Unexpectedly, we estimated a negative coefficient on the lq_2 variable. Of the FIA survey-unit dummy variables (*D*2 to *D*37), all except *D*9 and *D*23 were significantly different from zero at the 5-percent level, indicating systematic differences across the FIA survey units not accounted for by the other variables in the model.[9] The insignificance of *D*9 (southwest unit in Arkansas) and *D*23 (northwest unit in Louisiana) seems to be due to the similarities between these units–they are adjacent to each other.

The results for the second equation, $1\text{n}(y_3/y_1)$, supported the previous empirical findings that the driving forces determining what land is developed are population and locations. Population density (*pd*) had a positive and significant effect on the ratio of urban and other land to forest land. Conversely, the effect of distance (*dist*) on the share ratio was negative and significant, thereby indicating that a county closer to cities has more urban and other land relative to forest than countries farther away.

It is conceivable that the area of urban and other land could decline as forest rent increases, thus leading to a negative sign on forest rents (*fr_saw*), because of the possibility that “other land” is converted to forest. Unexpectedly, we observed a positive sign on forest rents; however, it was not statistically significant. We do not have much a priori information on how agricultural rents (*ar*) affect the ratio of urban and other land to forest land. However, we observed positive, but not significant, effects. The effects of lq_1 and lq_2 on $1\text{n}(y_3/y_1)$ are ambiguous a priori. The results showed that counties with

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[9] Parameter estimates for the FIA survey-unit dummy variables are not reported in table 6 owing to space limitation.

Table 6—Estimation results of models for the South-Central United States[a]

Independent variable	Model 1, dependent variables		Model 2, dependent variables	
	$1n(y_2/y_1)$	$1n(y_3/y_1)$	$1n(y_2/y_1)$	$1n(y_3/y_1)$
Constant	0.74**	-1.48**	1.67**	-1.05**
	(0.22)	(0.25)	(0.26)	(0.27)
fr_saw	-0.001**	0.0006		
	(0.0004)	(0.0004)		
fr_pulp			-0.025**	-0.007*
			(0.004)	(0.004)
ar	0.003**	0.0001	0.002**	0.000002
	(0.0004)	(0.0005)	(0.0004)	(0.0005)
pd	0.07	1.40**	0.03	1.39**
	(0.08)	(0.04)	(0.07)	(0.08)
dist	-0.001	-0.006**	-0.001	-0.006**
	(0.0006)	(0.0007)	(0.0006)	(0.0007)
lq_1	-0.64**	-0.16**	-0.65**	-0.17**
	(0.03)	(0.04)	(0.03)	(0.04)
lq_2	-0.56**	0.21	-0.63**	0.18
	(0.22)	(0.23)	(0.22)	(0.23)
Adjusted R^2	0.74	0.44	0.74	0.44

* Significance at the 10-percent level.

** Significance at the 5-percent level.

[a] Parameter estimates for FIA survey-unit dummy variables, *D*2 to *D*37, are not reported in this table. Standard errors are in parentheses.

higher average LCC ratings (lq_1), corresponding to lower average land quality, tended to have more urban and other land relative to forest. Counties with a greater share of high-quality land (lq_2) tend to have more urban and other land relative to forest; however, the co-efficient estimate was not significant. High-quality land tends to be level and accessible, so it may provide better opportunities for conversion to developed uses. Of the FIA survey-unit dummy variables (*D*2 to *D*37), all variables except *D*2, *D*9, *D*23, and *D*36 were statistically significant from zero at the 5-percent level, thereby indicating system-atic differences across the FIA survey units.[10]

The adjusted R-squared statistics indicated that the explanatory variables explain 74 percent and 44 percent, respectively, of the total variation in the dependent variables of the $1n(y_2/y_1)$ and $1n(y_3/y_1)$ equations.

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[10] D2, D9, D23, and D36 are dummy variables for the southwest-north unit in Alabama, southwest unit in Arkansas, northwest unit in Louisiana, and northeast unit in Texas, respectively.

Model 2

The estimation results for model 2 (table 6) were similar to those for model 1. One notable difference was that the dependent variables were more responsive to pulpwood rents than to sawtimber rents. For the $\ln(y_2/y_1)$ equation, in particular, the coefficient estimate for *fr_pulp* (-0.025) was 25 times larger in absolute value than that for *fr_saw* (-0.001). It is conceivable that landowners are more sensitive to pulpwood prices than to sawtimber prices because of shorter rotation ages associated with pulpwood production. Another plausible explanation for this difference is that the pulpwood and sawtimber rent measures provide the same information, but the smaller magnitude of the pulpwood rent variable inflates the coefficient estimate.

All the signs of the coefficient estimates in the two equations are the same as for those in model 1, except the sign for forest rents in the $\ln(y_3/y_1)$ equation. As well, with the exception of the sawtimber and pulpwood rent variables, the magnitudes of most coefficient estimates are similar to those in model 1. Thus, all the interpretations regarding coefficient estimates in model 1 are carried over. For the $\ln(y_2/y_1)$ equation, all FIA survey-unit dummy variables except *D*21, *D*22, *D*23, *D*27, *D*32, and *D*34 are significantly different from zero. For the $\ln(y_3/y_1)$ equation, all FIA survey-unit dummy variables except *D*9, *D*21, *D*23, *D*32, and *D*36 are statistically significant.[11] The explanatory powers of model 2, indicated by adjusted R-squared statistics, are 0.74 and 0.44 for the $\ln(y_2/y_1)$ and $\ln(y_3/y_1)$ equations, respectively.

Land Use Projections

The parameter estimates in the models (table 6) were used to project land use shares for the South-Central United States. The projected land use shares were computed as:

$$\hat{p}_{ikt} = \frac{\exp(\hat{\beta}_k' X_{it})}{\sum_{s=1}^{3} \exp(\hat{\beta}_s' X_{it})} \quad , \tag{4}$$

where $k = 1, 2, 3$; $\hat{\beta}_k$ is the vector of coefficient estimates for the $\ln(y_k/y_1)$ equations in table 6; $\hat{\beta}_1 = 0$; and X_{it} is the corresponding vector of explanatory variables for county i in time t. We set the coefficient estimate equal to zero for the forest rent variable in the $\ln(y_3/y_1)$ equation in model 1 to preclude land use projections inconsistent with historical trends and opposite to expectations, owing to the estimated wrong sign. This procedure can be justified by the coefficient estimate not being statistically significant, and the magnitude of estimate being very close to zero. Thus, it was not expected to have much influence on the size of changes. Another justification was that important factors determining urban land use are population and locations and not direct economic rents.

The projections of land use shares to 2050 were based on projections of stumpage prices and population, as all other variables were assumed to remain constant at values in 1992. Thus, the land allocations in 1992 were used as the baseline for the projections. We assumed a 0.5-percent real annual increase in stumpage prices for both sawtimber and pulpwood by examining stumpage price trends for the past 20 years. The projections of population (table 7) were from the U.S. Department of Commerce (1995) and were linearly interpolated for the projection years. Long-term projections of agricultural rents were not available for this analysis.

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[11] *D*9, *D*21, *D*22, *D*23, *D*27, *D*32, *D*34, and *D*36 are FIA survey-unit dummy variables representing the southwest unit in Arkansas, southwest unit in Louisiana, southeast unit in Louisiana, northwest unit in Louisiana, south unit in Mississippi, west-central unit in Tennessee, plateau unit in Tennessee, and northeast unit in Texas, respectively.

Table 7—Population projections to 2045, by state, South-Central United States

State	2000	2005	2015	2025	2045
			Thousands		
Alabama	4,383	4,516	4,841	5,211	5,899
Arkansas	2,567	2,655	2,854	3,078	3,461
Kentucky	3,967	4,086	4,364	4,666	5,217
Louisiana	4,478	4,611	4,901	5,221	5,751
Mississippi	2,750	2,819	2,987	3,180	3,524
Oklahoma	3,406	3,517	3,764	4,036	4,484
Tennessee	5,521	5,771	6,282	6,784	7,686
Texas	19,724	20,734	22,673	24,514	27,635
Total	46,796	48,709	52,666	56,690	63,657

Source: U.S. Department of Commerce 1995.

We introduced two sets of scenarios to evaluate various possibilities. The first set was based on the estimates of model 1 (scenarios 1 and 2), and the second set (scenarios 3 and 4) was based on the estimates of model 2. Scenario 1 include only population change, and scenario 2 included both population and sawtimber price changes, given the estimates of model 1. Scenario 3 contained only population change, and scenario 4 incorporated both population and pulpwood price changes, along with the estimates of model 2.

Both scenarios 1 and 3, reflecting changes in population only but based on equation coefficients from different models, provide similar projections of future land use. According to the projection results from scenario 1 (table 8), the land allocated to urban and other land will continue to increase with population growth from 32.9 million acres in 1992 to 35.2 million acres in 2050. Private timberland and agricultural land decreases over the projection period to compensate for the increase in urban and other land. Similar land use projections are gained from scenario 3 (table 9). Urban and other land increase from 32.9 million acres in 1992 to 35.4 million acres in 2050, and the private timberland and agricultural land diminish over time. Comparing the two scenarios, increases in urban and other land due to population growth are slightly greater with the estimates of model 2 (using pulpwood prices) than model 1 (using sawtimber prices). The private timberland and agricultural land decrease over the projection period to compensate for the increases in urban and other land. Results from both scenarios show that more forest land than agricultural land is converted to urban and other land.

Once we included stumpage price changes as a part of the scenario along with population change, the projection results provided quite different pictures of future land use, depending on which model's estimates were used. Although the results from both scenarios showed the same trend of land use allocations over the projection period, the magnitudes of change, especially in forest land, were notably different. According to the projection results from scenarios 2 (table 10) and 4 (table 11), the increases in forest land for the entire region over the next 50 years (due to stumpage prices increases based on the estimates with model 2) are about 4 million acres greater than increases with model 1.

Table 8—Projections of land use in the South-Central United States to 2050 with scenario 1[a b]

	Year					
Land use	**1992**	**2010**	**2020**	**2030**	**2040**	**2050**
	Thousand acres					
Private timber	101,705	101,174	100,911	100,667	100,441	100,219
Agriculture	57,984	57,683	57,538	57,406	57,285	57,167
Urban and other	32,855	33,687	34,095	34,472	34,818	35,158
Total area	192,544	192,544	192,544	192,544	192,544	192,544
	Proportion					
Private timber	0.528	0.525	0.524	0.523	0.522	0.520
Agriculture	0.301	0.300	0.299	0.298	0.298	0.297
Urban and other	0.171	0.175	0.177	0.179	0.181	0.183
Total	1.000	1.000	1.000	1.000	1.000	1.000

[a] Population change only with the estimates from model 1.

[b] The baseline year for the projections is 1992. Total lands in table 8 through 11 exclude public forest lands and thus are different from those in table 1.

Table 9—Projections of land use in the South-Central region to 2050 with scenario 3[a b]

	Year					
Land use	**1992**	**2010**	**2020**	**2030**	**2040**	**2050**
	Thousand acres					
Private timber	101,705	101,146	100,865	100,602	100,358	100,117
Agriculture	57,984	57,654	57,492	57,343	57,206	57,073
Urban and other	32,855	33,745	34,187	34,599	34,980	35,355
Total area	192,544	192,544	192,544	192,544	192,544	192,544
	Proportion					
Private timber	0.528	0.525	0.524	0.522	0.521	0.520
Agriculture	0.301	0.299	0.299	0.298	0.297	0.296
Urban and other	0.171	0.175	0.178	0.180	0.182	0.184
Total	1.000	1.000	1.000	1.000	1.000	1.000

[a] Population change only with the estimates from model 2.

[b] The baseline year for the projections is 1992. Total lands in table 8 through 11 exclude public forest lands and thus are different from those in table 1.

Table 10—Projections of land use in the South-Central region to 2050 with scenario 2[a] [b]

Land use	1992	2010	2020	2030	2040	2050
	Thousand acres					
Private timber	101,705	101,815	101,860	101,938	102,051	102,183
Agriculture	57,984	57,139	56,742	56,347	55,952	55,548
Urban and other	32,855	33,590	33,941	34,258	34,541	34,813
Total area	192,544	192,544	192,544	192,544	192,544	192,544
	Proportion					
Private timber	0.528	0.529	0.529	0.529	0.530	0.531
Agriculture	0.301	0.297	0.295	0.293	0.291	0.288
Urban and other	0.171	0.174	0.176	0.178	0.179	0.181
Total	1.000	1.000	1.000	1.000	1.000	1.000

[a] Both population and sawtimber prices change with the estimates from model 1.

[b] The baseline year for the projections is 1992. Total lands in table 8 through 11 exclude public forest lands and thus are different from those in table 1.

Table 11—Projections of land use in the South-Central region to 2050 with scenario 4[a] [b]

Land use	1992	2010	2020	2030	2040	2050
	Thousand acres					
Private timber	101,705	103,459	104,127	104,844	105,610	106,408
Agriculture	57,984	55,348	54,207	53,053	51,887	50,697
Urban and other	32,855	33,738	34,210	34,647	35,048	35,439
Total area	192,544	192,544	192,544	192,544	192,544	192,544
	Proportion					
Private timber	0.528	0.537	0.541	0.545	0.548	0.553
Agriculture	0.301	0.287	0.282	0.276	0.269	0.263
Urban and other	0.171	0.175	0.178	0.180	0.182	0.184
Total	1.000	1.000	1.000	1.000	1.000	1.000

[a] Both population and pulpwood prices change with the estimates from model 2.

[b] The baseline year for the projections is 1992. Total lands in table 8 through 11 exclude public forest lands and thus are different from those in table 1.

Forest land in model 2 increases by 4.703 million acres from 1992 to 2050, while forest land in model 1 increases by 0.478 million acres. This difference in projections seems to be attributable to the model estimation result that the dependent variables, the ratio of agricultural to forest land and the ratio of urban and other land to forest land, in model 2 are more sensitive to forest rents based on pulpwood prices than are those based on sawtimber prices in model 1.

Based on the projections with scenario 2 (table 10), private timberland increases slightly from 101.7 million acres in 1992 to 102.2 million acres in 2050. The urban and other lands are projected to increase from 32.9 million acres in 1992 to 34.8 million acres in 2050. Agricultural land continuously decreases, mirroring the increases in the timberland and urban and other land. The projection results with pulpwood price changes (scenario 4, table 11) indicate that the private timberland is projected to increase from 101.7 million acres in 1992 to 106.4 million acres in 2050. Urban and other lands are projected to increase from 32.9 million acres in 1992 to 35.4 million acres in 2050. The agricultural land continuously decreases to compensate for the increases in timberland and urban and other land.

Conclusions

There were two objectives for this exercise. One was to present the historical trends and future projections of forest, agricultural, and urban and other land uses for the South-Central region of the United States. The other objective was to examine which stumpage price series, sawtimber or pulpwood, better fits the data and which is more appropriate to use for long-term projections. To serve these purposes, we adopted a standard land use share model and constructed a panel data set, which covers both time-series and cross-sectional observations. Two versions of the model were estimated to generate long-term projections of land use for the South-Central region. In each case, the same set of independent variables was used, except in model 1 forest rents were calculated from sawtimber prices and in model 2 from pulpwood prices. These two versions of the model allowed us to investigate the second objective of this study.

Estimation results for the two versions were similar, except that the coefficient estimates of pulpwood rents were considerably larger than those for sawtimber rents. One explanation for this difference is that the pulpwood and sawtimber rent measures provide the same information, yet the smaller magnitude of the pulpwood rent variable inflates the coefficient estimate. Another plausible explanation can be provided from the perspective of a landowner’s decision process. Landowners may be more sensitive to pulpwood prices than to sawtimber prices owing to shorter rotation ages for pulpwood production. Also, the estimate of forest rent based on sawtimber prices from the $\ln(y_3/y_1)$ equation in model 1 shows a wrong sign, even if it is not statistically significant. The explanatory powers of both models, however, indicated by adjusted R-squared statistics, were almost identical for both equations. The R-squared statistics in both models were 0.74 for the $\ln(y_2/y_1)$ equations and 0.44 for the $\ln(y_3/y_1)$ equations. If we were to consider the performance of the forest rent variables only, then pulpwood forest rents might be a better choice; however, the same explanatory powers from both models warrant a caveat. Thus, further investigation is needed, and it is difficult to reach a conclusion on which stumpage price series is more appropriate for use in long-term projections.

We augmented the standard land use share model by incorporating fixed effects for cross-sectional observations as measured by a set of FIA survey-unit dummy variables. For the purpose of long-term land projections with panel data, which in our case has only a few time-series observations and comparatively many cross-sectional observations, it is important to control for spatial variation in the dependent variable so that limited information over time can be used to capture the temporal relations. Most of the FIA dummy variables were statistically significant, thereby indicating the presence of systematic differences among the FIA survey units. Further investigation of spatial variation is warranted for future data improvements and related research. This would include associated investigations in land use studies of spatial relations involving land quality, population, and distance to economic nodes.

We developed long-term projections of land use to 2050 for the South-Central United States, by using a 0.5-percent annual increase in real stumpage prices and baseline projections of population growth, with two versions of the models. This led to two sets of projection results. We examined four scenarios. Scenario 1 included only population change, and scenario 2 includes both population and sawtimber price changes based on the estimates of model 1. Scenario 3 contains only population change and scenario 4 incorporates both population and pulpwood price changes based on the estimates of model 2.

Projections from scenario 1 and 3 were very similar. Major differences in land use projections are found in the results from scenarios 2 and 4 (tables 10 and 11). The increase in forest land over the next 50 years due to stumpage price increases is almost four million acres larger or 10 times greater with model 2 than with model 1. These differences in forest land projections were somewhat expected because we observed that the dependent variables were more sensitive to pulpwood rents than to sawtimber rents. The magnitudes of the coefficients have implications for projections of land use.

It is difficult to suggest which price series is more appropriate for the purpose of long-term forest land projections based on the results of this study, because both price series provided the same general trends in projected long-term land allocations. Although forest land projections from the pulpwood price series presented notably larger numbers than those from the sawtimber price series, the absolute magnitude of increase in forest land for the next 50 years (4.703 million acres) can be viewed as plausible. One might argue that the projected changes in forest land with sawtimber prices are too small. In addition, the assumed increases in stumpage prices (0.5- percent annual increases in this exercise) are critical to the magnitudes of changes in forest land projections. For example, if instead we assume an annual increase of 1.5 percent in stumpage prices, then the increases in timberland with pulpwood prices are likely to be relatively large as a result of the relatively large magnitude of coefficient estimate.

The decision on which stumpage price to use may depend largely on whether landowners consider sawtimber or pulpwood rents in making land allocation decisions. Further research is warranted to determine whether landowners consider sawtimber rents or-pulpwood rents–or perhaps, some combination of the two–in making land allocation decisions. A contribution of this exercise is an empirical finding that landowners are more sensitive to pulpwood price series than sawtimber price series. However, reliable stumpage price projections will certainly improve the reliability of forest land projections. Finally, a caveat is that our projections assume that real agricultural rents remain fixed at 1992 levels, and additional research is warranted to provide consistent long-term agricultural price projections.

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