Tree Planting in the South: What Does the Future Hold?

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ABSTRACT: *Projected increasing demands for timber coupled with reduced harvests on public lands have led to concern among some forest policymakers regarding the adequacy of future U.S. timber supplies. One question concerns the likelihood that prevailing market incentives will induce industrial and nonindustrial private landowners to intensify forest management. We develop empirical models of historical tree planting in the southern United States as functions of economic variables and federal cost sharing. We use the models to test whether tree planting has been measurably different in recent years and to make 50 yr projections of future tree planting. Harvest rates, tree planting costs, and federal cost-sharing are shown to be important factors affecting nonindustrial private tree planting, while harvest rates, land values, and interest rates are important factors affecting industrial tree planting. Nonindustrial private tree planting is projected to decline gradually with anticipated rising planting costs and continuation of lower levels of federal tree planting cost-share assistance. Industrial tree planting is projected to rise gradually with anticipated increasing industrial harvest rates. South. J. Appl. For. 26(2):99–107.*

Key Words: Nonindustrial private forest owners, forest industry, cost-share programs, carbon sequestration, Renewable Resources Planning Act.

Economic and social forces affecting forest management in the United States have been changing in recent years. Increasing human populations, sustained economic growth, and rising incomes have led to increasing national and international demands for timber (Haynes et al. 1995). These factors, along with changing public attitudes toward the environment, are also resulting in growing demands for nontimber forest outputs such as outdoor recreation, aesthetics, and wildlife habitat. Interest also continues to grow regarding the role of the nation's forests in mitigating global climate change through the sequestration of carbon and protecting biological diversity. Together, these factors have led forest policymakers to question the adequacy of forestlands in the United States to meet growing and competing demands of the future.

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Management on privately owned forestlands in the southern United States is of particular interest. It possesses over half of the privately owned timberland in the United States and nearly 40% of the nation's total timberland (Smith et al. 2001). Timberland is defined as forestland capable of producing at least 20 ft^3 of merchantable wood per acre per year. Forest management practices on private timberlands are important determinants of the distribution, composition, and structure of forests (Guldin and Wigley 1998, Wyant et al. 1991). Reduced timber harvests from western national forests have influenced the supply dynamics of timber in the entire United States (Adams et al. 1996). The effects these changes have had on forest management and investment by private landowners in the southern United States remain unclear.

One possibility is that southern forestland owners will intensify their timber management activities and increase their rates of tree planting (Alig et al. 1998). Although the economic potential of increased tree planting is significant (Alig et al. 1999), especially on nonindustrial private lands, historical trends suggest that its actual likelihood is less certain. Higher levels of tree planting would increase future timber supplies and reduce demands on other U.S. forestlands that produce desired nontimber outputs such as ecological protection and other environmental amenities.

To help clarify these issues, we examine historical rates of tree planting in the southern United States. We develop econometric models of tree planting as functions of economic variables and federal cost sharing. We use the models to examine whether rates of tree planting during recent years have been statistically different from longer term historical rates, as a test of increasing forest management intensity. The empirical models also are used to make 50 yr projections of future tree planting by nonindustrial and industrial private forestland owners for the Renewable Resource Planning Act (RPA) Assessment and to examine the likely impact of different economic and policy scenarios. The analysis and projections are intended to contribute to current and future forest policy and management decisions by describing and discussing the impact of various factors on private investment in forestry.

Tree Planting in the South

Several studies have examined tree planting by private landowners in various regions of the United States (Alig et al. 1990 review several studies, Hardie and Parks 1991, Lee et al. 1992). The study area for this analysis includes 12 states classified by the USDA Forest Service as the South in the 2000 Renewable Resource Planning Act Assessment, including Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North and South Carolina, Oklahoma, Tennessee, Texas, and Virginia (Figure 1). Kentucky also is generally included in the southern region, but is excluded from this analysis because statewide data describing key explanatory variables are unavailable and because Kentucky historically has had relatively low rates of tree planting. The South accounts for a significant proportion of all land planted in trees in the United States—79% in 1998 (Moulton and Hernandez 2000). The South contains nearly 180 million ac of privately owned timberland (Smith et al. 2001).

The timberlands of the South occur across a diversity of physiographic regions, including parts of the Atlantic and Gulf Coastal Plains, the Piedmont, Mountains, and Interior Highlands. These timberlands occupy a diversity of topographic positions ranging from perennially flooded swamps to relatively dry sites on deep, coarse sands. Southern timberlands are comprised of five major forest types including planted pine, naturally regenerated pine, mixed oak–pine, upland hardwoods, and bottomland hardwoods (Butler and Alig n.d.). Ninety percent of the timberlands in the South are owned by private landowners, with the balance split between various public ownerships. Of private timberlands, 79% are owned by nonindustrial private landowners and 21% are owned by forest industry landowners, defined as entities owning or operating primary wood processing facilities (Smith et al. 2001).

Historically, industrial landowners have accounted for a greater proportion of tree planting in the South than have nonindustrial private landowners (Figure 2), with the exceptions being years during significant tree planting efforts associated with such federal programs as the Soil Bank (1956 to 1963) and Conservation Reserve Programs (since 1986). Industrial tree planting reached a historical peak during the mid-1980s, declined somewhat since 1988, and has been on par with nonindustrial private planting since then. The modest increase in industrial tree planting evident during 1997 was due largely to replanting efforts in Alabama on industrial forestlands damaged by Hurricane Opal in October 1995 (Moulton 1999). Dramatic declines in timber harvesting on public lands located mostly in western states have lead many forest industry observers to expect resulting increases in investment in tree planting on private lands in the South as private landowners speculate on future timber demands (Adams et al. 1996). However, recent declines in tree planting by industrial landowners have prompted speculation regarding whether a structural change has occurred in industrial planting behavior.

Conceptual Framework

A conceptual framework for examining tree planting by private landowners is based on an economic market model describing the supply and demand for tree plantations (Cohen 1983, Lee et al. 1992). The supply of tree plantations can be described as

$$Supply_{PL} = f(P_{PL}, Z, CS) \tag{1}$$

where P_{PL} is the price of tree plantations, Z is a vector of other factors influencing plantation supply decisions such as the availability of vacant land on which to plant trees, input costs for additional land as well as planting costs, and potential revenues derived from future timber production, and CS is a

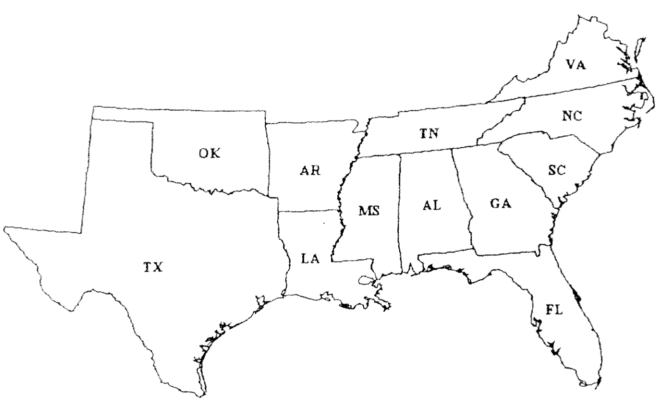

Figure 1. States comprising the southern United States,

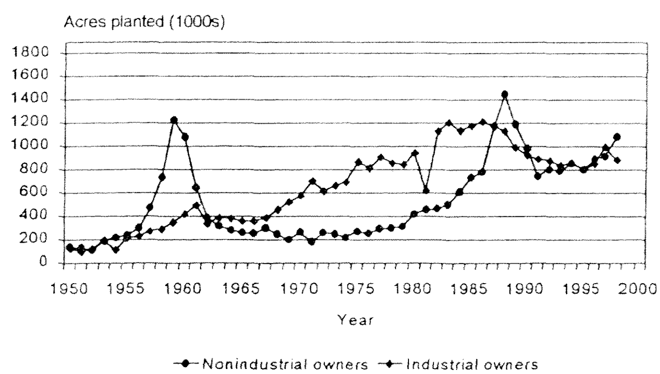

Figure 2. Tree planting by private owners in the South, 1950–1998 (USDA Forest Service 1950–1998).

vector representing the areas of land planted using federal cost-sharing assistance. The demand for tree plantations can be described as

$$Demand_{PL} = f(P_{PL}, X) \tag{2}$$

where P_{PL} is the price of tree plantations and X is a vector of factors influencing the demand for tree plantations, including the value of alternative investments (Lee et al. 1992).

Following Lee et al. (1992, p. 205), we derive a reduced form equation. At market equilibrium, the quantity of tree plantations supplied equals the quantity demanded so that the supply and demand equations intersect as

$$S_{PL}(P_{PL}, Z, CS) = D_{PL}(P_{PL}, X) \tag{3}$$

Solving for plantation price P_{PL} we obtain

$$P_{PL} = f(X, Z, CS) \tag{4}$$

Finally, we replace P_{PL} in the supply equation (1) with Equation (4) to obtain an expression describing the quantity of tree plantations supplied Q_{PL} as

$$Q_{PL} = f(X, Z, CS) \tag{5}$$

which is the equation to be estimated in our econometric models (Lee et al. 1992).

Econometric Models

We estimate two econometric models using ordinary least squares to describe historical rates of tree planting by nonindustrial and industrial private landowners as functions of several explanatory variables. The dependent variables used in the two equations represent quantities of tree plantations (Q_{PL}) as total areas of land planted in trees by nonindustrial and industrial private landowners each year (USDA Forest Service 1950–1998). Tree planting data include both cost-shared acres planted using federal cost-sharing assistance as well as non-cost-shared acres. Several explanatory variables (Table 1) are included in the econometric models to account for factors potentially influencing tree plantation supply and demand decisions (Z and X), as well as the areas of land planted using federal cost-sharing assistance (CS).

There are likely several factors that have the potential to affect tree planting over time. These factors might include the future demand for pulpwood and sawtimber from southern forests, changes in forest productivity, changes in forest ownership and management, and economic changes that affect the value of alternative land uses such as agriculture, among others. In econometric modeling, variable selection often necessitates that trade-offs be made among data availability, quality, and temporal or spatial coverage. Effects of any omitted factors remain as potential sources of error in estimated models. Alig et al. (1990) provide detailed discussion regarding explanatory variables commonly used in econometric tree planting models and how well each has performed in previous studies. This previous work guided our selection of explanatory variables tested in the empirical models.

Industrial private and industrial timber harvest rates are included in the models to represent the potential supply of recently harvested forestland available for replanting and are

Table 1. Definitions of explanatory variables tested in the tree planting models.

Variable	Definition
Nonindustrial private harvest	Softwood harvest on other private timberlands in millions of cubic feet (Adams 2000) during the preceding year.
Industrial harvest	Softwood harvest on forest industry timberlands in millions of cubic feet (Adams 2000) during the preceding year.
Stumpage price	Average value of softwood pulpwood stumpage sold (Timber Mart-South 1999) in dollars (1992) per standard cord. Data for 1950 to 1977 estimated using linear regression with pulpwood prices reported by Ulrich (1987): $y = (0.262*x) - 0.116$, $R^2 = 0.928$, and $F = 103.955$ ($df = 8$). The t-statistic for the slope coefficient is 10.196.
Pulpwood price	Weighted average value of delivered southern pine pulpwood by harvested area for the southeast and south central regions (Ulrich 1987, Howard 1999) in dollars (1992) per standard cord.
Planting cost	Average planting costs in dollars (1992) per acre, including mechanical site preparation, hand-planting, machine-planting, chemical tree removal, and prescribed burning (Dubois et al. 1997), weighted based on area of treatment. Data reported on a 3 yr average interval. Costs for missing years found by interpolation.
Land value	Weighted average of farm real estate values in dollars (1992) per acre by state, from the USDA Economic Research Service annual time series of farm real estate values.
Interest rate	3 month Treasury Bill rate reported by the Federal Reserve.
Soil Bank cost-shared acres	Acres (1,000s) planted in trees cost-shared under the Soil Bank Program (Lee et al. 1992).
ACP cost-shared acres	Acres (1,000s) planted in trees cost-shared under the Agricultural Conservation Program (Lee et al. 1992; National Agricultural Statistics Service 1980–1998).
FIP cost-shared acres	Acres (1,000s) planted in trees cost-shared under the Forestry Incentive Program (Lee et al. 1992; National Agricultural Statistics Service 1980–1998).
CRP cost-shared acres	Acres (1,000s) planted in trees cost-shared under the Conservation Reserve Program (Lee et al. 1992; Farm Service Agency 1999).
1989	Dummy variable equal to 1 for years after 1988 and 0 otherwise.

expected to have a positive influence on the area of land planted in trees (Table 1). Harvest data are lagged by 1 yr so that harvest rates from 1 yr affect planting rates of the following year. Stumpage and pulpwood prices are included to represent potential revenues derived from future timber harvests and also are expected to have a positive influence on tree planting rates. Sawtimber prices were tested in early versions of the empirical models but consistently failed to perform as well. Stumpage prices are used in the nonindustrial private tree planting model, while delivered pulpwood prices are used in the industrial tree planting model. An index of planting costs is included to reflect tree plantation input costs, which are expected to have a negative influence on tree planting. Land can represent both an input to production, causing land prices to have a negative influence on the quantity of tree plantations supplied, as well an alternative to plantations, causing land prices to have a positive influence on the quantity demanded (Lee et al. 1992). As a result, the expected sign on the land value variable is ambiguous. Prevailing interest rates potentially reflect the value of alternative investments to tree plantations and are expected to have a negative influence on tree planting.

Previous studies have hypothesized that federal programs that offer cost-sharing assistance for tree planting induce landowners to substitute cost-shared tree planting for private investment in tree plantations (Cohen 1983, Lee et al. 1992). If so, we could expect that variables describing the areas of land planted under federal programs that offer cost-sharing assistance would have a negative influence on the areas of land planted in trees that were not cost-shared. Some previous tree planting studies for the South have shown no empirical evidence of such substitution (de Steiguer 1984, Lee et al. 1992) while another has found evidence of substitution (Cohen 1983). Because in this analysis the dependent variable Q_{PL} includes all acres planted in trees, including those cost-shared under federal assistance programs, it is likely that variables describing the areas of land planted using federal cost-sharing will have a positive influence on tree planting as described by the dependent variable Q_{PL}. Generally, only nonindustrial private landowners have qualified for federal cost sharing. In the absence of substitution behavior by landowners, we would expect a one-to-one correspondence between variables describing the areas of land planted using federal cost-sharing and nonindustrial private tree planting, and no correlation between cost-sharing variables and industrial tree planting.

The specific regression model estimated for nonindustrial private tree planting is

$$\begin{aligned} Q_{PL}^{NONIND} = {} & \alpha_0 \\ & + \alpha_1\ (nonindustrial\ \ private\ \ harvest) \\ & + \alpha_2\ (stumpage\ \ price) \\ & + \alpha_3\ (planting\ \ cost) \\ & + \alpha_4\ (land\ \ value) \\ & + \alpha_5\ (interest\ \ rate) \\ & + \alpha_6\ (ACP\ \mathrm{cos}t - shared\ \ acres) \\ & + \alpha_7\ (Soil\ \ Bank\ \ \mathrm{cos}t - shared\ \ acres) \\ & + \alpha_8\ (FIP\ \ \mathrm{cos}t - shared\ \ acres) \\ & + \alpha_9\ \ CRP\ \ \mathrm{cos}t - shared\ \ acres) + \varepsilon \end{aligned}$$

where the αs are coefficients to be estimated and ε is random error. The estimated model is highly significant ($R^2 = 0.92$, $F = 60.69$ with 9, 37 *df*, $P < 0.0001$) and the signs of the estimated coefficients generally are consistent with expectations (Table 2). Multicollinearity among the explanatory variables tested was not found to be a significant problem in model estimation. The time-series nature of the data creates a potential for autocorrelation in the model (see Greene 1997, p. 580–882). The Durbin-Watson statistic for the model is 1.831 and falls just within the upper limit of the inconclusive range for autocorrelation. Coefficients estimated in an alternative model corrected for first-order autocorrelation are quite close to those of the uncorrected model in terms of their signs, magnitudes, and statistical significance (Table 2). The value of *rho* in the corrected model is not statistically different from zero (see Greene 1995, 278). Together, these tests suggest that autocorrelation is not a significant problem in the nonindustrial private tree planting model.

Table 2. Estimated coefficients of the nonindustrial private tree planting regression model.

	Ordinary least squares regression		Corrected for 1st order autocorrelation	
Variable	Estimated coefficient	*t*-ratio	Estimated coefficient	*t*-ratio
Intercept	−1,170.758***	−5.875	−1,068.440***	−4.764
Nonindustrial private harvest	0.388***	3.338	0.386***	3.110
Stumpage price	28.177**	2.245	24.114*	1.845
Planting cost	−6.952***	−2.853	−5.546**	−1.994
Land value	0.615**	2.124	0.437	1.369
Interest rate	−13.071	−0.946	−9.607	−0.650
ACP cost-shared acres	1.451***	3.863	1.428***	3.435
Soil Bank cost-shared acres	0.994***	6.017	0.999***	5.576
FIP cost-shared acres	−0.042	−0.069	0.321	0.479
CRP cost-shared acres	1.244***	7.045	1.096***	6.012
Rho	—	—	0.199	1.377

NOTE: The dependent variable is area (1,000 ac) of tree planting by nonindustrial private landowners (USDA Forest Service 1950-1998) aggregated for southern states. Independent variable definitions are provided in Table 1. Summary statistics: $N = 47$, adjusted $R^2 = 0.921$, $F = 60.69$ ($df = 9{,}37$), and Durbin-Watson statistic = 1.831. The *, **, and *** show significance at $P < 0.10$, $P < 0.05$, and $P < 0.01$.

The estimated coefficients for the lagged nonindustrial private harvest variable is statistically significant at the 1% level and suggests a positive influence on nonindustrial private tree planting. The estimated coefficient for the planting cost variable also is statistically significant at the 1% level and suggests a negative influence on nonindustrial private tree planting. The estimated coefficients for the stumpage price and land value variables are statistically significant at the 5% level and suggest a positive influence on nonindustrial private tree planting. The estimated coefficient for the interest rate variable is not statistically different from zero and suggests that interest rates have little influence on overall nonindustrial private tree planting in the South as described by the data analyzed. The statistical significance or insignificance of individual explanatory variables generally is consistent with other earlier studies of tree planting behavior by nonindustrial private landowners (Alig et al. 1990, p. 4). Our empirical results differ somewhat from the more recent study by Lee et al. (1992), which found an interest rate variable to be statistically significant variables in an empirical model of tree planting in the South. However, Lee et al. (1992) did not include nonindustrial private timber harvest rates to describe the potential supply of recently harvested forestland available for reforestation, which is an important statistically significant variable in our model.

Estimated coefficients for variables describing the areas of land planted under ACP, Soil Bank, and CRP cost-sharing are positive and statistically significant at the 1% level. Auxiliary t-tests reveal that the coefficients also are statistically very close to one ($t = 1.200$, 0.037, and 1.383), suggesting a near one-for-one correspondence between these federal cost-sharing assistance programs and nonindustrial private tree planting. The estimated coefficient for the FIP variable is negative but not statistically different from zero. An auxiliary t-test reveals that the FIP coefficient is statistically different from one at the 10% level ($t = -1.69$), suggesting that nonindustrial private landowners could be substituting this federal program for private investment in tree planting. This result is consistent with results reported by Cohen (1983) regarding the FIP program, but is not consistent with results reported by Lee et al. (1992).

The regression model estimated for industrial tree planting is

$$
\begin{aligned}
Q_{PL}^{IND} = \ & \beta_0 \\
& + \beta_1 \ (\textit{industrial harvest}) \\
& + \beta_2 \ (\textit{pulpwood price}) \\
& + \beta_3 \ (\textit{planting cost}) \\
& + \beta_4 \ (\textit{land value}) \\
& + \beta_5 \ (\textit{interest rate}) \\
& + \beta_6 \ (\textit{ACP cost-shared acres}) \\
& + \beta_7 \ (\textit{Soil Bank cost-shared acres}) \\
& + \beta_8 \ (\textit{FIP cost-shared acres}) \\
& + \beta_9 \ \textit{CRP cost-shared acres}) + \varepsilon
\end{aligned}
$$

where the βs are coefficients to be estimated and ε is random error. The estimated model is highly significant ($R^2 = 0.91$, $F = 55.51$ with 9, 37 df, $P < 0.0001$) and the signs of the estimated coefficients also are generally consistent with expectations (Table 3). Again, multicollinearity among the explanatory variables tested was not found to be a significant problem in model estimation. The Durbin-Watson statistic for the model is 1.785 and falls just within the upper limit of the inconclusive range for autocorrelation. Coefficients estimated in an alternative model corrected for first order autocorrelation are relatively close to those of the uncorrected model in terms of their signs, magnitudes, and statistical significance (Table 3). The value of *rho* in the corrected model is not statistically different from zero. Together, these tests suggest that autocorrelation is not a significant problem in the industrial private tree planting model.

The estimated coefficient for the lagged industrial harvest variable is statistically significant at the 1% level and suggests a positive influence on industrial tree planting. This result is consistent with forest cover studies (Alig 1985, Butler and Alig n.d.) which suggest that timber harvest is a key determinant of area trends for planted pine. The estimated coefficient for the interest rate variable is

Table 3. Estimated coefficients of the industrial private tree planting regression model.

	Ordinary least squares regression		Corrected for 1st order autocorrelation	
Variable	Estimated coefficient	t-ratio	Estimated coefficient	t-ratio
Intercept	−468.499	−1.483	−458.881	−1.448
Industrial harvest	0.345***	4.262	0.321***	3.777
Pulpwood price	−3.688	−0.587	−2.897	−0.478
Planting cost	−4.068	−1.619	−3.045	−1.074
Land value	1.844***	6.347	1.718***	5.391
Interest rate	−50.930***	−3.969	−50.125***	−3.609
ACP cost-shared acres	0.567	1.415	0.485	1.120
Soil Bank cost-shared acres	0.051	0.297	0.067	0.370
FIP cost-shared acres	−1.288*	−1.907	−0.931	−1.303
CRP cost-shared acres	0.704***	5.124	0.606***	4.071
Rho	—	—	0.192	1.325

NOTE: The dependent variable is area (1,000 ac) of tree planting by industrial private landowners (USDA Forest Service 1950–1998) aggregated for southern states. Independent variable definitions are provided in Table 1. Summary statistics: $N = 47$, adjusted $R^2 = 0.914$; $F = 55.51$ ($df = 9{,}37$), and Durbin-Watson statistic = 1.785. The *, **, and *** show significance at $P < 0.10$, $P < 0.05$, and $P < 0.01$.

statistically significant at the 1% level and suggests a negative influence on industrial tree planting. The estimated coefficient for the land value variable is statistically significant at the 1% level and suggests a positive influence on industrial tree planting. Estimated coefficients for pulpwood price and planting cost variables are not statistically different from zero, suggesting that these variables have little influence on industrial tree planting.

The estimated coefficient for the variable describing the areas of land planted under CRP cost-sharing is positive and statistically significant at the 1% level, suggesting that CRP cost-sharing may have a positive influence on industrial tree planting. The positive and statistically significant value of the CRP coefficient is consistent with results of Lee et al. (1992). CRP cost-sharing was at its peak during the mid to late 1980s just when industrial tree planting also reached historical peaks and both have mostly declined during years since then. Given that there is little reason to assume that industrial forest owners qualified for CRP participation, it is conceivable that these two simultaneously occurring trends are unrelated. The negative and statistically significant FIP cost-sharing coefficient suggests that industrial landowners could be viewing acres planted under FIP cost-share assistance as a substitute for resource investment.

A final set of econometric models are estimated to test for the possibility that structural changes have occurred in industrial tree planting since the 1980s. Reduced timber harvests from national forests primarily in the West have shifted some timber demand to the South. For example, Murray and Wear (1998) find that the Pacific Northwest and the southern timber markets became more integrated since 1989 after harvest restrictions were imposed in the Pacific Northwest to protect habitat for the northern spotted owl (*Strix occidentalis caurina*). Analyses using existing economic models have suggested that these changes would potentially result in significant increases in private investment in timber, including increases in tree planting (Adams et al. 1996, Alig et al. 1999). To examine this possibility, several alternative econometric models were tested by creating dummy variables reflecting more recent years and interacting these variables with each of the other variables to obtain and test several slope dummy variables.

In the first alternative model, an intercept dummy variable (1989) reflecting years since 1989 is included. The estimated coefficient for the 1989 variable is negative but only weakly and statistically significant at the 15% level and suggests a potential reduction in industrial tree planting since 1989 (Table 4). In the second alternative model, two slope dummy variables are created by interacting the 1989 dummy variable with the planting cost and interest rate variables to test for structural change regarding planting costs and interest rates. The estimated coefficient for the "1989 * planting cost" slope dummy variable is negative and statistically significant at the 1% level and suggests that planting costs have had a negative and statistically significant influence on industrial tree planting since 1989. The estimated coefficient for the "1989 * Interest rate" slope dummy variable is positive and statistically significant at the 5% level (Table 4) and essentially cancels out since 1989 the negative influence that interest rates historically have had on industrial tree planting.

Projecting Future Tree Planting

We used the estimated model coefficients (Tables 2 and 3) to make 50 yr projections of future tree planting by nonindustrial and industrial private landowners consistent with the needs of the Renewable Resource Planning Act Assessment. The projections are based on assumptions regarding future values of explanatory variables included in the econometric models. We compute future nonindustrial private and industrial timber harvest volume, future stumpage and pulpwood prices, and interest rates consistent with projections developed by Adams (2000) for the Renewable Resource Planning Act Assessment. We assume that tree planting costs will rise by 2.5% annually which is consistent with the historical rate of increase. Land values are held constant at 1998 levels, and federal tree planting cost-shared acres are assumed to remain at levels equal to averages for the past 5 yr. The resulting projections through 2050 show tree planting by nonindustrial private landowners gradually

Table 4. Estimated coefficients of alternative industrial private tree planting regression models including variables characterizing changes in tree planting since 1989.

	Model including an intercept dummy variable		Model including two slope dummy variables	
Variable	Estimated coefficient	t-ratio	Estimated coefficient	t-ratio
Intercept	−598.798*	−1.868	−1,116.705***	−3.086
Industrial harvest	0.470***	4.199	0.551***	5.000
Pulpwood price	−2.472	−0.399	6.682	0.978
Planting cost	−3.761	−1.523	−3.698	−1.608
Land value	1.684***	5.570	1.576***	5.551
Interest rate	−47.205***	−3.689	−59.973***	−4.624
ACP cost-shared acres	0.822*	1.935	0.883**	2.235
Soil Bank cost-shared acres	−0.023	−0.135	−0.022	−0.138
FIP cost-shared acres	−1.286*	−1.943	−0.701	−1.055
CRP cost-shared acres	0.615***	4.221	0.330*	1.866
1989	−155.117	−1.584	—	—
1989 * planting cost	—	—	−13.772***	−2.975
1989 * interest rate	—	—	72.400**	2.451

NOTE: The dependent variable is area (1,000 ac) of tree planting by industrial private landowners (USDA Forest Service 1950–1998) aggregated for southern states. Independent variable definitions are provided in Table 1. The *, **, and *** show significance at $P < 0.10$, $P < 0.05$, and $P < 0.01$.

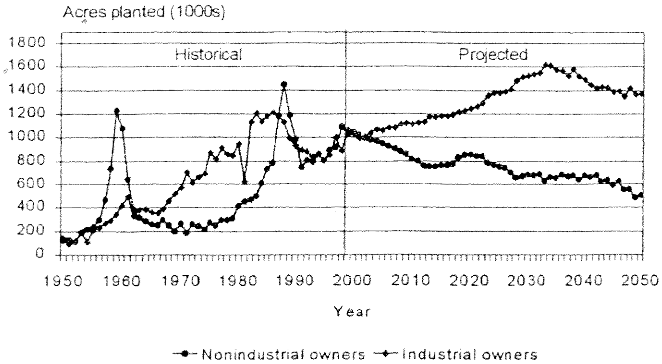

Figure 3. Historical and projected tree planting by private owners in the South, 1950–2050.

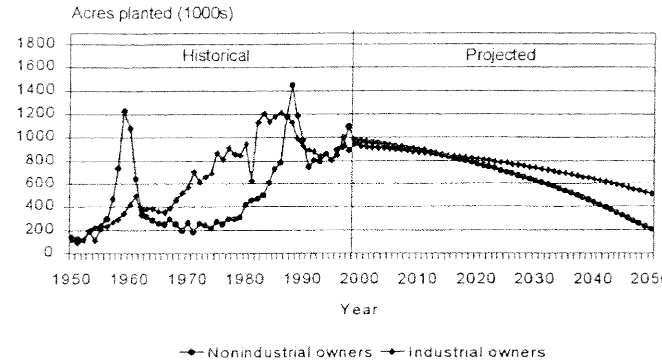

Figure 4. Historical and projected tree planting by private owners in the South, 1950–2050–with average harvest rates of the 1990s.

declining over the next 50 yr but generally remaining above historical levels (Figure 3). Tree planting by industrial landowners is projected to increase gradually over the next 30 yr to somewhat higher than historical levels, then decline over the next 20 yr to levels closer to those of the 1980s.

Projected increases in industrial tree planting depicted in Figure 3 result in part from assumptions regarding projected increasing timber harvest volumes on industrial forestlands reported by Adams (2000). Annual industrial harvest volumes are assumed to increase above three billion ft^3 by 2012 and above 4.0 billion ft^3 by 2026. These harvest volumes are significantly higher than historical annual industrial harvest rates throughout the 1990s which averaged 2.3 billion ft^3 (1990–1997). Projected increases in annual harvest volumes for nonindustrial private landowners are more modest than projected increases for industrial landowners, fluctuating between three and four billion ft^3, compared to historical annual nonindustrial private harvest volume throughout the 1990s which averaged 3.3 billion ft^3 (1990–1997). If average harvest volumes of the 1990s were to prevail in future years, nonindustrial private and industrial tree planting would be projected to be substantially less (Figure 4). Steady decline through 2050 would occur largely due to projected increasing tree planting costs.

Planting costs have a significant impact on the areas of land planted in trees, particularly among nonindustrial private landowners. If we assumed that planting costs will remain constant rather than increasing annually by 2.5%, projected tree planting by both nonindustrial private and industrial landowners would be higher. For example, if tree planting costs remained constant at their average level during the last 5 yr (1993 to 1997) of data used to estimate the empirical models, tree planting by nonindustrial private landowners would be projected to gradually increase to above 1.2 million acres annually by 2040 (Figure 5). Tree planting by industrial landowners would be projected to increase faster over the next 30 yr and level off at around 1.8 million ac annually through 2050. Cumulative projections assuming constant tree planting costs suggest that about 16.2 million ac of additional nonindustrial private land and 8.9 million ac of additional industrial land would be planted in trees over the next 50 yr (Figure 5), when compared to the base case scenario with increasing planting costs (Figure 3).

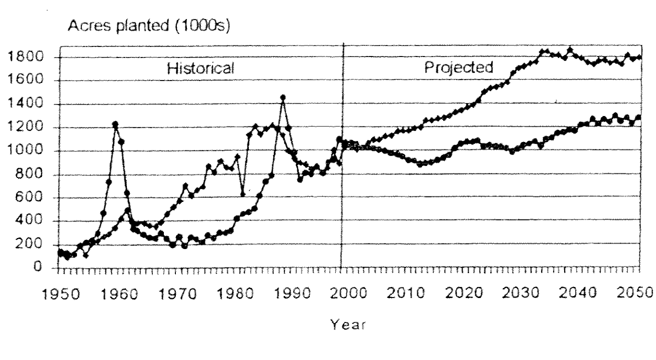

Figure 5. Historical and projected tree planting by private owners in the South, 1950–2050—with constant planting costs.

Federal cost-share assistance programs traditionally have played a significant role in motivating tree planting among nonindustrial private landowners. In addition, some southern states offer state-funded cost-share programs. The potential future effects of cost-share assistance programs on tree planting can be examined by projecting nonindustrial private tree planting under different cost-share assistance levels. We project tree planting under three scenarios: (1) assuming that nonindustrial private landowners would receive no cost-sharing, (2) assuming that all nonindustrial private landowners would receive 50% cost-sharing, and (3) assuming that all nonindustrial private landowners would receive 100% cost-sharing. The projections are computed by reducing projected tree planting costs according to the percentage cost-share level in each scenario and setting the federal cost-share program (ACP, Soil Bank, FIP, and CRP) variables equal to zero.

In the absence of any cost-sharing, projected tree planting by nonindustrial private landowners would gradually decline through 2050 (Figure 6). With 50% cost-sharing, projected tree planting by nonindustrial private landowners would fluctuate somewhat but generally remain within the historical range of the 1990s. Cumulative projections suggest that 15.8 million ac of additional nonindustrial private land would be planted in trees over the next 50 yr. At 5% interest, the present value of total annual costs of a 50% cost-share assistance program through 2050 would be about $800 million in 1992 dollars. With 100% cost-sharing, projected tree planting by nonindustrial private landowners would gradually increase through 2050. Cumulative projections suggest that about

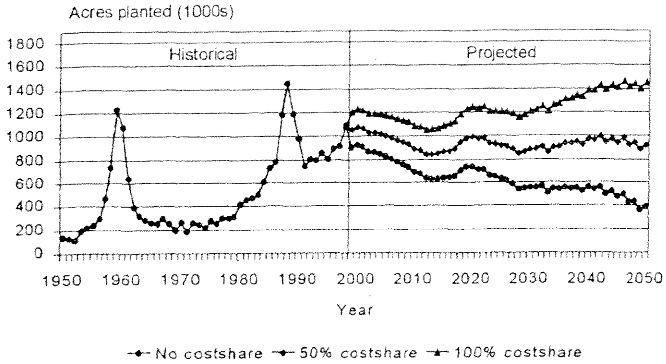

Figure 6. Historical and projected tree planting by private owners in the South, 1950–2050—with three cost-share levels

31.6 million ac of additional nonindustrial private land would be planted in trees over the next 50 yr. At 5% interest, the present value of total annual costs of a 100% cost-share assistance program through 2050 would be about $2.0 billion in 1992 dollars. The projections illustrate the potential range of effects that future cost-share assistance programs could have on tree planting on nonindustrial private lands. The actual effects of any future programs would depend on administrative rules and participation rates of nonindustrial private landowners.

Conclusions and Policy Implications

Econometric models were developed describing historical tree planting by nonindustrial and industrial private landowners in the southern United States as functions of economic variables and federal cost-sharing. Harvest volumes, stumpage prices, tree planting costs, land values, and federal cost-sharing all are shown to be statistically significant factors affecting tree planting by nonindustrial private landowners. Harvest volumes, land values, and interest rates are shown to be statistically significant factors affecting tree planting by industrial landowners. Estimated coefficients for Soil Bank, ACP, and CRP cost-shared acres generally suggest that neither industrial nor nonindustrial private landowners substitute cost-shared acres under these programs for private investment in tree planting. Estimated coefficients for FIP cost-sharing assistance provide some evidence that industrial and nonindustrial private landowners may substitute FIP cost-shared acres for private investment in tree planting. Further progress in addressing the substitution issues depends in part on improved time series data reporting that separates tree planting into afforestation and reforestation categories.

Alternative specifications of the industrial tree planting model incorporating intercept and slope dummy variables for years since 1989 provide some evidence of the possibility that tree planting behavior among industrial landowners may have changed in recent years. Some forest policy analysts have hypothesized that tree planting by private landowners might increase as a result of positive market incentives to increase investment in timber production. This effect is not reflected in trends in actual tree planting by industrial landowners, which have been mostly downward sloping in recent years. Alternative empirical models suggest an overall reduction in the area of forestland planted by industrial landowners in recent years. Some of this reduction could be due to a decline in the area of timberland owned by forest industries—down 2.5% from 1987 to 1997 for example (Smith 2001). However, this decline does not entirely account for the 15% reduction in the area of forestland planted by industrial landowners during the same time period. It also is conceivable that the steady increase over the past 50 yr in forestland area devoted to planted pine relative to natural pine could have left little natural pine forestland available for conversion to planted pine in recent years. However, Butler and Alig (n.d.) report that natural pine still comprised 41% of all pine forestlands in 1987—28% in 1997—suggesting that significant areas of natural pine still exist. Our results suggest that since 1989, industrial landowners have responded more to planting cost and less to interest rates than they had in other years included in the time series analyzed. Whether these responses are evidence that real structural changes have occurred in industrial tree planting remains uncertain.

The empirical models were used to project potential future tree planting through 2050. Tree planting by nonindustrial private landowners is projected to decline gradually due largely to anticipated rising tree planting costs and the continuation of relatively low levels of federal tree planting cost-share assistance evident in recent years. Tree planting by industrial private landowners is projected to rise gradually due largely to anticipated increased harvest rates on industrial forestland. Declines in timber harvest on federal lands likely will continue. Greater investment in tree planting by private landowners is viewed as an important factor in meeting projected future timber demands. The success with which privately owned lands meet future timber demands will influence the degree to which public forestlands can continue to focus increasingly on ecological protection and other nontimber goals. The direct role of privately owned lands in providing future timber supply and their indirect role in continued ecological protection on public lands, should make future tree planting activities of private landowners of particular interest to forest managers and policymakers concerned with ecological protection.

Although federal funding for programs that offer tree planting cost-share assistance has declined in recent years, increasing concerns regarding global climate change could prompt tree planting programs in the future (Moulton 1999, Moulton and Hernandez 2000). Given that nonindustrial private forestland owners own 58% of U.S. timberland (Smith et al. 2001), their participation in any proposed national tree planting efforts would be desirable. Empirical analysis of tree planting presented here and in previous studies (see Alig 1990, Hardie and Parks 1991, Lee et al. 1992) suggest that historically, cost-share assistance has induced nonindustrial private landowners to plant trees. Empirical studies also suggest that many nonindustrial private forest owners are motivated by nontimber values, such as wildlife, aesthetics, and recreation, as well as timber production (Kline et al. 2000, Kuuluvainen et al. 1996), which could indicate a willingness among some owners to participate in national environmental programs. Whether a national program offering cost-share assistance for tree planting would be an appropriate part of global climate change policy would depend on an assessment of tree planting program costs relative to likely climate change mitigation benefits and other alternative strategies.

There are many factors that contribute uncertainty to future tree planting in the South. Changes in federal forest management, increased use of recycled fiber, changes in timber and fiber production abroad, improvements in productivity, and changing land ownership patterns are just a few factors that will potentially affect the supply and demand for sawtimber and pulpwood from southern forests in the future, with resulting effects on private investment in forestry. For example, one factor that could potentially influence nonindustrial tree planting in the future is the increasing ownership of timberland by timber investment management organizations. Currently, tree planting by these organizations is recorded under the nonindustrial private forest owner category; however, it is conceivable that these organizations actually manage timberland more intensively than that ownership group. Present data do not permit a more detailed analysis of potential impacts resulting from shifts in ownership to these organizations. Although recent survey data (Siry and Cubbage 2001) suggest that total timberland holdings by timber investment management organizations remain relatively low (less than 3% of total), it is one factor potentially impacting future tree planting that is not fully accounted for in the empirical models.

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