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economics

# Timberland Ownerships and Reforestation in the Southern United States

**Xing Sun, Daowei Zhang, and Brett J. Butler**

**Timberland owners have different objectives and apply different management methods and management intensities to their lands. In this study, we look into the reforestation behaviors of various timberland owners in the southern United States based on plot-level data from the latest complete USDA Forest Service Forest Inventory and Analysis cycle. Our results show that, after controlling for market and locational variables for all sampled plots in the study, the probability of reforestation was higher for institutional and industrial owners than for nonindustrial private forest owners and was the highest for timberland investment management organizations. These findings imply that the institutional timberland owners do reforest and embrace sustainable forestry practices.**

**Keywords:** institutional timberland ownership, reforestation behavior, forest management, plot-level data, logistic regression

One of the critical decisions in forest management in the southern United States is whether to replant following a timber harvest. Often, forest landowners have different management objectives, technical know-how, and constraints, and thus apply different management methods and management intensities to their lands—including whether to reforest (Newman and Wear 1993, Li and Zhang 2007). While many previous studies on reforestation in the United States (e.g., Lee et al. 1992, Li and Zhang 2007) have focused on the forest industry and nonindustrial private forest landowners, forest landownership has substantially changed in the country in the past decade (Sun and Zhang 2011). In particular, most industrial timberlands previously owned by vertically integrated forest products companies have been sold to institutional investors or have been converted or sold to timberland real estate investment trusts (Timberland REITs). The institutional investors that have bought industrial timberland outright typically include pension funds, endowments, foundations, and insurance firms that favor diversified portfolios. These institutional investors often hire timberland investment management organizations (TIMOs) to manage and oversee their timberland assets. Timberland REITs, on the other hand, are mostly controlled by another institutional entity—mutual funds (Gunnoe 2012, Zhang et al. 2012). It is unknown whether results from previous studies hold for these two new groups of timberland owners, commonly known as TIMOs and Timberland REITs, which are collectively called institutional timberland owners in this paper.

The purpose of this paper is to study the reforestation behaviors of four main private forest landowner groups in the US South: industrial, TIMOs, Timberland REITs, and other private that correspond to the traditional concept of nonindustrial private forest (nonindustrial private forestland [NIPF]) landowners. The last group is composed primarily of families and individuals, and is perhaps better called family forest owners (Butler 2008). Zhang et al. (2012) called for research on the behavior of the newly emerged forest landowners, which is one source of motivation for this study. As reforestation is a long-term investment and most institutional investors owning timberland through TIMOs often have a limited investment period of 5 to 15 years, it might be expected that they would not invest in activities with long-term payoffs, such as reforestation, unless they can get an acceptable rate of return for their investment when they sell their timberlands. On the other hand, Timberland REITs are obliged to pay some 90% of their dividends back to their investors and often want to keep their regular dividend payments, especially when timber markets are down, by cutting spending, including spending on reforestation. They, too, may behave differently from traditional forest products companies that own timberlands mainly to secure timber supply for their mills and that do not have to pay dividends on a regular basis (Zhang et al. 2012). Furthermore, the rise of institutional timberland ownership raises public interest in this new group of landowners and their attitudes toward forest sustainability and management (such as land conversion, timber supply, fire suppression, and research and development), and reforestation is an indicator of forest sustainability

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**Affiliations:** *Xing Sun (sun.xing@mail.shufe.edu.cn), Shanghai University of Finance and Economics. Daowei Zhang (zhangdw@auburn.edu), Auburn University. Brett J. Butler (bbutler01@fs.fed.us), USDA Forest Service.*

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and management. Finally, to the best of our knowledge, there has not been a reforestation study based on plot-level data, although reforestation studies based on landowner surveys likely yield similar results (Zhang and Flick 2001, Sun et al. 2008). The benefit of studying reforestation at the plot level is that site-specific data are very reliable, but a drawback is that one has to use regional stumpage price and reforestation cost data.

Several previous studies have focused on the reforestation behavior of forest industry and NIPF landowners (e.g., Lee et al. 1992, Beach et al. 2005, Li and Zhang 2007) although many studies are on ownership and timber supply (e.g., Binkley 1981, Kuuluvainen et al. 1996, Amacher et al. 2003, Jin and Sader 2006, Favada et al. 2009). Often this behavior is modeled as a binary choice: to reforest or not to reforest. Royer (1987), for example, employed a logistic regression to model NIPF reforestation probabilities. Income, reforestation costs, government cost sharing, technical assistance, and pulpwood price were found to be related to reforestation. Hyberg and Holthausen (1989) and Straka and Doolittle (1988) used a similar approach to investigate harvest timing and reforestation choices of nonindustrial private landowners and reached similar conclusions.

Other approaches used include ordinary least square (OLS) (e.g., Lee et al. 1992), two-step selectivity (e.g., Zhang and Flick 2001), and panel data (e.g., de Steiguer 1984, Li and Zhang 2007) models. The most recent and relevant one to this study is perhaps Li and Zhang (2007) who controlled for spatial correlations and analyzed the treeplanting activities of NIPF and forest industry owners in the US South. They concluded that sawtimber price, income, cost of capital, and cost-share programs were significantly related to NIPF treeplanting, and stumpage prices and reforestation costs significantly influenced forest industry treeplanting.

In addition to the above variables, we have added locational and population density variables that are included in some studies on timber supply and land-use changes (e.g., Prestemon and Wear 2000, Kline et al. 2004, Nagubadi and Zhang 2005, Polyakov and Zhang 2008). By using a profit-maximizing approach and plot-level data that cover one cycle (5–7 years in between measurements) for each of the nine southern states (Alabama, Arkansas, Florida, Georgia, North Carolina, South Carolina, Tennessee, Texas, and Virginia, as data are missing for other southern states) in the USDA Forest Inventory Analysis (FIA) surveys, we were able to estimate determinants of reforestation among these private landowners. Our results show that TIMOs reforest more often than all other landowners and that industrial owners and timberland REITs are more likely to reforest than NIPF (or family) landowners. The next section provides an analytical framework, followed by methodology, data, and results. The final section provides a summary and discussion.

## Analytical Framework and Hypothesis

Using the widely accepted approach—the Faustmann model that assumes that private forests are managed on the basis of maximizing the expected net present value of future cash flow associated with a forest, Hyde (1980) and Chang (1983) show that reforestation investment or treeplanting is positively related to timber stumpage prices and negatively to planting costs and costs of capital. Zhang and Pearse (2011) demonstrate algebraically that these results hold for all silvicultural investment, that environmental considerations lead the government to subsidize private treeplanting activities, and that amenity-oriented family forest landowners may plant more trees than other landowners (Hartman 1976).

To maximize land expectation value or the net present value over infinite rotations ($V$), one needs to choose rotation age ($T$) and silvicultural reforestation effort ($E$). Mathematically this is given by

$$\max_{T,E} V = [\hat{P}Q(T, E)e^{-rT} - wE](1 - e^{-rT})^{-1} \quad (1)$$

where $\hat{P} = P(1 - y)$ denotes the after-tax stumpage price given that the government levies a yield tax, $y$, and expected market stumpage price, $P$; $Q(T, E)$ is the forest growth function; $r$ is an interest rate; and $w$ is the unit cost of reforestation activities.

Equation 1 means that reforestation activities are decided independent of harvesting the current existing timber stands. In other words, reforestation, like all investments, should only be done if the present value of future benefits is positive. Reforestation is a cost not to current timber stands but to future timber stands (Zhang 2007, p. 62). The first-order condition for Equation 1 with respect to the reforestation effort is mathematically expressed as

$$V_E = \hat{P}Q_E(T, E)e^{-rT} - w = 0. \quad (2)$$

which shows that the optimal condition for the reforestation effort is that marginal benefit of the last unit of effort equals its cost.

It is evident in Equation 1 that the forest yield tax works in the same way as a decrease in stumpage price. The more complicated and widely used income tax, on the other hand, simply applies a tax rate to net timber income, which is the numerator of Equation 1, although US tax law does not allow for discounting timber revenue or compounding the interests of silvicultural expenses. We argue, however, that the realized (after-tax) timber stumpage prices or the realized (after-tax) timber income, planting costs, and especially interest (discount) rates differ among the four types of landowners. Consequently, the behavior in reforestation and other forest management activities varies.

For after-tax stumpage prices or more precisely after-tax timber income, all Timberland REITs and most TIMOs pay no taxes on timberland income while investors do pay capital gains tax on profit or dividend; NIPF landowners pay capital gain tax on timber income, which is lower than ordinary income and corporate income although many do not take advantage of this (Butler et al. 2012); and forest industry often pays corporate income taxes that are close to 35% and corporate shareholders pay dividend tax as well (Lehman Brothers 2006). Thus, all other things being equal, the realized, after-tax stumpage prices or after-tax timber income are higher for Timberland REITs and TIMOs than NIPF and industrial landowners, and industrial landowners are the most-disadvantaged group of the four.

On the other hand, industrial, Timberland REITs, and TIMOs possess an economy of scale in site preparation and planting activities and typically have lower per-unit planting costs than NIPF owners. While some NIPF landowners in the US South do receive subsidies from treeplanting from government cost-share programs (Zhang 2004), such subsidies are mostly reserved for conservation-oriented treeplanting or afforestation activities, not for reforestation.

Finally, the cost of capital may be lower for TIMOs and REITs than for forest industry. This is because timberland investment has a lower risk and offers better diversification potential than an investment in forest industry (Binkley et al. 1996). In fact, one of the main reasons that industrial timberland owners started to sell their timberlands is that raising capital through divesture of timberland is less costly than that from equity or debt markets (Rinehart 1985). Empirically, while the required rate of return for TIMOs is often stated at 5–8% per year in real terms, the cost of capital for forest industry firms has been around 8–11% in the last decade (Roberts et al. 2004, Lehman Brothers 2006). NIPF landowners who represent the greatest number of private owners and the largest percentage of the southern forestland base are the most diverse among the four groups. Although the average cost of capital for this group of landowners is unknown, individual families and family corporations that own forestland, because they are typically small, are expected to have higher costs of capital than corporate owners.

Based on this discussion, we hypothesize that the propensity of reforestation is the highest for TIMOs and REITs and the lowest for NIPF landowners. Industrial landowners have advantage in planting costs. They also have an added benefit or another motivation for owning timberland: They need timber as insurance against vagaries of timber markets. Thus, their propensity for reforestation should be higher than NIPF landowners that often have objectives other than timber supply.

## Methodology and Data

Our study method is logistic regression. Specifically, landowners maximize their expected profits by choosing whether to replant their newly harvested timberland. The probability of a plot (tract) being reforested after timber harvesting is

$$P_i = Prob(Y_i^* \geq 0) \tag{3}$$

where $i$ denotes the $i$th plot. $Y_i^*$ is the expected profit of reforestation activity on the $i$th plot, which is not directly observable but can be approximated by market conditions, stand characteristics (e.g., site productivity, stand slope, location of the tract), and landowner characteristics that control for variations in ownership objectives and constraints. So when reforestation takes place on the $i$th plot, $P_i = 1$, it can be readily seen that

$$Prob(P_i = 1) = Prob(Y_i^* \geq 0) = \beta' x_i + \varepsilon_i \tag{4}$$

where $x_i$ are independent variables that cover market conditions, stand characteristics, population density, and ownership, $\beta$ are parameters to be estimated, and $\varepsilon_i$ is a residual, $\varepsilon \sim N(0, 1)$.

Equation 4 is a logistic model that is used to estimate the determinants of the probability of reforestation. The cumulative distribution of the logistic function is

$$Prob(P_i = 1) = \frac{e^{\beta' x_i}}{1 + e^{\beta' x_i}} = \Lambda(\beta' x_i) \tag{5}$$

Estimation of the binomial model is usually based on the maximum likelihood method (Greene 2003). Although systematic differences in the distribution of $Y^*$ across plots might not meet the optimality properties of maximum likelihood estimation (Greene 2003), the large sample for all ownerships used in this study negates this issue.

As noted earlier, our data are at the plot (stand) level and are from FIA. FIA is charged with assessing the country's forest resources, including ownership changes, and has established a grid of permanent inventory plots across the country (Bechtold and Patterson 2005). There is one sample plot per approximately 6,000 acres (or 2,428 ha) and the plots are remeasured once every 5–7 years across the southern United States. For every forested plot that is encountered, the ownership is determined from tax records and forest mensuration data are collected in the field.

Prior to 2007 (e.g., Smith et al. 2004), FIA reports classified private timberland landowners into industrial and NIPF owners. Starting with the 2007 report which covers the period from 2003 to 2007 (Smith et al. 2009), private landowners were classified into corporate and noncorporate ownerships. The corporate owners include all firms such as industrial, TIMOs, REITs, other forestry corporations (forestry consultants, loggers, and tree farmers), incorporated family operations (such as Johnson Farm, LLC), and nonforestry corporations (such as utility, mining, real estate). The noncorporate owners include individuals (or families) and entities such as conservation organizations, unincorporated partnerships (associations and clubs), and tribal. Zhang et al. (2012) classified all private landowners into industrial, TIMOs, REITs, and NIPF. This allows us to focus on the main private timberland ownership categories: forest industry, TIMOs, REITs, and NIPF landowners, which collectively own about 90% of all forestland in the region.

The sample plots included in this study were all clearcut during the most recent inventory cycles. A clearcut harvest was defined as the removal of the majority of the merchantable trees on a plot. Although reforestation behavior is not necessarily undertaken immediately on harvesting (Amacher et al. 2003), treeplanting is significantly and positively related to previous-year harvests (Li and Zhang 2007). Further, the majority of landowners who reforest their lands do so within 1 year after a timber harvest (Sun et al. 2008).

Using the available FIA data, Equation 4 is expressed as

$$\begin{aligned} P_i^* = {} & \omega_{0i} + \omega_{1i} Sawtimber\ Price + \omega_{2i} Pulpwood\ Price \\ & + \omega_{3i} Cost + \omega_{4i} Distance + \omega_{5i} Slope + \omega_{6i} Coastal \\ & + \omega_{7i} Productivity + \omega_{8i} Density \\ & + \omega_{9i} Ownership + \varepsilon_i \end{aligned} \tag{6}$$

where *Sawtimber Price* is defined as the average of real regional prices for sawtimber during the re-measurement period, *Pulpwood Price* is defined as the average of real regional prices for pulpwood during the remeasurement period, and *Cost* is expressed as reforestation cost in real terms. *Distance* is equal to one if horizontal distance from the plot to an improved road is less than or equal to 0.5 miles and zero otherwise, *Coastal Plain* is a dummy variable indicating whether the plot is sampled from coastal plains, *Slope* expresses the angle of slope of the plot condition, and *Productivity* is equal to one if the potential growth capacity of industrial wood is more than or equal to 85 cubic feet/acre/year (6.4 cubic m/ha/year) and zero otherwise. *Density* is population density (persons/square mile) in the county where the plot is located and is a proxy for urbanization, and *Ownership* are three dummy variables representing industrial, TIMOs, and REITs, respectively.[1] The specific form of Equation 6 is (introducing the ownership category index, $j$)

$$\begin{aligned} P_{kj}^* = {} & \omega_{0kj} + \omega_{1kj} Sawtimber\ Price + \omega_{2kj} Pulpwood\ Price \\ & + \omega_{3kj} Cost + \omega_{4kj} Distance + \omega_{5kj} Slope \\ & + \omega_{6kj} Coastal + \omega_{7kj} Productivity \\ & + \omega_{8kj} Density + \varepsilon_{kj} \end{aligned} \tag{7}$$

where $k \in j$ denotes the plot *k* under the timberland ownership category *j*.

We used the most recent and complete inventory cycles with the fixed radius plot design across nine southern states: Alabama cycle 8 (2001–2005), Arkansas cycle 8 (2000–2005), Florida cycle 8 (2002–2007), Georgia cycle 8 (1998–2004), North Carolina cycle 8 (2003–2007), South Carolina cycle 9 (2002–2006), Tennessee cycle 8 (2005–2009), Texas cycle 8 (2004–2008; East Texas only), and Virginia cycle 8 (2002–2007). Forest Service FIA was the source for all variables, except stumpage prices, reforestation costs, and county population density whose sources are described below.

Since FIA provided the information about reforestation behavior on stands during the remeasurement period, we have linked stumpage prices and reforestation cost to reforestation activities by using the averaged prices and cost during the remeasurement period. The two price variables of softwood (for sawtimber and pulpwood) were used in Equation 6. Nominal stumpage prices for sawtimber and pulpwood during the remeasurement period for each survey unit were obtained from Timber-Mart South (1990–2010). Reforestation costs included mechanical site preparation and hand planting. Nominal reforestation costs for forestry practices in the South during the remeasurement period were obtained from the Cost and Cost Trends series produced on 2-year intervals (Dubois et al. 1995, Dubois et al. 1997, 1999, 2001, Dubois et al. 2003, Folegatti et al. 2007). For the unreported years, reforestation cost was calculated by averaging the costs over the years in-between. Real prices and costs, expressed in 1992 dollars, were calculated using the Producer Price Index. Real stumpage prices and reforestation costs during the remeasurement period for a plot were taken as the average annual index-deflated stumpage prices and reforestation cost. For example, if a plot in Alabama was measured in 2005 during the FIA cycle 8 and the number of years between measurements is 6, the real stumpage prices and reforestation cost were averaged over the year 2000–2005. Finally, the variable *Density* was obtained from the 2010 complete economic and demographic data source (CEDDS) to indicate urbanization level by county.

**Table 1. Description and statistical summary for all ownerships.**

| Variable | Definition | Mean | Standard deviation |
|---|---|---|---|
| Reforestation | Reforestation probability | 0.75 | – |
| Sawtimber price | Sawtimber real price ($/cubic meter) | 60.69 | 21.31 |
| Pulpwood price | Pulpwood real price ($/cubic meter) | 3.64 | 1.20 |
| Cost | Reforestation real cost (1,000 $/ha) | 0.29 | 0.09 |
| Distance | Dummy: 1 if horizontal distance to improved road was less than or equal to 0.5 mile, and 0 otherwise | 0.86 | – |
| Slope | The angle of slope of the plot | 3.43 | 6.85 |
| Coastal | Dummy: 1 if coastal plain; 0 otherwise | 0.63 | – |
| Productivity | Dummy: 1 if the potential growth capacity of industrial wood is more than or equal to 85 cubic feet/acre/year, 0 otherwise | 0.51 | – |
| Density | Population density in the county (persons/square mile) | 66.80 | 86.58 |
| Industry | Industrial: 1 if industry landowner; 0 otherwise | 0.23 | – |
| TIMOs | Timberland investment management organizations (TIMOs): 1 if TIMOs; 0 otherwise | 0.09 | – |
| REITs | Timberland real estate investment trusts (REITs): 1 if REITs; 0 otherwise | 0.19 | – |

## Results

There are 1,202 clearcut plots included in the preanalysis to determine the attribution of forest type to the replanting probability. Of the 1,202 plots, 493 were replanted following the harvest. For 45% of the 1,202 plots, pine was the predominant forest type. Of the softwood plots, about 75% were replanted following a clearcut. Of the hardwood plots, about 14% were replanted. Moreover, forest type significantly correlated with the probability of reforestation at the 1% level and the correlation coefficient was 0.62. The strong relationship between forest type and replanting probability reduced the impacts of other independent variables. Subsequently, only the 538 softwood plots were used in this study.

About 49% of these softwood plots were owned by NIPF landowners, 23% by forest industry, 19% by Timberland REITs, and 9% by TIMOs (Table 1). The average stumpage prices were $61/cubic meter and $4/cubic meter for sawtimber and pulpwood, respectively. The average reforestation cost $290/ha in 1992 dollars. The predominant mileage of horizontal distance to improved road for 86% landowners was less than or equal to 0.5 miles (0.8 km). Average angle of slope, in percent, of the site condition was 3.4. About 63% of the plots were in the Coastal Plains while the remainder was in either the Piedmont, or mountain, or delta physiographic regions. Of the 538 plots, about 51% were capable of growing 85 cubic ft/acre/year or more industrial woods. County population densities averaged 67 persons/square mile (173 persons/square km).

The descriptive statistics for the variables by ownership group are reported in Table 2. The reforestation probability was 0.80 for forest industry, 0.86 for TIMOs, 0.80 for REITs, and 0.69 for NIPF landowners. In addition, we used pairwise Wald test statistics to examine the difference of independent variables among the four types of ownership. *Distance* for institutional plots was significantly

**Table 2. Sample statistics by each type of ownership.**

| | Industrial | | TIMOs | | REITs | | NIPF | |
|---|---|---|---|---|---|---|---|---|
| Variable | Mean | Standard deviation | Mean | Standard deviation | Mean | Standard deviation | Mean | Standard deviation |
| Reforestation | 0.80 | – | 0.86 | – | 0.80 | – | 0.69 | – |
| Sawtimber price | 60.76 | 19.01 | 55.83 | 19.81 | 59.75 | 24.04 | 61.94 | 21.44 |
| Pulpwood price | 3.43 | 0.91 | 3.21 | 0.76 | 3.65 | 1.26 | 3.82 | 1.33 |
| Cost | 0.29 | 0.08 | 0.28 | 0.09 | 0.28 | 0.10 | 0.29 | 0.09 |
| Distance | 0.83 | – | 0.90 | – | 0.95 | – | 0.82 | – |
| Slope | 3.54 | 6.66 | 3.67 | 6.71 | 1.59 | 3.90 | 4.05 | 7.73 |
| Coastal | 0.64 | – | 0.55 | – | 0.56 | – | 0.67 | – |
| Productivity | 0.56 | – | 0.53 | – | 0.52 | – | 0.47 | – |
| Density | 58.04 | 66.29 | 37.45 | 32.57 | 60.72 | 67.95 | 78.82 | 104.85 |
| Observation # | 124 | | 49 | | 103 | | 262 | |

lower than for both NIPF and industry-managed plots at the 10% level. Timberland owned by industry and managed by TIMOs were more likely to be capable of growing industrial woods than NIPF lands at the 10% significant level. In addition, NIPF plots were located in the counties with higher population density than industry, TIMOs, and REITs plots. Because these and other factors differ among the four types of ownership, inferences about the effect of ownership on reforestation call for additional econometric analysis.

The results of maximum likelihood estimation of the logit model for all plots are reported in Table 3. The *Chi-square* test statistic for the logit model was significant at the 1% significant level, indicating that the model fits well. The coefficients for *Industry*, *TIMOs*, and *REITs* were positive and significant, with marginal effects of 0.12, 0.19, and 0.10, respectively. This implies that, all else being equal, industry and institutional timberland investors were more likely to conduct reforestation than NIPF landowners.

Among market factors, *Pulpwood Price* positively influenced replanting probability, with marginal effects equal to 0.09. Therefore, a one unit change in pulpwood price increased the probability of reforestation by 0.09. Among the stand characteristics, *Coastal Plain* and *Productivity* significantly had a positive impact on the replanting probability. The marginal effects of these two variables were 0.09 and 0.08, respectively. The predicted reforestation probability was 0.09 greater for plots in the Coastal Plain region than for plots in the Piedmont, mountain, or delta physiographic regions. The coefficient for *Population Density* was significantly negative at the 1% level. The finding that sawtimber prices do not matter is counterintuitive. However, the prices used here are current prices, not the expected prices as indicated in Equation 1, and empirical studies using current prices are inconclusive (e.g., Lee et al. 1992, Kline et al. 2002). Further, as described earlier, stumpage prices used here were calculated by averaging real regional stumpage prices in the remeasurement period of 5 to 7 years rather than stumpage prices that landowner actually received.

These results indicate that, after allowing for other influences, institutional and industrial landowners are more likely to reforest than NIPF landowners. Using the results in Table 3, we predicted the probability of reforestation for each plot and then tested whether the predicted probabilities are significantly different among landowner groups. Not surprisingly, the results of pairwise Wald test statistics again show that predicted reforestation probabilities for industry and institutional plots are significantly higher than for NIPF plots at the 1% level (Table 4). The predicted reforestation probability for TIMOs was higher than, and significantly different from, those for Industry and REITs (with $P$ value $= 0.000$ for TIMOs versus industry and $P$ value $= 0.001$ for TIMOs versus REITs, respectively). Yet, the predicted probabilities for industry and REITs were not significantly different ($P$ value $= 0.87$). This implies that, all else being equal, TIMOs had a higher propensity to reforest than the traditional forest industry owners and timberland REITs. The average predicted probability of reforestation with plot deviation and the range between minimum and maximum probability for all four landownership groups (Figure 1). There was substantially more variation for the full range of the replanting probability (from min. to max.) on NIPF land, which ranged approximately from 0.22 to 0.96, whereas the replanting probability for the middle half of the plots fell within 0.70 and 0.90 for industry, 0.78 and 0.94 for TIMOs, and 0.68 and 0.91 for REITs.

We also applied the logit model to each of the four ownerships, and the results are presented in Table 5. All models except for the one for TIMOs ($P$ value $= 0.22$) have relatively good fit at the 5% significant level or better. As Hosmer–Lemeshow's goodness-of-fit test cannot reject the logit model fits the data for TIMOs ($P$ value $=$ 0.59), the insignificant fit of TIMO model is likely due to a small

**Table 3. A logit regression model estimating reforestation probabilities for all sampled plots located in the nine southern states.**

| Variable | Coefficient | *z*-test | Marginal effect |
|---|---|---|---|
| Constant | 0.69 | 0.93 | – |
| Sawtimber price | −0.02 | −0.98 | – |
| Pulpwood price | 0.54[a] | 3.60 | 0.09 |
| Cost | −3.13 | −0.77 | – |
| Distance | −0.10 | −0.32 | – |
| Slope | −1.52E-3 | −0.09 | – |
| Coastal plain | 0.51[c] | 1.85 | 0.09 |
| Productivity | 0.45[b] | 2.02 | 0.08 |
| Density | −3.36E-3[a] | −2.57 | −5.79E-4 |
| Industry | 0.67[b] | 2.43 | 0.12 |
| TIMOs | 1.12[b] | 2.49 | 0.19 |
| REITs | 0.61[b] | 1.97 | 0.10 |
| Log likelihood | −272.27 | | |
| Chi-square | 61.62[a] | | |
| Observation # | 538 | | |

[a], [b], and [c] indicate statistical significance, different from zero at the 1, 5, and 10%, respectively.

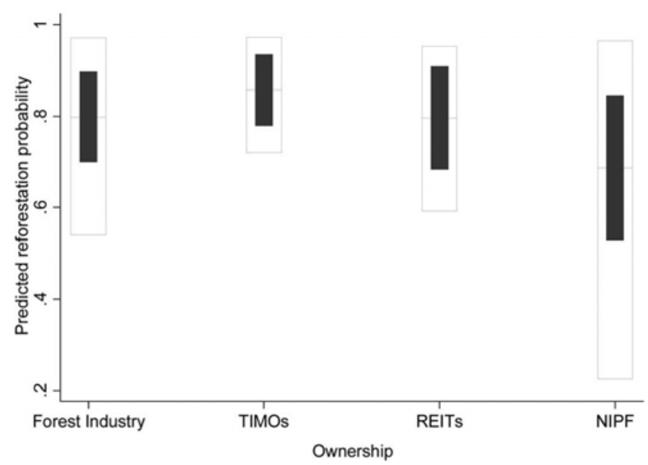


**Figure 1. Average predicted probability among timberland owners.**

**Table 4. Pairwise comparison of predicted reforestation probabilities between landowners.**

| | Industry versus TIMOs | Industry versus REITs | Industry versus NIPF | TIMOs versus REITs | TIMOs versus NIPF | REITs versus NIPF |
|---|---|---|---|---|---|---|
| Difference on average reforestation probability | −0.06 | 2.27E-3 | 0.11 | 0.06 | 0.17 | 0.11 |
| *t*-ratio | −3.73[a] | 0.16 | 7.18[a] | 3.40[a] | 7.34[a] | 6.37[a] |

[a] indicates statistical significance, different from zero at the 1%.

**Table 5. A logit regression model estimating reforestation probabilities by each type of ownership in the nine southern states.**

| Ownership | Variable | Coefficient | *z*-test | Marginal effect |
|---|---|---|---|---|
| Forest Industry | Constant | 4.59[b] | 2.26 | – |
| | Sawtimber price | 0.04 | 0.82 | – |
| | Pulpwood price | −0.01 | −0.01 | – |
| | Cost | −18.60[c] | −1.65 | −2.44 |
| | Distance | −0.93 | −1.05 | – |
| | Slope | 0.05 | 1.12 | – |
| | Coastal plain | 0.83 | 1.34 | – |
| | Productivity | 0.90[c] | 1.65 | 0.12 |
| | Density | −0.01[b] | −2.30 | −1.18E-3 |
| | Log likelihood | −52.58 | | |
| | Chi-square | 19.50[b] | | |
| TIMOs | Constant | −3.75 | −1.04 | – |
| | Sawtimber price | −0.03 | −0.41 | – |
| | Pulpwood price | 0.47 | 0.44 | – |
| | Cost | 8.68 | 0.44 | – |
| | Distance | 3.49[b] | 2.22 | 0.27 |
| | Slope | −0.06 | −0.89 | – |
| | Coastal plain | 1.56 | 1.08 | – |
| | Productivity | 0.55 | 0.51 | – |
| | Density | 2.27E-3 | 0.09 | – |
| | Log likelihood | −14.77 | | |
| | Chi-square | 10.64 | | |
| REITs | Constant | −3.68 | −1.45 | – |
| | Sawtimber price | −0.07 | −0.74 | – |
| | Pulpwood price | 0.59 | 0.96 | – |
| | Cost | 14.62 | 0.68 | – |
| | Distance | 2.55[b] | 2.25 | 0.33 |
| | Slope | −0.14[b] | −2.05 | −0.02 |
| | Coastal plain | 0.86 | 0.68 | – |
| | Productivity | 0.43 | 0.70 | – |
| | Density | 0.01 | 1.02 | – |
| | Log likelihood | −42.24 | | |
| | Chi-square | 19.71[b] | | |
| NIPF | Constant | 1.03 | 1.10 | – |
| | Sawtimber price | −0.02 | −1.10 | – |
| | Pulpwood price | 0.61[a] | 3.30 | 0.12 |
| | Cost | −2.56 | −0.52 | – |
| | Distance | −0.54 | −1.32 | – |
| | Slope | 3.14E-3 | 0.15 | – |
| | Coastal plain | 0.52 | 1.38 | – |
| | Productivity | 0.36 | 1.20 | – |
| | Density | −2.99E-3[b] | −2.10 | −6.06E-4 |
| | Log likelihood | −145.46 | | |
| | Chi-square | 34.72[a] | | |

[a], [b], and [c] indicate statistical significance, different from zero at the 1, 5, and 10%.

sample ($N = 49$). Among the market variables, *Pulpwood Price* had a positive and significant impact on the replanting probability for NIPF with the marginal effects of 0.12. *Reforestation Cost* significantly and adversely affected the replanting probability for industry with the marginal effects of −2.44. Among the plot characteristics, *Distance* had positive and significant effect on the probability of replanting for TIMOs and REITs, and the marginal effects were 0.27 and 0.33, respectively. *Slope* adversely affected the reforestation probability for REITs. *Productivity* was significantly and positively associated with the replanting probability for industry. Moreover, *Density* adversely affected the reforestation probability for forest industry and NIPF.

## Summary and Discussion

In this study, we used a binomial logit model to examine the probability of reforestation among timberland ownership groups. Our results show that industrial and institutional timberland owners, especially those managed by TIMOs, reforest more often than nonindustrial forest owners shortly after timber harvesting. These results are indirectly confirmed in a survey conducted by Rogers and Munn (2003), which reveals that institutional timberland owners manage their timberland as intensively as industrial owners in Mississippi, and are similar to Lee et al. (1992) and Li and Zhang (2007) regarding reforestation by industrial and nonindustrial forest owners. Despite the fact that institutional investors often invest in timberlands for a specified period of time, their reforestation activities demonstrate that they do consider and make long-term investment. Perhaps this is related to the facts that some of them have the option of extending the length of investment and that a few even have a stated long-term, open-ended horizon (Block and Sample 2001). At a minimum, it appears that TIMOs and REITs believe that their investment in reforestation will bring them adequate returns in capital appreciation even though their trees may not be mature if they decide to sell their timberlands (Zhang et al. 2012).

Several factors might have contributed to the institutional investors' inclination to reforestation. First, the current capital gain tax and certain tax exemption policies allow institutional investors to obtain a greater return in long-term silvicultural investments. Second, institutional investors may not have the capital constraints as some NIPF landowners might have (Browne 2001) and have a lower cost of capital than traditional industrial timberland owners which are C-corporations. Third, under US "Generally Accepted Accounting Principles," the traditional industrial timberland owners that only consider the profit realized from the harvesting and processing of trees. The institutional investors, however, recognize the total returns, both income and appreciation in the value of timberland assets (Block and Sample 2001, Ravenel et al. 2002). As for the difference between TIMOs and REITs, TIMOs value timberland more and look at a longer time frame than public equity investors do (Block and Sample 2001). Finally, as Siry and Cubbage (2001) and Zhang et al. (2012) note, planted pine dominates the holdings of many TIMOs, and pine plantations are more likely to be followed by another plantation.

Thus, as far as the reforestation aspect of forest sustainability is concerned, the institutional timberland owners have a higher propensity to reforest than NIPF landowners and are at least at the level of traditional industrial timberland owners. This does not suggest that NIPF landowners manage their lands less sustainably than institutional owners. Rather, it may suggest that the government should continue to offer reforestation cost-share programs to NIPF landowners. Two more critical questions are whether institutional timberland owners are more likely to convert forestlands to nonforest uses, which often represents a permanent forest loss, and whether forest certification has an impact on reforestation. These could be questions for future research. Future studies could also look into variations among landowners in other silvicultural treatments, such as the use of prescribed fire, fertilization, and herbicide, and into the environmental impacts of their forest practices.

### Endnote

1. FIA collects and maintains the name and address information from tax records since 2004, while the study period of this paper is from 1998 to 2009. Among the plots with which we could identify ownership in both FIA cycles, about 13% had different ownership categories between the two FIA cycles. Since we do not know exactly which year the legal transformation of timberland ownership took place, we have treated the ownership of all plots the same as in the last FIA cycle in our study period.

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