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Nonindustrial private forest landowner participation in incentive programs and regeneration behavior

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NONINDUSTRIAL PRIVATE FOREST LANDOWNER PARTICIPATION IN INCENTIVE PROGRAMS AND REGENERATION BEHAVIOR

By

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Nonindustrial private forest (NIPF) landowners have been major players in increasing forest productivity and improving forest health. Understanding what factors influence landowner participation in government programs, and what factors determine how quickly after harvest landowners regenerate, is critical for developing policies to improve landowner behavior. The data were obtained through a 2006 telephone survey of randomly selected Mississippi NIPF landowners. A two-step landowner behavior model was constructed to explain NIPF landowner participation in government incentive programs, conditional on their awareness. The second study used duration analysis to analyze the time elapsed between harvest and regeneration. Interest in timber production, past regeneration experience, education, and membership in forestry organization influenced landowner awareness of incentive programs and were significant predictors of participation. The interval between harvest and reforestation was reduced by maintaining an interest in timber production, consulting forester for harvest, residing on forest land, having planted pines, and increasing timber prices.

Key words: Duration analysis, incentive programs, nonindustrial forest landowners, participation behavior, reforestation delay, two-step estimation

DEDICATION

I would like to dedicate this research to my parents, Lili Ma and Yankui Sun, and my brother Yan Sun.

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CHAPTER I

INTRODUCTION

Nonindustrial private forest (NIPF) landowners have played major roles in both increasing forest productivity and improving environmental health (Boyd, 1984; Gunter et al., 2001; Wear and Greis, 2002). The greatest impact NIPF landowners had on increasing timber production was through intensive planting and management (Hardie and Parks, 1991). For example, in Mississippi in 2002, 72% of the forest land was owned by NIPF landowners who were responsible for 67% of total timber production (Smith et al., 2004). Currently, the potential for enhancing productivity largely depends on the performance of NIPF landowners. Moreover, NIPF landowners have the greatest capability to contribute to forest health, including soil conservation, carbon storage, and maintenance of air and water quality (Alig, 2003; Wear and Greis, 2002).

Numerous studies have analyzed the behavior of NIPF landowners with regard to their participation in governmental incentive programs and their decisions related to regeneration activities (Amacher et al., 2003). However, NIPF landowners do not always take advantage of governmental incentive programs and many landowners do not reforest after harvesting, which may not only affect timber supply, but also reduce non-timber outputs and benefits from the forest. Therefore, this research focuses on NIPF landowner participation and reforestation behavior in Mississippi, which is a typical southern state where timber and secondary forest outputs are important.

Objectives

This research is intended to improve upon previous research by increasing our understanding of landowner behavior through two studies of Mississippi NIPF landowners. In the first study, considering that landowners decide whether or not to participate in incentive programs only if they are aware of these programs, we analyzed factors influencing NIPF landowner participation in government incentive programs contingent on their awareness and constructed a two-step model. Recognizing that many landowners do not regenerate promptly after harvest, in the second study, we focused on the time interval between harvest and regeneration, instead of a discrete decision (yes/no) only.

More specifically, the study objectives were to determine:

1) factors associated with NIPF landowner awareness of three economic assistance programs available to them in Mississippi;
2) factors associated with NIPF landowner participation in these three programs, given their awareness of these programs;
3) how long NIPF landowners wait to reforest after harvesting;
4) factors that affect the lag time between harvesting and reforestation; and
5) how much each factor contributes to the percentage of final harvests that are followed by reforestation; and

6) how much each factor contributes to the length of the interval between completion of harvest and beginning of regeneration.

Structure of Thesis

This thesis provides information on Mississippi's NIPF landowner participation in governmental programs and the time interval between harvesting and regenerating, and has implications for developing policies related to governmental incentive programs and silvicultural activities.

CHAPTER II investigates factors associated with NIPF landowner awareness of government programs, and given their awareness of government programs, factors associated with participation in these programs. Instead of using a binary choice model, we employ a two-step model of NIPF landowner participation behavior, conditional on their awareness of government incentive programs.

CHAPTER III investigates the time elapsed between harvest and regeneration and explores factors that influence how quickly landowners regenerate their harvested timberlands. Duration analysis is used to analyze the length of the interval between completion of harvest and beginning of regeneration.

CHAPTER IV summarizes the research including practical implications of the results and provides guidelines for future research.

CHAPTER II

NIPF LANDOWNER PARTICIPATION IN INCENTIVE PROGRAMS

Introduction

NIPF landowners have been major players in forestry in the United States. Timberlands are owned by the public (29%), forest industry (13%), and NIPF landowners (58%); they accounted for 8%, 29%, and 63% of the timber harvested in 2001, respectively (Smith et al., 2004). Furthermore, forests not only generate timber as raw material for the wood products industry, but also contribute environmental amenities, including soil conservation, carbon storage, and maintenance of air and water quality. Forests also protect wildlife habitat and enhance recreation (Alig, 2003; Wear and Greis, 2002). Therefore, public agencies have provided NIPF landowners with a variety of public assistance programs to help achieve their management goals and also meet societal needs.

Forest land management can be capital-intensive, particularly in stand establishment (Gunter et al., 2001). A long period of growth must occur before income can be produced from the forest. Public assistance programs can influence the management of NIPF lands, compensate NIPF landowners for high costs of tree planting, and encourage better forest stewardship (Wear and Greis, 2002). In particular, tree planting (i.e., regeneration) after timber harvest has been a major practice that public assistance programs targeted. The goal of many regeneration programs is to reduce the financial burden and encourage NIPF landowners to replant their lands after harvest. For example, in 1973, the Forestry Incentives Program (FIP) was authorized by the U.S. Congress to share the cost of tree planting and timber stand improvement with private landowners. The federal share by FIP has ranged up to 65% of replanting and improving costs.

Many studies have been conducted to analyze the behavior of NIPF landowners with regard to their participation in government incentive programs and their decisions in silvicultural activities (Amacher et al., 2003). Previous studies generally agreed that these programs have successfully influenced the management of NIPF lands and stimulated more planting activities (Boyd, 1984; Mehmood and Zhang, 2001; Nagubadi et al., 1996). However, in spite of the benefits, these studies also revealed that NIPF landowners have not always taken advantage of these programs. Gunter *et al.* (2001) found the majority (54.3%) of 427 Mississippi NIPF landowners who regenerated their timber stands following a harvest during the 5-year period from 1994 to 1998 did not receive public cost-sharing funds for regeneration under FIP, Mississippi's Forest Resource Development Program (FRDP), Conservation Reserve Program (CRP), or Mississippi Reforestation Tax Credit (RTC). Among the 829 landowners that responded to the survey, only 38% knew of FIP, 24% of FRDP, and 27% of RTC.

This research focused on participation behavior of NIPF landowners in government programs in Mississippi, a typical southern state where timber and the related forest industry have been important. In Mississippi in 2002, NIPF landowners owned 72% of forest lands and produced 67% of timber outputs (Smith et al., 2004). The objective of this study was to examine NIPF landowner knowledge of three government incentive programs in Mississippi and their participation in these programs from 1996 to 2006. These programs included the FIP, FRDP, and RTC. A two-step sample selection model was developed to examine what factors were associated with landowner awareness of these programs, and conditional on landowner awareness, what factors affected the probability of participation.

Literature Review and Determinants of Participation Behavior

Financial Incentive Programs for Tree Planting

Financial incentive programs were designed to help NIPF landowners by subsidizing their initial reforestation costs (Wear and Greis, 2002). Of these programs, FIP is a federal cost-share program, FRDP is a Mississippi state cost-share program, and RTC is a Mississippi tax incentive program. Their history, eligibility, criteria, and financial assistance arrangements are briefly described as follows.

FIP is a major federal program related to regeneration. Authorized in 1973, the main purpose of FIP has been to increase timber production and encourage good forest management on NIPF lands by sharing the cost of tree planting, timber stand improvement, and site preparation. To participate in FIP, eligible lands owned by NIPF landowners can range from 10 to 1,000 acres, and with special authorization up to 5,000 acres (Wear and Greis, 2002). Incentives provided to NIPF landowners can extend up to

65% of actual costs, with a maximum annual cost share payment of $10,000. Funding for FIP has declined dramatically over the past decade (Wear and Greis, 2002). In the 2002 Farm Bill, the FIP program was replaced by Forest Land Enhancement Program (FLEP), though some contracts have been funded through 2004.

Mississippi's FRDP was established in 1974. It has been a state cost-share program for reforestation and timber stand improvement (Wear and Greis, 2002). FRDP was developed to provide financial assistance to eligible landowners for establishing and improving forest land. This program offsets landowner expenses by sharing the cost of implementing specific forestry practices to produce timber and enhance wildlife development. FRPD requires that applicants submit a management prescription for the desired treatment area, comply with Mississippi Forestry Commission standards during operations, and maintain practices for 10 years. Cost-share payments of FRDP cover 50 to 75% of the total cost of implementing forest practices, with a maximum annual assistance of $5,000 (Wear and Greis, 2002).

Mississippi RTC was initiated in 1999 to promote reforestation on nonindustrial private lands. The credit is applied to Mississippi state income taxes by excluding cost-share payments for reforestation and some other practices from their taxable income (Wear and Greis, 2002). It gives Mississippi NIPF landowners tax credit up to 50% of the cost of approved hardwood and pine reforestation practices. It has the annual credit limit of $10,000, and allows the participant to carry forward to succeeding taxable years any unused portion of the credit in 2006. In 2007, the state legislature raised the annual income tax credit limit from the current amount of $10,000 to $75,000. In addition, a landowner may claim a tax credit of up to $10,000 in any single year with an unlimited carry-forward provision.

Binary Choice Model for NIPF Landowner Participation

Many empirical studies have examined NIPF landowner participation behavior in governmental incentive programs. Typical studies of NIPF landowner participation in incentive programs have relied on a binary choice model (e.g., Bell et al., 1994; Nagubadi et al., 1996). The dependent variable was a dummy variable indicating participation. Independent variables included landowner characteristics (e.g., income, education) and land features (e.g., acreage). Landowner participation in public assistance programs has been positively associated with total acres owned, membership in forestry organizations, interest of land investment for timber production, income, and residence on the landowner ownership location relative to woodland (Konyar and Osborn, 1990; Nagubadi et al., 1996; Straka et al., 1984).

Unfortunately, an oversimplified binary model may be inadequate in analyzing landowner participation in incentive programs. As revealed in studies like Gunter *et al*. (2001), many NIPF landowners have been unaware of the existence of these incentive programs. Thus, it was inappropriate to examine landowner participation in government programs if they are not aware of them. A binary choice model was derived from an individual’s utility maximization from comparing two choices: participation or no participation. If an individual is not aware of the program and has not made the comparison, the dependent variable is actually a missing value, instead of zero. In other words, zero-values for the dependent variable in previous studies might come from two sources: individuals who knew of the program and decided not to participate, and individuals who did not know of the program and did not consider the participation question at all.

The problem with previous studies has originated from their oversimplified assumption in the binary choice model with regard to landowner behavior. A more suitable approach would be a two-step decision model for a NIPF landowner with regard to participation in government incentive programs. The innovation was to recognize the reality in forestry that many NIPF landowners were not aware of these incentive programs. The appropriate econometric technique is the sample selection estimation (Greene, 2003), which has been widely applied in the literature to other issues (e.g., Katchova and Miranda, 2004; Lee et al., 2003).

Conceptual Framework, Survey Data, and Variables

Analytical Framework

Given the study objectives, this research was designed to use cross-sectional survey data from Mississippi to determine how land features, management experiences, and landowner characteristics influence landowner knowledge and enrollment probability for three selected incentive programs: FIP, FRDP, and RTC. The analysis was conducted separately for each of them. The survey covered the period from 1996 to 2006. For specific programs, the time span varied slightly because not all of them were available over the study period. The survey covered nine years for FIP (1996-2004), 10 years for FRDP (1995 to 2005), and six years for RTC (1999 to 2005).

The empirical design was a two-step sample selection model. It assumed that landowner participation in an incentive program was contingent upon whether the landowner knew of the program. In the first stage, a landowner's knowledge of a program, z_i, was modeled as a function of variables, w_i, that were related to land features, management experiences, and landowner characteristics:

(2-1) Selection equation: $z_i = g(w_i)$

where z_i was a binary variable that measured the knowledge of landowner i about an individual program (i.e., FIP, FRDP, RTC). z_i was zero if a landowner had no knowledge of the program, and one if the landowner knew about the program.

In the second stage, the participation decision of the landowner in the incentive program was modeled as a function of land features, management experiences, and landowner characteristics, x_i:

(2-2) Outcome equation: $y_i = f(x_i)$, $y_{i,}$ observed only when $z_i = 1$

where y_i was a binary variable for landowner participation in the incentive program during the time period surveyed. y_i was zero if a landowner did not participate in program, and one if the landowner participated in the program. The motivation for constructing knowledge (z_i) and participation (y_i) of NIPF landowners together was that they were related but distinct characteristics, and might be influenced by a same set of factors to a different degree. Therefore, x_i might be different from w_i.

The nature of dependant variables, z_i and y_i, required a bivariate probit model with sample selection. In estimating the model, a predicted value was computed in estimating the selection equation. It was then used in the outcome equation to analyze participating probability.

Survey and Sample

The Social Science Research Center at Mississippi State University conducted the telephone survey in August 2006 and collected the data used in this study. The survey sample was drawn from a database of landowner records in Mississippi. The database covered 81 of the 82 counties in Mississippi as the records for Hinds County were not available. NIPF landowners were the study focus so companies and partnerships were excluded. In addition, only NIPF owners with at least 100 acres of land were selected to eliminate these small landowners with infrequent forest management activities. That yielded a list of about 20,000 landowners. Furthermore, names and addresses of these landowners were used to find their phone numbers through a commercial service agency. Finally, among these landowners with phone numbers, a random sample of 9,925 landowners were selected and used in the telephone survey.

During the telephone survey, several questions were asked to further select landowners relevant for the study. First, the landowner database has been proven to be inaccurate for specific items, including land acreage. Thus, the survey began with a question about the acreage owned and, if it was less than 100 acres, the subject would not have to fill out the remainder of the survey. Second, the study objective focused on the participation of landowners in incentive programs. An assumption was that a landowner should have harvesting activities during the time period surveyed. So another question, asked at the beginning of the survey, would exclude those landowners without harvesting activities from 1995 to 2006.

Questionnaires and Variables

The survey questionnaire was designed to collect information for variables needed for the empirical analysis, as described in Table 2-1. There were two sets of dummy dependent variables, i.e., z_i and y_i. One set defined landowner knowledge of three individual incentive programs, i.e., FIP, FRDP, and RTC. The other recorded a landowner participation in each program during the survey period.

Independent variables contained in w_i and x_i were divided into three groups: land features, management experiences, and landowner characteristics. First, three variables were used to represent land features: *Acreage*, *Land Type*, and *Forest Type*. *Acreage* was the total land area owned by the landowner in Mississippi. *Land Type* was a dummy variable equal to one if the predominant use was forestry, and zero for agriculture or other uses. *Forest Type* was a dummy variable equal to one if the predominant forest type was planted pine, and zero for hardwood and mixed pine-hardwood forests.

Second, three variables were constructed to represent management experiences of the landowner: *Year*, *Timber*, and *Regeneration*. *Year* was the number of years the landowner owned the land. *Timber* measured the landowner interest in timber production, and the dummy variable equaled one if the landowner was strongly interested in timber production, and zero if not. *Regeneration* was the number of times the landowner regenerated during the survey period.

Finally, eight variables were used to represent the demographic characteristics of individual landowner: *Age*, *Education*, *Income*, *Employment*, *Race*, *Gender*, *Membership*, and *Residence*. *Age* represented landowner's age in 2006. *Education* was equal to one for those landowners who had bachelor's or higher degree, and zero otherwise. *Income* represented the landowner's household income before taxes for tax year 2005. *Employment* was equal to one if the landowner was retired, and zero otherwise. *Race* was equal to one for Caucasian landowners, and zero otherwise. *Gender* was equal to one for male landowners, and zero for female. *Membership* was equal to one if the landowner was a member of any forestry organization (e.g., Mississippi Forestry Association, Mississippi County Forestry Association, Society of American Foresters, Southern Forestry Association), and zero if not. *Residence* was equal to one if the landowner resided on their forest land, and zero if not.

Methodology ─ Two-Step Estimation

The underlying idea of sample selection models is that an outcome variable is only observed if some criterion, defined with respect to a selection variable, is met (Greene, 2003). For this study, a two-step model with sample selection examined landowner participation in an incentive program, conditional on their knowledge of the program. Specifically, in the selection stage, knowledge of incentive programs (z_i) can be estimated with a probit model. In the outcome stage, the binary variable reflects whether or not participation in the incentive program was observed. Participation (y_i) can be modeled using a probit regression, given landowner knowledge of the incentive program. Formally, the two-step model can be expressed as (Greene, 2003):

(2-3) Selection equation: $z_i^* = w_i\gamma + e_i$

$$z_i = 1 \text{ if } z_i^* > 0;\ 0 \text{ otherwise}$$

$$\Pr(z_i = 1) = \Phi(w_i\gamma)$$

$$\Pr(z_i = 0) = 1 - \Phi(w_i\gamma)$$

(2-4) Outcome equation: $y_i^* = x_i\beta + \varepsilon_i$

$$y_i = 1 \text{ if } y_i^* > 0;\ 0 \text{ otherwise}$$

$$y_i \text{ observed only when } z_i = 1$$

where z, y, w and x are variables as defined previously and indexed by landowner *i*; γ and β are parameters to be estimated; Φ is the normal cumulative distribution function; and e and ε are error terms. In the selection equation, z is a realization of an unobserved continuous variable (z^*) having a normally distributed, independent error, e, with mean zero and constant variance σ_e^2. In the outcome equation, y is a realization of an unobserved continuous variable (y^*) and is observed for value of z =1. y has error ε, with mean zero and constant variance $\sigma_\varepsilon{}^2$.

Preliminary analysis revealed that majority of Mississippi's NIPF landowners did not participate in government programs. Thus, the binary dependent variable measuring participation, y, was skewed. This motivated us to employ the Gompertz model, which has been used for estimating models with skewed binary data (Greene, 2002). Formally, the probabilities of a Gompertz model for y conditional on z determined by a probit model can be expressed as follows (Greene, 2002):

$$\text{(2-5)} \qquad \Pr(y_i = 1) = \exp\{-\exp[-x_i\beta - \varepsilon_i \Phi(w_i\gamma)]\}$$

$$\Pr(y_i = 0) = 1 - \exp\{-\exp[-x_i\beta - \varepsilon_i \Phi(w_i\gamma)]\}$$

If y is simply regressed on x using those observations for which $z = 1$, the estimates of β will be both biased and inconsistent. In estimating the model, a typical way of addressing the problem involves two steps (Murphy and Topel, 1985). The essential part is the correction of the estimated asymptotic covariance matrix for the estimator in the outcome equation for the randomness of the estimator carried forward from the selection equation (Greene, 2002). Let V_1 be the estimator of the asymptotic covariance matrix for the parameter estimates obtained in the selection equation. Let V_2 be the uncorrected covariance matrix computed in the outcome equation, using the parameter estimates obtained in the selection equation as if they were known. Both of these estimators were based on the respective log likelihood functions. In addition, define:

$$\text{(2-6)} \qquad C = \sum_{i=1}^{n} \left[\frac{\partial \log f(x_i)}{\partial \beta}\right]\left[\frac{\partial \log f(x_i)}{\partial \gamma'}\right]$$

$$R = \sum_{i=1}^{n} \left[\frac{\partial \log f(x_i)}{\partial \beta}\right]\left[\frac{\partial \log g(w_i)}{\partial \gamma'}\right]$$

where n is the number of observations.

With these in hand, the corrected covariance matrix for the estimator of the outcome equation, V_2^*, is as follows:

(2-7) $$V_2^* = V_2 + V_2\left[CV_1C' - RV_1C' - CV_1R'\right]V_2 .$$

Hence, the model consists of two marginal distributions: $g(z \mid w, \gamma)$ and $f(y \mid w, x, \gamma, \beta)$.

Overall, first estimate the probit model through maximum likelihood and denote the estimated parameter as $\hat{\gamma}$. Then, estimate the Gompertz model in which a predicted value from the model in the selection equation appears on the right hand side of the outcome equation and denote the full set of parameters as $\hat{\beta}$. This predicted value is specified for the correction of selectivity in the linear model (that is, the Mill ratio) and can be expressed as follows:

(2-8) $$P1V = \frac{\phi\left(z_i^*\right)}{1 - \Phi\left(z_i^*\right)}$$

where $\phi(.)$ and $\Phi(.)$ are, respectively, the density and distribution function for the selection equation. *P1V* is included in the explanatory variables of the outcome equation, *x*. When the coefficient of estimated *P1V* is significant, it implies the parameter estimators for the outcome stage would be biased if two-step estimation procedures were not used. This entails modeling *y* as dependent upon variables *x* but considering the fact that *y* is only observed when z=1.

Finally, the two sets of explanatory variables, *w* and *x*, can be the same or different. If *w* is equal to *x*, or *w* is a subset of *x*, then it may still be possible to identify the parameters of the outcome equation because of the nonlinearity of the model (Breen, 1996). Where both equations are linear then, given the nonzero correlation between the error terms, the model would not be identified. In practice, reliance on the nonlinearity of the probit model can result in unstable parameter estimates. As a general rule, it is not a good idea to rely on the model nonlinearity for identification. It is much better to place restrictions on coefficients, such that a variable that affects the selection stage has no effect on the outcome. This will ensure model identification, although which restrictions are appropriate will depend upon the conceptual model that underlines the analysis (Breen, 1996).

To deal with this issue, two models for each incentive program were estimated. First, a general model that treated *w* and *x* as the same, respectively, in selection and outcome equations was employed. However, estimation results for many important explanatory variables were not significant. It suggested a collinearity problem among these variables. Thus, through preliminary analysis, some variables were deleted which did not affect the outcome stage but were collinear with other important explanatory variables. Therefore, in a restricted model, the coefficients in the outcome equation, *x*, was a subset of the coefficients in the selection equation, *w*.

Empirical Results

Survey Results and Descriptive Statistics of Variables

Of the 9,925 landowners contacted by telephone, 2,126 owned less than 100 acres and another 2,132 did not harvest timber in the past 10 years, so these landowners were excluded from the study. There were also 1,110 wrong telephone numbers. Other reasons for unsuccessful calls included communication problems, refusal to participate, and deceased landowners. In the end, 2,229 valid and complete observations were recorded and available for the statistical analysis. The adjusted return rate was 49.8%, i.e., 2,229 / (9,925 - 2,216 - 2,132 - 1,110).

Variable definitions and their descriptive statistics were presented in Table 2.1. First, concerning landowner knowledge of individual programs, 43.7% of 2,229 landowners surveyed knew of FIP, 39.8% of FRDP, and 40.6% of RTC. Overall, nearly 60% landowners were not aware of these incentive programs. This was consistent with findings from a previous survey in Mississippi (Gunter et al., 2001). Furthermore, NIPF landowner participation in these incentive programs was low. Among 2,229 landowners surveyed, a total of 75 participated in FIP (3.4%); 63 landowners participated in FRDP (2.8%); and 207 landowners participated in RTC (9.3%).

For the independent variables of land features, the average acreage owned for the sampled landowners was 507 acres. For most landowners (i.e., 76.9%), forest land was the predominant land use. For about half (i.e., 51.0%), pine was the predominant forest type with the remainder having either hardwood or mixed forest types. Average length of ownership was 35 years. Most landowners (i.e., 88.2%) were interested in timber production. Average number of times landowners had regenerated after harvesting during the study period was 0.3 times.

On average, surveyed landowners were 66 years old; 47.3% had a bachelor’s or higher degree; and their household income in 2005 was $66,127. In addition, 55% of respondents were retired, 96.6% Caucasian, and 70.4% male. Approximately, 25.3%

were members of a forestry association. Finally, 48.0% resided on their lands. In the following analyses of the regression results, to address the study objective directly, the determinants of landowner knowledge of these incentive programs were examined first and then the determinants of landowner participation in these programs followed.

Determinants of Landowner Knowledge of Incentive Programs

Regression results about NIPF landowner knowledge were reported for FIP, FRDP, and RTC (Table 2-2). For the selection equation, the correct prediction rate for the knowledge variable was 63.9% for FIP, 64.6% for FRDP, and 68.9% for RTC. Regardless of model size (general model or restricted), the probit approach for the selection equation yielded the expected results.

The first stage of the binary probit model generated similar results across the three incentive programs. Among the land features, coefficients for *Acreage* were positive and significant for all three programs. Thus, landowners with more land were more likely to know about incentive programs. *Land Type* was not significant in any of the programs. *Forest Type* had positive and significant coefficient for FIP and RTC only, implying that landowners who had higher proportions of pine forest were more likely to know about these incentive programs.

Among the three land management variables, the coefficients for *Timber* were positive and significant for all three programs. *Timber* was highly significant for every program, suggesting that landowner interest in timber production motivated them to learn more about these programs. *Regenerate* was positive for FIP and RTC, suggesting that landowners were more likely to know of incentive programs if they had previously regenerated their timber lands. *Year* was not significant.

Finally, three demographic characteristics (i.e., *Education, Gender, Membership*) had positive and significant coefficients over all three programs. Thus, landowners with these characteristics were more likely to know about incentive programs. Results for the other demographic variables were mixed. *Age* had a negative and significant impact on RTC only; *Income* had a positive and significant impact on RTC only; *Employment* had a positive and significant impact on FRDP only; *Race* and *Residence* had positive and significant impacts on FIP only.

Overall, landowner knowledge of incentive programs was positively related to *Acreage*, *Forest Type*, *Timber, Regenerate*, *Education*, *Gender,* and *Membership*. Among these variables, *Membership* had the largest marginal effect, ranging from 0.208 for FRDP to 0.270 to RTC. *Timber* and *Gender* also had relatively large marginal effects. Landowners with these characteristics were either better motivated or better educated about incentive programs.

Determinants of Landowner Participation in Assistance Programs

Regression results about NIPF landowner participation were reported for FIP, FRDP, and RTC (Tables 2-3 to 2-5). Independent regression models without sample selection were employed to compare with two-step estimation. In independent regression models, landowner participation was not conditional on program awareness. In the unrestricted model of two-step sample selection models, there were no significant variables for FIP, one for FRDP, and three for RTC. That few variables were significant suggested a collinearity problem among variables in outcome equations. Hence, in the restricted model, *Acreage*, *Forest Type,* and *Age* were excluded from the outcome equation because they were correlated with *Income*, *Timber,* and *Employment*. Restricted models statistically produced more significant results for FIP and FRDP but did not improve results for RTC. Hence, estimation results for the two-step sample selection model suggested that the restricted model was a better fit for FIP and FRDP, and the general model for RTC.

Further, in the restricted models for FIP and FRDP, the coefficient on *P1V* was significant and positive. This suggested that parameter estimators for landowner participation in FIP and FRDP would be biased if two-step estimation procedures were not used. However, the coefficient on *P1V* was not significant for the general model of RTC. This indicated that two-step estimation provided no additional benefits when estimating participation in RTC.

Compared with the two-step method, estimation results from independent regression models did not change in estimating landowner awareness of these programs. When estimating landowner participation, the independent models generated fewer statistically estimated coefficients for FIP and FRDP even under conditions in which the method worked well. The independent model for RTC, however, produced more significant estimates in landowner participation. Finally, the restricted model with two-step sample selection was more suitable for the parametric estimations of FIP and FRDP;

however, the independent regression model was better for the determinants of landowner participation in RTC.

Land features had no effect on landowner participation in FIP and FRDP. Among the set of variables representing management experience, *Regenerate* was positive and significant for FIP and FRDP. *Timber* was positive and significant for FIP only. Among the significant landowner characteristics, *Education*, *Gender*, and *Membership* positively influenced participation in FIP and FRDP; *Residence* was positive and significant for FIP. When landowners knew of these programs, their participation probability was higher for landowners with these characteristics. *Membership* had the largest marginal effect on participation probability. *Education* and *Regenerate* had relatively large marginal effects. Landowners with these characteristics were either more connected with timber production, or were more likely to regenerate.

In the independent model of RTC, *Acreage* had a negative and significant impact on participation, while *Regenerate*, *Education*, and *Gender* were significantly positively related to participation. *Regenerate* had the largest marginal effect. Therefore, landowners with previous regeneration experience were more likely to participate in RTC.

Overall, when landowners were aware of FIP, FRDP, and RTC, they were more likely to participate if they had the following characteristics: more regeneration experience, better education, were male, or belonged to forestry associations. The largest marginal effects were associated with *Membership* for FIP and FRDP, and with *Regenerate* for RTC.

Conclusions

This study estimated how land features, management experiences, and landowner characteristics influenced participation in three financial assistance programs available to NIPF landowners in Mississippi. A two-step sample selection model was used to analyze the probability of participation conditional on NIPF landowner awareness of incentive programs. A combination of binary probit and Gompertz models was used. Modeling the participation probability conditional on landowner awareness yields more accurate results than simple binary regression typically employed in the literature.

Only about 40% NIPF landowners in Mississippi knew of FIP, FRDP, and RTC. Participation in these incentive programs was quite low. Among the 2,229 landowners surveyed, 75 participated in FIP; 63 participated in FRDP; and 207 participated in RTC during the survey period. On average, these landowners owned 507 acres, for 76.9% forestry was the dominant land use, for 51.0% pines were the predominant forest type, and they owned the land for an average of land ownership of 35 years. Most of these landowners were interested in timber production. Average age was 66 years; 47.3% had a bachelor’s or higher degree; and their household income in 2005 was $66,127. About 25.3% were members of a forestry organization and close to half resided on their forest land. Overall, the major results revealed that the sample was typical for Mississippi.

The two-step regression with sample selection generated several clear results. Landowner knowledge of incentive programs was positively correlated with land acreage, having predominantly pine forests, interest in timber production, past regeneration experience, better education, being male, and membership in forestry organizations. Furthermore, when landowners were aware of incentive programs, participation was higher for those with more regeneration experience, better education, male, or membership in forestry organizations.

These results have several policy implications for promoting and implementing government incentive programs. Given that most NIPF landowners in Mississippi have no knowledge or a limited understanding of government incentive programs, these results suggest that future efforts should be spent to disseminate this information among the forestry community. Based on these results, Extension outreach can be more effective through forestry organizations. The results also suggested that motivating landowners to take an interest in timber production would be an effective approach to increasing NIPF landowner awareness of these programs in the forestry community.

Empirical results also pointed out the importance of membership in forestry organizations in promoting landowner participation in assistance programs. Forestry organizations typically provide information and technical guidance and thus affect landowner participation in programs by emphasizing the benefits of taking advantage of these opportunites. Therefore, a useful strategy may be to encourage NIPF landowners to join forestry organizations.

Among landowners aware of these incentive programs, participation was relatively higher for landowners with more previous regeneration experience, better education, or membership in forestry organizations. Landowners aware of these incentive programs might be motivated to participate in government programs.

Given the continued emphasis on incentive programs, concerns regarding the future strategies of financial assistance programs related to reforestation were illustrated. Still more work needs to be done to carry forward insights obtained from this research. Future studies on incentive programs would benefit by enlarging the surveyed scope. Although we attempted to overcome data limitations by employing different regression models based on the characteristics of dependent variables (e.g., a combination of binary/count models) and different transformations of explanatory variables (e.g., transform the continuous number of *Acreage* to the natural logarithm of *Acreage*), these efforts still encountered problems due to extreme data distribution. Another concern is that financial assistance, constrained by government budgets, creates a challenge of how to efficiently allocate funds to achieve maximum participation. Given limited government budget, the cost of increasing participation by improving NIPF landowner knowledge must be compared with the start-up cost. The identification of such costs is vital to making sound policy decisions regarding the most efficient way to promote financial assistance programs.

Table 2-1. Summary statistics of the variables used in two-step analysis for nonindustrial private forest landowner awareness and participation behavior in Mississippi from 1996 to 2006.

Variables	Definitions	Mean	Std. Dev.
	Dependent variables		
Selection equation (z_i)			
Knowledge of FIP	Dummy = 1 if the landowner knows of FIP; 0 otherwise	0.437	--
Knowledge of FRDP	Dummy = 1 if the landowner knows of FRDP; 0 otherwise	0.398	--
Knowledge of RTC	Dummy = 1 if the landowner knows of RTC; 0 otherwise	0.406	--
Outcome equation (y_i)			
Participation in FIP	Dummy =1 if the landowner participated in FIP; 0 otherwise	0.034	--
Participation in FRDP	Dummy =1 if the landowner participated in FRDP; 0 otherwise	0.028	--
Participation in RTC	Dummy =1 if the landowner participated in RTC; 0 otherwise	0.093	--
	Independent variables		
Land features			
Acreage	Total acreage owned by the landowner	506.555	1,007.470
Land Type	Dummy = 1 if forest land is the predominant land use; 0 otherwise	0.769	--
Forest Type	Dummy = 1 if pine forests are the dominant forest type; 0 otherwise	0.510	--
Management experience			
Years	Years of land ownership	34.719	19.766
Timber	Dummy= 1 if the landowner is interest in timber production; 0 otherwise	0.882	--
Regenerate	Number of regeneration activities during the survey period	0.312	0.573
Landowner characteristics			
Age	Landowner age	66.127	11.070
Education	Dummy = 1 if the landowner has a bachelor degree or better; 0 otherwise	0.473	--
Income	Household income before taxes in 2005 ($1,000)	62.961	27.956
Employment	Dummy = 1 if the landowner is retired; 0 otherwise	0.550	--
Race	Dummy = 1 if Caucasian; 0 otherwise	0.966	--
Gender	Dummy = 1 if male; 0 otherwise	0.704	--
Membership	Dummy = 1 if the landowner is a member of any forestry association; 0 otherwise	0.253	--
Residence	Dummy = 1 if the landowner resides on the land; 0 otherwise	0.480	--

Table 2-2. Estimates of the determinants of nonindustrial private forest landowner awareness of government assistance programs in Mississippi from 1996 to 2006.

Variables	FIP Coeff. (*t*-ratio)	FIP Marginal effect	FRDP Coeff. (*t*-ratio)	FRDP Marginal effect	RTC Coeff. (*t*-ratio)	RTC Marginal effect
Constant	-1.181***	-0.464	-0.809***	-0.312	-1.054***	-0.407
	(-4.195)		(-2.900)		(-3.655)	
Land features						
Acreage	5.839E-5*	2.297E-5	1.183E-4***	4.553E-5	8.021E-5**	3.095E-5
	(1.836)		(3.081)		(2.252)	
Land Type	-0.069	-0.027	-0.012	-0.004	0.086	0.033
	(-1.033)		(-0.172)		(1.239)	
Forest Type	0.092*	0.036	-0.020	-0.008	0.190***	0.073
	(1.655)		(-0.363)		(3.306)	
Management experience						
Years	0.002	0.001	0.001	3.779E-4	3.898E-4	1.504E-4
	(1.029)		(0.629)		(0.242)	
Timber	0.290***	0.111	0.200**	0.075	0.351***	0.129
	(3.175)		(2.204)		(3.617)	
Regenerate	0.098**	0.038	0.068	0.026	0.393***	0.152
	(1.981)		(1.389)		(7.623)	
Landowner characteristics						
Age	-0.004	-0.002	-0.005	-0.002	-0.009***	-0.004
	(-1.181)		(-1.485)		(-2.673)	
Education	0.148**	0.058	0.113*	0.044	0.105*	0.041
	(2.474)		(1.888)		(1.729)	
Income	0.002	0.001	-0.001	-2.623E-4	0.002*	0.001
	(1.394)		(-0.615)		(1.762)	
Employment	0.053	0.021	0.174**	0.067	0.064	0.025
	(0.752)		(2.445)		(0.875)	
Race	0.305*	0.115	0.119	0.045	0.170	0.064
	(1.914)		(0.761)		(1.045)	
Gender	0.320***	0.124	0.279***	0.105	0.301***	0.114
	(5.163)		(4.463)		(4.696)	
Membership	0.575***	0.226	0.533***	0.208	0.693***	0.270
	(8.901)		(8.299)		(10.512)	
Residence	0.105*	0.041	0.101*	0.039	-0.003	-0.001
	(1.804)		(1.748)		(-0.042)	
Correct prediction	63.930%		64.558%		68.910%	
Log Likelihood	-1,425.316		-1,421.979		-1,330.953	
Chi-squared	203.900		153.384		349.671	
Observation	2,229		2,229		2,229	

***, **, and * indicate significance at the 1%, 5%, and 10%, respectively.

Table 2-3. Estimates of the determinants of nonindustrial private forest landowner participation in Forestry Incentive Program in Mississippi from 1996 to 2006.

	Outcome equation (General)	Outcome equation (Restricted)		Gompertz (Separately)	
	Coeff. (*t*-ratio)	Coeff. (*t*-ratio)	Marginal effect	Coeff. (*t*-ratio)	Marginal effect
Constant	-0.928	-2.098***	-0.071	-2.014***	-2.014***
	(-0.378)	(-4.120)		(-5.235)	
P1V	-24.603	-4.711*	-0.161	--	--
	(-0.986)	(-1.819)			
Land features					
Acreage	4.00E-04	--	--	--	--
	(0.711)				
Land Type	-0.735	-0.209	-0.025	-0.079	-0.079
	(-1.236)	(-1.182)		(-0.666)	
Forest Type	0.727	--	--	--	--
	(0.721)				
Management experience					
Years	0.015	0.003	1.075E-4	0.001	0.001
	(0.742)	(0.736)		(0.500)	
Timber	2.86-	0.713*	0.051	0.171	0.171
	(1.102)	(1.711)		(0.780)	
Regenerate	1.794	1.066***	0.036	0.857***	0.857***
	(1.564)	(5.434)		(10.257)	
Landowner characteristics					
Age	-0.031	--	--	--	--
	(-0.652)				
Education	1.452	0.352*	0.040	0.077	0.077
	(1.027)	(1.717)		(0.726)	
Income	0.015	0.003	1.100E-4	2.053E-4	2.053E-4
	(0.819)	(1.005)		(0.107)	
Employment	0.405	0.002	2.706E-4	-0.011	-0.011
	(0.512)	(0.016)		(-0.110)	
Race	2.565	0.314	0.027	-0.214	-0.214
	(0.902)	(0.706)		(-0.859)	
Gender	3.108	0.713**	0.064	0.136	0.136
	(1.029)	(2.022)		(1.159)	
Membership	5.652	1.271**	0.228	0.223**	0.223**
	(0.995)	(2.083)		(2.172)	
Residence	1.077	0.297*	0.033	0.101	0.101
	(0.980)	(1.764)		(0.982)	
Log Likelihood	-218.275	-219.558		-222.366	
Chi-squared	219.671	217.104		211.488	

***, **, and * indicate significance at the 1%, 5%, and 10%, respectively.

Table 2-4. Estimates of the determinants of nonindustrial private forest landowner participation in Forest Resource Development Program in Mississippi from 1996 to 2006.

	Outcome equation			Gompertz (Separately)	
	(General)	(Restricted)			
	Coeff. (*t*-ratio)	Coeff. (*t*-ratio)	Marginal effect	Coeff. (*t*-ratio)	Marginal effect
Constant	-0.791	-1.455***	-0.054	-1.722***	-0.069
	(-0.469)	(-3.322)		(-5.239)	
P1V	-6.780	-2.807*	-0.104	--	--
	(-0.882)	(-1.642)			
Land features					
Acreage	1.603E-4	--	--	--	--
	(0.560)				
Land Type	-0.029	-0.023	-0.003	-0.002	-1.767E-4
	(-0.135)	(-0.159)		(-0.013)	
Forest Type	-0.186	--	--	--	--
	(-0.957)				
Management experience					
Years	0.002	0.001	2.563E-5	1.298E-4	5.235E-6
	(0.309)	(0.210)		(0.053)	
Timber	0.430	0.126	0.013	-0.084	-0.010
	(0.700)	(0.532)		(-0.488)	
Regenerate	0.967***	0.850***	0.032	0.758***	0.031
	(3.576)	(6.796)		(9.483)	
Landowner characteristics					
Age	-0.005	--	--	--	--
	(-0.274)				
Education	0.428	0.251*	0.029	0.124	0.015
	(1.143)	(1.672)		(1.171)	
Income	-0.001	1.447E-4	5.385E-6	3.255E-4	1.313E-5
	(-0.273)	(0.061)		(0.170)	
Employment	0.351	0.131	0.015	0.019	0.002
	(0.632)	(0.882)		(0.186)	
Race	0.032	-0.167	-0.021	-0.257	-0.036
	(0.062)	(-0.571)		(-1.090)	
Gender	0.790	0.385*	0.039	0.095	0.011
	(0.948)	(1.688)		(0.830)	
Membership	1.576	0.751**	0.115	0.159	0.020
	(0.989)	(1.985)		(1.534)	
Residence	0.370	0.221	0.025	0.096	0.011
	(1.057)	(1.515)		(0.965)	
Log Likelihood	-201.769	-203.211		-204.963	
Chi-squared	170.003	167.118		163.615	

***, **, and * indicate significance at the 1%, 5%, and 10%, respectively.

Table 2-5. Estimates of the determinants of nonindustrial private forest landowner participation in Reforestation Tax Credit in Mississippi from 1996 to 2006.

	Outcome equation			Gompertz (Separately)	
	(General)	(Restricted)			
	Coeff. (*t*-ratio)	Coeff. (*t*-ratio)	Marginal effect	Coeff. (*t*-ratio)	Marginal effect
Constant	-2.551***	-1.873***	-0.168	-1.964***	-0.165
	(-4.042)	(-5.339)		(-4.299)	
P1V	4.611	0.100	0.009		
	(1.489)	(0.110)			
Land features					
Acreage	-2.783E-4***	--	--	-1.718E-4**	-0.144E-4
	(-3.094)			(-2.456)	
Land Type	-0.317**	-0.149	-0.026	-0.181	-0.031
	(-2.111)	(-1.325)		(-1.625)	
Forest Type	-0.232	--	--	0.080	0.013
	(-0.991)			(0.874)	
Management experience					
Years	-4.220E-4	2.422E-4	-2.170E-5	1.128E-4	0.948E-5
	(-0.147)	(-0.100)		(0.044)	
Timber	-0.371	0.156	0.024	0.177	0.026
	(-0.919)	(0.706)		(0.944)	
Regenerate	0.825*	1.432***	0.128	1.463***	0.123
	(1.944)	(8.886)		(15.726)	
Landowner characteristics					
Age	0.016	--	--	0.001	0.880E-4
	(1.388)			(0.195)	
Education	-0.008	0.155	0.026	0.165*	0.027
	(-0.050)	(1.483)		(1.666)	
Income	-0.003	-0.001	-6.824E-5	-0.114E-4	-0.959E-6
	(-1.136)	(-0.401)		(-0.006)	
Employment	-0.175	-0.048	-0.008	-0.066	-0.011
	(-1.196)	(-0.506)		(-0.575)	
Race	-0.389	-0.096	-0.017	-0.108	0.019
	(-1.217)	(-0.365)		(-0.419)	
Gender	-0.270	0.200	0.032	0.228**	0.035
	(-0.774)	(1.337)		(2.105)	
Membership	-1.016	0.101	0.018	0.157	0.027
	(-1.276)	(0.397)		(1.560)	
Residence	-0.024	-0.035	-0.006	-0.026	-0.004
	(-0.226)	(-0.374)		(-0.280)	
Log Likelihood	-400.752	-404.728		-401.653	
Chi-squared	576.557	568.603		574.755	

***, **, and * indicate significance at the 1%, 5%, and 10%, respectively.

CHAPTER III

NIPF LANDOWNERS' REGENERATION BEHAVIOR

Introduction

Reforestation is essential for maintaining productive timberlands. Replanting trees on productive timberlands after harvesting is an effective way to increase the commercial value to nonindustrial private forest (NIPF) landowners. Landowners benefit not only monetarily from higher timber production, but also from more attractive aesthetic landscapes with clearer water and enhanced wildlife habitat. However, nearly half (48.5%) of Mississippi NIPF landowners do not reforest their timber following a harvest (Gunter et al., 2001).

Timely reforestation after harvest is even more important for both timber production and environmental protection. Not replanting after harvesting or delayed replanting may affect timber supply and reduce non-timber outputs and benefits (e.g., those related to air, water, soil, wildlife). Softwood removals exceeded growth by approximately 18% in Mississippi in 2002 (Smith et al., 2004). This will impact future timber markets. In addition, if lands are not replanted for a prolonged period of time, water, soil, and amenity values on the harvested lands may deteriorate and wildlife habitat may degrade (Wear and Greis, 2002). Therefore, time elapsed before reforestation is a critical indicator of good forest resource management.

Considerable empirical studies have investigated the impact of various factors such as characteristics of landowners, land, and management on landowner reforestation decisions (Amacher et al., 2003). None has considered the time dimension of reforestation. How long NIPF landowners wait to reforest after harvesting and what factors delay reforestation are important but unanswered questions. Answers to these questions would be useful in formulating policies to help landowners reforest in a timely manner after harvesting.

Research focused on the interval between harvesting and regeneration by NIPF landowners in Mississippi, a typical southern state where timber plays an important role in the state economy and most timberland is owned by NIPF landowners. The study objective was to examine how long NIPF landowners waited to reforest after harvesting, what factors affected this interval, how much each factor contributed to the probability of reforestation, and how much each factor contributed to the interval length. Duration analysis was employed to examine the time elapsed between completion of harvest and beginning of regeneration.

Literature Review of NIPF Landowner Regeneration Behavior

Many empirical studies have examined NIPF landowner regeneration. Typical regeneration studies have relied on a binary choice model (Hyberg and Holthausen, 1989; Royer, 1987). A typical dependent variable was a binary variable indicating regeneration or no regeneration. Independent variables included land characteristics (e.g., acreage, land type), owner demographics (e.g., household income, education, residence), and market factors (e.g., sawtimber price, pulpwood price, reforestation costs).

In Royer (1987) logistical regression models were applied to estimate the probability of reforestation by southern landowners who had conducted final harvests on 10 or more acres between 1971 and 1981 in 12 southern states. Income, reforestation costs, government cost-sharing, technical assistance, and pulpwood price were highly important determinants of reforestation (Royer, 1987). Hyberg and Holthausen (1989) also used logistic regression to investigate the harvest timing and reforestation investment decisions of private landowners and obtained similar results.

More recently, Zhang and Flick (2001) used a two-step selectivity model and determined that income and government financial assistance programs increased the probability of reforestation. Gunter *et al.* (2001) determined useful factors for predicting reforestation by NIPF landowners in Mississippi. Landowners more likely to regenerate were those with large ownerships, higher income levels, more education, work in professional or business occupations, white males, and larger city residents (Gunter et al., 2001). Beach *et al.* (2005) showed that both tract size and timber prices had a significant positive effect on reforestation and, among landowner characteristics, income influenced reforestation.

Earlier works explored NIPF landowner reforestation behavior using qualitative response models and identified a set of relevant variables. Those influential factors included timber prices, input costs, interest rates, physical land characteristics, and land demographics. However, previous research has not explored the relationship between these influential factors and the time elapsed before regeneration.

Conceptual Framework, Survey Data, and Variables

Analytical Framework

This research used cross-sectional survey data from Mississippi to determine how land, ownership, demographics, management, and market factors influenced how quickly landowners regenerated their timberland following harvest. The survey period covered 1996 to 2006.

The empirical econometric approach of duration analysis was employed to examine the time interval between finishing harvest and beginning reforestation. Duration analysis is a class of statistical methods for studying the occurrence and timing of events (Allison, 1995; Greene, 2003). The focal variable is the survival time, T, measured as the time between harvest completion and initiation of planting. The event of interest in this study is whether NIPF landowners reforested their harvested timberland within the survey period, which is indicated by an additional variable *Status* (*Status* = 1 if regeneration occurred within the study period; else *Status* = 0). If an individual did not regenerate within the study period, the observation is censored in the sense that the duration before regeneration is at least the observed lifetime. Estimation needs to account for the censored nature of the data. The survival time, *T,* is expressed as follows:

(3-1) $$T = f(x) = f\left(L, O, M, K\right)$$

where T was treated as a random variable. Explanatory variables consisted of land features (*L*), landowner characteristics (*O*), management characteristics (*M*), and market factors (*K*).

There were four equivalent ways to describe the continuous probability distribution for *T*. The probability density function (p.d.f.) denoted as $f(t)$ and the cumulative distribution function (c.d.f.) denoted as $F(t)$ are used to estimate model parameters. T's probability density function (p.d.f.) and cumulative distribution function (c.d.f.) can be mathematically expressed as:

$$\text{(3-2)} \qquad f(t) = \frac{dF(t)}{dt} = \lim_{\Delta t \to 0} \frac{\Pr(t \leq T < t + \Delta t)}{\Delta t}$$

$$\text{(3-3)} \qquad F(t) = \Pr(T \leq t) \int_0^t f(x) dx \, .$$

Equation (3-3) illustrated the probability that T will be less than or equal to any t value examined.

In addition to these two functions, survivor function $S(t)$ and hazard function $h(t)$ are in the duration analysis and more related to the research questions. Survivor function $S(t)$ is an unconditional probability distribution and defined as the probability that the interval between harvesting and regenerating will be greater than *t*. It can be expressed mathematically as follows:

$$\text{(3-4)} \qquad S(t) = \Pr(T > t) = 1 - F(t) = \int_t^\infty f(x) dx \, .$$

In this study, the survivor function will give the probability of non-reforestation beyond any time t. $S(t)$ reaches the maximum probability when t equals 0.

Hazard function $h(t)$ is a conditional density distribution and represents the instantaneous rate of reforestation at time t, given that the harvested timberland has not been reforested up to t. This function is a popular and useful way of describing T's distribution in duration analysis (Allison, 1995). Its mathematical equation is defined as follows:

$$\text{(3-5)} \qquad h(t) = \lim \frac{\Pr(t \le T < t + \Delta t \mid T \ge t)}{\Delta t} = \frac{f(t)}{S(t)}.$$

Equation (3-5) illustrates the probability that regeneration occurs in the small interval between t and $t + \Delta t$ conditional on $T \geq t$. The functions $f(t)$ and $F(t)$ are used for parameter estimation while $S(t)$ and $h(t)$ are used to answer research questions.

Survey and Sample

The Social Science Research Center at Mississippi State University conducted a telephone survey during July and August 2006. The survey sample was drawn from a database of landowner records in Mississippi. The database covered 81 of the 82 counties in Mississippi. The records for Hinds County were not available. NIPF landowners were the study focus so companies and partnerships were excluded. In addition, only NIPF landowners with at least 100 acres of land were selected to eliminate small landowners with infrequent forest management activities. That yielded a list of about 20,000 landowners. Telephone numbers were provided by a commercial service agency. Finally, among landowners with telephone numbers, a random sample of 9,925 landowners was selected and used in the survey.

During the survey, several questions were asked to further select landowners relevant for the study objectives. First, landowners were asked how many acres they owned. If the answer was less than 100 acres, the telephone interview was stopped. Since the study objective focused on landowner regeneration, only landowners harvesting during the time period of interest were included. So another question was asked to exclude landowners without harvesting activities.

In addition, this research explored landowner regeneration behavior. Only when the harvest was a final cut, could landowners regenerate. So landowners who carried out a thinning or a selection cut were excluded. Furthermore, *T* was measured by the time interval between finishing harvest and beginning regeneration. Landowners who harvested and regenerated within the survey period but could not recall either the harvest date or regeneration date were deleted.

Questionnaire and Variables

The survey questionnaire was designed to collect information for the variables needed for the empirical analysis (Table 3-1). There were two dependent variables *T* and *Status*. *T* was the interval length in months between the completion of harvest and the beginning of regeneration. If the landowner provided only the season and not an exact month, the mid-point of the season was used (i.e., March for Spring, June for Summer, September for Fall, and December for Winter). The independent variables were divided into four groups: land and ownership characteristics (L), landowner demographics (O), harvest management experience (M), and market factors (K).

Four variables were used to represent land and ownership characteristics: *Acreage*, *Forest Type*, *Years*, and *Timber*. *Acreage* was the total land area in Mississippi owned by the landowner. *Forest Type* was a conditional dummy variable that equaled one if the predominant forest type was pine, and zero otherwise (e.g., hardwood, mixed pine-hardwood forests). *Years* were number of years the landowner owned the land. *Timber* measured the landowner's degree of interest in timber production and equaled one if the landowner expressed a strong interest in timber production, and zero if little to no interest.

Second, seven variables represented the landowner demographics: *Age*, *Education*, *Income*, *Race*, *Gender*, *Membership*, and *Residence*. *Age* measured a landowner's age. *Education* was equal to one for landowners who had bachelor's degree or higher and zero otherwise. *Income* represented landowner household income before taxes for tax year 2005. *Race* was equal to one if the landowner was Caucasian, and zero otherwise. *Gender* equaled one if the landowner was male, and zero for female. *Membership* was equal to one if the landowner was a member of any forestry organization (e.g., Mississippi Forestry Association, Mississippi Country Forestry Association, Society of American Foresters, Southern Forestry Association). *Residence* was equal to one for landowners residing on their forest land and zero if otherwise.

Third, three variables were used to represent harvest management experience of the landowner: *Harvest Acreage*, *Harvest Date*, and *Consult*. *Harvest Acreage* measured the harvested land area. *Harvest Date* was time from harvest until the end of survey. *Consult* was equal to one if a consultant was involved in the harvest and zero if otherwise.

Finally, three variables were constructed to represent market factors: *Sawtimber Price*, *Pulpwood Price*, and *Reforestation Cost*. Nominal prices for sawtimber and pulpwood were obtained from Timber-Mart South. Nominal costs for forestry practices in the South were obtained from the Cost and Cost Trends series produced on two-year intervals (Dubois et al., 1997; Dubois et al., 1999; Dubois et al., 2001; Dubois et al., 1995; Dubois et al., 2003; Smidt et al., 2005). For the unreported-year, cost was calculated by averaging the costs over adjacent years. Reforestation costs included chemical site preparation and hand planting. Real values of prices and costs were calculated by dividing their nominal values by the Producer Price Index (1996). Thus, *Sawtimber Price*, *Pulpwood Price*, and *Reforestation Cost* were the real value of sawtimber price, pulpwood price, and reforestation cost, respectively.

Methodology ─ Duration Analysis

Non-parametric, semi-parametric, and parametric analyses were employed in this study. Non-parametric analysis was used to analyze the relation between the interval length to the beginning of regeneration (Allison, 1995). Semi-parametric analysis was used to examine the effect of influencing factors on timely reforestation behavior, without limiting the analysis to a particular distribution function. Parametric analysis examined the effect of influential factors on timely reforestation behavior, based on the model in which the full functional form of the disturbance, probability distribution, was defined.

Non-Parametric Duration Analysis

Non-parametric techniques were used to compute survival time and plot survival probability. Survival time was the time elapsed between completion of harvest and beginning of regeneration. Two non-parametric methods were employed: Kaplan-Meier Product Limit method and Life Table method. Kaplan-Meier estimation was used to obtain exact survival proportions and survival time. The survival function and hazard function were estimated with the Life-Table method.

Non-parametric techniques, as the name suggests, drop the formal modeling framework (Greene, 2003). Furthermore, they do not consider the impact of other variables on the dependent variable. Therefore, non-parametric duration analysis was the most general technique, but, consequently, the least precise. So, semi-parametric and parametric analyses were used to provide a more complete characterization of the relationship between *T* and various variables influencing the regeneration interval.

Semi-Parametric Duration Analysis

Semi-parametric duration approach examined the relationship between *T* and influencing variables based on the additional dependent variable, *Status*, through a regression model in which the specific distributional assumption was dropped. Semi-parametric duration analysis uses Cox's partial likelihood method, which was based on a proportional hazards model (Allison, 1995). The model was written as:

$$h_i(t) = \lambda_0(t)\exp\{\beta_1 x_{i1} + \ldots + \beta_{17} x_{i17}\}. \tag{3-6}$$

This equation represented the hazard for individual *i* at time *t* where $\lambda_0(t)$ is a baseline hazard function; and $x_{i1}, \ldots, x_{i17}$ are the 17 influencing variables in this study.

The β coefficients of the proportional hazard model were estimated without having to specify the baseline hazard function $\lambda_0(t)$ because the hazard for any individual is a fixed proportion of the hazard for any other individual at the same time *t* (Allison, 1995). To see this, take the ratio of the hazards for two existing individuals *i* and *j* at the same time *t* and applying equation (3-6):

$$\frac{h_i(t)}{h_j(t)} = \exp\{\beta_1(x_{i1} - x_{j1}) + \ldots + \beta_{17}(x_{i17} - x_{j17})\}. \tag{3-7}$$

As a result, the hazard ratio is constant over time because $\lambda_0(t)$ cancels out.

The Cox model may be a reasonable description of the relationship between the distribution of the survival time and explanatory factors (Cox, 1975). However, the results may be misleading if $\lambda_0(t)$ does not comply with the proportional hazards assumption that the underlying hazard function is an arbitrary nonnegative function of time giving the hazard when $x_i = 0$ (Cox, 1975). Although the semi-parametric approach was more general (and more robust) than the parametric approach, it provides far less flexibility in terms of the types of data analysis that may be performed (Greene, 2003). Thus, formulating a parametric model will contribute additional precision with which conclusions about the data generating process may be made. In parametric settings, hypothesis tests, model extensions, and other interaction analysis are simpler than in semi-parametric analysis.

The coefficients of semi-parametric duration estimates may be interpreted as describing the direction and amount of the log hazard ratio resulting in an increase of one unit in the explanatory factor. The *t* ratio, the Wald test for the null hypothesis that each β is equal to 0, was calculated by squaring the ratio of each β and its estimated standard error. Another interesting statistic of partial likelihood estimates was the Hazard Ratio, calculated as e^{β}, which was used to interpret the impact of changes in each explanatory variable on hazard ratio (Allison, 1995). An increase in an explanatory variable increases the probability of regeneration if the hazard ratio of this factor is larger than one, and decreases the regeneration probability if the hazard ratio is less than one. For explanatory variables with values of 1 and 0, the hazard ratio is the ratio of the estimated hazard for those with a value of 1 to the estimated hazard for those with a value 0. For continuous explanatory variables, a more helpful statistic is obtained by subtracting 1 from the hazard ratio and multiplying by 100. This provided the estimated percent change in the hazard for each one-unit increase in the explanatory variable.

Parametric Duration Analysis

Parametric duration analysis produces estimates of parametric regression models using maximum likelihood by the accelerated failure time (AFT) model (Allison, 1995). The AFT model describes a relationship between survival functions of any two individuals. If $S_i(t)$ is the survival function for individual *i*, $S_j(t)$ for another individual *j*, the AFT model expressed as:

$$\text{(3-8)} \qquad S_i(t) = S_j(\phi_{ij} t) \ \text{ for all } t$$

where ϕ_{ij} is a constant that is specific to the pair (*i*, *j*).

What the parametric duration analysis actually estimates is quite similar in form to an ordinary linear regression model (Allison, 1995). Let T_i be a random variable denoting the time interval for the i^{th} individual, and $x_{i1}, \ldots, x_{i17}$ be 17 explanatory variables used in this study. Then, the model is:

$$\text{(3-9)} \qquad \log T_i = \beta_0 + \beta_1 x_{i1} + \ldots + \beta_{17} x_{i17} + \sigma_{\varepsilon i}$$

where $\beta_0, \ldots, \beta_k$, and σ are parameters to be estimated; ε_i is a random disturbance term that σ is its variance. The log transformation of T is to make sure that predicted values of T were positive, regardless of the values of the x's and β's. Thus, exponentiating both sides of equation (3-9) gives an alternative way of expressing the model:

$$\text{(3-10)} \qquad T_i = \exp\{\beta_0 + \beta_1 x_{i1} + \ldots + \beta_{17} x_{i17} + \sigma\varepsilon_i\}.$$

Therefore, alternative models of the AFT class were taken by testing σ and ε_i over i. For example, if $\log T$ has a normal distribution, then T has a log-normal distribution.

All models in parametric duration analysis were estimated by maximum likelihood (Allison, 1995). Because this study included censored observations, the basic mathematics of constructing the likelihood function were expressed as followed:

(3-11) $$L = \prod_{i=1}^{n} \left[f_i(t_i) \right]^{\delta_i} \left[S_i(t_i) \right]^{1-\delta_i}$$

where n is the number of total observations; t_i is the time of the event or the time of censoring; δ_i is an indicator variable with a value of 1 if t_i is uncensored or 0 if censored; $\prod(.)$ indicates repeated multiplication; and the p.d.f. $f(t_i)$ represents the probability of each observation. The survival function $S(t_i)$ evaluated at time t_i was the probability of an event time greater than t_i.

It is generally easier to work with the natural logarithm of the likelihood function to maximize equation (3-11) because the logarithm is an increasing function, so whatever maximizes the logarithm also maximizes the original function (Greene, 2003). Thus, taking the logarithm of both sides of equation (11), the basic mathematics of maximizing the likelihood function is expressed as follows:

(3-12) $$\log L = \sum_{i-1}^{n} \delta_i \log\left[f_i(t_i) \right] + \sum_{i-1}^{n} (1-\delta_i) \log\left[S_i(t_i) \right].$$

Once a particular model is chosen, appropriate expressions related to β can be substituted for the p.d.f. and the survival function. Then, Newton-Raphson algorithm is used to find the maximum change in parameter estimates. This method is an iterative process, finding approximations to the zeros in the first derivative of log L with respect to β (Allison, 1995).

In parametric duration analysis, coefficient signs reveal the direction of the relationship (Allison, 1995). For example, for binary variables, positive coefficients indicate that those with a value of 1 take longer to regenerate than those with a value of 0, whereas negative coefficients indicate the opposite. Because parametric duration estimates were in log-survival time format, while semi-parametric duration estimates were in log-hazard format, the sign of parametric estimates was reversed in these two duration analyses.

As with semi-parametric duration analysis, the *t*-ratio, a Wald test for the null hypothesis that each β is equal to 0, was calculated by squaring the ratio of each β and its estimated standard error. However, the numerical magnitudes of coefficients in parametric duration analysis were not informative but a simple transformation can lead to interpretive values (Allison, 1995). For dummy variables, we simply take e^{β} and then get the estimated ratio of the expected (mean) survival times for the two groups. For quantitative variables, we use the transformation 100(e^{β}-1), which represented the percent increase in expected survival time for each one-unit increase in the variable.

Additionally, logit regression analysis was also employed. This approach provided insight into the regeneration behavior that was described as inherently a discrete, qualitative response variable. Because the logit regression model is more familiar to readers and widely used in previous studies, its econometric details, (e.g., full functional model, hypothesis), will not be described again.

Empirical Results

Survey Results and Descriptive Statistics of Variables

Of the 9,925 landowners contacted by phone, 2,126 owned less than 100 acres, another 2,132 did not harvest timber in the past 10 years. These landowners were excluded from the survey. There were also 1,110 wrong telephone numbers. Other reasons for unsuccessful calls included communication problems, refusal to participate, and deceased owners. Hence, there were 2,229 landowners who finished the survey.

There were 1,081 final harvests conducted by these 2,229 landowners. Of these, 695 had replanted by the end of the study period and 386 had not. Among the 695 respondents replanting, 264 of them did not recall either the harvest date or regeneration date and another 36 recalled that the harvest date happened later than the regeneration date, which was not feasible, so these observations were excluded from the analysis. Of the 386 respondents who had not replanted, 121 did not recall the harvest date and another 5 recalled that the harvest date had not happened during the survey period, but rather in future. Hence, these observations were also excluded from the analysis.

In the end, 655 observations were available for statistical analysis. The completion rate was 60.6% (i.e., 655/1,081). For 395 observations landowners harvested and then regenerated timberland within the study time frame and for 260 observations landowners harvested but did not regenerate.

Variable definitions and their descriptive statistics were presented in Table 3-1. First, as described above, 60.3% of the 655 harvests were replanted. Conversely, about 39.7% were not reforested. The average acreage owned was 560 acres. For 33.1 % of respondents, pine was the predominant forest type. The average length of ownership was 32 years. Most landowners (i.e., 79.5%) were strongly interested in timber production.

On average, respondents were 65 years old and their household income in 2005 was $66,382. About half of respondents (i.e., 50.5%) had a bachelor’s degree or better.

In addition, 96% were Caucasian and 79.5% male. About 29.5% belonged to a forestry organization and 50.1% resided on their forest land.

Average harvested acreage was 98 acres and average time from harvest to the end of time frame was 65 months. A total number of 357 landowners hired consultants during harvest. Finally, on average, sawtimber price was $40.77 per ton; pulpwood price was $8.87 per ton; and reforestation cost was $104.23 per acre in real terms based on 1996.

Non-Parametric Duration Analysis

Non-parametric duration analysis estimated the time interval between the completion of harvest and beginning of regeneration with an additional consideration: regeneration or not. Average time elapsed before regeneration (*T*) was 11 months for harvests that were regenerated within the survey period for the 395 observations, and 44 months for harvests regardless of whether regeneration had occurred during the study period for all observations (n = 655).

The probability that a harvested site was not regenerated at time *t* was shown in Figure 3-1. This figure depicted the survival function $S(t)$ at time t_i, and the probability of nonregeneration following harvest when the waiting time is greater than the given time. The general trend was that the probability that the landowner has not regenerated after harvest declined as the length of time from harvest completion increased. The reduction in the rate was typically off. The probability that the tract has not been regenerated after harvest decreased rapidly during the first 25 months, then leveled off.

The probability distribution of the estimated hazard function was shown in Figure 3-2. This figure depicted the hazard function $h(t)$ at time t_i, and the probability of regeneration at this given time following harvest. This probability reached its highest value in the 16^{th} month and thereafter decreased rapidly until the 28^{th} month. In the 28^{th} month, the probability of regeneration was approximately 0.6% and remained less than 1% as the time increased. Along this prediction tract, the probability of regeneration approached zero as the time since harvest increased.

Semi-Parametric Duration Analysis

The results estimated from semi-parametric duration and logistic regression analyses were reported in Table 3-2. Logistic regression analysis and semi-parametric duration analysis, respectively, estimated the odds and hazard ratios. However, regardless of hazard and odds ratios, both described the probability of regeneration with regard to the changing influence of certain variables. Comparing these results, the same sign of parametric estimates on the probability of regeneration were produced, but the standard errors were larger in semi-parametric duration analysis than in logistic regression analysis. Estimates from semi-parametric duration analysis have good properties regardless of the actual shape of the baseline hazard function (Allison, 1995). Hence, semi-parametric duration analysis produced more general parametric estimates than logistic regression.

Four factors were tested in the group of land and ownership characteristics in semi-parametric duration analysis. *Forest Type* and *Timber* had significant positive effects on reforestation probability at the 1% level. Hazard ratios of these two variables were more than 1, indicating that NIPF landowners were more likely to regenerate their harvested timberlands if pine was their predominant forest type or they were strongly interested in timber production. Moreover, the probability of regeneration for these landowners with pine as predominant forest type was about 44.7% greater than for those landowners with hardwood or mixed forest as dominant forest type. The probability of regeneration for landowners who had strong interest in timber production was about 203.6% greater than for landowners less interested. *Acreage* and *years* were not significant.

Among landowner demographics, *race* and *residence* were significant and positively related to the probability of reforestation. According to their hazard ratios, 2.207 and 1.463, respectively, Caucasian landowners living on their forest land were more likely to replant following harvest than other landowners. The probability of regeneration for Caucasian landowners was about 120.7% greater than other landowners. The probability of regeneration for landowners residing on their forest land was about 46.3% greater than other landowners. Other demographics (e.g., *age*, *education*, *income*, *gender*, and *membership*) were not significant.

Among management experience, *consult* was significant and positively influenced the reforestation probability at the 1% level. The hazard ratio was 1.795, implying landowners who used a forester were more likely (i.e., 79.5%) to regenerate than those who did not.

Among market factors, pulpwood real price had a significantly positive effect on the probability of reforestation, whereas reforestation real cost had a negative effect. Their hazard ratios were 1.039 and 0.972, respectively, indicating that the higher the real price of pulpwood in Mississippi, the larger the possibility of regeneration, whereas the higher the real cost of reforestation, the less the regeneration probability. Furthermore, for each one-unit increase in the real pulpwood price, the regeneration probability went up by an estimated 3.9%, whereas for each one-unit increase in the real reforestation cost, the regeneration probability went down by an estimated 2.8% (i.e., $100 \times (0.972\text{-}1)$).

Parametric Duration Analysis

The Log-normal model was selected from a number of AFT sub-models because the assumed distribution for T was similar with a log-normal distribution. Moreover, through the preliminary analysis, the shape parameter of the generalized gamma model was almost exactly 0 (i.e., 0.072), which indicated that the log-normal model should be employed in this study (Allison, 1995).

First, among land and ownership characteristics, *Forest Type* and *Timber* were significant and negative. If pine was their predominant forest type, landowners took less time to regenerate than others. Landowners interested in timber production regenerated more rapidly than non-interested landowners. Ratios of waiting time for these two variables were 0.566 and 0.185, respectively. Therefore, the predicted planting interval for landowners with pine as the predominant forest type was 43.4% less than other landowners with mixed forest or hardwood as a predominant forest type. The predicted time to regenerate for landowners with a strong interest in timber production was 81.5% less than landowners less interested.

Next, among landowner demographic variables, only *Race* and *Residence* had negative and significant coefficients, with ratios of waiting time at 0.314 and 0.605, respectively. Caucasian landowners waited 68.6% less time to regenerate than other landowners. The predicted waiting time to regenerate for those living on their forest land was 39.5% less than for those who did not.

Among management experience characteristics, only *Consult* was significant and negatively related with the time to regenerate, with a ratio of waiting time equal to 0.438. This indicated that predicted waiting time to regenerate for landowners who used a forester was 56.2% less than those who did not.

Finally, all market factors had significant impacts on the waiting time to regenerate. *Sawtimber Price* and *Pulpwood Price* negatively influenced the time to regenerate, and *Reforestation Cost* had a positive effect on the time, with the ratios of waiting time equal to 0.962, 0.926, and 1.046, respectively. Therefore, each additional dollar increase in *Sawtimber Price* was associated with a 3.8% decrease in predicted time to regenerate. Each additional dollar increase in *Pulpwood Price* was associated with a 7.4% decrease in predicted time to regenerate. Each additional dollar increase in R*eforestation Cost* was associated with a 4.6% increase in predicted time to regenerate.

Conclusions

This study surveyed Mississippi NIPF landowners to address the timely regeneration of harvested lands. Non-parametric, semi-parametric, and parametric duration analyses were used. Modeling three duration analyses yielded more insightful results in terms of both the generality of technique and the flexibility of data analysis than a simple logistic regression model. Furthermore, this study is the first attempt to use duration analysis to examine effects of various factors on the time interval associated with reforestation decisions.

Duration analysis generated several clear results. The survey revealed that about 40% NIPF landowners in Mississippi did not replant their harvested timberland in past 10 years. On average, NIPF landowners that had replanted waited 11 months to regenerate after harvest. After the 16^{th} month following harvest, the probability of regeneration decreases rapidly until the 28^{th} month. Interest in timber production, consulting a forester, having predominantly pines, seeing higher real values of stumpage and pulpwood, residing on forest lands, and race have positive impacts on the probability of reforestation, and were significant indicators of taking less time to regenerate. Reforestation cost significantly reduces the time interval between harvest completion and the beginning of regeneration at a slightly higher confidence level than sawtimber and pulpwood price. These findings have significant practical implications in terms of policy formulation.

First, efforts should be made to induce landowners to be interested in timber production. Landowners who have a strong interest in timber production were more likely to have intensive management of their woodlands to recreate productive timberland and actively seek out the opportunity of regeneration to increase their rate of return on investment. Moreover, their timberlands may provide productive site conditions for tree reproduction.

Second, to increase the probability of regeneration and decrease time elapsed before regeneration, a useful strategy may be to approach foresters to gain their assistance in making owners aware of regeneration benefits. An effective approach may be to identify landowners who have previously sought out information on harvest practices. Finally, an important reason for not regenerating is still the high cost of reforestation. Efforts should be made to inform landowners about the availability of government incentive programs to regenerate. Since the high cost of reforestation lowers the likelihood of reforestation, landowners should be made aware that government programs can assist them in their regeneration endeavors.

These results need to be qualified. First, we have considerable findings and implications about the reforestation decisions of NIPF landowners and in this study we also show the concerns about timely reforestation. However, the use of survey data and their geographic scope are worth noting. The parametric estimates from this study may not be directly comparable with south-wide data, even though Mississippi is located in a typical region in the South in which NIPF landowners hold the majority of the pineland and tree planting occurs on cutover timberland. The state-wide data use in this study lies in the opportunity to specify a model of timely reforestation behavior, while the south-wide data perhaps avoids local biases. Second, the intent of this study targets the timely regeneration behavior after harvesting. The impetus stems from the recent softwood removals that have exceeded growth. However, this is just one of several landowner behaviors; others would include the timely harvest behavior and other forestry management to provide a more comprehensive look at landowner behavior.

Table 3-1. Summary statistics of the variables used in duration analysis for nonindustrial private forest landowner regeneration behavior in Mississippi from 1996 to 2006.

Variable	Definitions	Mean	Std. Dev.
	Dependent variables		
T	Time from finishing harvest to beginning regeneration (month)	28.246	35.928
Status	Dummy=1 if the landowner replanted; 0 otherwise	0.603	--
	Independent variables		
Land & ownership characteristics (L)			
Acreage	Total acreage owned by the landowner	559.669	938.201
Forest Type	Dummy=1 if pine is the dominant forest type; 0 otherwise	0.331	--
Years	Years of land ownership	32.266	18.624
Timber	Dummy=1 if the landowner is strongly interested in timber production; 0 otherwise	0.795	--
Landowner demographic (O)			
Age	Landowner age	64.570	12.008
Education	Dummy=1 if the landowner has a bachelor degree or better; 0 otherwise	0.505	--
Income	Household income before taxes in 2005 ($1,000)	66.382	28.908
Race	Dummy=1 if Caucasian; 0 otherwise	0.960	--
Gender	Dummy=1 if male; 0 otherwise	0.795	--
Membership	Dummy=1 if the landowner is a member of any forestry association; 0 otherwise	0.295	--
Residence	Dummy=1 if the landowner resides on forest land; 0 otherwise	0.501	--
Harvest Management (M)			
Harvest Acreage	Harvested acreage for each harvest activity	98.208	123.768
Harvest Date	Time (month) from beginning harvest to end of survey	65.413	40.901
Consult	Dummy=1 if a consultant is involved in the harvest; 0 otherwise	0.545	--
Market & cost characteristics (K)			
Sawtimber Price	Sawtimber real price (base = 1996)	40.769	4.671
Pulpwood Price	Pulpwood real price (base = 1996)	8.866	3.289
Reforestation Cost	Reforestation real cost (base = 1996)	104.229	9.439

Table 3-2. Estimates of the determinants of semi-parametric duration analysis that models factors that contribute to the probability of regeneration in Mississippi from 1996 to 2006.

	Semi-parametric duration analysis		Logistic regression analysis	
Variable	Coefficient	Hazard ratio	Coefficient	Odds ratio
Constant			-5.278***	
			(8.495)	
Land & ownership characteristics (L)				
Acreage	7.280E-5	1.000	1.740E-4	1.000
	(2.028)		(2.416)	
Forest Type	0.370***	1.447	0.889***	2.433
	(11.754)		(17.835)	
Years	0.005	1.005	0.011*	1.011
	(2.469)		(3.448)	
Timber	1.111***	3.036	1.586***	4.882
	(39.842)		(40.727)	
Landowner demographic (O)				
Age	-0.001	0.999	-0.008	0.992
	(0.045)		(0.757)	
Education	0.034	1.034	0.239	1.270
	(0.083)		(1.250)	
Income	2.175E-4	1.000	0.003	1.003
	(0.013)		(0.880)	
Race	0.792**	2.207	1.032**	2.807
	(5.304)		(4.173)	
Gender	0.033	1.034	0.048	1.050
	(0.063)		(0.040)	
Membership	0.095	1.100	-0.003	0.997
	(0.705)		(1.000E-4)	
Residence	0.380***	1.463	0.645***	1.906
	(12.204)		(10.319)	
Harvest Management (M)				
Harvest Acreage	1.902E-4	1.000	1.800E-5	1.000
	(0.246)		(0.001)	
Harvest Date	0.003	1.003	0.015***	1.015
	(2.015)		(12.718)	
Consult	0.585***	1.795	1.189***	3.285
	(26.421)		(36.148)	
Market & cost characteristics (K)				
Sawtimber Price	0.020	1.020	0.064***	1.066
	(2.656)		(7.822)	
Pulpwood Price	0.038*	1.039	0.021	1.021
	(2.850)		(0.228)	
Reforestation Cost	-0.029***	0.972	-0.017	0.983
	(8.254)		(0.877)	

***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Table 3-3. Estimates of the determinants of parametric duration analysis that models factors that contribute to the time interval between harvest and regeneration in Mississippi from 1996 to 2006.

Variable	Coefficient	*t*-ratio	Ratio of waiting time
Constant	4.247***	8.230	69.895
Land & ownership characteristics (L)			
Acreage	-1.000E-4	1.620	1.000
Forest Type	-0.570***	12.340	0.566
Years	-0.007	2.540	0.993
Timber	-1.689***	58.660	0.185
Landowner demographic (O)			
Age	0.003	0.140	1.003
Education	-0.001	0.000	0.999
Income	-7.000E-4	0.050	0.999
Race	-1.157**	6.500	0.314
Gender	-0.018	0.010	0.982
Membership	-0.086	0.250	0.918
Residence	-0.503***	9.750	0.605
Harvest Management (M)			
Harvest Acreage	-2.000E-4	0.090	1.000
Harvest Date	-0.001	0.020	0.999
Consult	-0.825***	25.660	0.438
Market & cost characteristics (K)			
Sawtimber Price	-0.039**	4.650	0.962
Pulpwood Price	-0.077**	5.130	0.926
Reforestation Cost	0.045***	8.880	1.046
LOG Likelihood	-954.942		

***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

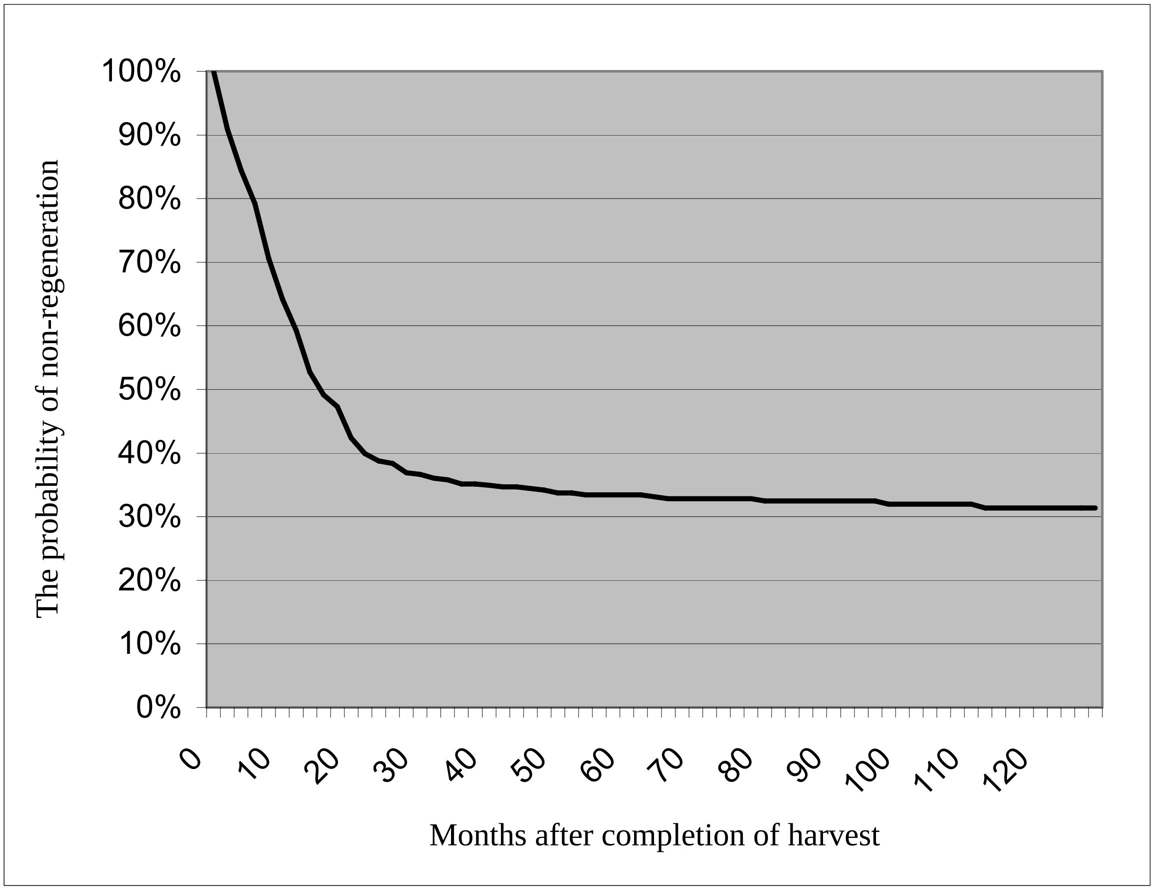

Figure 3-1. Survival function of non-parametric duration analysis that depicts the probability of nonregeneration by nonindustrial private forest landowners in Mississippi from 1996 to 2006.

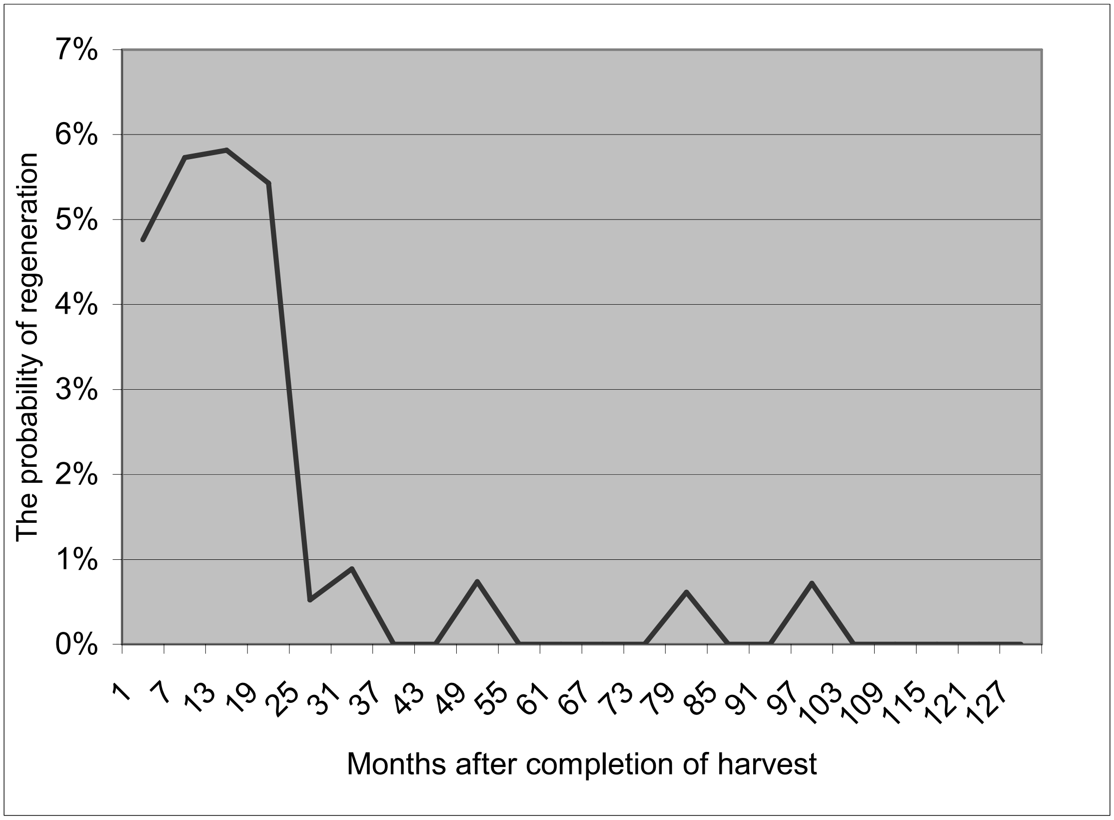

Figure 3-2. Hazard function of non-parametric duration analysis that depicts the probability of regeneration by nonindustrial private forest landowners in Mississippi from 1996 to 2006.

CHAPTER IV

SUMMARY

Major Findings

NIPF landowner participation in government incentive programs was analyzed by the method of a bivariate probit model with sample selection. Modeling the participation probability conditional on landowner awareness yields more accurate results than simple binary regression typically employed in the literature. In Mississippi, only about 40% of NIPF landowners knew of FIP, FRDP, or RTC programs. NIPF landowner participation in these incentive programs was low, with 3.4% in FIP, 2.8% in FRDP, and 9.3% in RTC, for those who were aware of these programs. Landowner knowledge of incentive programs were positively correlated with land acreage, pine forest type, interest in timber production, past regeneration experiences, education, gender, and membership in forestry organizations. When landowners had good knowledge of these incentive programs, participation rates were higher for landowners with previous regeneration experience, better education, were male, or belonged to a forestry organization.

The time elapsed before a landowner replants following harvest was analyzed by duration analysis approach. Modeling duration analyses yielded more insightful results in terms of both the generality of technique and the flexibility of data analysis than a simple logistic regression model. From 1996 to 2006, about 39.7% of respondents did not reforest after harvest. On average, the waiting time interval to regenerate was 11 months (s.e. = 0.6) for those that harvested and regenerated within the study period. After the 16th month following harvest, the probability of regeneration decreased. Strong interest in timber production, consulting a forester for harvesting, residence on forest land, pine as predominant forest type, sawtimber price, and pulpwood price significantly influenced the time interval between the harvest and the beginning of reforestation. Landowners with these characteristics either better actively managed regeneration activities or took less time to reforest after harvest. These results have several policy implications for promoting and implementing NIPF landowner behavior in participation in incentive programs and regeneration decisions.

Results indicated that forestry organizations may encourage landowners to participate in government programs and regenerate their harvested timberlands. A larger percentage of landowners were aware of these programs and they also had a higher rate of participation. Efforts should be made to induce landowners to participate in forestry organizations. If they are not aware of government incentive programs and beneficial information on regeneration, these landowners may not have considered regeneration and have not taken the advantage of government incentive programs.

Moreover, significant numbers of landowners did not receive any assistance from a professional forester, which may have contributed to their decision not to reforest. It was likely that they were uninformed of the reforestation options available to them. Finally, landowners with an interest in timber production were more likely to replant productive timberland and take advantage of government incentive programs to avail the subsidy for high costs of tree planting.

Future Research

With continued emphasis on the behavior of NIPF landowners in Mississippi, this thesis illustrated vital concerns regarding the future strategies of economic assistance programs related to reforestation and how to assist in regenerating quickly. An important concern that future research may address relates to efficiently allocating budgets to achieve maximum participation. Given a limited budget for these programs, the cost of increasing the participation rate by improving NIPF landowner knowledge must be compared with the start-up cost of government incentive programs. The identification of such costs is vital to make sound policy decisions regarding the most efficient way to promote assistance programs. Moreover, the use of data drawn from a survey is worth noting. Mississippi is a typical southern state where timber and the related forest industry is important and NIPF landowners hold the majority of the pineland. However, demographic characteristics of NIPF landowners in other states have different impacts on forestry investments that are based on the landowner economic situation, land management goals, and knowledge of forestry investment opportunities.

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APPENDIX A

MISSISSIPPI FOREST OWNER REGENERATION SURVEY

Question Introduction

I would like to begin by learning a little about your land.

Question Q1

In total, how many ACRES of land do you currently own in Mississippi?

NOTE: If none enter 0; More than 99,996 enter 99997;

Don't Know/Not Sure 99998; Refused 99999.

Question Q2

Currently, is your land primarily agricultural land, forest land or being used for some other purpose?

1. Agricultural land
2. Forest land
3. Other land
4. About half agriculture & half forest
5. Don't Know
6. Refused

Question Q3

How many of your acres are forestland?

NOTE: If none enter 0; More than 99,996 enter 99997;

Don't Know/Not Sure 99998; Refused 99999.

Question Q3a

Do you own at least 100 acres of forestland in Mississippi?

1. Yes
2. No
3. Don't Know/Not Sure
4. Refused

Question Q3b

Have you ever harvested your Mississippi forestland in the last 10 years?

1. Yes
2. No
3. Don't Know/Not Sure
4. Refused

Question Q4

What is the major forest type on your Mississippi land, would you say:

1. Planted pine,
2. Natural pine,
3. Hardwood, or
4. Mixed pine and hardwood
5. Don't Know
6. Refused

Question Q5

How many years have you owned your LARGEST piece of forestland?

NOTE: If less than 1 year enter 0; if more than 95 years enter 96;

all my life enter 97; Don't Know 98; Refused 99.

Question Q6

Do you currently live on any of your Mississippi forestland?

1. Yes
2. No
3. Don't Know/Not Sure
4. Refused

Question intrprog

Next, I am going to name several government incentive programs, please tell me how familiar you are with each one

Question Q7

Are you very familiar, somewhat familiar or not at all familiar with the Mississippi Forest Resource Development Program (FRDP)?

1. Very familiar
2. Somewhat familiar
3. Not at all familiar
4. Don't Know/Not Sure
5. Refused

Question Q8

Are you very, somewhat or not all familiar with the Conservation Reserve Program (CRP)?

1. Very familiar
2. Somewhat familiar
3. Not at all familiar
4. Don't Know/Not Sure
5. Refused

Question Q9

How familiar are you with the Forestry Incentive Program (FIP)?

1. Very familiar
2. Somewhat familiar
3. Not at all familiar
4. Don't Know/Not Sure
5. Refused

Question Q10

How familiar are you with the Mississippi Reforestation Tax Credit (RTC)?

1. Very familiar
2. Somewhat familiar
3. Not at all familiar
4. Don’t Know/Not Sure
5. Refused

Question Q11

Would you say that you are strongly interested, moderately interested, somewhat interested or not at all interested in timber production on your land?

1. Strongly
2. Moderately
3. Somewhat
4. Not at all interested
5. Don’t Know/Not Sure
6. Refused

Question Q12

Did you harvest timber on your land between 1995 and the present?

1. Yes
2. No
3. Don’t Know
4. Refused

Question Q13

How many times did you harvest timber during this period? times

NOTE: If never enter 0; More than 16 times enter 17; Don’t Know 18; Refused 18.

Question Intrharv

NOTE: Question 14 through 32 are repeated for each harvest.

Next, I am going to ask a few questions about EACH harvest.

Question Q14

For the first harvest, how many acres were harvested? acres

NOTE: If Don’t Know/Remember enter 99998; Refused 99999.

Question Q15

Was this harvest a clear-cut, final cut such as a seed tree cut or shelterwood cut, a thinning, or a selection cut?

1. Clear-cut
2. Final cut such as a seed tree cut or shelterwood cut
3. Thinning
4. Selection cut
5. Other type (specify):
6. Don't Know/Remember
7. Refused

Question Q16yr

What year did the first harvest after 1995 begin?

1. 1996
2. 1997
3. 1998
4. 1999
5. 2000
6. 2001
7. 2002
8. 2003
9. 2004
10. 2005
11. 2006
12. Don’t Know/Remember
13. Refused

Question Q16mon

What month did this harvest begin?

1. January
2. February
3. March
4. April
5. May
6. June
7. July
8. August
9. September
10. October
11. November
12. December
13. Don’t Know/Remember
14. Refused

Question Q16seasn

To the best of your recollection, did it start in the Winter, Spring, Summer, or Fall?

1. Winter
2. Spring
3. Summer
4. Fall
5. Don't Know/Remember
6. Refused

Question Q17yr

What year did the first harvest end?

1. 1996
2. 1997
3. 1998
4. 1999
5. 2000
6. 2001
7. 2002
8. 2003
9. 2004
10. 2005
11. 2006
12. Harvest is still going on
13. Don't Know/Remember
14. Refused

Question Q17mon

What month did this harvest end?

1. January
2. February
3. March
4. April
5. May
6. June
7. July
8. August
9. September
10. October
11. November
12. December
13. Don't Know/Remember
14. Refused

Question Q17seasn

To the best of your recollection, did it end in the Winter, Spring, Summer, or Fall?

1. Winter
2. Spring
3. Summer
4. Fall
5. Don't Know/Remember
6. Refused

Question Q18

Did you consult a forester for this harvest?

1. Yes
2. No
3. Don’t Know/Not Sure
4. Refused

Question Q19

Did you use a public, private or industry forester?

1. Public forester
2. Private forester
3. Industry forester
4. Other type (specify):
5. Don’t Know/Remember
6. Refused

Question Q20

Did you regenerate this land between 1995 and 2006?

1. Yes
2. No
3. Don’t Know/Not Sure
4. Refused

Question Q21yr

What year did this regeneration begin?

1. 1996
2. 1997
3. 1998
4. 1999
5. 2000
6. 2001
7. 2002
8. 2003
9. 2004

11. 2006
12. Don’t Know/Remember
13. Refused

Question Q21mo

What month did this regeneration begin?

1. January
2. February
3. March
4. April
5. May
6. June
7. July
8. August
9. September
10. October
11. November
12. December
13. Don’t Know/Remember
14. Refused

Question Q21seasn

To the best of your recollection, did it start in the Winter, Spring, Summer, or Fall?

1. Winter
2. Spring
3. Summer
4. Fall
5. Don't Know/Remember
6. Refused

Question Q22yr

What year did this regeneration end?

1. 1996
2. 1997
3. 1998
4. 1999
5. 2000
6. 2001
7. 2002
8. 2003
9. 2004
10. 2005
11. 2006
12. Regeneration is still going on
13. Don’t Know/Remember

14. Refused

Question Q22moend

1. January	2. February	3. March
4. April	5. May	6. June
7. July	8. August	9. September
10. October	11. November	12. December
13. Don’t Know/Remember		14. Refused

Question Q22seasn

To the best of your recollection, did it end in the Winter, Spring, Summer, or Fall?

1. Winter
2. Spring
3. Summer
4. Fall
5. Don't Know/Remember
6. Refused

Question Q23

How many acres were regenerated?

NOTE: If Don’t Know/Remember enter 99998; Refused 99999.

Question Q24

What types of trees did you plant, would you say mostly:

1. Pine,
2. Hardwood, or
3. Mixed pine and hardwood (about half and half)
4. Other
5. Don’t Know
6. Refused

Question Q25

Did you consult a forester when you regenerated this land?

1. Yes
2. No
3. Don’t Know/Not Sure
4. Refused

Question Q26

Did you use a public, private or industry forester?

1. Public forester
2. Private forester
3. Industry forester
4. Other type (specify):
5. Don’t Know/Remember
6. Refused

Question Q27

Did you do any site preparation on this harvested land before replanting?

1. Yes
2. No
3. Don’t Know/Not Sure
4. Refused

Question Q28

What kind of site preparation did you do on this land before regenerating?

Did you do:

Chemical site preparation,

Mechanical site preparation,

Prescribed burning or

Some other type of preparation (specify):

NO MORE that is all - GO TO NEXT QUESTION

None

Don’t Know/Remember

Refused

Question Q29

For this regeneration, did you apply to the Forest Resource Development Program (FRDP) or the Forestry Incentive Program (FIP) for financial assistance?

1. DID NOT APPLY TO EITHER ONE
2. The Forest Resource Development Program (FRDP)
3. The Forestry Incentive Program (FIP)
4. Both
5. Don't Know/Remember
6. Refused

Question Q30

Did you enroll in the Forest Resource Development Program (FRDP)?

1. Yes
2. No
3. Don’t Know/Not Sure
4. Refused

Question Q31

Did you enroll in the Forestry Incentive Program (FIP)?

1. Yes
2. No
3. Don’t Know/Not Sure
4. Refused

Question Q32

For these regeneration costs, did you use the Reforestation Tax Credit (RTC) provision on your state income tax return?

1. Yes 2. No

3. Don’t Know/Not Sure 4. Refused

Question intrdemo

Finally, I have a few background questions I would like to ask.

Question associa

Of what professional forestry associations are you currently a member?

Mississippi Forestry Association

County Forestry Association

Other (Please Specify):

NO MORE that is all - GO TO NEXT QUESTION

None

Don’t Know/Remember

Refused

Question yrborn

What year were you born? 19

NOTE: If before 1901 enter 0; if after 1996 enter 97; Don't Know/Not Sure 98; Refused 99.

Question race

What is your race? Would you say:

1. White or Caucasian, 2. Black or African-American,

3. Asian or Pacific Islander, or 4. American Indian or Alaska Native

5. Other (specify):
6. Don’t Know/Not Sure
7. Refused

Question edu

What is the highest level of education you have completed?

1. Less than a High School degree
2. High School degree or GED
3. Associate's degree (2 year degree)
4. Bachelor's degree (4-year degree)
5. Master's Degree
6. Doctorate Degree
7. Don't Know/Not Sure
8. Refused

Question employed

During most of 2005, were you:

1. Employed full-time,
2. Employed part-time,
3. Unemployed,
4. A homemaker,
5. A student,
6. Retired, or
7. Unable to work
8. Don’t Know
9. Refused

Question hhincome

I am going to read some income categories. Stop me when I get to the one that best describes your total 2005 household income BEFORE taxes.

1. Less than $20,000
2. 20 to $40,000
3. 40 to $60,000
4. 60 to $80,000
5. 80 to $100,000
6. More than $100,000
7. Don't Know/Not Sure
8. Refused

NOTE: If you are not sure of the respondent's gender ask now.

Question thanks

We have completed the interview.

Thank you for taking the time to participate in this important study.

Question gender

What is the respondent's gender?

1. Male
2. Female
3. Refused and couldn't tell