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# Knowledge of three regeneration programs and application behavior among Mississippi nonindustrial private forest landowners: A two-step sample selection approach

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## Abstract

Various public financial assistance programs are available to nonindustrial private forest (NIPF) landowners in the United States. Many landowners have limited knowledge of these programs and have not utilized them. This study employed a two-step sample selection model to examine the determinants of NIPF landowner knowledge of three regeneration programs, and conditional on their knowledge, the determinants of the application frequency to these programs since 1996. Data were collected using a phone survey of NIPF landowners in Mississippi. The survey revealed that among these qualified landowners who had clearcut in the past 10 years, about 50% knew of one or more of the programs. Their application frequencies to individual programs ranged from 0 to 5. Landowner knowledge of the programs was positively related to land size, regeneration experience, gender, and membership in forestry associations. For landowners who knew of these programs, application frequencies were higher for those that had less acreage, had lower education or income, were fully employed, were female, or had no membership in forestry organizations.


***JEL classification:*** C35; Q23

***Keywords:*** Count data; Financial assistance; Harvesting; Poisson distribution; Regeneration

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## Introduction

Nonindustrial private forest (NIPF) landowners have been a major participant in forestry in the United States. In 2002, NIPF landowners owned 58% of total timberlands, forest industry 13%, and the public (e.g., US Forest Service) 29%; they accounted for 63%, 29%, and 8% of total timber harvested, respectively (Smith et al., 2004). Furthermore, NIPF landowners not only produce timber as raw material for the forest products industry, but also provide numerous environmental amenities, including soil conservation, carbon storage, wildlife habitats, maintenance of air and water quality, and recreational opportunities (Wear and Greis, 2002; Alig, 2003). Therefore, for a long time, a variety of public assistance programs have been justified and created for NIPF landowners in the United States. These programs have been designed with the intent of helping landowners to achieve their management goals and also meet societal needs.

Forestland management can be capital intensive and a long period of growth is usually needed before income can be generated. Consequently, when forest landowners harvest their land, they face a critical decision of whether to reforest the land, to let the land regenerate naturally, or to use the land for agriculture, commercial development, or other alternative purposes (Arano et al., 2004). Public assistance programs can influence the management of NIPF lands, compensate landowners for high costs of tree planting, and encourage better forest stewardship (Wear and Greis, 2002). Many public regeneration programs have been specifically designed to reduce the financial burden from regeneration on NIPF landowners and encourage them to replant their lands after harvest. For example, in 1973, the Forestry Incentives Program (FIP) was authorized by the US Congress to share the cost of tree planting and timber stand improvement with private landowners. The share by FIP has ranged up to 65% of these costs for regeneration or improvement (Gaddis et al., 1995).

Many studies have been conducted to analyze the silvicultural decisions by NIPF landowners and their participation in public assistance programs (Amacher et al., 2003). These studies also examined the economic efficiency of these programs, practice retention rate, capital substitution, equity, and subsidiary effects (Gaddis et al., 1995). Previous studies generally agreed that these programs have successfully influenced the management of NIPF lands and stimulated more planting activities (Boyd, 1984; Nagubadi et al., 1996; Mehmood and Zhang, 2001; Sun, 2007). However, in spite of the benefits, these studies also revealed that NIPF landowners have not always utilized these programs. For example, Gunter et al. (2001) found that among the 829 landowners that responded to a survey in Mississippi, more than 60% of them did not know of these public financial assistance programs covered. The majority (54.3%) of the landowners who regenerated their timber stands after harvesting from 1994 to 1998 did not receive any financial assistance from these programs (Gunter et al., 2001). At present, many questions related to public assistance programs still have not been fully addressed in the literature. For example, what determines landowner knowledge of a public assistance program, and furthermore, what is the impact of availability of program information on the application behavior of landowners?

The objective of this study was to examine NIPF landowner knowledge of three regeneration programs in Mississippi and their application behavior after harvesting their lands from 1996 to 2006. Mississippi is a typical southern state in the United States where timber and the related forest products industry have been important. In 2002, NIPF landowners owned 72% of forest lands in Mississippi and produced 67% of the state's timber outputs (Smith et al., 2004). Three programs were included in this study: Mississippi Forest Resource Development Program (FRDP), FIP, and Mississippi Reforestation Tax Credit (RTC). They have been the major programs that provide public financial assistance to NIPF landowners in Mississippi for regeneration activities over the past several decades. An innovative two-step sample selection model was developed to examine what factors were associated with landowner knowledge of these programs, and conditional on landowner knowledge, what factors affected their application frequency. The results have important policy implications for designing and promoting public financial assistance programs for NIPF landowners.

## Major regeneration programs and the response of landowners

### Major public financial programs for regeneration

A number of public programs have provided financial assistance to NIPF landowners to share reforestation costs (Mehmood and Zhang, 2002; Wear and Greis, 2002). Of these programs, FRDP, FIP, and RTC are the major ones available to NIPF landowners in Mississippi for reforestation activities. FRDP is a Mississippi cost-share program, FIP is a federal cost-share program, and RTC is a Mississippi tax incentive program. Their history, eligibility, application and approval criteria, and financial assistance arrangements are briefly described here.

FRDP was established in Mississippi as a state cost-share program for reforestation and timber stand improvement in 1974 (Wear and Greis, 2002). FRDP provides financial assistance to eligible landowners for establishing and improving forest lands. This program offsets landowner expenses by sharing the cost of implementing specific forest practices to produce timber and enhance wildlife development. FRDP 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 50–75% of the total cost of implementing forest practices, with a maximum annual assistance of $7000. The funding for this program has been generated through a timber severance tax in Mississippi. Approximately, 2–4 million dollars each year have been distributed to forest landowners in the past 10 years. From 1974 to 2005, FRDP had a total expenditure of $72 million (Mississippi Forestry Commission, 2007).

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 (Wear and Greis, 2002). To participate in FIP, eligible lands owned by NIPF landowners can range from 10 to 1000 acres, and with special authorization up to 5000 acres. Assistance provided to NIPF landowners can be up to 65% of actual costs, with a maximum annual cost-share payment of $10000. In the 2002 Farm Bill, the FIP program was replaced by the Forest Land Enhancement Program; however, some FIP contracts were funded through 2004. From 1974 to 1994, FIP provided more than $200 million to fund 3.32 million acres of tree planting, 1.45 million acres of timber stand improvement, and 0.27 million acres of site preparation for natural regeneration in the United States (Gaddis et al., 1995). The southern states accounted for 90% of the program's allocation. Annual appropriations for FIP have ranged from $10 to $15 million in the last decade (Sun, 2007).

RTC was initiated in 1999 to promote reforestation on nonindustrial private lands in Mississippi. The credit is applied to Mississippi state income taxes. RTC is favorable to NIPF landowners because cost-share payments for reforestation and some other practices can be excluded from their taxable income (Wear and Greis, 2002). RTC has provided Mississippi NIPF landowners tax credit up to 50% of the cost of qualified reforestation practices. Before 2007, both the annual and lifetime credit limits were $10,000 and landowners were allowed to carry forward any unused credit. In 2007, the Mississippi state legislature made the program even more attractive by raising the lifetime credit limit to $75000 (Mississippi Forestry Commission, 2007). Compared with cost-share programs like FRDP and FIP, RTC as a tax incentive program has no budget constraint and does not need approval by administrative agencies.

## Response of NIPF landowners to public assistance programs

As reviewed by Amacher et al. (2003), numerous studies have examined the participation behavior of NIPF landowners in public assistance programs in the United States. Typically, these studies have relied on binary choice models (e.g., Bell et al., 1994; Nagubadi et al., 1996). The dependent variable was a binary dummy indicating participation behavior. Independent variables usually included landowner characteristics (e.g., income, education) and land features (e.g., acreage). Landowner participation in public assistance programs has been found to be positively associated with total acres owned, membership in forestry organizations, interest in timber production, income, and residence on the forest lands (Straka et al., 1984; Konyar and Osborn, 1990; Nagubadi et al., 1996).

Unfortunately, this type of binary model may be inadequate in analyzing landowner participation in public programs. As revealed in studies like Gunter et al. (2001), many NIPF landowners have been unaware of these existing public programs. A binary choice model is derived from an individual's utility maximization by comparing two choices: participation or no participation. If an individual is not aware of a public assistance program and has not made the assessment, 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 were not aware of the program and did not consider the participation choice at all.

The problem with previous studies has originated from the oversimplified assumption in the binary choice model with regard to the behavior of NIPF landowners. A more suitable approach would be employing a two-step decision model to examine the response of NIPF landowners to public assistance programs. As demonstrated below, the innovation of the two-step decision process is to recognize the reality in forestry that many NIPF landowners are not aware of these public programs. Similar sample selection models (Greene, 2003) have been widely applied in the literature to other comparable issues (e.g., Lee et al., 2003; Katchova and Miranda, 2004; Starbuck et al., 2004).

## Methodology

Two-step sample selection models have been widely used in the literature to analyze cost-share programs, hunting lease markets, and other forestry-related issues (Starbuck et al., 2004; Ovaskainen et al., 2006; Zhang et al., 2006; Hussain et al., 2007). In this study, a two-step sample selection model is employed to examine the determinants of landowner knowledge of individual public programs and their application frequencies. It is assumed that their applications to a public program are contingent upon whether these landowners know of the program. In the selection stage, landowner knowledge of a specific program is modeled as a function of variables, $w_i$, that are composed of land features, management experiences, and landowner characteristics. In the outcome stage, landowner application frequency in the program over the study period is specified as a function of similar explanatory variables, $x_i$. Conceptually, the model is expressed as follows:

$$\text{Selection equation}: \quad z_i = g(w_i) \tag{1a}$$

$$\text{Outcome equation}: \quad y_i = f(x_i) \tag{1b}$$

where $z_i$ is a binary variable that indicates whether landowner $i$ knows of an individual program (i.e., FRDP, FIP, RTC); $z_i$ equals to one if the landowner is aware of the program, and zero otherwise. $y_i$ is the frequency that the landowner applies to the program during the study period (i.e., 1996–2006). Some landowners may have harvested timber multiple times over the study period and they may have applied to the program several times. $y_i$ is observed only when $z_i = 1$. The variables of knowledge ($z_i$) and application ($y_i$) are related but may be influenced by different explanatory variables, or by a same set of factors to a different degree. Therefore, $w_i$ may be different from $x_i$.

The nature of the dependent variables, $z_i$ and $y_i$, requires a combination of binary probit model and count data model. The logic of sample selection model is that an outcome variable is only observed if some criterion, defined with respect to a selection variable, is met (Greene, 2003). In estimating the model, a correction factor for sample selection is computed from the binary probit model. It is then used in the count data regression to analyze application frequency. Mathematically, the two-step sample selection model can be expressed as follows:

$$\begin{aligned} z_i^* &= w_i\gamma + e_i \\ z_i &= 1 \quad \text{if} \;\; z_i^* > 0; 0 \;\; \text{otherwise} \\ \Pr(z_i = 1) &= \Phi(w_i\gamma) \\ \Pr(z_i = 0) &= 1 - \Phi(w_i\gamma) \end{aligned} \tag{2a}$$

$$\begin{aligned} y_i &= x_i\beta + \varepsilon_i \\ \Pr(y_i|x) &= \frac{\mathrm{e}^{-\lambda_i}\lambda_i^{y_i}}{y_i!} \\ \lambda_i &= \mathrm{e}^{x\beta} \end{aligned} \tag{2b}$$

where $\gamma$ and $\beta$ are parameters to be estimated, $\Phi$ the normal cumulative distribution function, $e_i$ and $\varepsilon_i$ the error terms, and $\lambda_i$ the Poisson distribution parameter. In the selection equation, $z_i$ is a realization of an unobserved continuous variable ($z_i^*$) with a normally distributed, independent error, $e_i$. In the outcome equation, $y_i$ is observed only when $z_i = 1$. The two error terms are correlated such that ($e_i$, $\varepsilon_i$)~NID (0, 0, ${\sigma_e}^2$, ${\sigma_\varepsilon}^2$, $\rho$).

The binary probit model, used for the selection equation, is a standard regression method (Greene, 2003). For the outcome equation, modeled in the second stage, the choice among various count data models is worthy of some elaboration here. The Poisson regression model is usually central to the development of various models for count data analysis. As a unique feature of the Poisson distribution, its conditional mean is equal to its conditional variance (also known as equidispersion), i.e., $E(y_i|x) = \mathrm{Var}(y_i|x) = \mathrm{e}^{x\beta} = \lambda_i$.

In practice, the Poisson regression model is inappropriate if the assumption of equidispersion is not met. The conditional variance is often greater than the conditional mean so overdispersion is quite common. If that is the case, the estimates from the Poisson regression model are consistent but inefficient. The negative binomial regression (NBR) model can be constructed to remedy the limitation. The NBR model allows the variance of the dependent variable to differ from its mean (Long, 1997; Greene, 2003) by replacing $\lambda_i$ with a random variable $\tilde{\lambda}_i$:

$$\tilde{\lambda}_i = \exp(x\beta + u_i) = \lambda_i\delta_i \tag{3}$$

where $\delta_i = \exp(u_i)$. To compute $\Pr(y_i|x)$ without conditioning on $\delta_i$, the form of the probability density function of $\delta_i$ needs to be specified and used. The most common assumption is that $\delta_i$ has a gamma distribution $\Gamma(v_i)$ with parameter $v$. By utilizing the Poisson distribution and the gamma distribution together, the NBR model can generate the probability of the dependent variable $y_i$ conditional on covariates $x$ as follows:

$$Pr(y_i|x) = \frac{\Gamma(y_i + v_i)}{y_i!\Gamma(v_i)} \left(\frac{v_i}{v_i + \mu_i}\right)^{v_i} \left(\frac{\mu_i}{v_i + \mu_i}\right)^{y_i} \tag{4}$$

The conditional mean and variance are now different from each other:

$$E(y_i|x) = \exp(x\beta) = \lambda_i \tag{5a}$$

$$\text{Var}(y_i|x) = \lambda_i\left(1 + \frac{\lambda_i}{v_i}\right) = \lambda_i + \alpha\lambda_i^2 \tag{5b}$$

where $\alpha = 1/v_i$ is known as the dispersion parameter. When $\alpha = 0$, the conditional variance equals to the conditional mean so the NBR model reduces to the Poisson regression model. In practice, if $H_0$:$\alpha = 0$ is rejected, the NBR model should be employed.

There are several ways to estimate the selection and outcome equations jointly as a system (Greene, 2003). A nonzero correlation between the error terms is intrinsic to the model. If simply regressing $y_i$ on $x_i$ using those observations for which $z_i = 1$, the estimates of $\beta$ will be both biased and inconsistent. In dealing with the issue, commonly used approaches include full information maximum likelihood (FIML) and two-step method (Murphy and Topel, 1985; Starbuck et al., 2004). FIML approach may be inappropriate when defining the joint distribution is problematic. FIML also frequently has convergence problems, which occurred during the preliminary data analyses in this study. In contrast, two-step method can be used under more general conditions because there is no need to determine a joint-density function for the errors, and as long as each separate function is estimable, it does not have convergence problems (Greene, 2003). Given these considerations, the two-step approach was finally employed in this study.

The two-step sample selection model consists of two marginal distributions: $g(z|w, \gamma)$ and $f(y|w, x, \gamma, \beta)$. First, estimate the binary probit model through maximum likelihood and denote the estimated parameter as $\hat{\gamma}$. Then, estimate the count data model with $\hat{\gamma}$ inserted in place of $\gamma$ as if it were known. The predicted value is commonly known as the inverse Mills ratio (IMR) and is specified for the correction of selectivity in the count data model:

$$\text{IMR} = \frac{\phi(z_i^*)}{1 - \Phi(z_i^*)} \tag{6}$$

where $\phi(\cdot)$ and $\Phi(\cdot)$ are the density and distribution function for the selection equation, respectively. When the coefficient of estimated IMR is significant, it implies the parameter estimators for the second stage of outcome would be biased if the two-step estimation procedure was not used. This entails modeling $y_i$ as dependent upon variables $x$ but considering the fact that $y_i$ is only observed when $z_i = 1$.

The key part of the two-step approach is to correct 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 from the selection equation. Let $V_2$ be the uncorrected covariance matrix computed from the outcome equation, using the parameter estimates obtained in the selection equation as if they were known. Both of these estimators are based on the log likelihood functions. In addition, define

$$C = \sum_{i=1}^{n} \left( \frac{\partial \log f(x_i)}{\partial \beta} \right) \left( \frac{\partial \log f(x_i)}{\partial \gamma'} \right) \tag{7a}$$

$$R = \sum_{i=1}^{n} \left( \frac{\partial \log f(x_i)}{\partial \beta} \right) \left( \frac{\partial \log g(w_i)}{\partial \gamma'} \right) \tag{7b}$$

where $n$ is the number of observations. The corrected covariance matrix for the estimator of the outcome equation, $V_2^*$, can be computed as

$$V_2^* = V_2 + V_2[CV_1C' - RV_1C' - CV_1R']V_2. \tag{8}$$

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). Given the nonzero correlation between the error terms, the model would not be identified if both equations are linear. In practice, reliance on the nonlinearity of the probit model can result in unstable parameter estimates. As a general rule, it is not recommended to rely on the model nonlinearity for identification; instead, it is much better to place restrictions on coefficients (Breen, 1996). This will ensure model identification, although which restrictions are appropriate will depend upon the conceptual model that underlines the analysis. In this study, with limited guidance from economic theory for variable selection, several insignificant variables were excluded from the second stage to ensure model identification.

## Data collection

A survey was designed and conducted in Mississippi to examine NIPF landowner knowledge of three regeneration programs and their application behavior. FRDP, FIP, and RTC were selected because of their focus on forest regeneration and their availability in recent years to NIPF landowners in Mississippi. Information was collected for each of them. Application to these programs was differentiated from participation. For FRDP and FIP, landowners may apply but not be able to participate in the programs for various reasons (e.g., unavailability of funds). In contrast, RTC is a tax incentive code for state income tax, and for qualified landowners application is synonymous with participation. This study focused on the response of NIPF landowners to public assistance programs so their application behavior was examined. Finally, considering that clearcut occurs infrequently for many NIPF landowners with small acreages, the survey covered 10 years from 1996 to 2006 to increase the likelihood that respondents had harvested during the study period. For specific programs, the time span varied slightly because not all of them were available over the whole study period. The survey covered 10 years for FRDP (1996–2006), 8 years for FIP (1996–2004), and 7 years for RTC (1999–2006).

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 population of NIPF landowners in Mississippi is similar to other southern states. In 2006, there were 245000 NIPF landowners in Mississippi, and they owned 13.5 million acres of forest lands in total, with an average of 55 acres per landowner (Butler, 2007). Among them, 32000 landowners (13% of all the landowners) owned at least 100 acres, and altogether, they owned 9.8 million acres (73% of the total acreage). In this study, the survey sample was drawn from a database of landowner records in Mississippi with several filters. All counties except Hinds in Mississippi were covered (there was a lack of records for Hinds). NIPF landowners were the study focus so companies and partnerships were excluded. Only NIPF owners with at least 100 acres of land were selected to eliminate small landowners with infrequent forest management activities. Then, names and addresses of these landowners were used to find their phone numbers through a commercial service agency. After this filtering, a random sample of 9925 landowners was selected and used in the telephone survey. Furthermore, during the survey, several questions were asked to select relevant landowners. The study objective focused on the application behavior of landowners in public programs. A landowner was supposed to have timber harvesting during the study period so a question was used to exclude those landowners without harvests. Another question was also asked about the types of harvesting activities (e.g., clearcut, thinning, and selective cut). A landowner was included only when the landowner conducted a clearcut because other harvesting types usually do not need regeneration.

Of the 9925 landowners contacted by phone, 2126 owned less than 100 acres (the database was inaccurate about acreage), and 2132 did not harvest timber in the past 10 years, so these landowners were excluded from the survey at the beginning. There were also 1110 incorrect telephone numbers. Other reasons for unsuccessful calls included communication problems, refusal to participate, and deceased landowners. As a result, 2229 landowners completed the survey for a completion rate of 49.8%, i.e., 2229/(9925–2126–2132–1110). Furthermore, among those with complete records, most of them only reported thinning or selective harvesting activities during the study period so they were excluded from the statistical analysis. At the end, there were 934 observations for FRDP, 833 for FIP, and 725 for RTC.

The survey questionnaire was designed to collect information on variables needed for the empirical analysis (Table 1). There were two sets of dependent variables, i.e., $z_i$ and $y_i$. One set measured landowner knowledge of the individual programs. The other set recorded their application frequencies in each program during the study 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*

**Table 1.** Definitions and descriptive statistics for the variables used in the two-step sample selection regressions by program

| Variables | Definitions | Mean (Std. dev.) | | |
|---|---|---|---|---|
| | | FRDP ($n = 934$) | FIP ($n = 833$) | RTC ($n = 725$) |
| $Z_i$ | Dummy = 1 if the landowner knew of the program; | 0.457 | 0.496 | 0.502 |
| | 0 otherwise | – | – | – |
| $Y_i$ | Application frequencies for the program over the study period | 0.143 (0.450) | 0.155 (0.472) | 0.263 (0.564) |
| *acreage* | Total acreage owned by the landowner | 491.410 (889.970) | 487.526 (917.826) | 493.247 (855.369) |
| *land type* | Dummy = 1 if forest lands; | 0.777 | 0.776 | 0.763 |
| | 0 otherwise | – | – | – |
| *forest type* | Dummy = 1 if pine forests; | 0.550 | 0.547 | 0.537 |
| | 0 otherwise | – | – | – |
| *year* | Years of land ownership till 2006 | 33.604 (19.098) | 33.473 (18.876) | 33.091 (19.216) |
| *timber* | Dummy = 1 if the landowner was interested in timber production; | 0.903 | 0.900 | 0.894 |
| | 0 otherwise | – | – | – |
| *regeneration* | Regeneration frequencies over the study period | 0.744 (0.680) | 0.712 (0.713) | 0.644 (0.715) |
| *age* | Landowner age in 2006 | 65.430 (11.262) | 65.456 (11.401) | 65.294 (11.070) |
| *education* | Dummy = 1 if the landowner only had high school education or lower | 0.337 | 0.343 | 0.353 |
| | | – | – | – |
| *income* | Household income before taxes in 2005 ($1000) | 64.507 (27.755) | 63.974 (27.577) | 64.234 (28.218) |
| *employment* | Dummy = 1 if the landowner was fully employed; | 0.392 | 0.382 | 0.403 |
| | 0 otherwise | – | – | – |
| *race* | Dummy = 1 if Caucasian; | 0.961 | 0.957 | 0.954 |
| | 0 otherwise | – | – | – |
| *gender* | Dummy = 1 if male; | 0.749 | 0.753 | 0.756 |
| | 0 otherwise | – | – | – |
| *membership* | Dummy = 1 if the landowner was a member of a forestry association; | 0.269 | 0.262 | 0.257 |
| | 0 otherwise | – | – | – |
| *residence* | Dummy = 1 if the landowner resided on the land; | 0.455 | 0.455 | 0.457 |
| | 0 otherwise | – | – | – |

*type*. Second, three variables were constructed to represent management experiences of the landowner: *year*, *timber*, and *regeneration*. Finally, eight variables were used to represent the demographic characteristics of individual landowner: *age*, *education*, *income*, *employment*, *race*, *gender*, *membership*, and *residence. Membership* equaled to one if a landowner was a member of any major forestry organization available to Mississippian landowners, and zero if not. In Mississippi, major organizations available to NIPF landowners are the Mississippi Forestry Association, the Mississippi County Forestry Association, and the Society of American Foresters.

## Results

### Descriptive statistics and model selection

The descriptive statistics for the variables used in the analysis are presented in Table 1. Landowner knowledge of individual programs was measured by a dummy variable so its mean also revealed the percentage—45.7% of the 934 qualified landowners knew of FRDP, 49.6% of the 833 qualified landowners knew of FIP, and 50.2% of the 725 qualified landowners knew of RTC. Overall, about 50% of these qualified landowners were not aware of these public programs. This was consistent with findings from a previous survey in Mississippi (Gunter et al., 2001). Furthermore, the application frequencies by qualified landowners varied slightly among programs. Among the 934 qualified landowners for FRDP, for instance, one applied five times during the study period, two applied four times, two applied three times, nine applied twice, 97 applied once, and 823 did not apply. The maximum application frequencies were five for FIP and four for RTC, and the distribution patterns were similar to that for FRDP. The variable mean was 0.143 for FRDP, 0.155 for FIP, and 0.263 for RTC so the application frequency was the highest for RTC.

The descriptive statistics for the independent variables were similar across the three programs. Taking FRDP as an example, the average acreage owned for the 934 qualified landowners was 491.4 acres. Forest lands were the predominant land use for 77.1% qualified landowners. Pine was the predominant forest type for 55.0% landowners while the remainder had either hardwood or mixed forest types. Average length of ownership was 33.6 years and 90.3% of them were interested in timber production. The mean of regeneration frequency was 0.7 times over the study period. For demographic characteristics, the qualified landowners who applied for FRDP were 65.4 years old on average; 33.7% had a high school diploma or lower education; and their household income in 2005 was $64,507. In addition, about 39.2% of the qualified landowners who applied for FRDP were fully employed, 96.1% were Caucasian, 74.9% were male, 26.9% were members of a forestry association, and 45.5% resided on their lands.

Regression results from the two-step sample selection model are reported in Table 2 for FRDP, Table 3 for FIP, and Table 4 for RTC. The coefficients on the

**Table 2.** Results of two-step sample selection estimation of NIPF landowner knowledge of Mississippi forest resource development program (FRDP) and their application behavior from 1996 to 2006

| Variables | First step: binary probit model | | Second step: negative binomial model | |
|---|---|---|---|---|
| | Coefficient ($t$-ratio) | Marginal effect | Coefficient ($t$-ratio) | Marginal effect |
| *constant* | −0.593 (−1.348) | −0.235 | −10.074*** (−8.685) | −0.961 |
| *acreage* | 2.309E−4*** (2.798) | 9.161E−5 | −0.001*** (−5.563) | −8.246E−5 |
| *land type* | −0.123 (−1.162) | −0.049 | 0.909*** (3.448) | 0.087 |
| *forest type* | −0.211** (−2.414) | −0.084 | 1.398*** (5.289) | 0.133 |
| *year* | 0.001 (0.533) | 0.001 | −0.006 (−1.046) | −0.001 |
| *timber* | 0.212 (1.409) | 0.083 | −0.834 (−1.437) | −0.079 |
| *regeneration* | 0.116* (1.719) | 0.046 | – | – |
| *age* | −0.001 (−0.275) | −0.001 | 0.020* (1.750) | 0.002 |
| *education* | −0.071 (−0.733) | −0.028 | 0.512** (2.055) | 0.049 |
| *income* | 0.001 (0.739) | 0.001 | −0.010** (−2.433) | −0.001 |
| *employment* | −0.169 (−1.498) | −0.067 | 1.389*** (5.120) | 0.132 |
| *race* | 0.025 (0.115) | 0.010 | – | – |
| *gender* | 0.274*** (2.704) | 0.108 | −1.645*** (−4.983) | −0.157 |
| *membership* | 0.435*** (4.382) | 0.172 | −2.439*** (−5.549) | −0.233 |
| *residence* | 0.029 (0.329) | 0.012 | −0.421** (−2.013) | −0.040 |
| Inverse mills ratio | – | – | 18.240*** (7.709) | – |
| *dispersion alpha* | – | – | 0.589* (1.826) | – |
| *log likelihood* | −607.734 | | −349.485 | |
| $\chi^2$ | 72.470 | | 5.667 | |

***Significance at 1% level.
**Significance at 5% level.
*Significance at 10% level.

IMR were significant for all of the three programs and they indicated that the use of the two-step sample selection model was appropriate. Two variables (i.e., *regeneration* and *race*) were not significant in the second stage, and with the confirmation of a Wald test, they were excluded from the second stage to ensure model identification. In addition, for the count data model, the dispersion parameter (*Alpha*) was significant for FRDP at the 10% level and for FIP at the 5% level. Consequently, the NBR model was employed for FRDP and FIP at the second stage. However, the dispersion parameter was not significant for RTC so the results from a Poisson regression model were reported. In the subsequent presentation, to address the study objectives directly, the determinants of landowner knowledge were first examined for the three public programs together. They are followed by the determinants of landowner applications in these programs.

## Determinants of landowner knowledge of public programs

The first stage of binary probit model generated similar results across the three programs. Among land features variables, the coefficients for *acreage* were positive

**Table 3.** Results of two-step sample selection estimation of NIPF landowner knowledge of Forestry Incentive Program (FIP) and their application behavior from 1996 to 2004

| Variables | First step: binary probit model | | Second step: negative binomial model | |
|---|---|---|---|---|
| | Coefficient ($t$-ratio) | Marginal effect | Coefficient ($t$-ratio) | Marginal effect |
| *constant* | −0.906* (−1.923) | −0.361 | −9.539*** (−7.378) | −0.888 |
| *acreage* | 1.832E−4** (2.435) | 7.307E−5 | −0.001*** (−5.435) | −7.156E−5 |
| *land type* | −0.057 (−0.513) | −0.023 | 0.360 (1.366) | 0.034 |
| *forest type* | −0.061 (−0.654) | −0.024 | 0.631*** (2.886) | 0.059 |
| *year* | −0.002 (−0.834) | −0.001 | 0.017*** (2.808) | 0.002 |
| *timber* | 0.486*** (3.006) | 0.188 | −2.983*** (−3.555) | −0.278 |
| *regeneration* | 0.115* (1.671) | 0.046 | – | – |
| *age* | −0.001 (−0.159) | −3.363E−4 | 0.014 (1.110) | 0.001 |
| *education* | −0.111 (−1.084) | −0.044 | 0.592** (1.951) | 0.055 |
| *income* | 0.001 (0.550) | 4.071E−4 | −0.012*** (−2.700) | −0.001 |
| *employment* | −0.105 (−0.856) | −0.042 | 1.145*** (4.026) | 0.107 |
| *race* | 0.234 (1.036) | 0.092 | – | – |
| *gender* | 0.254** (2.369) | 0.101 | −1.885*** (−4.971) | −0.175 |
| *membership* | 0.428*** (4.012) | 0.169 | −2.956*** (−5.932) | −0.275 |
| *residence* | −0.039 (−0.416) | −0.016 | 0.269 (1.210) | 0.025 |
| *Inverse mills ratio* | – | – | 20.866*** (7.244) | – |
| *dispersion alpha* | – | – | 0.889** (2.428) | – |
| *log likelihood* | −541.146 | | −323.204 | |
| $\chi^2$ | 72.433 | | 11.344 | |

***Significance at 1% level.
**Significance at 5% level.
*Significance at 10% level.

and significant for all the three programs. Thus, qualified landowners with more land acreage were more likely to know of these programs. *Land type* was positive and only significant for RTC, implying that qualified landowners with a majority of their land in forestry were more likely to know of the tax incentive program. *Forest type* was negative and only significant for FRDP so these qualified landowners with predominantly pine forest types were less likely aware of this program.

Among the three land management variables, the coefficients for *regeneration* were positive and significant for FRDP and FIP at the 10% level, and for RTC at the 1% level. This suggested that the regeneration experience usually helped qualified landowners learn about these programs. *Timber* was positive for FIP only, so qualified landowners were more likely to know of FIP if they were interested in timber production. The length of ownership as measured by *year* was not significant for any of them. Finally, among the eight demographic variables, two had consistent impacts across all the three programs. Both *gender* and *membership* were positive and significant at the 5% level or better. Thus, male landowners or those with membership in forestry associations had higher probability of knowing of these

**Table 4.** Results of two-step sample selection estimation of NIPF landowner knowledge of Reforestation Tax Credit (RTC) and their application behavior from 1999 to 2006

| Variables | First step: binary probit model | | Second step: Poisson model | |
|---|---|---|---|---|
| | Coefficient (*t*-ratio) | Marginal effect | Coefficient (*t*-ratio) | Marginal effect |
| *constant* | −1.064** (−2.125) | −0.424 | −5.508*** (−8.127) | −0.862 |
| *acreage* | 2.394E−4** (2.269) | 9.548E−5 | −0.001*** (−4.807) | −1.106E−4 |
| *land type* | 0.241** (2.006) | 0.096 | −0.884*** (−4.538) | −0.139 |
| *forest type* | 0.056 (0.551) | 0.022 | −0.262** (−1.917) | −0.041 |
| *year* | 0.001 (0.366) | 4.212E−4 | 0.003 (0.899) | 0.001 |
| *timber* | 0.275 (1.609) | 0.109 | −0.632 (−1.555) | −0.099 |
| *regeneration* | 0.282*** (3.663) | 0.112 | – | – |
| *age* | −0.004 (−0.635) | −0.001 | 0.018** (2.128) | 0.003 |
| *education* | −0.107 (−0.954) | −0.043 | 0.315* (1.761) | 0.049 |
| *income* | 0.002 (0.994) | 0.001 | −0.014*** (−4.746) | −0.002 |
| *employment* | −0.157 (−1.207) | −0.063 | 0.895*** (5.295) | 0.141 |
| *race* | 0.135 (0.567) | 0.054 | – | – |
| *gender* | 0.357*** (3.015) | 0.142 | −1.008*** (−4.451) | −0.158 |
| *membership* | 0.663*** (5.466) | 0.255 | −2.064*** (−9.685) | −0.324 |
| *residence* | −0.124 (−1.187) | −0.050 | 0.491*** (3.455) | −0.078 |
| *Inverse mills ratio* | – | – | 11.157*** (14.647) | – |
| *dispersion alpha* | – | – | 0.001 (0.182) | – |
| *log likelihood* | −443.232 | | −365.574 | |
| $\chi^2$ | 118.588 | | 216.794 | |

***Significance at 1% level.
**Significance at 5% level.
*Significance 10% level.

programs. Other demographic variables did not show any significant impacts on the awareness of the three programs.

Overall, landowner knowledge was positively influenced by land size, regeneration experience, gender, and membership in forestry associations, and the impact was consistent across all the three programs. Land types, forest types, and interest in timber production demonstrated different degrees of influence on landowner knowledge of some programs. Among these significant variables, *membership* had the largest marginal effect at 0.172 for FRDP, 0.169 for FIP, and 0.255 to RTC.

## Determinants of landowner applications to public programs

The second stage count data model examined the determinants of landowner applications to individual programs. The empirical results were comparable across the three programs. Among land features, *acreage* showed negative and significant signs for all the three programs at the 1% level. This revealed that when qualified landowners knew of these programs, their application frequency was higher for those with less land. Results for *land type* were mixed with a positive impact on FRDP and negative on RTC. *Forest type* had a positive impact on the application frequency for

FRDP and FIP at the 1% level, but negative for RTC at the 5% level. Furthermore, among the two variables representing management experience, *year* was positive for FIP and *timber* was negative for FIP. Thus, when qualified landowners knew of FIP, longer ownership of the land and weaker interest in timber production were associated with a higher application frequency in FIP. However, both *year* and *timber* were not significant for FRDP and RTC.

Most of the demographic variables had significant impacts and the results were similar across programs. Five variables had the same signs for all three programs: positive for *education* and *employment*, and negative for *income*, *gender*, and *membership*. This suggested that when qualified landowners knew of these programs, their application frequency was higher if they were fully employed, female or members of forestry organizations, and was lower as education and income increased. In addition, *age* had positive impact on the application behavior for FRDP and RTC but was not significant for FIP. *Residence* also had mixed results with a negative impact on FRDP, a positive impact on RTC, but no significant impact on FIP.

Overall, the results from the second stage revealed that application frequency was higher for qualified landowners that need more public assistance. Among these landowners with knowledge of the programs, application frequency was higher for landowners that in general had less acreage, lower education and income, or were not members in forestry associations. The marginal effect for *membership* had the largest impact on application frequency, with values of −0.233 for FRDP, −0.275 for FIP, and −0.324 for RTC.

## Summary

This study examined how land features, management experiences, and landowner characteristics have impacted NIPF landowner knowledge of public financial assistance programs and their application behavior. The three programs considered in this study (i.e., FRDP, FIP, and RTC) have provided financial assistance to forest landowners in Mississippi for a long time. The analysis was conducted on the landowners that clearcut some or all of their forest lands from 1996 to 2006. A two-step sample selection model was employed to analyze their application behavior conditional on their knowledge of these public programs. Modeling the application frequency conditional on landowner knowledge yields more inspiring results than simple binary regressions typically employed in the literature.

The survey revealed that among those NIPF landowners who conducted clearcuts in the past 10 years, about 50% knew of FRDP, FIP, and RTC. Their application frequencies to individual programs ranged from 0 to 5 times. The two-step sample selection model generated several clear results. From the first stage of selection and binary probit model, landowner knowledge of all three programs was positively related to land size, regeneration experience, gender, and membership in forestry associations. In other words, qualified NIPF landowners that had larger ownerships and more regeneration experience, were male, or were members of forestry associations were more likely to know of these assistance programs. Land type, forest type, and interest in timber production demonstrated different degrees of impact on their knowledge of individual programs. In the outcome stage, the application behavior of NIPF landowners in these programs was modeled conditional on their knowledge of the programs. When landowners knew of these programs, their application frequencies were higher for those with smaller land area, lower education or income, and full employment, that were female, or without membership in forestry associations. Therefore, the application frequency for these public programs was higher for landowners that need more public assistance.

These results have several policy implications for designing, promoting, and implementing public assistance programs. First, information asymmetry for small NIPF landowners is severe and it is clearly a vital issue that merits more attention and analysis. Half of the surveyed Mississippi NIPF landowners in this study had no knowledge of major public assistance programs for regeneration. Considering all NIPF landowners, including those that did not qualify for this survey such as landowners who owned less than 100 acres or had not clearcut any of their forest land during the study period, the proportion of landowners that have no knowledge of these programs is likely much higher. Thus, considering the similarity of nonindustrial private forestland ownership in the southern states, the assumption of perfect information for landowners as assumed in many previous studies is invalid. This information barrier also has been a concern for forest landowners in timber markets (Munn and Rucker, 1994; Amacher et al., 2003). To improve the efficiency of public assistance programs, more effort should be made to disseminate information among the forest landowner community. Extension outreach can be more effective through forestry organizations. Forestry organizations typically provide information and technical guidance and thus affect the involvement of NIPF landowners in public financial assistance programs. Therefore, a useful long-term strategy is to encourage NIPF landowners to join forestry organizations, and furthermore, attend workshops and meetings on a regular basis. Although membership costs for forestry associations in Mississippi are generally quite low, where these costs are burdensome for landowners, appropriate measures to reduce them could be introduced.

Second, the study results also address some equity concerns related to public assistance programs. Many public assistance programs, including FIP, are not designed as an income redistribution or regional development program (Gaddis et al., 1995). Nonetheless, these programs are often involved in debates related to equity. Equity consideration for public assistance programs has several aspects: distribution of funds among states or regions, income and wealth of program participants, secondary program benefits, and transitional equity. For example, a question that has often been asked is whether these programs are subsidizing wealthy landowners who could well afford to invest in reforestation without these public assistance programs. This study revealed that when disadvantaged landowners (i.e., with less acreage, less education, or lower income) were aware of these public assistance programs, they were more likely to apply to them. This is clearly different from the simplified conclusion in the literature that the richer a landowner, the higher the participation probability. Our results are probably indicative of the difference in perceptions of marginal costs and marginal benefits between advantaged and disadvantaged landowners. This also suggests that in designing public financial programs, the needs of small landowners should be emphasized through administrative procedures and regulations.

Finally, the difference between cost-share and tax incentive programs needs more examination. Compared with tax incentive programs, cost-share programs usually are more challenging and expensive for landowners to apply and for pubic agencies to manage. For example, about 10% of FIP appropriations in the past have been spent as administration costs for providing technical assistance, writing plans, and monitoring practices (Gaddis et al., 1995). Thus, other things being equal or similar, tax incentive programs should be more appealing to NIPF landowners than cost-share programs. However, cost-share programs may be better than tax incentive programs in program implementation and evaluation. In this study, NIPF landowners did demonstrate a higher application frequency for the state tax incentive program (i.e., RTC) than for cost-share programs (i.e., FRDP and FIP). The determinants of landowner knowledge of these programs and determinants of their application behavior were nevertheless similar across the three programs. Future research will need to further examine the different impacts of cost-share and tax incentive programs on both governments and forest landowners in achieving their objectives.

In summary, public financial assistance will continue to be a vital concern to governments and NIPF landowners in the United States. These assistance programs have faced many challenges over time. These challenges include how to handle the fluctuation of budgets and how to allocate funds effectively to achieve the program goals. Future research needs to examine how to improve program design and implementation to improve program efficiency.

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