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Willingness of Mississippi's nonindustrial private forest landowners to manage forests for ecosystem services

By

Edward Mutandwa

A Dissertation
Submitted to the Faculty of
Mississippi State University
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy
in Forest Resources
in the Department of Forestry

Mississippi State, Mississippi

December 2015

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Willingness of Mississippi's nonindustrial private forest landowners to manage forests for ecosystem services

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Private forest land in Mississippi provides a wide range of ecosystem services. This study examined nonindustrial private forest (NIPF) landowner familiarity with ecosystem services and conservation programs and quantified the proportion of forest land they were interested in managing for ecosystem services as well as determined compensation levels required for implementing forest management strategies featuring management restriction to facilitate production of multiple ecosystem services. The data collection process was based on a structured questionnaire administered to 2,025 NIPF landowners in Mississippi. Findings indicated that landowner familiarity with conservation programs was low. However, they were familiar with ecosystem services found in Mississippi. Familiarity with conservation programs was positively associated with gender, household income, possession of a forest management plan, and membership in conservation organizations. The study also determined whether landowners were interested in managing their forests for ecosystem services and the quantified proportion of forest land they would manage for such services. Findings revealed that landowners were interested in managing for multiple ecosystem services

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and 62% of the forest land could be available for production of such activities in the form of pine and bottomland hardwoods. The proportion of forest land that landowners were interested in managing for ecosystem services was positively associated with the percentage proportion of natural pine and bottomland hardwoods as well as personal recreation goals while negatively related to a possession of a written forest management plan. The research also used a contingent valuation to quantify monetary compensation levels that landowners were willing to accept to adopt forest management restrictions to facilitate ecosystem services. The willingness to accept (WTA) compensation levels ranged from $190.22 to $595.23/ha/year. Higher compensation was required with a higher level of management restrictions. WTA compensation to implement forest management activities was positively associated with bid level and long-term investment goal. Findings will be useful in facilitating outreach activities in terms of identifying groups of interested landowners, forest land available for multiple ecosystem service production, and quantifying the total cost of implementing forest management facilitating an increased production of ecosystem services.

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DEDICATION

I would like to dedicate my work to the Almighty God who represents the center of my faith. Without Him, I would not be able to have reached this stage. I also dedicate this effort to my family and myriads of my fellow colleagues deep in the heart of my homeland.

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TABLE OF CONTENTS

DEDICATION ii

ACKNOWLEDGEMENTS iii

LIST OF TABLES vi

CHAPTER

I. INTRODUCTION 1

1.1 Introduction 1
1.2 Rationale of the study 5
1.3 Study objectives 9
1.4 References 10

II. NONINDUSTRIAL PRIVATE FOREST LANDOWNER FAMILIARITY WITH CONSERVATION PROGRAMS 17

2.1 Abstract 17
2.2 Introduction 18
2.3 Methods 21
2.3.1 Study area 21
2.3.2 Data collection 22
2.3.3 Data analysis 23
2.4 Results 27
2.4.1 Landowner characteristics 27
2.4.2 Forest land characteristics 28
2.4.3 Familiarity with ecosystem services and conservation programs 29
2.4.4 Association of socioeconomic factors with conservation program familiarity 32
2.5 Discussion 34
2.6 Conclusions and policy implications 39
2.7 References 42

III. NONINDUSTRIAL PRIVATE FOREST LAND AVAILABILITY FOR PRODUCTION OF ECOSYSTEM SERVICES IN MISSISSIPPI 48

3.1 Abstract 48

www.manaraa.com

3.2 Introduction 49
3.3 Methods 53
3.3.1 Study area 53
3.3.2 Data collection 53
3.3.3 Data analysis 54
3.3.4 Model 55
3.4 Results 58
3.4.1 Landowner socioeconomic characteristics 58
3.4.2 Forest land characteristics 58
3.5 Association of socioeconomic factors with forest land area landowners were willing to manage for ecosystem services 59
3.6 Discussion 61
3.7 Conclusions and policy implications 65
3.8 References 67

IV. CONTINGENT VALUATION ESTIMATES OF WILLINGNESS TO ACCEPT COMPENSATION TO PROVIDE ECOSYSTEM SERVICES 74

4.1 Abstract 74
4.2 Introduction 75
4.3 Methods 81
4.3.1 Site description 81
4.3.2 Data collection methods 81
4.3.3 Analytical framework 84
4.4 Results 90
4.4.1 Demographic overview 90
4.4.2 Willingness to implement forest management restrictions 91
4.5 Determinants of willingness to accept compensation 93
4.6 Discussion 98
4.7 Conclusions and policy implications 104
4.8 References 107

V. CONCLUDING REMARKS AND POLICY IMPLICATIONS 116

APPENDIX

A. SURVEY INSTRUMENT 121

www.manaraa.com

LIST OF TABLES

2.1 Description of variables to quantify the association of socioeconomic factors with landowner familiarity with conservation programs. 25

2.2 Familiarity of Mississippi's nonindustrial private forest landowners with ecosystem services. 30

2.3 Socioeconomic factors associated with landowner familiarity with five assistance programs. 34

3.1 Description of socioeconomic variables associated with the proportion of forest land area targeted for ecosystem services. 56

3.2 Total forest land area owned and forest land area landowners were interested in managing for ecosystem services. 59

3.3 Weighted least squares (WLS) estimation of the determinants of the proportion of forest land available for ecosystem services. 61

4.1 Determinants of landowner willingness to accept compensation to provide ecosystem services. 88

4.2 Landowner preferences of forest management alternatives by bid amounts. 92

4.3 Reasons for not accepting alternatives featuring forest management restrictions to facilitate production of ecosystem services. 93

4.4 Socioeconomic factors associated with landowner willingness to accept compensation with unsure responses removed (model 1). 95

4.5 Socioeconomic factors associated with landowner willingness to accept compensation with no and unsure responses combined (model 2). 96

4.6 Mean willingness to accept compensation (WTA) values and 95% confidence for forest management alternatives. 97

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CHAPTER I

INTRODUCTION

1.1 Introduction

Ecosystem services have been receiving an increased amount of attention in various international forums (Deal et al. 2012). The growing research focus is partly due to global environmental issues including climate change, desertification, and deforestation (Pindyck 2012). Ecosystem services are mostly classified as essentially anthropocentric services because they generally improve human well-being (Boyd and Banshee 2007, Millennium Ecosystem Assessment 2005, Buttoud 2000). They include numerous benefits from the environment such as timber, recreation, wildlife habitat, biodiversity, food, water, herbs, and climate and pollution control (USDA Forest Service 2009). Different classification systems have been used to categorize ecosystem services (Constanza et al. 2014, Jose 2009, Chee 2004). The Millennium Ecosystem Assessment's system, (MEA 2005), identified provisioning, regulating, culturing, and supporting services, and seems to be most commonly used.

Ecosystem services constitute a central element in current U.S. forest policy which has undergone several revisions over the years (USDA NRCS 2014). The concept, understanding, and prioritization of ecosystem services in forest management have changed over time (Grebner et al. 2013). Prior to the 19th century, forest management focused on traditional ecosystem services such as timber and wildlife (Fedkiw 1999). As

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early as the 1920s, recreational access was informally integrated into public resource management (Lane and McDonald 2002). However, the emergence of environmental issues such as soil erosion and deforestation led to a reorientation of forest management at the policy level (USDA Forest Service 2009, Cubbage et al. 2007). This was coupled with a growing population and higher disposable income which increased recreational demand on forests (Lane and McDonald 2002). In addition, the continuous upgrade to the extensive transportation system made it easier to access recreational areas (Godbey et al. 2005). It was not until the 1960s and 1970s that a series of policy instruments were enacted, including Multiple-Use and Sustained-Yield Act of 1960 and National Forest Management Act of 1976, to explicitly include nonmarket forest benefits into decision-making for the USDA Forest Service, Bureau of Land Management (BLM) and Environmental Protection Agency (EPA) (Fisher et al. 2008, Pearse and Holmes 1993).

Currently, U.S. national forest policy is focused on management of forests for production of ecosystem services including timber, wildlife habitat, clean water and air, carbon sequestration, and aesthetics as represented by numerous provisions in the Farm Bill of 2014 (USDA NRCS 2014). These provisions ensure that current forest stocks and associated social and ecological services can be maintained for future generations (USDA NRCS 2014). Non-tangible ecosystem services are non-excludable and non-rival in nature and, thus, it is difficult to use market instruments to increase their supply because these services can be used and/or enjoyed by people without paying (Chee 2004).

Many conservation programs emerged as a response to the need to improve conservation of natural resources, improve forest productivity, and increase the supply of ecosystem services (USDA NRCS 2014, Ma et al. 2012, Nepal et al. 2012, Cooley and

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Olander 2011, Layton and Siikamäki 2009, Kilgore et al. 2007, Mayer and Tikka 2006). These conservation initiatives provide educational, technical, and financial assistance to nonindustrial private forest (NIPF) landowners (Matta et al. 2007, Cason et al. 2006, Nagubadi et al. 1996). They also provide landowners with opportunities to practice sustainable forest management and typically focus on wetland rehabilitation, carbon sequestration, and wildlife habitat restoration among other areas of concern (D'Amato et al. 2009, Baumgartner et al. 2003). Therefore, landowner knowledge of, and involvement in, conservation programs is likely to provide opportunities for reduced establishment and management costs, improved forest health management, and production of more ecosystem services on private forest land (LeVert et al. 2009).

In general, forests play important social and economic roles in the southern United States by providing income opportunities related to timber production, camping, hunting, fishing, wildlife watching, and carbon sequestration (Henderson et al. 2010, Arano and Munn 2006). For instance, recreational activities in the southern United States contributed US$8 billion while supporting 57 million jobs in 2006 (Munn et al. 2010). Furthermore, forests dominate the landscape by occupying about 99 million hectares (ha; Oswalt et al. 2014). They are owned by approximately four million NIPF landowners who have multiple objectives that are both monetary and non-monetary in nature (Kendra and Hull 2005, Birch 1996). Although forest ownership is predominantly characterized by NIPF landowners, there is also substantial ownership by Timber Investment Management Organizations (TIMOs) and Real Estate Investment Trusts (REITs) as well as a multitude of publicly owned forests (Ma et al. 2012, York et al. 2006, Gregory et al. 2003, Deller et al. 2001, Bliss et al. 1994). Together, TIMOs and REITs account for 6

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million ha (10%) of timber land in the southern United States (Zhang et al. 2012). Public forests, on the other hand, represent about 9.7 million ha (14.6%) of forest cover in the same area (Zhang et al. 2012).

Similarly to the other states in the southern United States, forests in Mississippi are widely distributed and occupy an estimated 8 million ha (Arano and Munn 2006). Although numerous efforts have been made to enhance the range and quantity of ecosystem services, the Mississippi forestry faces some challenges related to nonparticipation of NIPF landowners in existing programs, their lack of familiarity with management for ecosystem services and conservation programs, and the nonmarket nature of many ecosystem services (LeVert et al. 2009, Sun et al. 2009, Measells et al. 2005).

Landowners have been shown to have consistently low knowledge of conservation programs in the United States (LeVert et al. 2009, Sun et al. 2009, Mehmood and Zhang 2002). Familiarity and participation in conservation programs were shown to be associated with forest land area owned, landowner age, educational level, membership in forest associations, household income, physical location, and sources of information (Gruchy et al. 2012, Olenick et al. 2005, Nagubadi et al. 1996). Socioeconomic factors such as program payments, ownership system, location, and forest site index also influenced forest land area allocated for production of ecosystem services (Lubowski et al. 2008, Lambert et al. 2007, Soghnen et al. 2006, Gunter et al. 2000, Hardie et al. 2000, Skaggs et al. 1994).

A major proportion of ecosystem services produced do not have a market and their monetary value is usually not observed (Fisher et al. 2008). Therefore, economic

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valuation is necessary to assign monetary cost to the set of nonmarket ecosystem services (Lane and McDonald 2002). Given that many ecosystem services in the southern United States are produced on public and private forest lands, monetary value is used to illustrate the cost and help conduct informed financial comparisons of different forest management options as well as for those non-forestry activities such as residential housing and commercial development (Haab et al. 2013). In Mississippi, many ecosystem services produced on private forest lands are not paid for and landowners may not be motivated to expand their production (Grebner et al. 2013). Studies estimating the monetary value of multiple ecosystem services are few (Gruchy et al. 2012, Hite et al. 2012). However, this study assessed the willingness to accept (WTA) compensation for implementing forest management strategies that promote multiple ecosystem services. Three research questions presented in this dissertation are related to the familiarity with ecosystem services and associated conservation programs, proportion of forest land area potentially available for the production of ecosystem services, and monetary valuation of ecosystem services.

1.2 Rationale of the study

The broad goal of this research is to inform outreach and conservation activities in terms of landowner familiarity with ecosystem services and programs, forest area and types that landowners were interested in managing for multiple ecosystem services, and a monetary cost of implementing such forest management facilitating production of ecosystem services. This information is important for the success of activities related to adoption of forest management strategies promoting conservation and production of multiple ecosystem services. By determining whether landowners were interested in

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forest management for multiple ecosystem services and the associated forest types, this study's outputs will be useful for Extension professionals to focus on landowner segments that are interested in such activities. Furthermore, the study determined the costs and conservation budgets for active forest management that may be needed for multiple ecosystem services in Mississippi. While existing programs in the southern United States may include landowner objectives in their plans, they mostly focus on a few types of ecosystem services and are therefore not geared towards multiple forest management (Taylor Stein et al. 2003).

In the second chapter, it is argued that an increase in landowner familiarity with ecosystem services and related programs is crucial for enhancing adoption of sustainable forest management practices by NIPF landowners in Mississippi and increasing production of ecosystem services (USDA Forest Service 2009). Forest professionals involved in outreach activities can use socioeconomic characteristics to target different segments of landowners and encourage them to participate in conservation programs as well as increase the provision of ecosystem services such as clean air and water, aesthetics, and wildlife habitat (USDA Forest Service 2009a). In relation to these issues, the second chapter examines the extent to which landowners are familiar with ecosystem services and conservation programs including Conservation Reserve Program (CRP), Wildlife Habitat Incentives Program (WHIP), Environmental Quality Incentives Program (EQIP), Wetland Reserve Program (WRP), and conservation easements.

Conservation programs have varied goals that include educational, technical, and financial components that seek to promote conservation activities and enhance ecosystem services production from numerous resources such as wetlands, forests, rivers, and other

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unique natural systems (USDA Forest Service 2009). Through a better understanding of ecosystem services, landowners will be more aware of social, ecological, and economic values of forests (Oliver and Deal 2007). This will promote conservation on private forest lands and increase production of multiple ecosystem services because landowners will be more conversant with the cost-sharing opportunities associated with sustainable forest management (LeVert et al. 2009).

A number of previous studies (Jarrett et al. 2013, Creamer et al. 2012, Ma et al. 2012, Jacobson et al. 2009, Sun et al. 2009, Cason et al. 2006, Measells et al. 2005, Arano et al. 2004, Gunter et al. 2000) evaluated landowner involvement in incentive programs and factors influencing their participation. However, these studies did not explicitly examine the effects of landowner familiarity with conservation programs. Knowledge of programs is important since it may influence eventual landowner participation (Butler 2008). Therefore, the research gap relates to landowner knowledge of CRP, WHIP, WRP, EQIP, and conservation easements. Landowner knowledge of these programs is also important because they focus on various resources including wetlands, riparian areas, stream management zones, and upland forest lands which are likely to play a substantial role in the provision ecosystem services (USDA Forest Service 2009). These programs were included in this study because they are among most common and largest in terms of budgetary allocations (USDA NRCS 2014) and, therefore, were used as a proxy for future ecosystem service programs.

The third chapter quantified the forest area landowners were interested in managing for ecosystem services. Unlike previous research (Soghnen et al. 2006, Plantinga et al. 2001), that used regional models to identify factors affecting land

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allocation decisions, this research conducted a survey of NIPF landowners in Mississippi. A survey approach helped identify landowner opinions and perceptions about ecosystem services and their willingness to manage specific forest types for multiple ecosystem services. NIPF landowners are different with respect to their socioeconomic characteristics such as gender, age, education, and household income, and these characteristics are among the determinants of land allocation decisions (Nagubadi et al. 1996). However, previous research did not determine the proportion of forest land and forest types that can potentially be managed for ecosystem services production. These aspects are essential because they determine the ecosystem services that can be produced from NIPF land (Jack et al. 2008). Furthermore, such analysis can be potentially useful in developing educational programs to enhance conservation efforts and increase landowner interest in managing forest land for ecosystem services (Scarlett and Boyd 2011).

Research in the fourth chapter used an innovative approach suggested by LaRocco and Deal (2011) to valuate ecosystem services because instead of quantifying the monetary value of a specific ecosystem service, it focused on forest management practices that facilitate a simultaneous provision of numerous ecosystem services. Forest ecosystems typically provide numerous ecosystem services such as aesthetics, wildlife habitat, clean air and water (USDA Forest Service 2009). Payment mechanisms that consider a bundle of provided ecosystem services are important in determining the total value of forests (LaRocco and Deal 2011, Buttoud 2000). In addition, quantifying the monetary cost of forest management facilitating ecosystem services is important for comparing alternative forest uses, determining conservation budgets, and promoting sustainable management of forest resources.

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1.3 Study objectives

Specific study objectives were to:

1. Determine whether Mississippi's NIPF landowners were familiar with ecosystem services and related programs and quantify association of selected attitudinal, production, and socioeconomic factors with landowner familiarity.

2. Determine the proportion of forest land in Mississippi that can potentially be managed for ecosystem services and quantify the relationship between selected attitudinal, production, and socioeconomic factors with potentially available forest land area.

3. Determine willingness of Mississippi's NIPF landowners to manage their forests for ecosystem services at selected monetary compensation levels and how willingness was associated with socioeconomic and attitudinal factors, and compensation levels.

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CHAPTER II

NONINDUSTRIAL PRIVATE FOREST LANDOWNER FAMILIARITY WITH CONSERVATION PROGRAMS

2.1 Abstract

Many conservation programs have been introduced in the United States to create financial, educational, and technical incentives for the conservation of natural resources and increasing the provision of ecosystem services by agricultural and nonindustrial private forest (NIPF) landowners. Conservation of natural resources became an important issue in view of soil erosion and land degradation. The study objective was to examine Mississippi NIPF landowner familiarity with conservation programs and examine association of selected attitudinal and socioeconomic characteristics with landowner familiarity. A mail survey based on Dillman's Tailored Design Method was sent to 2,025 randomly selected NIPF landowners in Mississippi. A total of 663 usable questionnaires were returned resulting in an adjusted response rate of 37.1%. Survey responses were analyzed using descriptive statistics as well as a structural random effects probit model regression. Landowner program participation rates were as follows: CRP (28.3%), EQIP (7.2%), WHIP (6.3%), WRP (3.0%), and conservation easements (2.0%). Familiarity with conservation programs was positively associated with gender, forest land size, forest and conservation organization membership, and ownership of a written forest management plan ($p<0.05$). Results also suggested that participation in forestry- and

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agriculture-based organizations can help improve landowner knowledge of ecosystem services and enhance familiarity with conservation programs. However, future research may determine subgroups of landowners who may be interested in managing for ecosystem services and appropriate forest types.

Keywords: ecosystem services, mail survey, NIPF landowners, structural random effects probit model, Mississippi

2.2 Introduction

An increased knowledge of available conservation programs and related monetary incentives may motivate nonindustrial private forest (NIPF) landowners to manage their forests more actively for the provision of ecosystem services (USDA Forest Service 2009). Ecosystem services include a wide range of benefits derived from the environment (Costanza et al. 2014, Jeffreys 2004). Although some researchers have argued that current classification systems do not explicitly differentiate between ecosystem processes and final outputs (Yang et al. 2015), ecosystem services are broadly categorized into provisioning, regulating, supporting, and cultural services (Millennium Ecosystem Assessment 2005). Forested landscapes in the southern United States provide many market and nonmarket ecosystem services such as timber, recreation, wildlife habitat, biodiversity, clean air and water, and carbon sequestration (Zhang and Flick 2001). Future supply of ecosystem services in the southern United States will depend on awareness and engagement of NIPF landowners because they own the majority of forest land in the region (Measells et al. 2005, Gunter et al. 2001). However, effective engagement of landowners in managing land for ecosystem services is challenging and will require coordinated landscape-level land use planning incorporating a diversity of

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forest landowner ownership objectives and socioeconomic characteristics, spatial distribution of natural ecosystems, availability of assistance programs, and involvement of federal and private institutional stakeholders (Gagne et al. 2015, Kline et al. 2013, Butler and Leatherberry 2004).

Although many federal conservation programs are available to NIPF landowners, only 26% of their land is being actively managed for the provision of ecosystem services such as soil erosion control, carbon sequestration, and wildlife habitat (USDA Forest Service 2009). Many NIPF landowners are not willing to manage their forests for ecosystem services mainly due to the perception of poor financial returns from such an involvement (Kilgore et al. 2007) and the lack of, or low familiarity with, existing conservation programs and available incentives (Measells et al. 2005, Gunter et al. 2001). Despite these challenges, conservation programs have enhanced the provision of ecosystem services in numerous United States regions (USDA NRCS 2014). For example, about 60,000 hectares (ha) of wetland area in Mississippi has been restored to primarily provide habitat for various bird and aquatic species (USDA NRCS 2014).

In the United States, there are more than 60 federal and private conservation programs (Mayer and Tikka 2006). They offer technical and financial assistance to encourage landowners to sustainably manage their forested and agricultural lands and typically focus on wetland rehabilitation, carbon sequestration, forest regeneration, and wildlife habitat restoration among other conservation efforts (D'Amato et al. 2009). Examples of federal and state conservation programs in Mississippi include the Wetlands Reserve Program (WRP), Forest Resource Development Program (FRDP), Wildlife Habitat Incentives Program (WHIP), Conservation Reserve Program (CRP), and

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Mississippi Reforestation Tax Credit (RTC) program (Sun et al. 2009, USDA Forest Service 2009, Measells et al. 2005). Recent changes to the 2014 Farm Bill integrated WHIP into the EQIP, whereas WRP was merged with farm and grassland conservation programs to form the Agricultural Conservation Easement Program (ACEP, USDA NRCS 2014). Landowner eligibility varies across these programs but typically used criteria include gross household income, type of landowner enterprise, ownership length, specific environmental problems to be mitigated by the program, and ecosystem services to be generated (Ferris and Siikamäki 2009).

Research conducted in the United States (Jacobson et al. 2009, Sun et al. 2009, Butler 2008, Kilgore et al. 2007) has shown that most NIPF landowners were not familiar with existing conservation programs and thus did not utilize available technical and financial incentives. For example, Sun et al. (2009) found that less than 50% of surveyed Mississippi NIPF landowners knew about programs such as the Forest Resource Development Program (FRDP), Forest Incentive Program (FIP), or Reforestation Tax Credit (RTC) Program. Low familiarity with conservation programs is a challenging constraint because it results in lower participation and thus negatively affects land management practices and leads to a reduction in land capacity to provide market and nonmarket ecosystem services (Measells et al. 2005, Butler and Leatherberry 2004).

Various factors such as income level, membership in forest organizations, and possession of a written forest management plan were motivating factors for NIPF landowners to seek more information about assistance programs (Creamer et al. 2012). Other factors shown to impact NIPF landowner familiarity with, and participation in, conservation programs included landholding size, landowner age, geographic location,

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fear of property right loss, forest establishment costs, and sources of information (Gruchy et al. 2012, Gunter et al. 2001, Nagubadi et al. 1996). A number of studies indicated that older landowners and forestry-related work experience were likely to increase the probability of being familiar with conservation programs (Nagubadi et al. 1996). Alternatively, programs such as conservation easements, which require landowners to cede developmental rights, reduced the likelihood of participation and knowledge of such programs (Nagubadi et al. 1996). Disparities between landowner goals and program objectives, long-term commitment, and strict program requirements have also been noted as important factors related to poor knowledge and skepticism among landowners (LeVert et al. 2009). In addition, a better understanding of factors affecting landowner familiarity with conservation programs will help identify factors affecting participation in these programs and determine viability of increasing the provision of ecosystem services from private lands through these programs as well as promote new ecosystem service-dedicated programs.

The study objectives were to: (1) examine the familiarity of Mississippi NIPF landowners with specific federal conservation programs (2) quantify the association of selected attitudinal and socioeconomic factors with landowner familiarity.

2.3 Methods

2.3.1 Study area

This study was conducted in Mississippi which is one of 13 states in the southern United States. Mississippi has a total land area of 12.1 million hectares (ha, US Census Bureau 2012) of which approximately 8 million ha (67%) constitute forests under private and public landownership (USDA Forest Service 2009). Most forest land in Mississippi

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is owned by NIPF landowners whose ownership accounts for 70% of the forest land area (Arano and Munn 2006). There are about 315,000 NIPF landowners with an average forest land ownership of 20 ha (Londo and Auel 2004). Privately owned forests and associated forest products contributed $10 billion to the state economy in 2010 according to Impact Analysis for Planning (IMPLAN) studies (Dahal et al. 2013).

2.3.2 Data collection

Data were collected through a mail survey conducted between July and August 2012 in Mississippi. The sample included 2,025 randomly selected NIPF landowners whose addresses were identified based on county tax rolls and obtained from commercial providers. The sample size was designed to obtain at least 398 useable questionnaires necessary to maintain a 5% sampling error at the 95% confidence level (Dillman 2007). Survey design was based on the Dillman's Total Design Method and involved four mail contacts consisting of an initial informatory cover letter and three follow-up cover letters with questionnaires (Dillman 2007). The questionnaire instrument was pre-tested by the faculty and Extension personnel in the Department of Forestry at Mississippi State University. This was done because of the limited financial resources that were available for the activity.

The questionnaire was comprised of five sections. The first section described selected ecosystem services including aesthetics, carbon sequestration, clean air and water, hunting, woody biomass production for bioenergy, soil erosion control, tourism, watershed management, and wildlife habitat. The second section included questions related to owned forest types and ownership goals. The third section asked questions related to landowner familiarity and experiences with ecosystem services and related

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conservation programs. The fourth section presented a contingent valuation (CV) scenario to examine landowner preferences for providing ecosystem services in exchange for annual payments and to determine the monetary value for those services. The fifth section collected information about socioeconomic characteristics of Mississippi's NIPF landowners.

2.3.3 Data analysis

A non-response bias test was conducted by comparing socioeconomic characteristics and opinions on ecosystem services between the first and last 30 respondents in the sample (Poudyal and Hodges 2009). Non-response bias tests in previous research studies typically used 10% of the responses (Armstrong and Overton 1977). While follow-ups of non-respondents to determine reasons for not participating in the survey are recommended (Hudson et al. (2004), this option was not used due to limited financial resources. The sample was further validated by comparing respondent gender, age, education level, gross household income, and owned forest land size with statistics reported in National Woodland Owner Survey (NWOS) conducted by the USDA Forest Service (Armstrong and Stedman 2012). Descriptive statistics, including means and modes, were used to summarize continuous variables such as forest landholding size and landowner age. Categorical variables such as gender, education, possession of a written forest management plan, and participation in organizations were summarized using frequencies. A 6-point Likert scale (1 - very important, 2 - important, 3 - moderately important, 4 - of little importance, 5 - unimportant, and 6 - unsure) was used to identify the most important reasons for owning forest land and landowner familiarity with ecosystem services. The Friedman test was used to rank ordinal data

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variables measured on a 6-point Likert scale, whereas a Chi-square test was used to measure the association between landowner familiarity with conservation programs and socioeconomic characteristics. This is similar to Stokes et al. (2003) and Beasley and Zumbo (2003) who suggested that the Friedman test be used if ranking variables were based on ordinal data and the Chi-square test could be used for determining the statistical association of categorical data, respectively. To conduct chi-square tests involving landowner familiarity and different landowner socioeconomic characteristics, categories "extremely familiar" through "slightly familiar" were recoded as 1 ("familiar with ecosystem services"), whereas "not at all familiar" was recoded as 0 ("not familiar with ecosystem services"). "Unsure" responses were removed from the computation of this variable to aid analysis of those who were familiar and unfamiliar with ecosystem services. In addition, the proportion of unsure responses ranged from 3 to 9% for the different types of ecosystem services.

Responses related to familiarity and participation in conservation programs were originally categorized as "participated and familiar with the program," "did not participate but familiar with the program," and "did not participate and not familiar with the program." Responses were then recoded into a binary dependent variable representing familiarity with each conservation program where the first two original categories were coded as 1 ("familiar with the program") and the third original category as 0 ("not familiar with the program"). The recoding was done to facilitate the assessment of factors that were related to landowner familiarity. The random effects probit model was justified from the viewpoint that landowners were asked about their familiarity with CRP, WRP, EQIP, WHIP, and conservation easements in the same survey (Greene 2007). A point

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worth noting is that at the time of conducting the study, WHIP and WRP were separate programs from EQIP and the Agricultural Conservation Easement Program (ACEP), respectively (USDA NRCS 2014). Description of dependent and independent variables used in the models are presented (Table 2.1).

Table 2.1 Description of variables to quantify the association of socioeconomic factors with landowner familiarity with conservation programs.

Variables	Descriptions
Dependent	
CRP[1]	1 if familiar with CRP, 0 otherwise
WRP[2]	1 if familiar with WRP, 0 otherwise
EQIP[3]	1 if familiar with EQIP, 0 otherwise
WHIP[4]	1 if familiar with WHIP, 0 otherwise
CE[5]	1 if familiar with conservation easements, 0 otherwise
Independent	
EDUC	1 if bachelor degree or higher, 0 otherwise
GENDER	1 if male, 0 if female
ES PRODN	1 if a landowner managed forest land for production of ecosystem services, 0 otherwise
AGE	Landowner age in years
FOREST SIZE	Total hectares owned
MFA	1 if a member of Mississippi Forest Association, 0 otherwise
PROFORG	1 if a member of a professional organization, 0 otherwise
CONSORG	1 if a member of a conservation organization, 0 otherwise
FMP	1 if a landowner possessed a written forest management plan, 0 otherwise
FAM INDEX	1 if highly familiar with ecosystem services, 0 otherwise
ENVORG	1 if a member of an environmental organization, 0 otherwise
ENROL	1 if forest land was previously enrolled in a conservation program, 0 otherwise
INC	Gross annual household income earned in 2011 in US$

[1]Conservation Reserve Program, [2]Wetlands Reserve Program, [3]Environmental Quality Incentives Program, [4]Wildlife habitat Incentives Program, [5]Conservation Easements

Using previous studies to identify factors that are associated with the dependent variable, including Campbell (2007), Langpap (2006), Lynch and Lovell (2003), Cooper and Keim (1996), Nagubadi et al. (1996), Rahm and Huffman (1984), familiarity with a

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given conservation program was determined by a set of variables including gender, age, education level, production of ecosystem services, size of forest land owned, gross household income, membership in organizations, possession of a written forest management plan, familiarity with ecosystem services, and previous enrollment of forest land in conservation programs.

Overall familiarity with ecosystem services was represented as a grand Likert mean score calculated based on individual mean Likert scores for the 10 ecosystem services. To facilitate econometric analysis and interpretation of regression coefficients, the grand Likert score for ecosystem services was then recoded into a binary variable with 1 representing familiarity with ecosystem services and 0 otherwise. The specification of the structural random effects probit model was as follows:

$$\begin{aligned} \gamma_i^* &= \alpha_i X_i + q_i + u_{it} \\ Y_i &= 1, if\, \gamma_i^* > 0 \end{aligned} \tag{2.1}$$

where: γ_i^* is the probability of a landowner being familiar with a conservation program *i* (*i* represents CRP, WRP, WHIP, EQIP and conservation easements); α_i is the partial regression coefficient; X_i are the independent variables; q_i and u_{it} are errors terms which are multivariate normal, identically and independently distributed (iid), Y_i represents a respondent's familiarity with CRP, WRP, EQIP, WHIP, and conservation easements and takes a value of 1 if familiar and 0 if unfamiliar with program (Capellari and Jenkins 2003).

The structural random effects probit regression model was used because landowners were asked about familiarity with five programs in the same survey as suggested by Petrolia and Kim (2009). Furthermore, there was a possibility of error terms

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being related across programs (Capellari and Jenkins 2003). The hypothesis of independence of errors terms associated with each probit model was then tested. Rejection of the null hypothesis ($p<0.05$) would indicate that the structural random effects probit model was a better specification when compared to separate estimation of five probit models. Conditional marginal effects were also estimated using the model. These were estimated by setting a value of 1 for each program and zero for all others. In other words, the marginal effects showed marginal changes in independent variables assuming that the landowner was familiar with a given conservation program. As suggested by Capellari and Jenkins (2003), the advantage of such marginal effects is that they enabled the identification of independent variables that were uniquely associated with a program which could be used to provide specific recommendations.

2.4 Results

2.4.1 Landowner characteristics

A total of 663 questionnaires were returned resulting in an adjusted response rate of 37.1%. The non-response bias test indicated no significant differences between the first and last 30 respondents ($p>0.05$). Respondents and non-respondents were therefore not significantly different in terms of gender, age, education, annual household income, total forest land area owned, possession of a written forest management plan, and membership in professional, agricultural, and environmental organizations ($p>0.05$). Furthermore, sample estimates were consistent with estimates reported in NWOS. Males accounted for 78.0% of participating NIPF landowners, whereas females for 22.0%. The average landowner age was 66 years. Female landowners were older with a mean age of 68 years compared to 65 years for males ($p<0.05$). In terms of education, 52.4% of

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landowners had a Bachelor's degree or higher, 28.5% completed high school, 11.8% possessed vocational qualifications, and 7.2% did not complete high school. There was no significant difference in education level between male and female landowners ($\chi 2$=3.007, p=0.557). About 11.0% of landowners belonged to County Forestry Associations (CFA), 15.0% to farm-based organizations, 17.0% to community service organizations, and 9.0% to the Mississippi Forestry Association (MFA). Religious and church groups accounted for 74.0% of landowners. The mean gross annual household income in 2011 was about $75,000.

2.4.2 Forest land characteristics

Overall average landownership size was 101 ha. The Friedman ranking test was significant (p<0.000), implying that each landownership goal was ranked differently by landowners. The most important reason for forest landownership was to provide a legacy to heirs followed by long-term investment, and personal recreation. The least important reason for owning forest land was the provision of fee-based recreational services such as hunting leases, ecotourism, and horseback riding. Production of agro-forestry products such as nuts and fruits was of relatively low importance to landowners as well as the generation of income.

Approximately 17.3% of landowners had a written forest management plan. There was a significant relationship between gender and possession of a forest management plan ($\chi 2$=4.618, p<0.099). A higher proportion of male landowners (19.1%) had plans when compared to females (16.5%). About 3% of forest landowners were not sure if a written forest management plan was prepared for their forest land.

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2.4.3 Familiarity with ecosystem services and conservation programs

Landowners were familiar with personal recreation (84.1%), clean water (81.9%), soil erosion control (81.7%), wildlife habitat (80.8%), clean air (80.5%), and watershed management (76.7%) (Table 2.2). However, they were less familiar with carbon sequestration (60.2%), fee-based recreation (57.9%), woody biomass production (57.2%), and aesthetics (56.5%). There was no significant association between gender and familiarity with clean air (χ^2=4.749, p=0.441), clean water (χ^2=4.786, p=0.442), personal recreation (χ^2=9.584, p=0.088), and soil erosion control (χ^2=8.359, p=0.138). There was a statistical relationship between gender and familiarity with wildlife habitat (χ^2=12.409, p<0.030) and watershed management (χ^2=14.814, p<0.011). About 80% of male landowners were familiar with wildlife habitat and watershed management compared to 20% of females. There was no significant relationship between education and familiarity with clean air (χ^2=26.359, p=0.156), clean water (χ^2=22.547, p=0.312), and soil erosion control (χ^2=27.606, p=0.119). There was a significant association between education and personal recreation (χ^2=33.951, p=0.008), wildlife habitat (χ^2=43.647, p=0.000), and watershed management (χ^2=16.500, p=0.006).

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Table 2.2 Familiarity of Mississippi's nonindustrial private forest landowners with ecosystem services.

Ecosystem service	Familiarity (%)					
	Extremely familiar	Moderately familiar	Somewhat familiar	Slightly familiar	Not at all familiar	Unsure
Aesthetics	11.0	18.0	16.1	11.4	36.9	6.6
Biodiversity (i.e., increase richness of animal and plant species)	11.1	20.1	17.1	16.4	30.2	5.2
Carbon sequestration	9.5	18.1	17.6	15.0	33.1	6.7
Clean air	22.6	28.8	18.5	10.6	16.2	3.3
Clean water	24.1	32.7	16.4	8.7	14.9	3.3
Personal recreation (e.g., hunting, fishing, camping)	37.6	29.4	12.6	4.5	12.3	3.6
Providing fee- based recreation (e.g., hunting leases, ecotourism, riding trails)	11.9	15.9	15.8	14.3	33.0	9.1
Production of woody biomass for bioenergy	7.4	14.8	17.9	17.1	35.0	7.7
Soil erosion control	24.3	31.3	17.0	9.1	15.0	13.3
Watershed management	17.7	25.9	18.5	14.6	18.5	4.6
Wildlife habitat	25.6	31.0	14.8	9.4	14.6	4.5

Most landowners who indicated familiarity with wildlife habitat (60.0%), watershed management (58.4%), and personal recreation (56.8%) had at least a Bachelor's degree. Household income was associated with familiarity of only selected ecosystem services. There was no significant relationship between annual household income and familiarity with clean air (χ^2=65.486, p=0.46), clean water (χ^2=66.164, p=0.436), soil erosion control (χ^2=75.556, p=0.174), personal recreation (χ^2=82.871, p=0.382), and wildlife habitat (χ^2=81.661, p=0.084). However, there was a significant association between household income and watershed management (χ^2=80.545, p=0.006).

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Membership in forest- and agriculture-based organizations was associated with landowner familiarity with most ecosystem services. Membership in MFA had a significant linkage with landowner familiarity with clean air (χ^2=15.920, p=0.007), clean water (χ^2=19.880, p=0.001), personal recreation (χ^2=13.665, p=0.018), soil erosion control (χ^2=29.116, p=0.001), watershed management (χ^2=21.845, p=0.001), and wildlife habitat (χ^2=14.438, p=0.013). Membership in agriculture-based organizations was also associated with landowner familiarity with aesthetics (χ^2=27.239, p=0.001), biodiversity (χ^2=20.085, p=0.001), carbon sequestration (χ^2=9.814, p=0.081), clean water (χ^2=15.447, p=0.009), woody biomass for bioenergy (χ^2=21.845, p=0.001), soil erosion control (χ^2=26.199, p=0.000), watershed management (χ^2=16.192, p=0.006), and wildlife habitat (χ^2=25.067, p=0.000). However, there was no significant relationship between memberships in agriculture-based organizations and familiarity with clean air (χ^2=8.831, p=0.116) and fee-based recreation (χ^2=15.045, p=0.090).

There was a significant relationship between ownership of a written forest management plan and forest land management for the production of ecosystem services (χ^2=67.008, p=0.000) as well as enrollment in conservation programs (χ^2=60.955, p=0.000). About 14.3% of landowners managed their forest land for the provision of ecosystem services and 29.2% of landowners, who had a written forest management plan, were previously enrolled in a conservation program. About 11.7% of landowners with forest landholdings larger than 20 ha (the average for Mississippi) were previously enrolled in conservation programs, whereas landowners with forest properties smaller than 20 ha, it was only 1.9%. These small landowners also had a smaller mean household income of $59,239 which differed from the average income of $81,929 for landowners

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owning more than 20 ha (p<0.000). Only 10% of small landowners belonged to agricultural, conservation, or professional organizations and only 7% of these landowners actively managed their forests for ecosystem services. Small landowners typically had high school or vocational level education, and were males aged 66 years or older.

There was a significant association between enrollment in conservation programs and gender (χ^2=6.197, p=0.045). Although only a few landowners had enrolled their forest land in these programs, more male landowners (85%) participated in such programs compared to female (15%). The majority of landowners who had at least a Bachelor's degree (65%) enrolled some portion of their forest land in conservation programs. There was no relationship between household income and enrollment in conservation programs (χ^2=24.395, p=0.553). Landowner program participation rates were as follows: CRP (28.3%), EQIP (7.2%), WHIP (6.3%), WRP (3.0%), and conservation easements (2.0%). Other programs included FIP and FRDP which were less than 2%.

2.4.4 Association of socioeconomic factors with conservation program familiarity

Statistical associations were reported between socioeconomic factors and landowner familiarity with conservation programs (Table 2.3). Since the null hypothesis stating that rho (10 of them) was equal to zero was rejected, results indicated that it was a better specification than individual specification of five probit models (p<0.05). In the CRP model, male landowners with large forest land properties, past enrollment in a CRP program, a written forest management plan, and familiarity with ecosystem services were more likely to be familiar with CRP (p<0.05). Male landowners had a probability of

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program familiarity that was 12% higher than females, holding other factors constant. In addition, landowners who possessed a forest management plan had a 20% higher probability of being familiar with CRP than those without a plan, ceteris paribus. Past enrollment in CRP enhanced the probability of CRP familiarity by 19%, holding other factors constant. Furthermore, landowners who were highly familiar of ecosystem services had a 0.3% higher probability relative to those with lower scores. Membership to a conservation organization increased the chances of being familiar with CRP by 21.9%.

WRP model results indicated that landowners with higher annual income, with membership in MFA and conservation organizations, and a high familiarity with ecosystem services were associated with a greater probability of the landowner being familiar with WRP ($p<0.05$). The marginal effects of membership to MFA and conservation organizations were 11.5% and 18.3%, respectively. Three predictor variables were significant in the EQIP model and these were memberships in conservation organizations, familiarity with ecosystem services, and total size of their forest land. In the EQIP model, membership to conservation organizations was associated with a 17.4% increase in the probability in program familiarity ($p<0.05$). Again, the importance of ecosystem services awareness was underscored because it increased the probability of being familiar with EQIP by 0.5%, ceteris paribus. In the WHIP model, male landowners, memberships in MFA and conservation organizations, and a forest management plan as well as awareness of ecosystem services were more likely to be familiar with WHIP ($p<0.05$). Landowners with a written forest management plan had a probability that was 12% higher compared to those without a plan. High familiarity with ecosystem services was associated with a 0.6% increase in being familiar with WHIP,

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holding other factors constant. Conservation easement model results indicated that landowners who were members of MFA coupled with higher ecosystem service familiarity scores and high annual incomes were more likely to be familiar with conservation easement programs (p<0.05). Wald chi-square value was 215.97 with a p-value less than 0.05 indicating that a model with predictors was better than a null model.

Table 2.3 Socioeconomic factors associated with landowner familiarity with five assistance programs.

	CRP[1]		**WRP[2]**		**EQIP[3]**		**WHIP[4]**		**CE[5]**	
	Coef.	M.E	Coef.	M.E	Coef.	M.E	Coef.	M.E	Coef.	M.E
EDUC	0.15	0.05	-0.23	-0.00	-0.24	-0.00	0.03	0.00	0.11	0.03
GENDER	0.36	0.12*	0.25	0.08	0.22	0.06	0.47	0.14*	0.05	0.01
ES PRODN	0.08	0.02	-0.01	-0.00	0.01	0.00	0.03	0.01	0.37	0.10
AGE	0.00	0.00	0.00	0.00	-0.00	-0.00	0.00	0.00	0.00	0.00
FOREST SIZE	0.00	0.00*	0.00	0.00	0.00	0.00*	0.00	0.00	0.00	0.00
MFA	0.23	0.07	0.35	0.11	0.34	0.10	0.46	0.13*	0.43	0.11*
PROFORG	-0.00	-0.00	-0.17	-0.05	0.04	0.01	-0.03	-0.01	0.04	0.01
CONSORG	0.60	0.19*	0.36	0.18*	0.39	0.17*	0.78	0.23*	0.29	0.07
FMP	0.66	0.21*	0.14	0.04	0.16	0.04	0.40	0.11*	0.26	0.07
FAM INDEX	0.02	0.00*	0.02	0.00*	0.01	0.00*	0.02	0.00*	0.01	0.00*
ENVORG	-0.98	-0.31*	-0.66	-0.21	-0.36	-0.10	-0.43	-0.12	0.13	0.03
ENROL	0.38	0.19	0.10	0.05	0.23	0.06	0.00	0.00	0.09	0.02
INC	0.00	0.00	0.01	0.00*	-0.00	0.00	-0.00	-0.00	0.00	0.00*
Constant	-2.12		-2.33		-1.36		2.54		-2.59	

[1]Conservation Reserve Program, [2]Wetlands Reserve Program, [3]Environmental Quality Incentives Program, [4]Wildlife habitat Incentives Program, [5]Conservation Easements, Coef.: coefficients, M.E: marginal effects,*Independent variable significance at the 5% level

2.5 Discussion

The study's response rate of 37% was consistent with similar landowner studies conducted by Grala et al. (2012), Measells et al. (2005), and Sun et al. (2009). Sample estimates for age, gender, household income, forest land size and education were

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consistent with socioeconomic characteristics reported in NWOS (Butler 2008) and, therefore, were representative of NIPF landowners in Mississippi. In general, most landowners were not familiar with, and did not enroll in, conservation programs. This result was emphasized by previous studies (Creamer et al. 2012, Munn et al. 2010, Sun et al. 2009, Gunter et al. 2001). This was supported by the observation that only 28% of landowners were familiar with CRP, a major conservation program that has existed since 1985 (USDA Forest Service 2009). Further, of those who were familiar with CRP, about 27% did not participate in the program, indicating that they were not interested or their land was not eligible for enrollment (Nagubadi and Zhang 2005, Gregory et al. 2003).

Another explanation for low participation rates might be that most conservation programs have limited funding and, therefore, even landowners who are familiar with these programs and have eligible lands might not be able to enroll due to program budgetary constraints (USDA NRCS 2014). For example, in the last five years about 30% of WHIP and EQIP applications were not funded due to funding limits (USDA NRCS 2014). Findings also indicated that household income was not a significant factor in explaining program enrollment. However, a greater percentage of higher income households were actively managing their forest land for ecosystem services.

Socioeconomic factors and membership in natural resource organizations were also statistically associated with landowner familiarity with conservation programs. Male landowners were more likely to be familiar with the five conservation programs than female landowners. As such, conservation programs need to focus on gender aspects when developing Extension and outreach activities to increase knowledge and participation. Since male landowners own the majority of forest land and are more aware

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of conservation programs, they seem to be the most likely audience for outreach activities emphasizing conservation efforts that will enhance their ownership objectives (USDA Forest Service 2009). There is need to focus on landowner subgroups that may not be adequately receiving Extension support (Measells et al. 2005). However, female landowners, even though they own less land, should also be included in these efforts because they are increasingly becoming landowners (Warren et al. 2003) and are often more concerned with environmental issues than male landowners (Tarrant and Cordell 2002). Further, because female landowners were less familiar with conservation programs they might find that they will benefit from general information on program availability and conservation benefits.

Landowner membership in natural resource organizations was, on the other hand, associated with a higher probability of familiarity with conservation programs. In this context, various forestry-, agriculture-, and community-based organizations and associations can serve as platforms for disseminating information on various aspects related to conservation programs, ecosystem services, and incentives available to landowners (Langpap 2004). Such outreach activities can include publications, newsletters, field trips, hands-on presentations, use of social networks, and close cooperation with early adopting landowners (USDA Forest Service 2009, Majumdar et al. 2008). Furthermore, early adopters can act as ambassadors of conservation efforts and help popularize conservation efforts and ecosystem services within their communities.

Study results indicated that landowners were relatively less aware of emerging ecosystem services and perhaps were not utilizing potential income opportunities associated with these services. For example, landowners were more familiar with specific

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ecosystem services such as wildlife habitat, recreation, clean air and water, and watershed management compared with aesthetics and carbon sequestration. This could be attributed to the fact that these ecosystem services are an integral part of the socioeconomic and cultural setting in Mississippi. For instance, Henderson et al. (2010) and Munn et al. (2007) noted that the main outdoor recreational activities in Mississippi included hunting, fishing, and wildlife-watching. On the other hand, landowners were less familiar with production of woody biomass production for bioenergy, aesthetics, and carbon sequestration, a result which reflects that these ecosystem service concepts are relatively new to Mississippi landowners (Gruchy et al. 2012).

Conservation efforts may, therefore, focus on improving landowner knowledge of ecosystem services by prioritizing services that matter to landowners (Bengston et al. 2011). Furthermore, such information could be used as an input in regional planning undertaken by conservation programs. For example, landscape-level incentives may be developed that encourage wildlife habitat management for different bird species, as well as deer, and wild turkey over a given area (LaRocco and Deal 2011). Landscape-level efforts must, however, be tied to well-defined environmental goals reflecting regional, national, and global priorities (Reed and Massie 2013). Landscape Conservation Cooperatives (LCCs) under the auspices of the US Fish and Wildlife Service develop conservation goals over large areas where private forest owners and other stakeholders such as academic institutions share comparable environmental goals (USDI Fish and Wildlife Service 2014). In addition, goals include defining desired populations for different fish and wildlife species and appropriate habitats. Furthermore, it may be easier to coordinate, monitor, and evaluate the production of ecosystem services at the regional

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level. Smaller programs can be more easily established, managed, and monitored than larger ones and thus serve as examples for broader applications in the future (USDI Fish and Wildlife Service 2014). On the contrary, many current conservation programs focus on individual landowners, with few landowners benefiting financially since the approach results in random production of ecosystem services, which are less effective on a landscape-level (LaRocco and Deal 2011).

It was also found that a small proportion of landowners had a written forest management plan. Lack of forest management plans can negatively affect the future provision of ecosystem services. It helps to formalize landowner objectives related to a forest property and thus might improve land eligibility for enrollment in conservation programs as well as integrate ecosystem services into management prescriptions that will enhance landowner ownership goals (Creamer et al. 2012, Kilgore et al. 2007). Many federal conservation programs require NIPF landowners to develop a forest management plan as a condition for eligibility (USDA Forest Service 2009). Most landowners are, however, skeptical about having plans associated with public agencies because they believe that agency goals might take precedence over their personal goals and property rights (Fischer and Bliss 2009). The implication for future conservation programs is to build trust and improve communication between landowners and public land administrators because it lowers transactions costs associated with negotiations and contracting (Fischer and Bliss 2009). Program flexibility and participatory learning can help increase trust among landowners (Hahn et al. 2006).

Improving landowner familiarity with conservation programs and related ecosystem services is important to obtain greater social benefits and improve land-use

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practices (Grebner et al. 2013). However, there is a need to understand trade-offs that exist among different land-use practices and availability of ecosystem services as well as the impacts of forest land fragmentation and climate change on land conservation planning (Kline et al. 2013, Joshi and Mehmood 2011). Equally important is the provision of adequate financial and technical tools to create incentives for landowners to participate in long-term conservation efforts (Joshi et al. 2013, USDA Forest Service 2009). However, while many different landowner engagement scenarios can be implemented to promote and increase conservation efforts within specific landowner groups, it is also necessary to monitor and assess the effectiveness of these efforts (Emtage and Herbohn 2012).

2.6 Conclusions and policy implications

This study illustrated the extent to which landowners were conversant with ecosystem services and related conservation programs. An understanding of these issues is important because they can influence the types of forest management practices and programs for which landowners could be enrolled in and ultimately the types of ecosystem services produced. Generally, a large proportion of landowners were not familiar with available assistance programs. This indicates that there is potential for improving sustainability of forest operations and producing more ecosystem services through educational assistance. Potential conservation efforts aimed at increasing the provision of ecosystem services may focus not only on increasing landowner knowledge of ecosystem services and conservation programs, but also on incorporating ecosystem services into forest management in a way that it will enhance landownership objectives.

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From an outreach perspective, landowner knowledge of ecosystem services can be improved by using communication methods such as newsletters, publications and early adopters. The research findings showed that program familiarity was positively associated with membership in forest and conservation organizations, possession of a written forest management plan, forest land size, annual household income and gender. These socioeconomic parameters are useful to identify subgroups of landowners in the process of raising familiarity with ecosystem services and conservation programs. Focusing on landowner socioeconomic groups may help improve the efficacy of outreach activities. In this regard, the results showed that landowners constitute a heterogeneous group implying that their information needs are different. By educating landowners on how numerous opportunities may improve their management plans, this may enhance management of forests for the provision of ecosystem services, improve program eligibility, and provide an opportunity to generate additional income.

Whereas many of the highlighted previous studies researched on participation, this study focused on familiarity which can be considered to be an antecedent factor important in the eventual involvement of landowners in conservation programs. Without a clear understanding of ecosystem services and conservation programs, landowners may be less likely to implement forest management practices that promote multiple ecosystems or even participate in such programs. These outputs therefore help to extend the boundaries of existing knowledge pertaining to landowner behavior with respect to ecosystem services and programs. Moreover, it may be easier to develop conservation programs that can be managed at the landscape level with well-defined goals consistent with forest and environmental policy objectives. This will help improve forest

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management for the provision of ecosystem services, increase participation in conservation programs, and provide an opportunity to generate additional income. However, since this and recent studies used static analyses, it is important to carry out similar studies in the future to identify changing landowner objectives, determine landowner willingness to incorporate ecosystem services into land management, and assess their knowledge and participation in conservation programs over time.

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CHAPTER III

NONINDUSTRIAL PRIVATE FOREST LAND AVAILABILITY FOR PRODUCTION OF ECOSYSTEM SERVICES IN MISSISSIPPI

3.1 Abstract

Forest land in the southern United States is an important source of ecosystem services. Given the dominance of family forests in the Southern United States, landowner allocation decisions are, therefore, important in influencing the quantity and types of ecosystem services produced. The main study objective was to determine the proportion of nonindustrial private forest (NIPF) land in Mississippi that landowners would be interested in managing for the production of ecosystem services based on a mail survey of 2,025 NIPF landowners. Landowners were interested in providing approximately 61% of their land for producing ecosystem services. Weighted least squares (WLS) regression results indicated that personal recreation goal,percentage area under bottomland hardwoods, percentage area under natural mixed forests, and past participation in conservation programs were positively associated with the proportion of forest area that landowners were interested in managing for ecosystem services (p<0.05). Results indicated that there was a potential for increasing production of ecosystem services from NIPF lands. Results indicated the importance of developing future programs focused on different landowner socioeconomic groups and incorporating their objectives in the design of such programs to increase the production of ecosystem services. While the

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study provided insights on the proportion of land that landowners were interested in managing for ecosystem services, future research should focus on assessing the role of financial factors such as timber prices, net present values (NPV) and monetary values associated with the implementation of forest management strategies for multiple ecosystem services.

Keywords: ecosystem services, landowner interest, mail survey, weighted least squares, southern United States

3.2 Introduction

Southern forests occupy 33% (105 million ha) of the total forest land area in the United States (Oswalt et al. 2014) and are an important source of marketable and nonmarketable ecosystem services (Shugart et al. 2003). The importance of forests in terms of nonmarketable ecosystem services has been increasing over time due to a rising demand for these services globally, nationally, and regionally (Grado et al. 2011). For example, in 2012 the volume of carbon offsets demanded by private entities at the global level covered about 26.5 million ha, representing a 4% increase from 2011 (Peters-Stanley and Yin 2013). Furthermore, the total economic value of carbon offsets is estimated to reach more than $2 billion by 2020 (Peters-Stanley and Yin 2013). In 1996, at the national level, a total of 77 million individuals, over 16 years old, participated in wildlife-related recreation such as hunting, angling, and wildlife watching (US Census Bureau 1996). In 2011, the number of individuals involved in the same recreational activities increased to 90 million, indicating a 17% increase between 1996 and 2011 (Hussain et al. 2012, US Census Bureau 2011).

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A similar trend has been observed in the southern United States where the total expenditures associated with recreational activities amounted to $8.4 billion in 2006 and $38 billion in 2011 (Hussain et al. 2012). In Mississippi, the total economic impact of recreational activities amounted to $2.7 billion in 2010 (Henderson et al. 2010). Waterfowl hunting alone was estimated at $27 million in 2001 and it increased to $86 million in 2011 (Grado et al. 2011). Given that 59% of the forest land in the southern United States is owned by nonindustrial private forest (NIPF) landowners (Measells et al. 2005, Butler and Leatherberry 2004), the availability of NIPF land dedicated to ecosystem service management is crucial for sustaining a growing demand for ecosystem services (Jack et al. 2008).

NIPF landowners are motivated by diverse ownership goals such as timber production, wildlife habitat, recreation, aesthetics, and providing a legacy for future generations (Grebner et al. 2013, Joshi et al. 2013, Gruchy et al. 2012, Arano et al. 2004). These multiple objectives have important implications on implemented forest management regimes and types of ecosystem services produced (Kendra and Hull 2005). For example, landowners who manage their forest land primarily for timber may be able to simultaneously produce various ecosystem services (Grebner et al. 2013). However, the level of their production might not reflect full forest potential because ecosystem services might compete with timber production (Grebner et al. 2013). On the other hand, landowners who place a high value on personal recreation may emphasize managing their forest land for wildlife habitat and aesthetics, and might be willing to implement less intensive timber harvesting prescriptions and forgo part of potential timber income (Grado et al. 2011). A better understanding of landowner forest management intentions is

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important for determining the forest land area that can potentially be committed to ecosystem services management (Kilgore et al. 2007).

There is evidence suggesting that private forest land area in the southern United States will decrease by 6% over the next 35 years due to population growth, forest fragmentation, and urbanization (Rozance and Rabotyagov 2014, Feng et al. 2013). Declining forest land area will most likely have a negative impact on the provision of ecosystem services (Ahn et al. 2000). A decline in the supply of ecosystem services is further exacerbated by the fact that many ecosystem services are nonmarketable and NIPF landowners often do not have an incentive to actively manage their forests for these services because of potentially increased management costs, lower timber revenues, and lack of financial compensation (Hussain et al. 2007, Mozumdar et al. 2007, Richard and Stokes 2004).

Early work on land allocation to various economic activities can be traced back to Johann Heinrich von Thunen and David Ricardo's land rent models (Hardie et al. 2000). In these models, landowners were viewed as rational economic agents whose land use decisions were mainly driven by profit from existing land use alternatives (Lubowski et al. 2008). Various types of models based on land-use planning have also been used in contemporary land allocation research (Hagoort et al. 2008, Soghnen and Brown 2006, Verburg et al. 2004). Research related to forest management and forest landownership goals, however, suggested that landowners consider both economic and non-economic factors in their land-use decisions related to ecosystem services (Joshi and Arano 2009). Numerous aspects ranging from land productivity (e.g., site index, forest rent) to landowner socioeconomic characteristics (e.g., gender, education, annual household

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income) were reported as important factors affecting forest land availability for ecosystem service production (Lubowski et al. 2008, Lambert et al. 2007, Nagubadi and Zhang 2005).

Several research studies showed mixed results for factors such as gender, education, personal income, property taxes, and population density in terms of their effect on land allocated for the production of ecosystem services (Meng and Zhang 2013, Chen et al. 2012, Sullivan et al. 2005). Furthermore, many previous studies analyzed forest land availability for ecosystem services production but did not determine the proportion of NIPF land that can be managed for ecosystem services in the future and what forest ecosystem types might be allocated to ecosystem service production. This is important because it influences the quantity and types of ecosystem services that can potentially be available in the future (Jack et al. 2008, Ahn et al. 2002).

The goal of this study was to determine the proportion of NIPF land potentially available for the production of multiple ecosystem services across different forest types in Mississippi. Several multiple ecosystem services including timber, aesthetics, carbon sequestration, clean water, cleaner, wildlife habitat, watershed management, ecotourism, hunting, and woody biomass for bioenergy were considered in the study. These are commonly found in the southern United States (USDA Forest Service 2009). The research also examined the association of selected landowner socioeconomic factors with the proportion of forest land that landowners were interested in managing for ecosystem services. Information on the proportion of forest land and forest ecosystem types NIPF landowners are interested in managing for ecosystem services will help guide future land use planning decisions and coordinate conservation efforts.

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3.3 Methods

3.3.1 Study area

This research was conducted in Mississippi, located in the southern United States, where most of the major economic sectors include agriculture and forestry (USDA Forest Service 2009). Approximately 65% of Mississippi's land area (8 million ha) is forested and the majority of the forest land (70%) is owned by NIPF landowners (Londo and Auel 2004). The main forest types in Mississippi include hardwood and oak-pine forests (53%), pine forests (33%), and other forests (14%) (Southeast Mississippi Forest Inventory Report 2006). Previous studies indicated that the forest sector made a substantial contribution to Mississippi's economy, ranging from $17.0 billion in 2008 to $10.4 billion in 2010 (Dahal et al. 2013, Henderson and Munn 2013). Forests in Mississippi provide numerous ecosystem services, many of which have an increasing impact on the state economy. For example, Grado et al. (2011) indicated that economic impact of waterfowl hunting in Mississippi amounted to $87 million in 2011, whereas Henderson et al. (2010) reported a total state-wide economic impact of most recreational activities at $2.7 billion in 2010.

3.3.2 Data collection

Data were collected via a survey questionnaire mailed to 2,025 randomly selected NIPF landowners who were identified based on county tax records. Survey implementation approach followed the Tailored Design Method (Dillman 2011) in which landowners were contacted five times by an introductory letter describing the study, a letter with a questionnaire, a thank you/reminder postcard, and two follow-up letters with questionnaires. Faculty and Extension personnel in the Department of Forestry at

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Mississippi State University assisted with questionnaire calibration. The questionnaire had five sections which included a description of selected ecosystems services and questions related to forest ownership goals, experience with ecosystem services and associated programs, hypothetical ecosystem service valuation scenarios, and landowner socioeconomic characteristics.

3.3.3 Data analysis

A non-response bias test was conducted by comparing socioeconomic factors including gender, age, education, annual household income, total forest land area owned, possession of a written forest management plan, and membership in professional, agricultural, and environmental organizations. The comparison involved the first and last 30 forest landowners who returned their questionnaires following a protocol described by Armstrong and Overton (1977) who suggested using approximately 10% of responses. The study sample also was validated using descriptive statistics from the National Woodland Owner Survey (NWOS) conducted by the USDA Forest Service in 2006 (Butler 2008).

An exploratory analysis was performed by calculating means for variables measured on a continuous scale such as total area of forest land owned, forest land area under specific forest types, forest area which landowners were interested in managing for ecosystem services, annual household income, and landowner age. Categorical variables such as gender, education, and membership in associations or organizations were summarized using frequencies.

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3.3.4 Model

A multiple regression model was constructed to quantify the relationship between landowner and forest characteristics, and the proportion of forest land landowners would be interested in managing for ecosystem services. The model was based on the following survey question:

> "Please report the following: 1) how many acres you own by forest type and 2) how many acres you would be interested in managing for ecosystem services"

Following Gujarati and Porter (2009), the initial model was specified as follows:

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \ldots + \beta_n x_{ni} + \varepsilon_i \quad (3.1)$$

where Y_i represents the proportion of forest land landowners were interested in managing for ecosystem services (quantified by dividing a total area landowners were interested in managing for ecosystem services by total forest land area owned); X_i represents a set of independent variables including landowner gender, age, education, percentage area under pine, percentage area under natural pine, percentage area under bottomland hardwoods, percentage area under natural mixed forests, household income, past participation in conservation programs, participation in organizations (i.e., professional, environmental, agricultural), landownership goals (i.e., providing legacy to heirs, long-term investment, personal recreation), and familiarity with ecosystem services (Table 3.1); ε is the error term; and n represents the number of independent variables in the model for the i^{th} NIPF landowner.

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Table 3.1 Description of socioeconomic variables associated with the proportion of forest land area targeted for ecosystem services.

Variable	Variable description	Mean	SD
Y	Proportion of forest area targeted for ecosystem services	0.61	0.69
FAM INDEX	Familiarity with ecosystems services	0.57	0.49
P.RECR	1-if personal recreation is very important, 0-otherwise (Initially measured on a six-point Likert scale and converted to a binary variable with 1 if goal is important, 0 otherwise)	0.91	0.27
INVEST	1-if long-term investment is very important, 0-otherwise (Initially measured on a six-point Likert scale and converted to a binary variable with 1 if goal is very important, 0 otherwise)	0.93	0.24
LEGACY	1-if legacy for heirs is very important, 0-otherwise (Initially measured on a six-point Likert scale and converted to a binary variable with 1 if goal is important, 0 otherwise)	0.95	0.21
FMP	1-if landowner has a forest management plan, 0-otherwise	0.17	0.37
PROFORG	1-if member of a professional organization, 0-otherwise	0.26	0.44
ENVORG	1-if member of environmental organization, 0-otherwise	0.03	0.18
AGRICORG	11-if member of agricultural organization, 0-otherwise	0.15	0.35
ENROL	1-if land was previously enrolled in conservation program, 0-otherwise	0.09	0.29
EDUC	1-if Bachelor degree or higher, 0-otherwise	0.53	0.25
GENDER	1 if male, 0 female	0.77	0.41
INC	Gross annual household income in 2011 in US$ ($1,000)	77.08	47.27
AGE	Landowner age in years	65.55	12.03
P.PINE	Percentage area under planted pine	0.52	0.53
P.NTPINE	Percentage area under natural pine	0.21	0.25
P.BOTMLN	Percentage area under bottomland hardwoods	0.22	0.26
P.NTMXD	Percentage area under natural mixed forests	0.47	0.39

The final regression model based on weighted least squares (WLS) was specified as follows:

$$\ln(y_i) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \ldots + \beta_n x_{ni} + \varepsilon_i \qquad (3.2)$$

where ln (Y_i) is a log transformed dependent variable representing the proportion of forest land landowners were interested in managing for ecosystem services (quantified by

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dividing a total area landowners were interested in managing for ecosystem services by total forest land area owned); X_i represents a set of independent variables including landowner gender, age, education, percentage area under pine, percentage area under natural pine, percentage area under bottomland hardwoods, percentage area under natural mixed forests, household income, past participation in conservation programs, participation in organizations (i.e., professional, environmental, agricultural), landownership goals (i.e., providing legacy to heirs, long-term investment, personal recreation), and familiarity with ecosystem services.

Regression coefficients for binary variables were interpreted using $100[\exp(\beta - \frac{1}{2} \times v(\beta)) - 1]$, where β is the regression coefficient of the binary variable and $v(\beta)$ is the variance of β (Kennedy 1981). The statistical association of a binary variable with the dependent variable in percentage terms was expressed as $100[\exp(\beta - \frac{1}{2} \times v(\beta)) - 1]$ (Jan van Garderen and Shah 2002). The regression model was tested with respect to normality, heteroscedasticity, and multicollinearity to ensure that model coefficients were precisely estimated (Wooldridge 2010). The Kolmogorov-Smirnov test was used to determine if the error term was normally distributed (Gujarati and Porter 2009). Next, a log transformation of the dependent variable was implemented to normalize the error term, reduce the heterogeneity of variance, and to construct a non-linear functional form of the model (Gujarati and Porter 2009). To determine if the developed log-level regression model was appropriately specified, the Ramsey RESET test was conducted (Pevalin and Robson 2009). Multicollinearity diagnostics were conducted using the variance inflation factor (VIF) with a threshold value of 10 indicating absence of multicollinearity (Woolridge 2010). The Whites' test was initially used to determine if

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heteroscedasticity was present in the log-linear model, whereas the Weighted Least Squares (WLS) regression was used to reduce the effect of the remaining outlying y cases (Kutner et al. 2005). The White test was used again to examine whether use of WLS regression helped to eliminate heteroscedasticity in the model (Gujarati and Porter 2009).

3.4 Results

3.4.1 Landowner socioeconomic characteristics

The response rate from the mail survey was 37.1%. The sample was dominated by male landowners who constituted 78.0% of respondents, whereas 22.0% were female landowners. In general, 72% of landowners were above 60 years in age with an average of 65 years for male landowners and 68 years for female ($p<0.05$). While about half of the sampled landowners had a college degree, an almost equal percentage of landowners had a high school education or less. There was a statistical relationship between age and education level where older landowners (73 years and above) completed high school education or less and younger landowners (64 years or less) had at least a Bachelor's degree ($\chi^2 = 1.448$, $p<0.01$). In terms of membership, 11% were members of County Forest Associations, 9% belonged to MFA, and 26% indicated they were members of other professional organizations. An average gross annual household income generated in 2011 was $75,000.

3.4.2 Forest land characteristics

The mean size of the forest land owned by NIPF landowners in Mississippi was 101 ha and mainly included pine plantations, bottomland hardwoods, and mixed pine-hardwood stands. On average, landowners stated they were interested in managing about

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64.68 ha (64.3%) of their forest land for multiple ecosystem services. Not all forest types were found on each forest property resulting in a discrepancy between the total forest land area owned and total area of individual forest types summed together. In terms of forest types, NIPF landowners were willing to manage 33.62 ha of pine plantations, 24.93 ha of bottomland hardwoods, 20.04 ha of mixed pine-hardwood stands, 17.49 ha of natural hardwoods, and 13.68 ha of natural pine stands. This equates to 32% for pine plantations, 30% for natural mixed pine-hardwood, 28% for natural hardwood, 14% for bottomland hardwood, and 12% for natural pine forest land area. An average area for each forest type and the corresponding forest land area landowners were interested in managing for ecosystem services are presented in Table 3.2.

Table 3.2 Total forest land area owned and forest land area landowners were interested in managing for ecosystem services.

Forest types	**Forest land area owned (ha)**		**Forest land area landowners were interested in managing for ecosystem services (ha)**	
	Mean	Std	Mean	Std
Pine plantations	57.88	114.61	39.61	93.35
Bottomland hardwoods	33.78	96.91	24.95	70.01
Natural pine	28.09	83.65	13.69	30.80
Natural hardwoods	28.82	55.83	17.51	36.75
Natural mixed pine-hardwood	31.52	51.24	20.03	45.40

3.5 Association of socioeconomic factors with forest land area landowners were willing to manage for ecosystem services

An initial multiple regression model was heteroscedastic with the error term not normally distributed and, thus, it required transformation. A log transformation of the

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dependent variable eliminated heterogeneity of variance as indicated by the Whites test (F=52.49, p=0.77). The log-level regression model also satisfied the normality assumption with a Kolmogorov-Smirnov value of 0.96 (p=0.07). In addition, Ramsey Reset test results suggested that specification bias was not present in the log-level model (F=41.99, p=0.42). VIF values for each independent variable were less than 10 indicating that multicollinearity was also not present.

Several DFBETA values for regression coefficients were greater than 0.078 indicating outlying dependent variable (y) cases. To correct this situation, a weighted least squares model was implemented and estimation results are reported in Table 3.3. The pattern of variance suggested the use of the sample variance inverse ($1/s^2$) as a weight for WLS (Kutner et al. 2005). Heteroscedasticity was not present in the WLS regression model as reflected by the White test (χ^2=52.49, p=0.77). The Weighted Least Squares (WLS) regression model had six independent variables that were statistically related with the proportion of forest land targeted for producing multiple ecosystem services. Personal recreation goal, past enrolment in conservation program, percentage area under bottomland hardwoods and percentage area under natural mixed pine forests were associated with an increased proportion of forest land that landowners were interested in managing for ecosystem services. However, possession of a forest management plan was associated with decreased proportion of forest land which landowners stated they were interested in managing for ecosystem services.

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Table 3.3 Weighted least squares (WLS) estimation of the determinants of the proportion of forest land available for ecosystem services.

Variable	Estimate	Standard Error	t Value	Pr > |t|
Intercept	-2.206	2.033	-1.09	0.284
FAMINDEX	0.526	0.330	1.59	0.119
P.RECR	3.511	0.856	4.10	0.000*
INVEST	0.217	1.113	0.20	0.846
LEGACY	-0.084	0.607	-0.14	0.890
FMP	-0.622	0.259	-2.40	0.021*
PROFORG	-0.179	0.245	-0.73	0.469
ENVORG	-0.837	0.532	-1.57	0.124
AGRICORG	-0.356	0.329	-1.08	0.286
ENROL	0.551	0.321	1.71	0.094**
EDUCAT	0.801	0.974	0.82	0.415
GENDER	0.662	0.493	1.34	0.187
INC	0.001	0.002	0.76	0.452
AGE	0.008	0.012	0.73	0.470
P.PINE	-0.001	0.004	-0.26	0.795
BOTMLN	0.009	0.005	1.74	0.089**
P.NTPINE	0.002	0.005	0.45	0.653
P.NTMXD	0.012	0.006	2.01	0.051**

*Independent variables significant at 5%, **Significant at 10%

A one percentage increase in the proportion of area under bottomland hardwoods was associated with a 0.9% increase in the proportion of forest land that landowners were interested in managing for ecosystem services. Landowners who previously participated in conservation programs were likely to manage 45% more in terms of the proportion of forest land for ecosystem services than non-participating landowners. In contrast, landowners who possessed a forest management plan were likely to manage 43% less of the proportion forest land than landowners who did not have a plan.

3.6 Discussion

The mail survey's adjusted response rate was in line with other studies of NIPF landowners (Gruchy et al. 2012, Cross et al. 2011, Sun et al. 2009). Sample demographic statistics were also consistent with Joshi et al. (2013), Gruchy et al. (2012), Londo and

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Auel (2004) and Gunter et al. (2000) who reported that most landowners were male, in their 50s or 60s, and had an undergraduate education. It should be pointed out that while the average forest holding in this study (101 ha) was substantially greater than reported by other studies (Jones et al. 2001), it was still consistent with the USDA Forest Service's NWOS which reported an average forest landownership in Mississippi to be between 40 and 200 ha (Butler 2008).

Mississippi has a great potential for providing multiple ecosystem services from NIPF lands as 64% can potentially be allocated for this purpose. However, the stated proportion of NIPF land allocation was most likely in terms of bottomland hardwoods, pine and natural mixed pine-hardwood forests indicating a varying capacity and different management prescriptions needed to achieve a desired level of ecosystem services. For example, mixed bottomland hardwoods and natural pine-hardwood forests might provide a variety of ecosystem services such as wildlife habitat, hunting, fishing, clean air and water, and soil erosion control (Ribe 1989); however; they also might require more complex management prescriptions based on longer rotations, lower thinning intensities and partial cutting necessary to create a diverse forest for a variety of wildlife species (Lockhart et al. 2006). In contrast, loblolly pine (Pinus taeda) plantations, which are less diverse and require less complex management prescriptions, are also likely to provide less diverse ecosystem services (Raunikar and Buongiorno 2006). Forest management prescriptions for less diverse stands may include tree releases, pre-commercial thinning, and clear cutting activities (Grebner et al. 2013). In addition, they might be suitable for specific ecosystem services such as carbon sequestration or biomass production for bioenergy purposes. Furthermore, ongoing efforts to re-establish longleaf pine (Pinus

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palustris) to its natural range in the southern United States might lead to more diverse pine forest ecosystems and with different ecosystem services produced (Mitchell et al. 2006).

Results related to personal recreation showed that landowners who valued the goal as important were more likely to actively manage for multiple ecosystem services. This finding is consistent with previous studies conducted in the southern United States (Munn et al. 2010, Joshi and Arano 2009, Gunter et al. 2001,) which reported that landowners with a greater preference for recreational opportunities were more likely to manage forest for multiple ecosystem services to enhance their landownership goals. An increasing demand for recreational activities in the southern United States may be attributed to the strong connection between landowners and their forests as well as an appreciation for the natural environment (Cordell and Tarrant 2002). Further, the implication of this finding is that in addition to already existing programs, it is important to develop approaches to encourage such landowners to actively manage their forests. As such their forest management decisions will have a greater impact on the provision of ecosystem services in the future, thus emphasizing the importance for outreach activities designed specifically for this group (Kueper et al. 2014, Hughes et al. 2005, Warren 2003).

Regarding ownership of a forest management plan, our expectation was that possession of a plan will improve landowner knowledge of, and access to, relevant information about ecosystem services and available monetary incentives, and thus increase landowner interest in managing their forests for ecosystem services (Arano et al. 2004). However, results indicated that landowners with forest management plans were

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less likely to be interested in managing their forests for multiple ecosystem services. This result was not consistent with the majority of other studies that found possession of a forest management plan to be positively related to landowner decisions related to ecosystem services (Creamer et al. 2012, Sullivan et al. 2005, Joshi and Arano 2009, Gunter et al. 2001). One potential explanation is that landowners who had plans may have already committed their land to other ecosystem services (Joshi and Arano 2009, Arano et al. 2004). Thus, they may require technical assistance that will demonstrate how the management for multiple ecosystem services may improve their ownership goals (Kilgore et al. 2007). Furthermore, these landowners may benefit from information showing how such forest management practices will enhance the value of their property in the long-term (Jenkins et al. 2010). However, landowners who did not have plans may be targeted through Extension and outreach efforts to assist them to formalize their objectives and encourage them to actively manage their forests for ecosystem services production (Kluender and Walkingstick 2000).

The analysis also showed that previous participation in conservation programs had a positive association with the proportion of forest land that landowners were interested in managing for ecosystem services. Landowners who participated in previous conservation programs can be encouraged to share their experience and information on relevant conservation programs with other landowners and serve as leaders in their communities helping increase the use of best forest management practices (Cason et al. 2006). The use of landowner leaders may be an effective tool in promoting sustainable forestry because a large number of landowners are not actively involved in social networks and organizations (Rickenbach 2009, Butler 2008). For example, in Mississippi

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formal training programs from public forestry Extension reaches less than 2% of NIPF landowners, indicating the need for a wide range of strategies for outreach (Hughes et al. 2005).

3.7 Conclusions and policy implications

This study provided information regarding landowner behavior towards multiple ecosystem services, the types of landowners who may be likely to manage for such services, and forest types potentially allocated to their production. Given the long-term goals to provide ecosystem services, findings from this survey are potentially useful to conservation planners and outreach professionals as they help will them identify interested landowners and suitable forest areas. Since the results showed that approximately 62% of NIPF landowners stated they were interested in managing their forests for multiple ecosystem services, there is potential for increasing the production of ecosystem services in Mississippi. However, the proportion of forest land potentially available for ecosystem service management varied across their ownership goals and forest types. Most landowners were willing to provide bottomland hardwoods, pine and natural mixed pine-hardwood forests for the provision of multiple ecosystem services. In addition, landowner interest was significantly associated with personal recreation goal and past enrolment in a conservation program.

Study findings also suggested importance of inclusion of landowner objectives in the design of such programs. Some landowners who already manage their forests for ecosystem services might benefit from technical assistance. When combined with specific forest types, it will be helpful not only in determining the total forest land area available but also in identifying priority areas suitable for individual ecosystem services

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such as habitat for endangered species. Given that previous research studies highlighted in the introduction mainly focused on identifying the determinants of forest land area, this study is different because it provided information on the proportion of land that may be available for multiple ecosystem services as well as forest types. Therefore, this information adds to the already existing knowledge about landowner behavior regarding land allocation decisions because findings identified segments of interested landowners and possible forest types that can be allocated to production of multiple ecosystem services. Such information is important for the success of future programs focusing resource conservation and adoption of forest management strategies for producing multiple ecosystem services on private forest land. While this analysis examined landowner interest in managing forest land for ecosystem services, it did not include market factors such prices of commercial wood products, land value, interest rates, and taxes as well as the format of ecosystem service programs and agreements. These factors can affect landowner forest management decisions and consequently forest land area available for dedicated production of ecosystem services.

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CHAPTER IV

CONTINGENT VALUATION ESTIMATES OF WILLINGNESS TO ACCEPT COMPENSATION TO PROVIDE ECOSYSTEM SERVICES

4.1 Abstract

Ecosystem services sustain the society by providing different natural outputs such as clean air and water, carbon sequestration, and wildlife habitat. However, many of these services are often over-looked because they do not have a formal market. Consequently, some values of the forests are not taken into account in managerial decisions. This study used the contingent valuation method (CVM) to estimate minimum willingness to accept (WTA) compensation for managing a hypothetical 16.2 ha of loblolly pine *(Pinus taeda)* tract for ecosystem services. A survey was mailed to 2,025 nonindustrial private forest (NIPF) landowners and 663 questionnaires were returned. The contingent valuation scenario involved four forest management alternatives: a baseline with an immediate pine stand harvest (A), harvest delayed for 10 years with all silvicultural activities allowed (B), harvest delayed for 10 years with some silvicultural activities allowed (C), and harvest delayed for 10 years with no silvicultural activities allowed (D). A structural random effects probit model was used to examine the association of socioeconomic factors with required WTA compensation levels. WTA compensation estimates and 95% confidence intervals were generated using the Krinsky-Robb procedure. Mean WTA compensation amounts were $282.17, $342.72, and $510.26/ha/year for implementing

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forest management alternatives B, C, and D relative to a baseline management alternative (A), respectively. Required WTA amounts increased with the number of forest management restrictions. The offered bid and landowner's long-term investment ownership objective had a positive association with the probability of accepting compensation for all management alternatives ($p<0.05$). The study revealed the importance of increased budgets for the compensation of landowners to implement forest management regimes that facilitate multiple ecosystem services. This research focused on pine forests. Therefore, future research can be enhanced by including other forest types to determine how they affect WTA compensation values. Furthermore, WTP studies can be conducted to evaluate the amount of money that the society is willing to pay to support conservation activities that enhance production of multiple ecosystem services.

Keywords: mail survey, Mississippi, nonmarket valuation, structural random effects probit regression

4.2 Introduction

In the past, ecosystem services have been receiving increased attention because of their role in enhancing human welfare through the provision of a wide variety of commodities and benefits such as food, clean water, clean air, carbon sequestration, and recreation (Costanza et al. 2014, Millennium Ecosystem Assessment 2005, De Groot et al. 2002). The concept has often been defined as the set of benefits obtained from the natural environment (Constanza et al. 2014). They are also crucial to meet the social and economic needs of the growing global population (Benayas et al. 2009). In the United States, a substantial portion of ecosystem services are provided by nonindustrial private forest (NIPF) landowners, who represent 65% of owned forests (Munn et al. 2010, USDA

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Forest Service 2009, Kilgore et al. 2007, Arano et al. 2004). NIPF forest ownership in the southern United States and Mississippi is even greater and amounts to 70% of forest land (USDA Forest Service 2009). Therefore, private forest land has the potential to supply many ecosystem services to sustain society's needs by increasing the number of landowners involved in conservation programs in the United States (Butler 2008). NIPF landowners are, however, often not motivated to actively implement forest management practices facilitating the provision of non-market ecosystem services because of increased forest management costs, forgone timber income, and because such management activities may not be consistent with their forest ownership goals (Mozmuder et al. 2007). Policy efforts that seek to enhance the provision of ecosystem services from NIPF land should account for landowner objectives because they influence the probability of implementing forest management practices focused on production of multiple ecosystem services (Jacobson et al. 2009).

Most ecosystem services produced on public and private forest lands typically do not have a formal market (USDA Forest Service 2009, Wossink and Swinton 2007). However, management for ecosystem services on public forest land may be easier to implement because many conservation initiatives include social and environmental goals in their plans (USDA Forest Service 2009). On the other hand, conservation attempts on private forest land are more demanding because of the nonmarket nature of many ecosystem services and a need to enlist a voluntary involvement of NIPF landowners under conditions of budgetary limitations (Kline et al. 2013). Economic valuation of ecosystem services is, therefore, necessary to provide a mechanism for producing ecosystem services on private forest land through monetary incentives for landowners

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(Carlsson et al. 2003). Furthermore, monetary cost of producing of ecosystem services will help guide future land use decisions, enhance conservation, and promote adoption of forest management practices facilitating these services (Kreuter et al. 2006). Moreover, the economic value that society places on ecosystem services indicates the extent to which they prioritize natural resources and inform a budget allocation process for conservation activities (Campbell and Brown 2012). Consequently, the lack of monetary values may result in lower forest management activities and the possibility of forest land being converted to other uses (Yang et al. 2015, Costanza et al. 2014, Wossink and Swinton 2007).

Various methods have been used to evaluate ecosystem services and can be generally grouped into two categories involving stated and revealed preference methods (Clark and Friesen 2008). The contingent valuation method (CVM) is a commonly used stated preference approach which involves estimation of monetary values through the use of hypothetical scenarios presented to respondents (Chien et al. 2005, Dupraz et al. 2003, Cooper et al. 2002, Cummings et al. 1995). The CVM is typically based on the use of willingness to pay (WTP) for a marginal improvement in environmental quality or a specific nonmarket good or benefit (Mitchell and Carson 2013, Kling et al. 2012, Hanley et al. 2003, Arrow et al. 1993). However, the CVM can also use willingness to accept (WTA) compensation approach in situations where the property rights and legal institutions are defined and enforced (Saz-Salazar et al. 2009, Minkler 1998). WTA values are also relevant in cases where individuals are compensated for incurred environmental losses (Arrow et al. 1993). WTP and WTA compensations are based on Hickisian welfare constructs in which utility is assumed to be constant (Balistreri et al.

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2001). In the case of welfare increase, the maximum amount of money that an individual or household would pay for a marginal improvement in environmental quality is WTP (Carson 2012). On the other hand, if the individual or household is worse off due to a marginal decrease in environmental quality, they may require compensation which constitutes a minimum amount of money (WTA) required to ensure they are not worse off than the initial welfare condition (Alberini et al. 2003). In most research studies, WTP estimates were lower than WTA, even for the same valuation scenarios, because WTP respondents are bound by income limits in their valuation decisions in WTP surveys (Loomis et al. 1998). This is unlike WTA accept scenarios where respondents' decisions on the minimum amount of compensation is not linked to their income considerations (Loomis et al. 1998).

Many previous studies used WTP and WTA approaches to assess the monetary value of different ecosystem services including aesthetics, biomass production, carbon sequestration, hunting, and recreational access (Erickson et al. 2011, Bergstrom and Ready 2009, Raunikar and Buongiorno 2006, Nahuelhual et al. 2004, Kline et al. 2000, Loomis et al. 2000). WTA compensation values for carbon sequestration, biomass production and multiple ecosystem services ranged from $59/ha to $1,800/ha (Timmons 2013, Fletcher et al. 2009, LeVert et al. 2009, Kilgore et al. 2008, Raunikar and Buongiorno 2006). On other hand, WTP for aesthetics, hunting, and recreation ranged from $1.94 to $30.00 per household (Gruchy et al. 2012, Snyder and Smail 2009, Hussain et al. 2007, Nahuelhual et al. 2004). While landowners are different in terms of their objectives (Nahuelhual et al. 2004), the WTP and WTA values are relevant because they were conducted in the context of the United States and might therefore be useful as a

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guide for this survey. A wide range of factors such as education, bid amount, environmental preferences, size of forest land owned, and residency on property had a positive association with NIPF landowner WTP and WTA (Broch et al. 2013, Convery et al. 2012, Kilgore et al. 2008, Grutters et al. 2008, Kennedy 2001). Both WTP and WTA compensations have been shown to be statistically associated with landowner economic and non-economic decisions (Erickson et al. 2011, LeVert et al. 2009, Joshi and Arano 2009, Matta et al. 2009, Janota and Broussard 2008, Kreuter et al. 2006, Kline et al. 2000).

Although a number of studies were conducted to estimate the monetary value of ecosystem services in the Southern United States (for example Joshi et al. 2013, Timmons et al. 2013, Gruchy et al. 2012, Hite et al. 2012), most analyses in Mississippi were not based on the CVM and cannot be compared with the current study (Nepal et al. 2012, Grado et al. 2011, Jenkins et al. 2010). For instance, Nepal et al. (2012) used a simulation approach for carbon sequestration with NPV values of $937/ to $3364/ha for loblolly pine in Mississippi. Jenkins et al (2010) used physical site values and process models to determine an upper limit of $1,486/ha/year to restore wetlands for the production of selected ecosystem services. Grado et al. (2011) used the impact analysis for planning (IMPLAN) method and showed that waterfowl hunting was worth about $87 million annually, while Munn et al. (2010) reported that the total economic impact of wildlife recreation was about $38 billion in Mississippi. However, these studies quantified monetary values associated with specific ecosystem services such as recreational access, carbon sequestration, and nutrient cycling (LaRocco and Deal 2011). This is in contrast with the WTA approach used in this study to determine the amount of

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compensation required by NIPF landowners to implement forest management strategies facilitating multiple ecosystem services. This approach will be useful in comparative financial assessments such as those involving alternative management strategies such maintaining forests for hunting or timber production (Buttoud 2000).

Since the monetary value of ecosystem services assigned by NIPF landowners reflects their ownership objectives, understanding their goals and needed monetary incentives will help identify conservation efforts and tools that will help facilitate an increased supply of these services (Matta et al. 2009). Policymakers can also obtain an indication of budget sizes needed implement future incentive programs (LaRocco and Deal 2011). The provision of outreach information on best management practices can be used to assist landowners who are not financially motivated to optimize production of ecosystem services (USDA Forest Service 2009).

The main study objective was to quantify levels of monetary compensation that will induce NIPF landowners in Mississippi to manage their forest land for the provision of ecosystem services by implementing specific forest management alternatives. This research focused on multiple ecosystem services that included aesthetics, carbon sequestration, clean air, clean water, hunting, production of woody biomass for bioenergy, soil erosion control, ecotourism, wildlife habitat, and watershed management. These ecosystem services were selected because they are commonly found in the southern United States (USDA Forest Service 2009). The study also determined an association between landowner socioeconomic characteristics and landowner willingness to implement forest management alternatives.

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4.3 Methods

4.3.1 Site description

This research was conducted in Mississippi, located in the southern United States. Mississippi was chosen as a study site because of the substantial forest resources and a comparable proportion of family forest owners in the southern United States (Butler 2008). Information sourced from U.S Census Bureau (2012) indicated that Mississippi had a total land surface of 12.5 million hectares (ha). Forest land accounts for eight million ha of the total land holdings and its majority (70%) is owned by 315,000 NIPF landowners (Gordon et al. 2013, USDA Forest Service 2009). Three key forest types include pine, hardwood, and mixed pine-hardwood forests (USDA Forest Service 2009). Pine stands are commonly found in the southeastern portion of Mississippi, whereas hardwoods are mostly located in the western lowland part of the state (Southeast Mississippi Forest Inventory Report 2006). Mississippi has a humid subtropical climate with rainfall exceeding 1,270 millimeters (mm) per year and average minimum and maximum temperatures of 9 and 35 degrees Celsius, respectively (Sherman-Morris et al. 2012). As of 2010, Mississippi's total population was approximately 3 million and it constituted 0.95% of population in the United States (U.S. Census Bureau 2012). Most recent estimates reported an economic impact of $10.4 billion for the forest sector and its products in 2013 (Dahal et al. 2013).

4.3.2 Data collection methods

Primary data was obtained through a mail survey conducted in 2012. A total of 2,025 structured questionnaires were mailed to NIPF landowners in Mississippi based on tax rolls. The mail survey was implemented using the Dillman's Total Design Method

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which included a five-stage mailing process involving an initial letter to landowners to explain the study objectives, a letter with a survey questionnaire, a thank you/reminder postcard, and two follow-up letters with questionnaires (Dillman 2011).

A contingent valuation questionnaire section was included in the survey and designed following an approach used by Nahuelhual et al. (2004). This component included a hypothetical valuation scenario in which landowners were asked to assume they owned a 16.2 ha tract of 25-year old loblolly pine (Pinus taeda) stand managed for timber and that they were planning to harvest the stand at the end of 2012. Then, landowners were presented with an opportunity to participate in a new Conservation Reserve Program (CRP) administered by U.S. Department of Agriculture. Under the program agreement, they were required to defer their harvest by 10 years in exchange for an annual payment. In the CV scenario, a ten year period was used to reflect current obligations under the USDA's CRP that offers 10 to 15-year contracts to landowners (USDA NRCS 2014). Four forest management alternatives representing increasing levels of forest management restrictions were presented to landowners and are described below:

Management Alternative A: Harvest at the end of 2012. In this alternative, a landowner could harvest the loblolly pine tract as initially planned at end of 2012. As a result, a landowner would not participate in the CRP and would not receive an annual payment. For analysis purposes, this management alterative was set as the baseline scenario.

Management Alternative B: Delayed harvest with all silvicultural activities allowed. In this alternative, final harvest of the loblolly pine tract was delayed for 10 years to the end of 2022. However, the landowner was permitted to conduct all timber

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stand improvement activities (TSI), to produce timber including thinning, release of herbicides, prescribed burning, and sanitation activities.

Management Alternative C: Delayed harvest with only some silvicultural activities allowed. In this alternative, final harvest of loblolly pine stand was delayed for 10 years to the end of 2022. The landowner could conduct light thinning of the stand and other silvicultural practices but only if they enhanced provision of ecosystem services. Such management activities included prescriptions promoting game and non-game wildlife habitat, creating openings, implementing a prescribed burning, and implementing sanitation activities for good forest health. A consulting forester would provide guidance related to the forest management plan and related activities.

Management Alternative D: Delayed harvest with no silvicultural activities allowed. In this alternative, final harvest of a loblolly pine stand was delayed for 10 years to the end of 2022. During this time, a landowner was not permitted to thin their stand or carry out any TSI activities except for sanitation activities for safety reasons and achieving forest health.

It was assumed that these forest management alternatives would enhance ecosystem service production due to the differing levels of management intensity (Lockhart et al. 2006). A range of ecosystem services produced from given forest types were influenced by types of implemented forest management prescriptions (Kahl and Bauhus 2014). After the description of forest management alternatives, a landowner was presented with three discrete choice questions constructed as follows:

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"Would you manage your 40-acre loblolly pine tract according to management alternative (B) instead of alternative A if you were offered an annual payment of $____per acre for the duration of the 10 year contract?"

The landowner was given three possible responses to the question: yes, no, or unsure. Two additional questions presented to landowners included alternatives C and D with each being compared to a baseline alternative A. Fifteen bid amounts were used to elicit landowners WTA compensation for implementing forest management alternatives on their forest tract to facilitate ecosystem services: $1, $3, $5, $8, $12, $20, $30, $40, $50, $60, $80, $100, $120, $150, and $200. These values were originally expressed on per acre basis. To assess variation in landowner forest management preferences, all three questions involved the same bid level which was randomly selected for 15 groups of landowners with 135 landowners in each group. Bid amounts were determined based on the literature and consultation with Extension personnel in the College of Forest Resources at Mississippi State University.

4.3.3 Analytical framework

Non-response bias was tested by following a procedure suggested by Nybakk et al. (2009) and Armstrong and Overton (1977) and comparing 10 socioeconomic characteristics between the first and last 30 landowners in the sample. A group of the last 30 responding landowners was used as a proxy for landowners who did not return their questionnaires. A comparison of the two groups was conducted using a t-test as suggested by Nybakk et al. (2009). The National Woodland Owner Survey (NWOS) (Butler 2008), a robust data set, was used to compare the sample and landowner socioeconomic characteristics.

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The purpose of using frequencies was to summarize landowner socioeconomic variables. ANOVA was used to compare landowner preferences for the three forest management alternatives. The test was conducted to determine if mean percentages of landowners willing to accept each forest management alternative was statistically different ($p<0.05$).

A random utility model was used to determine the association of selected factors with landowner WTA compensation levels for implementing forest management restrictions facilitating ecosystem services (Shivan and Mehmood 2010, Beach et al. 2005, Arano et al. 2004, Lynch and Lovell 2003, Bell et al. 1994). The model assumed a landowner's utility function was not directly observed and it identified two scenarios in which the utility was linked with a baseline forest management alternative and three alternatives involving forest management restrictions facilitating ecosystem services (Joshi and Arano 2009). A baseline forest management alternative represented a "business as usual" situation in which a landowner did not participate in the CRP and harvested a pine stand at end of 2012 (equation 4.1). The utility function associated with the baseline scenario was specified as follows:

$$U_0 = f(y_0, z_0, \mathbf{t}_0; \varepsilon_0) \tag{4.1}$$

where U_0 represents an initial utility function associated with a baseline forest management alternative; y_0 represents timber and non-timber income from a baseline forest management alternative; z_0 is a vector of landowner socioeconomic characteristics such as gender, age, education; t_0 represents forest land characteristics such as forest land area owned and forest type; and ε_0 is the error term for unobserved factors (Shivan and Mehmood 2010, Lynch and Lovell 2003). The utility function associated with

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participation in forest management alternatives B, C, and D involved an increasing level of forest management restrictions (equation 4.2) to facilitate production of ecosystem services and was expressed as (Lynch and Lovell 2003):

$$U_1 = f(y_i + w_i, z_i, \mathbf{t}_i; \varepsilon_i) \quad (4.2)$$

where U_1 is utility function associated with implementation of an alternative featuring forest management restrictions at a specific compensation level; y_i is an annual household income; w_i is the compensation level; z_i is a vector of landowner socioeconomic characteristics such as gender, age, education, and compensation amount (bid); t_i represents forest land characteristics; and ε_i is the error term for unobserved factors. If utility associated with participation in a forest management alternative featuring management restrictions is greater than the utility associated with a baseline forest management alternative, a landowner will be willing to implement forest management restrictions facilitating ecosystem services. However, a landowner will not implement forest management restrictions if the utility associated with a proposed management change is lower than the utility associated with a baseline forest management alternative (Vokoun et al. 2010).

Each of three forest management alternatives was compared against a baseline alternative in which a forest stand was harvested in 2012. Therefore, landowner choices involved a comparison of two forest management alternatives: the baseline alternative versus a proposed forest management strategy (B, C, or D). Petrolia and Kim (2009) and Greene (2007) also noted that probit models may be correlated through error terms because heterogeneous choice decisions were constructed within the context of the same survey data. As such, they suggested the use of a structural random effects probit model

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for cross sectional data. Following, Petrolia and Kim (2009) as well as Capellari and Jenkins (2003), the model was formulated as:

$$\gamma_i^* = \alpha_i X_i + q_i + u_{it}$$
$$Y_i = 1, if\ \gamma_i^* > 0 \quad (4.3)$$

In addition:

$$e_{it} = q_i + u_{it} \quad (4.4)$$

and, the variance of the term be given by

$$\delta_i^2 + \delta_{it}^2 \quad (4.5)$$

As such, the correlation coefficient of error terms will be given by:

$$\frac{\delta_v^2}{1+\delta_v^2} \quad (4.6)$$

where γ_i^* is the probability of a landowner selecting an alternative i featuring forest management restrictions; α_i is a partial regression coefficient; X_i represents independent variables; and q_i and u_{it} are errors terms which are multivariate normal, identically, and independently distributed (iid). Variable Y_i represents the landowner's forest management choices B, C, and D and takes a value of 1 if a landowner was willing to implement a specific forest management alternative at an offered compensation level and 0 if a landowner was not willing to do so. Independent variables (Xi) included gender, age, education, familiarity with CRP, previous management of a forest land for ecosystem services, membership in professional organizations, possession of a written forest management plan, annual household income in 2011, compensation level per ha, legacy for heirs as a landowner goal, past enrollment of forest land in a federal conservation program, and total forest land area owned (Table 4.1).

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Table 4.1 Determinants of landowner willingness to accept compensation to provide ecosystem services.

Variable	Variable description
Dependent	
WTA vote for each alternative	1-if Yes for alternative B, 0-No
WTA vote for each alternative	1-if Yes for alternative C, 0-No
WTA vote for each alternative	1-if Yes for alternative D, 0-No
Independent	
BID	Amount of bid per in $/ha/year
FAM.CRP	1-if landowner was familiar of CRP, 0-if landowner was not familiar of CRP
GENDER	1-if male landowner, 0-if female landowner
AGE	Age in years
EDUC	1-if at least Bachelor's degree and higher, 0-Otherwise
ESPRODN	1-if forest tract is managed for ecosystem services, 0-Otherwise
ENVORG	1-if member of environmental organization, 0-if non-member
PROFORG	1-if member of professional organization, 0-Otherwise
FMP	1-if landowner possesses forest management plan, 0-Otherwise
INC	Gross annual household income in 2011 (scaled by 1000)
INVEST	1-if landowner long term investment is important, 0-Otherwise
LEGACY	1-if legacy for heirs is important, 0-Otherwise
P.RECR	1-if personal recreation is important, 0-Otherwise
FOREST SIZE	Total forest land owned in ha (scaled by 10)

Conditional marginal effects were calculated using the following formula:

$$\frac{\partial \text{Prob}(y_i = k_i, \ldots \mid x)}{\partial x} \tag{4.7}$$

where Y_i represents forest management choices; k_i are values of outcomes associated with the given choice *i* (1 if yes; 0 if no); and X represents a set of independent variables.

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To observe marginal effects of a given forest management alternative, a value of k was set to 1, whereas it was zero for other forest management strategies.

In total, two random effects probit models were estimated. This was necessitated by the fact that there is no agreement regarding the treatment of such responses as pointed by Groothius and Whitehead (2002). In model 1, responses of landowners who were unsure if they would implement a proposed forest alternative featuring management restrictions were removed from the analysis. In model 2, "unsure" responses were treated as "no" responses. It was also possible to develop an alternative model in which "unsure" responses were treated as "yes" responses (Groothius and Whitehead 2002). However, answers to a debriefing question revealed that most landowners would not accept the proposed management alternatives indicating that a model in which "unsure" responses were treated as "yes" would not be realistic. The econometric models were generated using Stata Version 13 and utilized the user-written "cmp" routine (Greene 2007). Capellari and Jenkins (2003) suggested using a number of draws equal to the square root of the effective sample size; therefore, 25 replications were used. Furthermore, the null hypothesis indicating that error terms were equal was used to evaluate if the structural model was an appropriate specification (Greene 2007). The likelihood ratio test was used to evaluate significance of the structural random effects regression models (Kutner et al. 2005). Results indicated that they were significantly better than using three independent probit models to determine factors influencing WTA compensation ($p<0.05$).

Statistical tests were further conducted to determine whether to using a constrained model would improve model fit of the structural models (Savalei and Kolenikov 2008). A test function was employed in Stata version 13 to assess whether

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partial regression coefficients were statistically different from each other (Petrolia and Kim 2009). The test indicated that all the independent variables were statistically different expect for "ecosystem service production" and "membership in environmental organizations" (p>0.05). The Akaike Information Criteria (AIC) of the constrained model was 797.61 and lower than that of the unconstrained model (804.67). However, the likelihood ratio test indicated no significant difference between the two models (χ^2=0.93, p=0.92). As suggested by Petrolia and Kim (2009), the unconstrained model was used for further analysis since it was associated with a lower set of model restrictions which could affect the degrees of freedom (DF).

The Krinsky-Robb procedure was used to calculate mean WTA compensation amounts to manage a forest stand according to alternatives featuring forest management restrictions to facilitate production of ecosystem services (Zander et al. 2014). A minimum of 5,000 simulations were recommended by Haab and McConnell (2002) to generate precise parameter estimates. Following the Central Limit Theorem, a total of 20,000 simulations were used in calculating mean WTA compensation amounts (Haab and McConnell 2002). After computing 95% confidence intervals, the procedure was also used to test whether compensation values were significantly different from zero. The analysis was conducted using Stata version 13.

4.4 Results

4.4.1 Demographic overview

After accounting for survey questionnaires that were not returned, those involving deceased landowners, and refusals, the adjusted response rate was 37.1%. Non-response bias was not detected after comparing 10 characteristics of respondents and non-

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respondents (p>0.05). Male landowners constituted the majority of sampled respondents (78%) when compared with females (22%). The sample was almost equally split between landowners who had attained at least a Bachelor's degree (52.4%) and those who had high school education or less (47.8%). Moreover, the majority of sampled landowners (90.5%) were aged between 50 and 80 years. The annual gross household for the sample was $75,000. In terms of landowner participation in professional organizations, approximately 9% and 10% were members of Mississippi Forestry Association (MFA) and County Forest Associations, respectively. Landowners also belonged to agricultural and conservation organizations including hunting and fishing organizations but these were not common.

4.4.2 Willingness to implement forest management restrictions

The proportion of NIPF landowners willing to implement forest management alternatives facilitating production of ecosystem services increased with higher compensation levels. Only a small proportion of landowners were willing to implement any of the forest management alternatives at low compensation levels (Table 4.2).

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Table 4.2 Landowner preferences of forest management alternatives by bid amounts.

Bids ($)	Total response in category	"Would delay harvest with all silvicultural activities" (B)	Yes Vote %	"Would delay harvest with some silvicultural activities" (C)	Yes Vote %	"Would delay harvest with no silvicultural activities" (D)	Yes Vote %
1	39	1	3	2	6	0	-
3	39	4	10	3	8	0	-
5	51	4	8	4	8	1	2
8	41	6	15	4	10	2	5
12	43	7	16	4	9	4	9
20	50	5	11	6	13	3	6
30	39	11	28	10	26	5	13
40	35	8	23	6	17	4	11
50	46	12	26	9	20	2	4
60	48	18	38	15	31	9	19
80	48	15	31	16	33	8	17
100	41	15	37	20	49	12	29
120	46	16	35	14	30	7	15
150	45	15	33	9	20	5	11
200	51	21	41	17	33	14	29

For example, at $2.47/ha/year, only 3, 6, and 0% of landowners were willing to implement forest management alternatives B, C, and D, respectively. When the monetary compensation level was increased to $247.05/ha/year, 37% of landowners would implement alternative B, 49% alternative C, and 29% alternative D. However, if the monetary compensation level was further increased to $494.10/ha/year, 41% of the landowners would implement B, while 33% were willing to accept C and 29% would consider D. On average, 24% of landowners were willing to implement alternative B, 21% alternative C, and only 13% alternative D. Results from one-way ANOVA indicated that percentages of landowners willing to implement each forest management alternative were statistically different from each other ($p<0.05$).

There were numerous reasons reported by NIPF landowners for 'no" and "unsure" responses to implementing proposed alternatives featuring forest management

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restrictions at offered compensation levels (Table 4.3). Most landowners did not support the idea of forest management restrictions (73.1%). In addition, 62.3% of landowners indicated that there were not interested in active forest management for ecosystem services. About 54% of landowners did not like long-term nature of forest management alternatives associated with the program, whereas about 26.1% of landowners were of the opinion that such a program would not be implementable.

Table 4.3 Reasons for not accepting alternatives featuring forest management restrictions to facilitate production of ecosystem services.

Reason	Frequency (%)
Do not like forest management restrictions associated with ecosystem services	73.1
Do not want to be involved in active management for ecosystem services even if a sufficient payment amount was offered	62.3
Do not like long-term forest management associated with ecosystem services	54
Do not think such as program would be implemented	26.1
Insufficient payment amount offered	20.9

However, there were a large proportion of landowners (46.0%) who were likely to delay a harvest, even in the absence of payments, due to current timber prices and future economic outlook. Only 23% of landowners would harvest their pine stand immediately in the absence of annual payments, whereas 32% were neutral.

4.5 Determinants of willingness to accept compensation

Model 1, in which "unsure" responses were removed, showed that gender had a significant association with the probability of implementing forest management alternative B with male forest landowners being 11% more likely to implement this

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alternative than female landowners (Table 4.4). Members of professional organizations were 17.3% more likely to implement management alternative C than non-members. Compensation level also had a positive association with the probability of implementing all forest management alternatives ($p<0.05$). Marginal effects for alternatives B, C, and D were 0.10, 0.09, and 0.07, respectively, indicating that a for a 1% increase in compensation level, probability of accepting these alternatives increased by 10, 9, and 7%, respectively (Table 4.4).

However, the marginal effect of a change in compensation level decreased when moving from a less restrictive forest management alternative to a more restrictive one indicating that NIPF landowners were more likely to accept a less restrictive alternative for a similar marginal change in compensation level. Furthermore, landowners who rated long-term investment as an important forest land ownership objective were more likely implement all forest management alternatives ($p<0.05$). Marginal effects were 36, 46, and 39%, respectively for alternatives B, C and D, respectively. Thus, a landowner who ranked long-term investment as an important objective was 32, 29, and 19% more likely to implement management alternatives B, C, and D, respectively, than a landowner who did not consider long-term investment as important ownership objective.

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Table 4.4 Socioeconomic factors associated with landowner willingness to accept compensation with unsure responses removed (model 1).

	Delayed harvest with all silvicultural activities allowed (B)			**Delayed harvest with some silvicultural activities allowed (C)**			**Delayed harvest with no silvicultural activities allowed (D)**		
	Coef.	Rob. S.E	M.E	Coef.	Rob. S.E	M.E	Coef.	Rob. S.E	M.E
Variable									
INC	0.003	0.004	0.003	0.004	0.004	0.001	-0.002	0.004	-0.003
AGE	0.000	0.006	0.000	-0.004	0.007	-0.001	0.004	0.007	0.001
EDUC	-0.085	0.337	-0.028	-0.210	0.547	-0.071	-0.071	0.610	-0.021
GENDER	0.347*	0.206	0.111	0.230	0.214	0.077	0.319	0.229	0.095
PROFORG	0.173	0.172	0.057	0.370**	0.173	0.125	0.030	0.180	0.009
ENVORG	0.218	0.381	0.072	-0.381	0.456	-0.129	-0.206	0.485	-0.061
FMP	0.306	0.193	0.101	0.228	0.187	0.072	-0.004	0.202	-0.001
FAM.CRP	0.228	0.169	0.075	0.185	0.167	0.062	0.177	0.173	0.053
BID	0.003**	0.000	0.01	0.002**	0.000	0.09	0.002**	0.000	0.07
LEGACY	0.033	0.440	0.100	0.221	0.433	0.007	-0.089	0.430	-0.02
P.RECR	0.247	0.378	0.081	0.169	0.367	0.057	0.202	0.393	0.060
ESPRODM	-0.001	0.204	-0.004	-0.090	0.188	-0.030	-0.195	0.220	-0.058
FOREST SIZE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
INVEST	0.990**	0.393	0.327	0.873**	0.398	0.295	0.650	0.403	0.195
Constant	-2.678	1.046		-1.792	1.021		-2.172	1.105	
Log likelihood	-350.31								
P-value	0.000								
atanhrho_12	1.441**								
atanhrho_13	1.236**								
atanhrho_23	1.562**								
N=463									

**Significant at 5% level; Significant at 10% level; Coef.: Coefficient; Rob. SE: Robust Standard Error; M.E: Marginal Effect

An analysis of model 1 results also indicated that annual gross household income, age, and landowner education did not have a statistical relationship with probability of implementing the three forest management alternatives (p>0.05, Table 4.4). Similarly, membership in environmental organizations, possession of a written forest management plan, familiarity with CRP, personal recreational goals, previous management for ecosystem services, and size of forest land owned were not associated with the probability of implementing any of three forest management strategies (p>0.05). Correlation coefficients between pairs of error terms were compared and in all cases statistical relationships were significant (p<0.05) indicating that a structural random

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effect probit model was a better specification than estimating individual probit models to estimate WTA compensation for each forest management alternative separately (Table 4.5). In addition, the likelihood ratio test indicated that the model was significant (p<0.05).

Table 4.5 Socioeconomic factors associated with landowner willingness to accept compensation with no and unsure responses combined (model 2).

	Delayed harvest with all silvicultural activities allowed (B)			**Delayed harvest with some silvicultural activities allowed (C)**			**Delayed harvest with no silvicultural activities allowed (D)**		
	Coef.	Rob. S.E	**M.E**	**Coef.**	**Rob. S.E**	**M.E**	**Coef.**	**Rob. S.E**	**M.E**
Variable									
INC	0.002	0.003	0.002	-0.001	0.003	0.002	-0.002	0.004	-0.002
AGE	-0.002	0.005	-0.000	-0.000	0.006	-0.000	0.001	0.006	0.000
EDUC	0.356	0.390	0.107	0.250**	0.391	0.107	0.214	0.440	0.004
GENDER	0.267	0.176	0.081	0.278	0.191	0.081	0.407	0.211	0.091
PROFORG	0.262	0.145	0.079	0.348	0.155	0.079	0.135	0.163	0.030
ENVORG	-0.638	0.321	-0.019	-0.346	0.283	-0.019	-0.551	0.351	-0.124
FMP	0.429	0.165	0.130	0.383	0.164	0.130	0.228*	0.193	0.051
FAM.CRP	0.296	0.143	0.089	0.208	0.148	0.089	0.173	0.155	0.039
BID	0.002**	0.000	0.000	0.002**	0.000	0.000	0.002**	0.000	0.000
LEGACY	0.302	0.379	0.091	0.220	0.377	0.091	-0.361	0.403	-0.081
P.RECR	0.373	0.295	0.113	0.388	0.354	0.113	0.374	0.313	0.084
ESPRODN	-0.062	0.181	-0.019	-0.003	0.168	-0.019	-0.078	0.205	-0.017
FOREST SIZE	0.000	0.000	0.000	0.000*	0.000	0.000	0.000	0.000	0.000
INVEST	0.651**	0.360	0.197	0.462**	0.361	0.197	0.408**	0.392	0.092
Constant	-2.953	0.848		-2.456	0.834		-2.469	0.828	
Log likelihood	-338.99								
P-value	0.000								
atanhrho12	1.870**								
atanhrho13	1.350**								
atanhrho23	1.603**								
N=336									

**Significant at 5% level; *Significant at 10%; Coef.: Coefficient; Rob. SE: Robust Standard Error; M.E: Marginal Effect

Compensation level and long-term investment objective were statistically significant in model 1, in which "unsure" responses were removed and in model 2, in which "unsure" responses were treated as "no" responses (p<0.05) (Table 4.6). However, education and possession of a forest management plan were significant in model 1, but

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not the model 2 (p<0.05). Remaining variables including age, annual household income, membership in environmental organizations, personal recreation as goal, familiarity with CRP, and forest size were non-significant variables in both models (p>0.05).

Generally, required WTA compensation amounts increased with a higher level of forest management restrictions. The mean WTA compensation values were $190.22, $237.84, and $423.28/ha/year for a management alternative allowing all silvicultural activities (B), some silvicultural activities (C), and no silvicultural activities (D), respectively.

Table 4.6 Mean willingness to accept compensation (WTA) values and 95% confidence for forest management alternatives.

	Forest management alternatives		
	Delayed harvest with all silvicultural activities allowed (B)	**Delayed harvest with some silvicultural activities allowed (C)**	**Delayed harvest with no silvicultural activities allowed (D)**
"No and unsure"			
Mean/median WTA ($/ha/year)	374.12	447.60	597.23
95% CI	304.93~491.55	354.34~625.84	469.05~862.95
p-values for WTA=0	0.00	0.00	0.00
"unsure removed"			
Mean/median WTA ($/ha/year)	190.22	237.84	423.28
95% CI	144.50~244.48	182.17~323.79	328.44~615.42
p-values for WTA=0	0.00	0.00	0.00

Lower and upper bounds for the 95% CI for alternative B were $144.50/ha/year and $244.48/ha/year, whereas values for alternative C were $182.17/ha/year and $323.79/ha/year, respectively. Lower and upper bound values for alternative D were $328.44 and $615.42, respectively. When "unsure" responses were treated as "no" responses, required compensation levels were substantially larger. The mean WTA

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compensation amounts were $374.12, $447.60, and $595.23/ha/year for implementing forest management alternatives B, C, and D, respectively. In addition, 95% CI for alternatives B, C, and D were $304.93 to $491.55/ha/year, $354.34 to $625.84/ha/year, and $469.05 to $862.95/ha/year, respectively.

4.6 Discussion

An analysis of monetary compensation levels required to implement forest management alternatives facilitating ecosystem services provides important information to various stakeholders including decision-makers, federal and state conservation planners, budget managers, and government and non-governments conservation organizations (Butler 2008). These stakeholders can make more informed conservation decisions and prioritize conservation efforts by knowing the potential monetary cost of ecosystem services, understanding landowner forest management preferences, and being able to determine budgets needed to achieve specific conservation objectives (Buttoud 2000).

This study's adjusted response rate of 37.1% was comparable to other studies completed in Mississippi which reported response rates ranging from 20 to 50% (Grala et al. 2012, Joshi and Arano 2009, Sun et al. 2009, Measells et al. 2005, Arano et al. 2004). Landowner socioeconomic characteristics were also consistent with previous research including National Woodland Owner Survey (NWOS) Gruchy et al. (2012), USDA Forest Service (2009), and Perez-Verdin et al. (2008).

Model 1 findings indicated that average WTA amounts increased with a greater number of forest management restrictions. This implied that landowners required a greater monetary compensation to implement management alternatives that had more

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management restrictions. The trend related to forest management restrictions is consistent with Matta et al. (2009), Janota and Broussard (2008) and Kreuter et al. (2006) who showed that landowners preferred forest management alternatives with a fewer limitations because it did not interfere with their ownership goals. This finding implied that forest management prescriptions featuring fewer restrictions are more likely to be accepted by NIPF landowners. On the other hand, sustainable forest management practices that limit landowner management options might still be accepted but might be costly to implement because of higher compensation required by landowners (Kreuter et al. 2006). Previous studies estimating WTA compensation values reported varying amounts required by NIPF landowners to manage forests for ecosystem services (Timmons 2013, Joshi et al. 2013, LeVert et al. 2009, Fletcher et al. 2009, Kilgore et al. 2008). For example, Kilgore et al. (2008) noted that a minimum of $59.29/ha could induce Minnesota landowners to participate in the Sustainable Forest Initiative (SFI) program. Timmons (2013) used the CVM and found that $793.05/ha was required for biomass production in Massachusetts. However, an estimate of $1,729/ha/year was required by landowners in Massachusetts and Vermont to delay forest harvest to produce a variety of ecosystem services (LeVert et al. 2009). The WTA compensation values obtained in this study were comparable to previous research including LeVert et al. (2009) and Fletcher et al. (2009). However, they are higher than the average of $33.00/ha/year offered by the existing Conservation Reserve Program (CRP) in Mississippi (USDA NRCS 2014). Given the fiscal constraints experienced at the national level (Butler 2008), it may be prudent to explore more efficient ways of using the already existing budget for conservation programs. For example, more than half of the budget

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meant for conservation purposes is usually allocated for fire-related activities in the United States (USDA NRCS 2014). As such, improvements in fire control may also help to unlock some financial resources into other areas of conservation of natural resources (Kilgore et al. 2008). Based on this study's WTA compensation values and the proportion of pine forest land under NIPF landownership, the total economic cost of increasing production ofecosystem services in Mississippi, as stated in the mail survey, ranged from $0.880 billion to $1.593 billion per year. The estimated cost of implementing forest management strategies is higher than the average annual CRP budget for Mississippi of about $32 million (USDA NRCS 2014). The involvement of private sector and nongovernmental organizations may also help to improve the financial resources available for conservation activities (Butler 2008).

In model 1, gender had a positive and significant relationship with probability of implementing the proposed forest management alternatives with male landowners being more likely to implement these strategies. This finding may be linked to the observation that male landowners represented about 80% of the sample size. A strategy that targets male landowners by providing appropriate information on conservation programs is therefore likely to enhance the adoption of best management practices because they constitute about 90% of the landowners in the southern United States (USDA Census of Agriculture 2007). However, it is also important to target female landowners because they constitute an increasing proportion of forest landowners in the United States (Warren 2003). Findings also indicated that members of professional organizations were more likely to implement forest management facilitating ecosystem services than non-members. When compared with community associations, the results showed that more

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landowners were members of professional organizations which could explain the significance in model 1. Efforts to increase implementation might focus on increasing landowner awareness through participation in professional associations (Rickenbach et al. 2006). This may also involve providing information through various outlets such as newsletters and publications on alternative forest management strategies that may promote protection of natural resources and simultaneously enhance the production of multiple ecosystem services (Mozmuder et al. 2007).

Higher compensation levels were associated with a greater probability of implementing forest management strategies and landowners were more likely to implement proposed forest management alternatives if the monetary compensation level was higher. This finding is consistent with many previous studies (Joshi et al. 2013, Broch et al. 2013, Gruchy et al. 2012, Convery et al. 2012, Kilgore et al. 2008, Mozmuder et al. 2007, Kreuter et al. 2006) who indicated that financially motivated NIPF landowners might not adopt proposed forest management regimes focused on ecosystem services if monetary incentives were not available (Matta et al. 2009, Nahuelhual et al. 2004). The implication of this finding is that the creation of monetary incentives may be used as a viable strategy for increasing conservation and producing more ecosystem services among NIPF landowners in the future programs.

Landowners who considered their forest land as a long-term investment were more likely to implement forest management facilitating ecosystem services at all payment levels than landowners who perceived the long-term investment objective as unimportant. The result is consistent with Janota and Broussard (2008)'s analysis of landowners in southern Indiana observing that investment goals represented an important

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determinant in the choice of alternative forest policies, strategies, and programs. This finding implies that landowner groups who seek a financial return from their forest land have a greater likelihood of implementing forest management regimes if monetary compensation if offered. This may be related to the higher opportunity cost associated with the implementation of restrictive silvicultural regimes (Janota and Broussard 2008). Furthermore, it may indicate the relative importance that such landowner groups place on financial goals as a reason for forest ownership (Kline et al. 2000). It may be prudent to include strategies for improving financial objectives such as hunting fees or creating recreational ventures (USDA NRCS 2015). For instance, an activity such as the establishment of quality wildlife habitat is important since it helps to increase the value of the land (Jenkins et al. 2010). Experiences in the United States, however, showed that some conservation programs administered through public agencies do not reflect the diverse ownership objectives of NIPF landowners (Jacobson et al. 2009). For example, a survey of NIPF landowners in Florida revealed that public agencies had programs for a few ecosystem services that did not cater to the diversity of landowner objectives (Taylor Stein et al. 2003). Furthermore, this program format resulted in limited participation and poor interest among NIPF landowners, and negatively impacted an adoption of sustainable forest management strategies.

Membership in environmental organizations, possession of a written forest management plan, and familiarity with CRP did not display a relationship with the implementation of forest management alternatives. This finding could be attributed to relatively few landowners who were members of environmental organizations, owning written forest management plans, or being familiar with CRP (Rickenbach 2009, Hughes

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et al. 2005). Further evaluation of factors influencing WTA compensation to implement forest management strategies indicated that annual gross household income, education, and age were not statistically significant in model 1. These findings were not similar with previous studies which observed that landowner socioeconomic variables such as education and income were important determinants of landowner decisions related to WTA compensation (Gruchy et al. 2012, Grutters et al. 2008, Kennedy 2001). Previous studies argued that environmental preferences did not differ by age, education, and household income in the southern United States and may explain why these variables were not significant because of reduced econometric variation in relevant independent variables (Greene 2007, Tarrant and Cordell 2002).

Personal recreation goals, previous management for ecosystem services, and total size of forest land owned were also insignificant explanatory variables for landowner decisions to implement forest management activities. These findings were similar to previous studies (Gruchy et al. 2012, Nahuelhual et al. 2004). Landowners who used their forest land for recreation might not have an incentive to implement other silvicultural prescriptions which may impede their ownership goals (Hedlund 2011). Similarly, landowners who previously managed their forests for ecosystem services might not be willing to participate in proposed management alternatives because they already committed their forests to producing different outputs (Main et al. 1999). Study findings also indicated that size of forest land owned was not significantly associated with landowner willingness to implement forest management alternatives. However, size of forest tract influences types of management prescriptions to be implemented as well as their costs (Grebner et al. 2013). Since the amount of expected financial compensation

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was dependent on landowner goals and size of forest land owned, this might explain why bid level was significantly associated with the probability of implementing proposed management alternatives (Knoot et al. 2015, Jacobson et al. 2009).

These results are relevant to different stakeholders including policy-makers, conservation planners, and conservation program administrators. Since this study established WTA compensation for forest management alternatives, similar surveys can be used to develop guidelines for the potential magnitude of financial resources required in conservation planning. In addition, information on management restrictions is important to conservation planners because forest management strategies that are flexible in terms management restrictions might be more readily implemented by NIPF landowners. This information can be useful to conservation program administrators because it helps identify types of landowners who are likely to participate in conservation efforts.

4.7 Conclusions and policy implications

This study increased an understanding of landowner preferences concerning financial compensation to implement forest management alternatives increasing production of multiple ecosystem services. The research also identified factors that were associated with landowner willingness to implement these management alternatives. Such information is important for budget managers as it helps to quantify the cost of attained specific conservation objectives.

Findings showed that minimum and maximum compensation levels required to induce landowners to adopt forest management alternatives facilitating production of ecosystem services were $190.22/ and $423.28/ha/year, respectively, and corresponded to

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total monetary cost of $0.9 to $1.6 billion, which represented the potential budget necessary to implement forest management practices facilitating ecosystem services in Mississippi. Therefore, Mississippi has potential for increasing production of ecosystem services from NIPF lands as most landowners were willing to implement forest management facilitating ecosystem services at offered compensation levels. However, the implementation of conservation practices by landowners is constrained by a limited CRP budget. Production of ecosystem services requiring substantial restrictions or modifications in forest management will require higher compensation levels than less restrictive forest management alternatives.

By accounting for the monetary cost necessary to facilitate production of ecosystem services, the outcomes from this study contributed to extant literature on contingent valuation of ecosystem services. This is because most previous studies focused on single or separate ecosystem services whereas this study determined the costs associated with implementing forest management facilitating multiple ecosystem services. The approach is likely to give an impetus for conservation among landowners because it takes into account the broader set of forest values. Results also suggested that for future conservation initiatives to be successful, they must be flexible in terms of forest management restrictions, target both male and female landowners, explore efficient use of available budgets, and incorporate landowner ownership objectives.

This study considered only pine forests and did not take into account other forest types such as hardwood or mixed pine-hardwood forests, which typically provide more diverse ecosystem services. Finally, the contingent valuation scenario in this study used WTA approach which helped approximate the budget necessary to increase production of

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ecosystem services but represented a less conservative estimate than the WTP approach. Further research is needed to quantify the public's WTP for ecosystem services which will be helpful in determining budgets necessary to achieve specific ecosystem services focused on conservation efforts, improved budget allocations, and the prioritization of conservation efforts from a public perspective.

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CHAPTER V

CONCLUDING REMARKS AND POLICY IMPLICATIONS

The extent to which landowners are familiar with ecosystem services and conservation programs is likely to influence their land allocation decisions, which in turn, will affect forest management regimes they adopt for the production of multiple ecosystem services. This research was based on three study objectives. The first objective was to determine the extent to which nonindustrial private forest (NIPF) landowners were familiar with ecosystem services and conservation programs and evaluate how their familiarity was associated with various socioeconomic variables. The second objective was to determine NIPF land area and forest types potentially available for production of ecosystem services. The analysis also examined the relationship between forest land availability for ecosystem service production and landowner socioeconomic characteristics. The third objective was to quantify monetary compensation levels necessary to induce NIPF landowners to implement forest management restrictions to facilitate production of ecosystem services. This analysis also examined the association between compensation levels and landowner socioeconomic characteristics.

Chapter II provided an overview of landowner knowledge of ecosystem services and associated conservation programs. Findings showed that landowner familiarity with conservation programs was low. Furthermore, most landowners were familiar with ecosystem services such as personal recreation, clean water, soil erosion control, and

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wildlife habitat. However, they were not familiar with aesthetics and woody biomass as ecosystem services. The Chapter II analysis also indicated that there was heterogeneity among landowners implying they were different in terms of their socioeconomic characteristics and ownership goals. Factors such as gender, education, annual household income, size of forest land owned, membership in conservation organizations, possession of a written forest management plan, and familiarity with ecosystem services were positively associated with ecosystem service and conservation program familiarity. These findings suggested the importance of increasing knowledge of conservation programs among landowners by using various socioeconomic characteristics to customize outreach efforts.

Chapter III focused on the proportion of forest land and forest types potentially available for production of ecosystem services. Results showed that 64% of the total forest land in Mississippi (8.9 million ha) can be potentially managed for ecosystem services. Most of the available forest land area was in the form of pine and natural mixed pine-hardwood forests. An evaluation of socioeconomic factors indicated that personal recreation goals had a positive relationship with the proportion of forest land they were willing to allocate for ecosystem service management. In addition, landowners with bottomland hardwoods and natural pine forests were more likely to manage their forests for ecosystem services. Landowners who possessed a forest management plan may require technical support to improve the quantity and quality of ecosystem services from their forest land over time. Furthermore, conservation planning should incorporate landowner goals to improve management of NIPF land for ecosystem services.

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Chapter IV used the contingent valuation method to quantify monetary compensation levels necessary to induce NIPF landowners to implement forest management alternatives facilitating production of ecosystem services. The Chapter focused on development of a hypothetical CV scenario to elicit required willingness to accept compensation (WTA) amounts to implement four alternatives featuring increasing levels of forest management restrictions. Findings from model 1, in which "unsure" responses were removed, showed that WTA compensation amounts ranged from $190.22 to $423.23/ha/year. This represents the total monetary cost of providing ecosystem services ranging from $0.9 to $1.6 billion and indicates a potential budget that might be needed to implement forest management facilitating the production of ecosystem services in Mississippi.

In general, compensation level and landowner investment objectives were positively associated with willingness to implement a proposed management alternative. A greater percentage of landowners were willing to implement a proposed management alternative at higher compensation levels. Therefore, higher payments through conservation programs may be necessary to expand implementation of forest management practices facilitating ecosystem services. There were also other factors statistically associated with WTA compensation for each forest management alternative depending on how "unsure" responses were treated and they included possession of a written forest management plan, membership in professional organizations, and size of forest land owned. Results will be useful in developing, designing, and implementing future conservation efforts to increase production of ecosystem services. Such conservation efforts need to recognize landowner motivations by including their

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ownership objectives. Flexibility of conservation programs related to landowner objectives is likely to improve the acceptability of forest management alternatives focused on multiple ecosystem services.

Overall, the three research topics presented in this dissertation are linked conceptually. First, information on landowner of knowledge of ecosystem services and associated programs provides decision-makers with guidelines on how existing and future programs can be improved to increase forest land area availability for production of ecosystem services. In this regard, results from the first article emphasized the importance of community associations, possession of forest management plans, household income and forest size. Second, types of forest management alternatives that landowners choose depend on forest land size and landowner socioeconomic characteristics. While findings from the second manuscript showed that landowner objectives were important, forest types that include bottomland hardwoods and mixed stands were likely to be managed for multiple ecosystem services. Past enrolment in conservation programs was also confirmed in the second manuscript suggesting the potential role that such landowners could provide to their peers. Third, the forest management alternatives that are preferred by landowners depend on the number of associated restrictions. Moreover, landowner choices of forest management strategies are reflected in the expected amount of financial compensation. Findings from the third manuscript confirmed the importance of landowner objectives in the determination of WTA compensation values.

Generally, the findings revealed that landowners were supportive of active forest management for multiple ecosystem services. They were most likely to provide pine and

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mixed pine and hardwoods for this purpose. Nonetheless, not much was known about existing conservation programs and some types of ecosystem services such as carbon sequestration, woody biomass for bioenergy and aesthetics. Furthermore, landowner behavior towards forest management for multiple ecosystem services could be influenced through the use of financial incentives and the inclusion of their objectives in the design and management of conservation programs.

There are analytical limitations that were not addressed in this study. The second chapter evaluated landowner familiarity with ecosystem services and conservation programs at a specific point in time. Follow-up studies of landowner familiarity will be helpful in identifying changing landowner attitudes and re-designing conservation programs over time to meet landowner needs. The third chapter did not account for economic parameters such as forest land values and interest rates which may affect the nature of forest management activities. The fourth chapter evaluated WTA compensation associated with pine forests. However, this study can be further improved by quantifying compensation levels for mixed pine-hardwood and hardwood forests. Further, future research might use willingness to pay (WTP) approach to quantify the monetary value of ecosystem services from a general public perspective that will be helpful in determining the importance of future budget allocations.

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APPENDIX A

SURVEY INSTRUMENT

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A Survey of Mississippi Forest Landowner Willingness to Provide Ecosystem Services

Conducted for the Department of Forestry
Forest and Wildlife Research Center
Mississippi State University

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PART 1. In this survey, we would like to learn about your willingness to manage your forest for ecosystem services. Please, read information included in this section and then answer the questions that follow.

Ecosystem services include a wide range of goods, services, and benefits that people obtain from natural resources. Some examples of ecosystem services include the following:

Aesthetics: Forest lands can improve the visual appearance of surrounding landscapes and make them more enjoyable.

Carbon sequestration: Trees and plants sequester carbon dioxide from the atmosphere, store carbon in their biomass and, therefore, help improve air quality.

Clean air: Trees and plants produce oxygen and help purify air.

Clean water: Trees and plants decrease soil and chemical runoff to nearby rivers, streams, lakes, and ponds and, therefore, help improve water quality.

Hunting: Forest lands provide a preferred habitat for many game species and make these landscapes desired hunting grounds.

Production of woody biomass for bioenergy: Biomass of trees and grass species can be substituted for traditional fossil fuels and used for production of electricity, biofuels, and chemicals.

Soil erosion control: Best Management Practices such as planting trees, shrubs and grasses help stabilize soil and prevent its movement into nearby rivers, streams, lakes, and ponds. These voluntary guidelines for the state of Mississippi protect water from soil erosion.

Tourism (including ecotourism): Forest tracts provide diversity to surrounding landscapes, making them more desirable for recreational purposes.

Watershed management: Forests serve as recharge areas for local aquifers, thereby decreasing the likelihood of droughts and floods.

Wildlife habitat: Forest lands provide a suitable habitat for many non-game wildlife species and, therefore, help maintain biodiversity.

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PART 2. We would like to learn about the forest land that you own and your ownership goals for that land.

1. **How many acres of forest land do you own in Mississippi** (include all tracts of forest land in the state)? _____acres

2. **In what county is your largest tract located?** _____ County

3. **How important to you are the following reasons for owning your forest land?** *Please, check only one importance box for each ownership reason.*

Reason for owning forest land	Importance					
	Very important	Important	Moderately important	Of little importance	Unimportant	Unsure
Generating current income	☐	☐	☐	☐	☐	☐
Production of ecosystem services	☐	☐	☐	☐	☐	☐
Long-term investment	☐	☐	☐	☐	☐	☐
Providing a legacy to my heirs	☐	☐	☐	☐	☐	☐
Production of traditional forest products (e.g., sawlogs, pulpwood)	☐	☐	☐	☐	☐	☐
Production of agroforestry products (e.g., forage and shelter for livestock, nuts, and fruits)	☐	☐	☐	☐	☐	☐
Personal recreation (e.g., hunting, fishing, camping, wildlife watching, privacy, solitude)	☐	☐	☐	☐	☐	☐
Providing fee-based recreation (e.g., hunting leases, ecotourism, riding trails)	☐	☐	☐	☐	☐	☐

4. **Do you have a written management plan for any of your forest land tracts?** *Please, circle only one item.*
   a. Yes
   b. No
   c. Don't know

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PART 3. We would like to ask you several questions regarding your experience with ecosystem services and associated programs.

5. **How familiar are you with the following ecosystem services? Please, check only one box for each ecosystem service.**

Ecosystem Services	Familiarity					
	Extremely familiar	Moderately familiar	Somewhat familiar	Slightly familiar	Not at all familiar	Unsure
Aesthetics	☐	☐	☐	☐	☐	☐
Biodiversity (increase richness of animal and plant species)	☐	☐	☐	☐	☐	☐
Carbon sequestration	☐	☐	☐	☐	☐	☐
Clean air	☐	☐	☐	☐	☐	☐
Clean water	☐	☐	☐	☐	☐	☐
Personal recreation (e.g., hunting, fishing, camping, wildlife watching)	☐	☐	☐	☐	☐	☐
Providing fee-based recreation (e.g., hunting leases, ecotourism, riding trails)	☐	☐	☐	☐	☐	☐
Production of woody biomass for bioenergy	☐	☐	☐	☐	☐	☐
Soil erosion control	☐	☐	☐	☐	☐	☐
Watershed management	☐	☐	☐	☐	☐	☐
Wildlife habitat (game wildlife, non-game wildlife including rare, threatened, and endangered species)	☐	☐	☐	☐	☐	☐
Other (please specify): _____	☐	☐	☐	☐	☐	☐
_____	☐	☐	☐	☐	☐	☐
_____	☐	☐	☐	☐	☐	☐

6. **Has your forest land ever been <u>managed</u> specifically for ecosystems services (such as described on page 2)?**
   a. Yes
   b. No
   c. Don't know

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7. **Has your forest land ever been enrolled in any ecosystem services-related program?**
   a. Yes
   b. No
   c. Don't know

8. **In the following table, report: 1) how many acres you own by forest type and 2) how many acres you would be interested in managing for ecosystem services.**

Forest Land Type	Acres Owned	Acres You Would be Interested in Managing for Ecosystem Services
Pine plantations (trees planted in rows)		
Bottomland hardwoods		
Natural pine stands		
Natural hardwood stands		
Natural mixed pine and hardwood stands		
Other *(please, specify):*		

9. **How familiar are you with the following assistance programs?** *Please, check only one box for each program.*

Program	Participated	Didn't participate but I am familiar with the program	Didn't participate and I am not familiar with the program
CRP (Conservation Reserve Program)	☐	☐	☐
WRP (Wetland Reserve Program)	☐	☐	☐
EQIP (Environmental Quality Incentives Program)	☐	☐	☐
WHIP (Wildlife Habitat Improvement Program)	☐	☐	☐
Conservation easements	☐	☐	☐
Other (please, specify): _____	☐	☐	☐
_____	☐	☐	☐
_____	☐	☐	☐

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PART 4. We would like to know whether you would be interested in managing your forest land for ecosystem services in exchange for an annual payment. Information presented below is necessary for you to make informed decisions when answering questions in this section.

Assume that you own a 40-acre tract of loblolly pine managed for timber and located in the county where you own your largest forest tract (as you answered in Question 2). The stand is currently 25 years old and you plan to harvest it at the end of this year (2012). You have been offered the opportunity to enroll it into an ecosystem services program administered by the U.S. Department of Agriculture's Conservation Reserve Program (CRP). Under this program you will manage this tract for ecosystem services over the next 10 years in exchange for an annual payment.

Under the program agreement you will postpone a final harvest by 10 years to the year 2022, but you will have an option to select one of the three forest management intensity levels listed below.

Because some of these ecosystem services might require you to modify your management, you will have to change your current forest management plan to make accommodations for thinning and final harvest restrictions. This implies that timber revenues from your stand might be lower than you expected. However, if you enroll in this program, you will receive an annual payment over next 10 years from the CRP. The payment amount will depend on what management intensity alternative you choose. If you break the contract, you will have to refund the agency for already received funding plus appropriate interest. However, if your forest experiences catastrophic damage such as those caused by hurricanes, tornadoes, fire, and pests you will be allowed to conduct salvage operations. You also will be allowed to conduct forest sanitation activities to prevent diseases and insect infestations.

The following section describes the four management alternatives that you can choose from. After considering these alternatives, please answer the questions that follow.

Management Alternative A: Harvest at the end of 2012. Under this option, you will harvest your loblolly pine tract as originally scheduled (at the end of 2012). You will not enroll in an ecosystem services program and will not receive any payment for providing such services.

Management Alternative B: Delayed harvest with all silvicultural activities allowed. Under this option, a final harvest of your loblolly pine tract will be delayed for 10 years (to the end of 2022). However, you will be allowed to perform all stand improvement activities necessary to maintain good quality timber. Such management might include thinning, release using herbicides, conducting prescribed burning, and sanitation activities necessary to maintain good forest health.

Management Alternative C: Delayed harvest with only some silvicultural activities allowed. Under this option, a final harvest of your loblolly pine tract will be delayed for 10 years (to the end of 2022). You will be allowed to lightly thin your stand and conduct other silvicultural activities only if they improve the provision of ecosystem services for which you enrolled. Such management might include enhancing game and non-game wildlife habitat, creating openings, prescribed burning, and sanitation activities necessary to maintain good forest health. Explanation of necessary activities and management plan will be provided to you by a program consulting forester.

Management Alternative D: Delayed harvest with no silvicultural activities allowed. Under this option, a final harvest of your loblolly pine tract will be delayed for 10 years (to the end of 2022). During this time you will not be allowed to thin your stand or perform any stand improvement activities except for removing dead or damaged trees for safety reasons and conducting sanitation activities necessary to maintain good forest health.

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10. **Would you manage your 40-acre loblolly pine tract according to *Management Alternative B* (delayed harvest with all silvicultural activities allowed) instead of *Management Alternative A* (harvest at the end of 2012) if you were offered an annual payment of $_____ per acre for the duration of 10-year contract.**
    a. Yes
    b. No
    c. Unsure

11. **Would you manage your 40-acre loblolly pine tract according to *Management Alternative C* (delayed harvest with only some silvicultural activities allowed) instead of *Management Alternative A* (harvest at the end of 2012) if you were offered an annual payment of $_____ per acre for the duration of 10-year contract.**
    a. Yes
    b. No
    c. Unsure

12. **Would you manage your 40-acre loblolly pine tract according to *Management Alternative D* (delayed harvest with no silvicultural activities allowed) instead of *Management Alternative A* (harvest at the end of 2012) if you were offered an annual payment of $_____ per acre for the duration of 10-year contract.**
    a. Yes
    b. No
    c. Unsure

13. **If you answered "No" or "Unsure" in Questions 10, 11, or 12 what was the reason for your answer?** *Please, select only one item.*
    a. Offered payment amount is too small.
    b. I don't think such a program will ever be implemented.
    c. I don't want to be tied up in a long-term forest management agreement.
    d. I don't want to be involved in active management for ecosystem services even if a sufficient payment amount was offered.
    e. I don't like forest management restrictions associated with ecosystem services.
    f. Other *(please, specify)*: _____

14. **Given current timber prices and future economic outlook, how likely is it that you would delay harvest of this 40-acre loblolly pine tract even if CRP payments for ecosystem services were not available?** *Please, select only one item.*
    a. Very Likely b. Likely c. Neutral d. Unlikely e. Very Unlikely

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PART 5. We would like to ask you several questions about yourself.

15. **What is your age?** _____ Years

16. **What is your gender?** *Please, circle only one item.*
a. Male b. Female

17. **What is the highest level of education you have completed?** *Please, circle only one item.*
a. Did not complete high school
b. Completed high school or a General Educational Development (GED) test
c. Vocational/technical training
d. Bachelor degree or equivalent
e. Postgraduate degrees (e.g., M.A., M.S., M.D., Ph.D.)

18. **Where do you live?** County: _____ State: _____

19. **To which of the following organizations do you belong?** *Please, circle all that apply.*
a. Community service organizations
b. Agriculture/farm based organizations
c. Mississippi Forestry Association
d. County Forestry Associations
e. Church or religious groups
f. Environmental organizations
g. Conservation organizations
h. Professional organizations
i. Other (please, specify): _____
_____

20. **Which of the following best describes your total 2011 household income before taxes?** *Please, circle only one item.*
a. Less than $30,000
b. $30,001-$40,000
c. $40,001-$50,000
d. $50,001-$60,000
e. $60,001-$70,000
f. $70,001-$80,000
g. $80,001-$90,000
h. $90,001-$100,000
i. $100,001-$110,000
j. $110,001-$120,000
k. $120,001-$130,000
l. $130,001-$140,000
m. $140,001-$150,000
n. More than $150,000

Thank you for participating in this survey. We appreciate your time and effort. If you wish to share any comments or suggestions regarding this survey or any related topics, please provide them below.

_____
_____
_____

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