FAMILY FOREST OWNERS' PREFERENCES AND CONSERVATION DECISIONS

by

MOON JEONG KANG

(Under the Direction of Jacek Siry)

ABSTRACT

The aim of this dissertation is to investigate family forest owners' preferences towards payments for ecosystem services (PES) programs. The research considers three factors, 1) individual risk preferences, 2) forest property characteristics, and 3) ownership objectives to analyze forest owners' decision to participate in PES programs.

The primary objectives involve eliciting forest owners' individual risk preferences, collecting and analyzing information about forest property characteristics and ownership objectives and forest owners' preferences towards various PES program designs using a choice experiment. Mail and online surveys were conducted in the southeast Georgia to collect the data.

The first study investigates the role of risk preferences in family forest owners' conservation decisions. Our study provides results using random parameter logit (RPL) model to analyze choice experiment survey data. The results reveal that one's level of risk aversion affects one's likelihood to participate in PES programs, as well as one's willingness to accept (WTA) compensation.

The second study examines how observable forest management behavior reveals forest owners' preferences towards PES programs. Research findings confirm that there are significant

correlations between the landowners' objectives and the composition of forest types. The RPL model results indicate that the existence of pine plantations and bottomland hardwoods forests on one's property significantly increases the likelihood that the forest owner will participate in PES programs.

The third study explores the role of ownership objectives in forest management decisions. We develop an empirical typology of family forest owners. Market segmentation techniques including principal component analysis and cluster analysis are adopted to segment the forest owner groups. Our research findings confirm that there are differences between different ownership groups in how they manage the forest and their likelihood of participating in PES programs.

INDEX WORDS: Family Forest Owners, Willingness to Participate, Willingness to Accept, Payments for Ecosystem Services, Risk Preferences, Forest Management, Typology

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CHAPTER 1

INTRODUCTION

The needs for supplying sufficient quality and quantity of ecosystem services continue to rise with expanding populations and growing environmental concerns (Millennium Ecosystem Assessment, 2005). Forests and woodlands, which account for about 819 million acres of the U.S. land cover (Oswalt, 2014), provide both material and non-material benefits that are indispensable to human well-being. In the last few decades, the conservation of public forests, as well as protection of private forests has received more attention. About 58 percent of the U.S. forestland is owned by private owners. Many environmental policies are now targeting family forest owners who account for 62 percent of the U.S. private forests (Butler, 2008). Family forest owners have a significant influence over large forested areas they manage and ecosystem services generated from the lands. Family forest owners are motivated by a combination of different objectives ranging from scenic beauty, income from timber sales, recreational activities on the property, family legacy, land investment, to environmental conservation (Bengston et al., 2011). They also have considerably more diverse ownership objectives and preferences for their properties than other private forest owners such as timberland investment management organizations (TIMOS) or real estate investment trusts (REITS). TIMOS and REITS are mostly focused on maximizing revenues generated from the forests (Binkley, 2007, Clutter et al., 2005). As a result, family forest owners are considered to be attractive targets for conservation programs.

Market-based conservation tools have been suggested as a potential solution for the conservation of private forest lands. Payments for ecosystem services (PES) programs are payment

schemes adopted in the U.S. and many other countries. A PES is a voluntary transaction where one or more ecosystem services or land use that can secure those services are transacted between an ecosystem services buyer and an ecosystem services provider on the condition that the provider secures continued provision of the ecosystem service (Wunder, 2005). Despite the popularity of the definition, there have been concerns that the definition by Wunder (2005) is rather limited and narrow (Schomers and Matzdorf, 2013, Muradian et al., 2010). Currently, it is common to see PES programs defined as flexible financial arrangements that can be modified and applied in various circumstances, not as specific models (United Nations, 2014). There are still ongoing discussions on how we should define ecosystem services and measurement of their monetary value (Fisher et al., 2009, Boyd and Banzhaf, 2007). Still, PES schemes have been known to be cost-effective and efficient alternatives compared to the conventional conservation tools (Jack et al., 2008).

While the goal of these programs is conservation of environment and preventing loss of ecosystem services, PES programs differ in their specific objectives (e.g., protection of endangered species, open space preservation, and maintaining current forest cover), contract attributes (e.g., amount of payment, types of incentives–tax, lump-sum payment, or periodical payments, length of contract, conservation requirements), and conservation targets (e.g., endangered species, scenic beauty, or bundled ecosystem services). For example, in the environmental services payments (Pago por Servicios Ambientales, or simply PSA) program in Costa Rica, forest owners receive financial compensation from the state for a variety of ecosystem services they provide. PCA contributes to reducing deforestation and consequently to maintaining the sustainable provision of various ecosystem services. On the other hand, there are payment schemes designed only for specific services such as carbon sequestration programs or incentive payments for biodiversity conservation.

In Georgia, there are various government and non-government PES programs targeting private forest owners such as the forest legacy program (FLP), conservation use value assessment (CUVA), environmental quality incentives program (EQIP), forest stewardship program (FSP), healthy forests reserve program (HFRP), agricultural conservation easement program (ACEP), conservation stewardship program (CSP), conservation technical assistance (CTA), conservation easements, working forest conservation easements (WFCE), and mitigation banks. Conservation easements, WFCE, and mitigation banks are mainly funded by non-government organizations and other private parties, and the other programs are government incentive programs that provide technical assistance, education, financial assistance, or tax benefits. Administration, contractual requirements, compensations to landowners, costs, eligibilities, and other contractual attributes vary depending on a program.

This study focuses on PES programs targeting the bundled ecosystem services by purchasing development rights on the property from the landowners. Landowners who participate in these types of PES programs relinquish development rights for the enrolled property for a limited period or permanently in return for financial compensation such as direct payment or tax benefits. By doing so, it is possible to limit certain activities that could damage forest ecosystems and to procure bundled ecosystem services generated from the forestland. Compared to the PES programs designed for conserving specific ecosystem services such as biodiversity, soil quality, or watershed services, PES programs targeting the bundled ecosystem services have broad conservation goals and aim to secure and enhance the provision of multiple ecosystem services. Most of the forest-based PES programs in the U.S. are targeting bundled ecosystem services, and they are receiving the majority of payments (Mercer et al., 2011). For example, conservation easements, WFCE, mitigation banks, FLP, ACEP, and HFRP are taking this approach.

Although PES programs have a long history in the U.S. and are gaining popularity as an effective tool for conservation, only a small number of private forest owners are participating, and the trend is particular to the U.S. South (Mercer et al., 2011). For example, private forest owners' participation rate in easement type PES programs that are designed to protect natural area for a long-term from development and wetland mitigation banks is low. As of 2016, 580,000 acres of land including farmland, forestland, and other areas are under conservation easement contracts in Georgia (National Conservation Easement Database, 2016). Therefore, it is possible to infer that about less than 3 percent of private forests in Georgia are enrolled in easement type PES programs.

This dissertation focuses on family forest owners who own riparian forests in Georgia. Riparian forests refer to the forests adjacent to streams, lakes, and other types of surface water bodies. Bottomland hardwood forests that occur on the floodplain areas are representative riparian forests in Georgia and other southeastern U.S. states. Riparian forests not only provide timber, but also provide critical ecosystem services such as natural filtering, stabilizing river banks, regulating water temperature, wildlife habitat and wildlife corridors, recreational opportunities, and others (Naiman et al., 2005). Land conversion to developed or agricultural uses and permanent forest removal can cause adverse impacts on the function of the riparian forests, and physical stream environment as well (Nagy et al., 2011).

The discharge of dredged or fill material into waters of the U.S. is regulated, and it is required to obtain Clean Water Act 404 permit for conducting such activities. Generally, normal and ongoing silvicultural activities occurring in jurisdictional waters of the U.S. are exempt from 404 permits. However, there are some exceptions when silvicultural activities are not exempted from the permit. For example, converting certain riparian forests into pine plantations is not considered to be normal or ongoing silvicultural activities. Activities that can impair the

hydrologic features of waters of the U.S. are not exempted from permission (U.S. Army Corps of Engineers, 2010).

However, not all riparian areas are considered as jurisdictional waters. In 2015, riparian areas only with a significant nexus to a jurisdictional water were recognized as waters of the U.S. under Clean Water Act. Therefore, while they provide a wide spectrum of ecosystem services as forested wetlands, they are less protected by regulations. Furthermore, recently, the risks of potential environmental impact of conversing riparian forests and forested wetlands into more intensively managed forests have been attracting the attention of environmental organizations (Natural Resources Defense Council, 2015a, Natural Resources Defense Council, 2015b, Conner et al., 2012).

This dissertation explores Georgia family forest owners' preferences towards PES programs. In particular, we investigate family forest owners who own forest parcels with riparian forest areas. In Chapter 2, we investigate whether underlying individual risk preferences affect forest owners' decision to participate in such programs. In Chapter 3, we discuss whether forest characteristics are associated with forest owners' conservation decision and if those observable characteristics of the forest properties could be used in estimating landowners' preferences towards PES programs. In Chapter 4, we conduct a typology of family forest owners and discuss the relationship between different forest owner types and their preferences towards PES participation.

CHAPTER 2

RISK ATTITUDES AND CONSERVATION DECISIONS: A CASE STUDY OF FAMILY FOREST OWNERS IN GEORGIA

Enrolling one's property in payment for ecosystem services (PES) programs can involve various risks and uncertainties such as opportunity costs, failure to meet contract requirements, or limitation in future land uses, which can be significant obstacles to encouraging program participation by family forest owners. Past studies found that risk attitudes are one of the critical determinants of forest owners' land management decisions. There is scarce information on how individual risk attitudes are associated with their participation in PES program.

Participating in PES programs is a major land management decision since it will limit certain land uses and require landowners to meet a set of specific requirements for a contract duration, which are sometimes permanent. This study attempts to investigate how the level of one's risk aversion affect one's decision to participate in long-term incentive programs that will require landowners to relinquish development rights for their forest property and to satisfy specified requirements. Understanding how individual landowner's risk attitudes affect their willingness to participate (WTP) in incentive programs can shed light on promoting PES programs among family forest owners. Furthermore, the information on how family owner's risk aversion level is associated with preferences for different levels of attributes of a PES program can provide useful insights for developing targeted PES programs. As far as we know, there are no studies that integrate the elicited risk attitudes of family forest owners and their willingness to enroll their land in conservation contracts and preferences for PES contract attributes. Our study would provide a

meaningful addition to the understanding of how family owners' personal preferences affect their conservation decision.

In this study, we elicit forest owners' risk coefficients associated with silvicultural decision-making using experimental economics approach. We classify forest owners into different risk groups based on the obtained risk coefficients and see if one's being relatively risk averse or risk seeking affect their willingness to accept (WTA) PES contracts. In this study, WTA represents compensating welfare measure of family forest owners, recognizing current level of utility (when there is no PES contract) as basis of comparison (Champ et al., 2003). Therefore, family forest owners' WTA can be interpreted as the amount of additional income that forest owners would need in exchange for their agreeing to participate in provided PES programs to obtain the current level of utility. Furthermore, we investigate if one's risk attitudes affect his or her preferences for different level of PES contracts.

The objectives of this study are to:

1) Elicit family forest owners' risk aversion coefficients using experimental economics approach
2) Analyze family forest owners' WTP and WTA associated with PES participation through a choice experiment
3) Discuss how one's risk attitudes affect his or her WTP and WTA associated with PES contracts
4) Discuss how one's risk aversion is associated with preferences for different levels of PES programs.

Background

1. Family forest owners' risk attitudes and land management decisions

In economics, it has been long believed that an individual has stable underlying risk attitudes that do not change depending on context. Various experiments have been devised for quantifying and assessing individual's risk attitudes and using the information to analyze one's risk taking behavior as well. However, there is also growing evidence that individual's risk attitudes are dependent on context (Deck et al., 2008, Weber et al., 2002, Reynaud and Couture, 2012), and may be not stable across different elicitation methods (Anderson and Mellor, 2009).

Previous studies tried to classify forest owners into different risk aversion groups. They used survey or experimental economics approaches to identify their risk aversion parameters. Some studies found that forest owners tended to be risk averse (Brunette et al., 2017, Petucco et al., 2015). A few studies suggested that risk aversion was not the dominant risk attitude of forest owners (Andersson and Gong, 2010, Andersson, 2012). Lönnstedt and Svensson (2000) suggested that forest owners' risk attitudes might change depending on the size of the asset.

Some studies investigated factors that seemed to be associated with forest owners' attitudes towards risk. Studies found that forest owners' gender (Andersson, 2012, Andersson and Gong, 2010, Brunette et al., 2017), ownership length (Andersson, 2012), forest income (Brunette et al., 2017), property characteristics (Andersson, 2012), age (Lönnstedt and Svensson, 2000, Brunette et al., 2017), and active use of the forest property (Andersson, 2012) seemed to be related to their level of risk aversion.

It has been found that risk aversion of family forest owners plays a major role in their decision-making regarding the management of their forestlands and planning. Studies investigated the impact of family forest owners' risk attitudes and preferences on the various land management

decisions such as final harvest decisions (Andersson and Gong, 2010, Gong and Löfgren, 2003, Petucco et al., 2015, Brunette et al., 2017), rotation length (Gong, 1998, Alvarez and Koskela, 2006, Lien et al., 2007), forest planning (Pukkala, 1998, Pukkala and Kangas, 1996), and perception on forest investment (Lönnstedt and Svensson, 2000). In research on Swedish private forest owners, Andersson and Gong (2010) examined forest owners' risk attitudes and risk perceptions about timber investment and if their risk attitudes were consistent with harvest decisions. They classified respondents into risk averse, risk neutral, risk seeking, and unsure groups based on their responses to two questions with contexts of decision-making associated with felling and selling of timber with certain risks and uncertainties. They found that the majority of the respondents were classified as risk neural and risk prone groups, and only 16% were found to be a risk averse group. The study found that risk seeking forest owner groups were more likely to conduct final felling compared to other risk attitudes groups. Gong and Löfgren (2003) suggested that risk aversion affected a landowner's harvest decision and consequently the short-term timber supply under the scenario of investing in portfolio assets. Brunette et al. (2017) elicited French forest owners' risk attitudes by using context-free risk measure developed by Eckel and Grossman (2008) and found that French forest owners were more likely to be risk averse and their risk attitudes affected harvesting decisions. They found that risk averse forest owners had a higher probability of conducting harvest than less risk averse owners, which was inconsistent with the findings of Andersson and Gong (2010). Petucco et al. (2015) also estimated the timber harvest model with elicited risk attitudes as one of explanatory variable and found that risk seeking forest owners were less likely to harvest than risk averse owners.

Gong (1998) introduced forests owners' risk aversion to the model to estimate the optimal harvest age. The study found that risk averse owners are likely to harvest earlier than risk neutral

forest owners, who make decisions based on the expected net present value maximization criterion, because of the uncertainties related to stumpage prices. Other studies also found similar results that forest owners who are risk averse are generally expected to conduct harvest earlier than risk seeking or neutral forest owners (Lien et al., 2007, Couture and Reynaud, 2011, Taylor and Fortson, 1991, Couture and Reynaud, 2008). Alvarez and Koskela (2006) modeled how risk averse forest owners would make a decision when presented with volatile interest rates and price scenarios. They found that risk aversion would lead to longer rotation cycle when the interest rate is fluctuating, and result in shorter rotation period when forest stand value is volatile.

Pukkala and Kangas (1996) integrated risk attitudes of forest owners as weights in the optimization of potential forest plan and discovered that optimal forest plans were not exactly the same among risk averse, risk neutral, and risk seeking owners. Pukkala (1998) introduced a forest planning approach that integrated risk and forest owners' risk attitudes and estimated the utility functions for the optimal plan derived from the approach. The study found that the forest management plan that was developed for risk neutral decision makers could decrease the utility of risk averse decision makers. The findings of the study emphasized the need to include both risk associated with decision alternatives and forest owners' risk attitudes in forest planning and decision analysis.

Lönnstedt and Svensson (2000) analyzed how family forest owners perceive a forest property as an investment option using forest owners' risk attitudes. They found that forest owners viewed investing in forests as a less risky choice than stock investment or bank saving. They also found that forests owners risk attitudes changed depending on the size of assets. For example, they were found to be risk seeking given with smaller assets and to be risk averse given with larger assets.

Though many studies attempted to explain forest owners' silvicultural or forest investment decisions using their risk attitudes and preferences, there is scarce information that how these factors affect their conservation decision.

2. Family forest owners' risk attitudes and willingness to participate (WTP) in PES programs

There have been many efforts trying to find the factors that affect family forest owners' conservation decisions. Individual owner's characteristics, property features, and program attributes are believed to have a significant impact on family forest owners' WTA conservation contracts. However, compared to these factors, family forest owners' attitudes towards risk and uncertainty have been less explored when modeling forest owners' participation in PES programs.

Some studies tried to include factors associated with family forest owners' perceived risks in modeling their willingness to participate (WTP) in PES programs. Nagubadi et al. (1996) found that family forest owners who fear the loss of property rights or management options were less likely to participate in forestry assistance programs. Kline et al. (2000c) suggested that forest owners might be willing to take part in a hypothetical conservation program for avoiding unwanted environmental regulation in the future. Based on the findings of Kline et al. (2000c), Langpap (2004) introduced family forest owners' perceived threat of regulation (in this case, the Endangered Species Act) as an independent variable in the model for estimating their willingness to enter into an incentive program for conserving endangered species. However, they found that the variable was statistically insignificant. Similarly, Rabotyagov and Lin (2013) included regulatory uncertainties perceived by landowners in the model for explaining small forest owners' participation in Working Forest Conservation Easements (WFCE) and found that the coefficient for the perceived risk toward regulatory uncertainties was insignificant. Matta et al. (2009)

included the number of landowners participating in the same program as an explanatory variable for investigating the impact of perceived risk on enrollment and found that the variable was not statistically significant. These variables associated with family forest owners' perceived risk in the studies above were found to be statically insignificant.

However, it is difficult to conclude that this is because the risk attitudes of family forest owners do not affect their decision-making regarding participation in PES programs. The studies integrated factors associated with forest owners' risk attitudes using indirect factors related to risk such as the fear of the potential introduction of a new environmental regulation (Rabotyagov and Lin, 2013, Langpap, 2004) or the number of other landowners who are participating in the same program in the region (Matta et al., 2009).

This chapter helps to fill this knowledge gap by introducing forest owners' risk coefficients obtained through a multiple price list methodology in the model to estimate their WTA and WTP associated with PES participations. In the following section, we explain how we selected survey participants and how we conducted the survey in the study area.

Data and Methods

1. Study area

We chose the southeastern Georgia area, which is one of Forest Inventory and Analysis (FIA) survey units, as the study site. There are thirty-six counties in total in the area, but six counties were excluded from the study because of data availability. The general area is geographically classified as the Coastal Plain region, which is represented by its relatively flat and sandy and clay soil. The climate is humid subtropical, and the region has relatively higher precipitation than other geographic areas in the state including the Piedmont and the southern

Appalachians (Nagy et al., 2011). Southeastern Georgia is one of the most forested areas in the state. Approximately 80 percent of the region is covered by forests (Oswalt, 2014).

2. Data collection

The survey design and procedures followed Dillman et al. (2014). The questionnaire consisted of four sections and a cover page with background information on the research (Appendix A). The first section of the survey asked family forest owners questions about their forest property, current management status, and ownership objectives. In the second part, family forest owners' risk attitudes and attitudes were elicited through a multiple price list methodology suggested by Eckel and Grossman (2008). In the next section, family forest owners were provided with multiple-choice sets with different level of attributes of PES contract. In the last part, we asked family forest owners about their socio-demographical information such as education, gender, income, and others. After the pilot survey was tested by expert groups, we revised the language, definition of terms, and examples based on their feedback. To identify family forest owners who own riparian forest parcels, we used data from each county's tax assessors' office. Parcel boundaries, parcel information, and addresses of the forest owners who own at least twenty-acre forest parcel that included riparian forests were obtained. Twenty acres was chosen as a cutoff point because family forest owners in Georgia own relatively large forest holdings compared to other parts of the country (Butler and Butler, 2016). After collecting the riparian forest parcel information, we checked the parcels again using ArcGIS so that we could ensure the forest parcels include riparian forests. We overlaid the parcel boundaries with National Hydrography Dataset provided by U.S. Geological Survey and removed the parcels without intermittent streams, permanent streams, or other surface water bodies. A total of 4,600 forest owners were identified. In late summer of 2016, first mail surveys were sent. Two weeks later, the reminder postcards were

sent. We sent the final replacement surveys four weeks later. We attached URL address to an online survey in all mail surveys and postcards so that respondents had the option of filling the survey online. Furthermore, we included phone numbers and email addresses of the principal investigator and co-investigator in the surveys and reminder postcards, so that survey participants could ask any questions associated with the survey.

Methods

1. Elicitation of risk attitudes

In this study, we measured family forest owners' risk attitudes in the context of financial decision-making associated with forest management using a multiple price list methodology (Eckel and Grossman, 2008). Eckel and Grossman risk measure (henceforth EG measure) is a lottery-choice approach that observes one's choice among multiple alternative lotteries and infers the person's risk attitudes. In this method, a subject is provided with multiple 50/50 lotteries and asked to choose one lottery that she or he most prefers to play. This method is similar to a risk measure suggested in a pioneering study of Binswanger (1981) in which subjects were presented with multiple lotteries with different amounts of expected payoff and risks and were required to choose one that subjects preferred the most. In EG measure, a set of lotteries consists of one certain lottery and four other lotteries with gradually increasing expected payoffs and risks. The probabilities of payoffs are fixed as 50/50 in all lotteries, but the amount of payoffs changes. Therefore, by observing one's choice of lottery, it is possible to obtain one's risk coefficient interval under the assumption of constant relative risk aversion (CRRA). Under CRRA assumption, utility can be represented as following:

$$U = \begin{cases} \dfrac{x^{1-r}}{1-r} & if\ \ r \neq 1 \\ \\ ln\ x & if\ r = 1 \end{cases} \quad (1)$$

where x is the wealth (in this study, it represents the amount of given payoff) and r is the implied CRRA coefficient.

By observing the choice the subject makes, it is possible to estimate the parameters of the risk aversion. The strong advantage of the method is that the task can be designed and implemented in a simple manner, but still ensures significant heterogeneity in choices, which allows estimation of the parameter for individual's risk attitudes. While widely used risk measure suggested by Holt and Laury (2002) (henceforth HL measure) requires a subject to make multiple choices (usually ten) in one experiment, EG measure only requires making one choice, reducing burdens of the participant. While EG measure does not generate as refined results as HL measure, it ensures enough heterogeneity in choices and far more simplicity and comprehensibility compared to HL measure (Dave et al., 2010). Furthermore, the EG measure seems to work better than HL measure when dealing with less skilled subjects due to its accessibility (Dave et al., 2010). Since this study used mail and online survey for collecting data, accessibility of the experiment was critical. Also, Dave et al. (2010) found that the simpler method may produce more stable results across the data, implying additional benefit of using the EG measure. However, the same study also suggests the potential trade-off between simplicity and predictive accuracy. Despite the potential trade-off, this study adopts EG measure taking advantage of its comprehensibility and simplicity, which is critical when using mail and online surveys for collecting data as in our case. Also, we found that the use of EG measure would be adequate based on Reynaud and Couture (2012)'s finding that despite the slight difference in coefficient estimates for risk attitudes between EG and HL measures, the rank orders for the risk attitudes are preserved between those two measures.

In the study, we used hypothetical payoffs. Using hypothetical payoffs in the experiment has a few advantages. First, it is less costly to run an experiment. It becomes a significant benefit when we want to run an experiment with high payoffs or multiple experiments with different scales of payoffs. Second, there is some evidence that it is possible to reveal individual's risk attitudes by using hypothetical payoffs. Binswanger (1981) found that subjects seemed to consider lotteries with hypothetical payoffs as seriously as those with real payments. As stakes of the lottery increased, subjects' risk aversion also increased even when they were provided with hypothetical payoffs. However, it is worth noting that in Binswanger (1981), subjects were given a sequence of lotteries that consisted of both real and hypothetical lotteries and therefore they could get used to such experiments. Using hypothetical payoffs in the experiment also involves some disadvantages as well. For example, it is generally believed that hypothetical payoffs can cause more noise in subjects' behavior. Also, when it comes to the high-stake context, it is still unclear if using large hypothetical payoffs is proper. In the study of Holt and Laury (2002), it was found that subjects' risk attitudes did not significantly change when hypothetical payoffs were scaled up, while they sharply reacted to scaling up of real payoffs. Furthermore, it is worth noting that hypothetical payoffs may reduce the incentive compatibility of the measure.

While original EG experiment consists of five lottery choices that can reveal risk averse attitudes of participants, we adjusted the method by introducing additional choice and changing the amounts of payoffs following Reynaud and Couture (2012)'s approach. While original EG measure only captures "risk aversion" of the subject, the adjusted EG measure allows estimating risk seeking behavior of the subject by providing the subject with more lottery choices. Reynaud and Couture (2012) provided nine lottery options to participants. However, in this study, to reduce the burden on respondents, we adjusted the number of options presented to the survey participants

to six. For doing so, we first set target CRRA ranges as in Table 2.1, and calculated payoffs that could achieve target CRRA ranges. We used CRRA ranges suggested in adjusted HL risk measure in Reynaud and Couture (2012) as a reference. CRRA utility function in Equation 1 was used for calculating payoffs.

To promote the understanding of the question and to obtain one's risk attitudes that is believed to associated with accepting PES contracts, we adopted a forest management context (Appendix A). Under this context, respondents were asked to choose the most preferred forest management scenarios among six forest management options (Table 2.1). Each scenario had a fifty-percent probability of generating income A and the fifty percent likelihood of generating income B in one year.

3. Choice experiment

The study adopts choice experiment (CE) method, which also called as attribute based stated choice method since the method is used to examine an individual's preference for different levels of program attributes, to study family forest owners' preferences for various contract attributes of PES program. In the CE, a subject is provided with choice sets that consist of two or more alternatives with varying levels of multiple attributes and is asked to choose the preferred one. By analyzing the choice made by the subject, it is possible to estimate the monetary value of environmental goods and services that do not have a market price as other nonmarket valuation techniques, as well as to evaluate the attributes of the environmental program, project or policy. Compared to other stated preference methods such as contingent valuation, CE method is unique in that it asks a subject's responses to the similar targets that vary in the levels of different attributes so that it produces detailed information about the subject's preferences for a diverse combination of attributes that are not observed in the market. For comparison, in an open-ended contingent

valuation method, which has been widely used in the valuation of environmental services, a subject is asked to express his or her direct valuation about a certain change in the status of ecosystem services (Freeman et al., 2014). Key advantages of CE are as follows (Holmes and Adamowicz, 2003). First, by using CE, a researcher can easily take control of the experimental stimuli associated with the attributes. Second, the statistical design under CE can generate the results with greater statistical efficiency, as well as control the collinearity among attributes. Third, the problem of tradeoff among the attributes can be controlled, which is not eliminated when using other stated preference methods.

3.1 Choice experiment design

The survey provided the information about a hypothetical PES program for conserving riparian forests to the survey participants. The PES program would provide a certain amount of annual compensation to family forest owners who own riparian forests and who participate in the program in exchange for not converting land to developed or agricultural uses and for satisfying specified management requirements. We explained that the whole property of which parcel number is specified on the questionnaire should be enrolled in the program. Survey participants were presented with an example of CE question, and each participant was asked to complete six CE tasks. Each task consisted of three alternatives: Option A, Option B, and Status Quo. Option A and Option B were composed of different levels of contract attributes. If the participants did not want to participate in any of the two options, they were asked to select Status Quo option.

In designing CE, we reviewed previous studies that investigated family forest owners' willingness to enroll in incentive programs and currently available PES programs in Georgia. We chose following contract attributes: 1) annual payment, 2) contract length, 3) payment modes, 4) minimum streamside management zones (SMZs) width required, and 5) restriction on increasing

pine plantation area. Table 2.2 demonstrates the contract attributes and specific levels. Forest owners who enroll their lands in the program would receive an annual payment in dollars per acre for the given duration of the contract. We provided tax id number of the property, which is unique identifier of one's property, and explained that forest owners should enroll the whole property, not part of it. Therefore, if a landowner has one property with 20 acres and the presented payment amount is 5 dollars per acre, the landowner will receive 100 dollars every year. To calculate the annual payment, we collected information about various incentive payment amounts of the current incentive programs in Georgia. We set minimum payment value of $10, which is similar to the compensation amount of CUVA, which is a popular tax incentive in the study area, and the highest payment value of $80, which is close to the market price of easements. Usually, easement prices are evaluated in a lump sum purchase prices. Therefore, we used the following equation for calculating the annual payment amount:

$$\text{Annual payment} = \text{Lump sum}\left(\frac{r}{1-(1+r)^{-n}}\right) \quad (2)$$

where r is the interest rate of 0.05 and n is number of years. We found that most easement type PES programs in Georgia provide a tax incentive instead of a cash payment from communications with land trusts and experts. Therefore, we chose two payment modes of tax credits and cash payments to investigate if forest owners prefer one type of payment mode over the other. In the survey, we included the explanation that tax credits can be used to reduce state property and income taxes and federal income tax. Required management practices include two separate practices for protecting water quality and maintaining riparian forests: 1) establishing specified minimum streamside management zones (SMZ), and 2) limiting increasing pine plantation area. SMZs are buffer strips that are adjacent to water bodies. SMZs should be managed with special considerations to protect water quality, and they are part of BMPs. Georgia Forestry Commission

provides the forestry BMP guidelines and suggests that riparian forest owners establish minimum 40 feet SMZs on each side of the stream (Georgia Forestry Commission, 2015). To investigate family forest owners' WTA fulfilling additional management requirements, we adopted the establishment of SMZs from 40 feet, which is a current minimum SMZ level in Georgia, to 150 feet. Converting bottomland hardwoods forests into pine plantation requires drainage, which can alter the hydrologic features of streams on the property and consequently alter the riparian ecosystem. Recently, concerns surrounding conversion of bottomland hardwood forests into pine plantation in the southeastern U.S. were expressed by environmental groups (Natural Resources Defense Council, 2015a). Therefore, in this study, we attempt to investigate how riparian forest owners will respond to the limitation on increasing pine plantation on the enrolled property.

We have three four-level attributes and two two-level attributes, which generate 256 alternatives with a different combination of attribute levels. However, using the full factorial designs with 256 alternatives can place burden to the participant. Therefore, instead of full factorial design, we adopted D-optimal fractional factorial design. D-optimal design has been used in the design of CE scenarios in previous studies (Vedel et al., 2015; Rabotyagov and Lin, 2013). Using SAS MktEx macro (Kuhfeld, 2009), we generated a D-optimal design with 36 choice sets. We restricted the design so that there was neither repetitive alternative nor dominant alternative. Choice sets were divided into six blocks with six choice sets respectively. Each respondent was randomly assigned to one of six blocks and asked to complete six choice scenarios.

3.2 Econometric model

The theoretical foundation of CE is based on Lancaster's theory (Lancaster, 1966) and random utility theory The underlying assumption of Lancaster's characteristic theory is that the utility for a good is the sum of separable utilities derived from its various attributes which provides

a theoretical background for individual's choice decision (Lancaster, 1966). Random utility maximization (RUM) model provides the framework for analyzing the choice experiments using CE (Holmes and Adamowicz, 2003). RUM model (McFadden, 1974b) describes that the utility for a good (U) can be decomposed into the systematic component (V) and random component (ε):

$$U_{ij} = U(X_{ij}) = V(X_{ij}) + \varepsilon_{ij} \quad (3)$$

where i represents a family forest owner and j represents a PES contract alternative with a unique profile of attributes. U_{ij} is a function of PES alternative (X_{ij}) and the elicited risk attitude of individual i (R_i). $V(X_{ij}, R_i)$ is the systematic component that is observable, and random component ε_{ij} is an error term that is unobservable and reflects the difference between individual i's utility and measurable component. According to RUM, individual i's choice of alternative j over alternative k occurs when utility of U_{ij} is greater than U_{ik}. If individual is provided with a choice set C consisting of competing alternatives of PES contracts with different level of attributes, the probability that individual i chooses alternative j from the choice set C is expressed as:

$$Prob(j \mid C) = Prob(U_{ij} > U_{ik})$$

$$= Prob(V(X_{ij}, R_i) + \varepsilon_{ij} > V(X_{ik}, R_i) + \varepsilon_{ik}, \forall\ j \neq k, k \in C) \quad (4)$$

By rearranging the equation (4), we can see that the differences in utilities of alternatives decide individual i's choice as following:

$$Prob(j \mid C)$$

$$= Prob(V(X_{ij}, R_i) - V(X_{ik}, R_i) > \varepsilon_{ik} - \varepsilon_{ij}, \forall\ j \neq k, j, k \in C) \quad (5)$$

In this study, we adopted the random parameter logit (RPL) —also referred to as mixed logit—model specification. RPL has been widely used in recent discrete choice studies due to its comparative advantages to standard logit models such as multinomial logit (MNL) model that has stricter assumptions. For example, MNL model specification assumes Independence of Irrelevant

Alternatives (IIA) (McFadden, 1974b). Furthermore, under MNL specification the coefficients are fixed across different individuals. By adopting RPL model specification, we can allow correlations among various alternatives. Also, it is possible to incorporate the preference heterogeneity among respondents, as well as the specification allowing multiple choices (Train, 2009a).

We estimated two models to assess: 1) whether one's risk preference affects a landowner's participation in PES program and overall WTA compensation and 2) whether risk aversion level is associated with preferences for different levels of attributes of PES programs. The utility of selecting one option among the two PES alternatives and the status quo option is as follows:

$$U_{ijn} = \alpha_j + Z_{ijn}\beta_i + \eta_j E_{ij} + \varepsilon_{ijn} \quad (6)$$

where α_j is an alternative specific constant (ASC) associated with each alternative, Z_{ijn} represents contractual attributes of PES alternatives and individual i's risk attitude ($Z_{ijn} = [X_{jn}; R_i]$), E_{ij} is random error component with zero mean, and η_j is parameter estimate for the error component. ε_{ijn} represents an error term with independent and identically distributed extreme value distribution. We extended RPL model by using error component to capture an additional unobserved variance for status quo alternative as suggested in Hensher et al. (2015). Since our PES alternatives were unlabeled, which means that the name of the choice alternative does not have specific meaning, we restricted ASCs for two PES alternatives to zero. Consequently, ASC represents the participant's utility of choosing the status quo option. The impact of one's risk attitudes on their decision was captured by examining the risk variables' preference weights on the ASC (Champ et al., 2003). Since risk attitude of individual i is constant across the alternatives, in the first model R_i in the utility function of choosing any of the two PES alternatives was normalized to zero ($Z_{ijn} = [X_{jn}; 0]$). When we estimated the second model, individual i's risk attitude was normalized to zero in the utility function for those selecting the status quo option. In

this model, risk preference variables were interacted with PES program attributes. The following function demonstrates sample likelihood of respondent i to choose an alternative j in nth choice sequence for RPL model:

$$Prob(j|C) = \iint \prod_{n=1}^{N} \left[\frac{exp\left(Z_{ijn}\beta_i + \eta_j E_{ij}\right)}{\sum_j^J exp\left(Z_{ijn}\beta_i + \eta_j E_{ij}\right)} \right] \phi(\beta_i)\phi(E_i) d\beta_i dE_i \quad (7)$$

The random parameter logit (RPL) model was estimated using maximum likelihood procedure in Nlogit 6.0 software. We used 1,000 Halton draws to estimate the model. We assumed the parameters for program attributes other than the annual payment amount would follow a normal distribution. We also assumed the distribution of annual payment amount coefficient to be fixed so that we could estimate the parameters and distributions for WTP compensation to participate in PES program. WTA estimates of the variables and distributions of WTA estimates were calculated using delta method (Hensher et al., 2015). Table 2.3 demonstrates the variables used in econometric analysis.

We had three four-level attributes and two two-level attributes, which generated 256 alternatives with a different combination of attribute levels. However, using the full factorial designs with 256 alternatives could place an excessive burden on the participant. Therefore, instead of full factorial design, we adopted D-optimal fractional factorial design. Using SAS MktEx macro (Kuhfeld, 2009), we generated a D-optimal design with 36 choice sets. We restricted the design so that there was no repetitive alternative and no dominant alternative. Choice sets were divided into six blocks with six choice sets respectively. Each respondent was randomly assigned to one of six blocks and asked to complete six choice scenarios.

Results

1. Survey results

The response rate was 22 percent. We received total 296 mail and online surveys and concluded that 253 surveys were usable after excluding the incomplete questionnaires. Since all the participants were provided with six choice scenarios, total observations were 1,518. To address potential nonresponse bias, we adopted the extrapolation method suggested by Armstrong and Overton (1977), which is to make a comparison with known values for the population. As known values for the population, we used the National Woodland Owner Survey (NWOS) data, which is the official census of forest owners in the U.S. collected on an annual basis in each state. We compared the respondents' socioeconomic characteristics and forest property characteristics to the NWOS data gathered in Georgia from 2011 to 2013. We found that our sample is representative of the population.

1.1 Respondent characteristics

Table 2.4 demonstrates the respondent characteristics. More than 60 percent of the respondents reported that they are more than 60-year-old. Also, 77 percent was male respondents, and 74 percent had some college degree. About half of the respondents answered that their annual household income is lower than 150,000 U.S. dollars. The proportion of respondents who replied that they were retired (55 percent) was slightly higher than those who were not (42 percent). Only 17 percent reported that they are a member of forestry organization. We found that 26 percent of respondents were member of the environmental organization. Also, 26 percent of respondents stated that they had any type of environmental education or career related to environmental issues. More than 60 percent of the respondents answered that they had owned the forest parcel more than 20 years. The most popular mode of acquisition was purchase (58 percent), followed by inheritance

(37 percent). More than 40 percent of the forest parcels that were investigated in this study were greater than 100 acres. However, it should be noted that many forest owners own more than one parcel of forest properties, but in this study, we were only looking at one forest parcel per owner. Consequently, we expect that the respondents who own more than 100 acres of forestland would far exceed 40 percent if we consider multiple forest holdings owned by one owner.

2. Risk attitudes

We elicited riparian forest owners' risk attitudes using experimental economics approach using the adjusted EG method as in Reynaud and Couture (2012). By doing so, we could extend the EG method so that the method can elicit risk seeking attitudes of subjects, as well as risk averse attitudes. Table 2.5 shows the respondents' risk attitudes. The respondents were classified into three risk preference groups: risk averse, risk neutral, and risk seeking based on the CRRA criteria (Reynaud and Couture, 2012). We found that 53 percent of the respondents were classified as being risk averse. About 20 percent of the participants were classified as risk neutral, and 27 percent were considered to be risk seeking. Previous studies that used the similar risk elicitation method found that forest owners tended to be risk averse (Petucco et al., 2015, Brunette et al., 2017), which was consistent with our finding. However, in the study on Swedish private forest owners, Lönnstedt and Svensson (2000) suggested that forest owners' risk preference might change depending on the size of the asset. The study found that forest owners tended to be risk seeking when a small amount of money was at stake, but they tended to be risk averse on the vice versa. The participants' risk attitudes were introduced into the econometric models as a continuous variable. We coded each participant's CRRA based on the lottery selection they made. The CRRA coefficients of the forest owners who chose lottery 1, 2, 3, 4, 5, and 6 were coded as 1.37, 1.025, 0.415, 0, -0.55, and -0.95 respectively.

3. Econometric analysis

Table 2.6 provides estimation results for the RPL model to predict forest owners' decision to participate in PES programs. The positive coefficients of the program attributes increase the likelihood of respondents' participation in given PES programs and decrease the amount of required financial compensation. On the other hand, the negative program attribute coefficients reduce the likelihood of their participation and increase the necessary compensation amount to accept the contract.

To interpret the coefficients for the variables, we used marginal WTA (Table 2.6). It should be noted that WTA values in Table 2.6 represent marginal WTA value expressed in an annual per acre payment. All monetary amounts are reported in U.S. dollars. Being consistent with previous studies and economics theory, annual per-acre compensation is positive and significant at p-value of 1 percent level, which means that as the higher the payment amount, the higher one's WTP. The contract length is negative and significant. As the contract duration increases by one year, the forest owner would require additional annual compensation of 1.6 dollars per acre. Forest owners show strong negative preferences towards permanent contracts. When they were asked to participate in permanent PES contracts, they expected an annual compensation of 98 dollars per acre. When it comes to the payment mode, forest owners preferred cash payments to tax credits. Providing compensation as cash payments instead of tax credits reduced forest owners' annual WTA by 11 dollars per acre. The coefficients for minimum SMZ widths are not significant for SMZ of 70 ft. and SMZ of 100 ft. However, the coefficient is significant and negative for the minimum SMZ requirement of 150 ft. Forest owners would require additional 17 dollars if they have an obligation to establish minimum SMZ of 150 ft. Restriction on pine plantation areas is also negative and significant. Forest owners need to be paid about 7 dollars per acre each year to

accept this management restriction. All the standard deviations of statistically significant random parameters are also significant, which implies the existence of unobserved heterogeneity in preferences for corresponding program attributes.

The positive coefficient of ASC indicates that the average forest owners would be likely to choose the status quo (no participation) option with all the other conditions remaining the same and no incentive provided. Forest owners would expect to receive about 33 dollars per acre annually as a baseline payment to enroll their parcel in the contract without considering the other program attributes. The impact of one's risk attitudes in forest owners' decision was captured by examining the risk variable's preference weights on the ASC (Holmes and Adamowicz, 2003). Continuously coded risk variable (*Risk attitude*) was interacted with the dummy variable for the status quo option. We found that the interaction term between ASC and individual's risk attitude was statistically significant, which indicates that one's level of risk aversion might play a certain role in forest owners' decision to participate in hypothetical PES programs. The coefficient for the variable is negative and significant, which means that risk averse forest owners (forest owners with high and positive CRRA coefficients) were more likely to choose from provided PES alternatives over status quo option. On the other hand, risk neutral and risk seeking forest owners (forest owners with low and negative CRRA coefficients) were more likely to choose not to participate in PES programs by selecting status quo option. The difference in preferences towards PES participation was relatively high between forest owners with different risk attitudes. For example, the difference in annual WTA compensation was as large as 67 dollars per acre between very risk averse group (CRRA = 1.37) and very risk seeking group (CRRA = -0.95).

We also estimated another RPL model with interactions between attributes and different levels of risk aversion but did not find any significant results. It seems that forest owners' risk

preferences do not affect their preferences for presented PES program attributes such as contractual length, payment mode, and management requirements covered in our hypothetical PES design.

Discussion and Conclusions

1. Contract attributes

When it comes to the contract length, forest owners required to receive more compensation as the contract length increased. Forest owners required 98 dollars per acre per year for accepting the permanent contract. However, it is also notable that forest owners expected to receive 97 dollars per acre per year for accepting PES contract with 60-year contract period, which is a similar amount of money that they expected to receive when they were asked to participate in a permanent contract. Previous studies found that forest owners had negative preferences for permanent PES contracts (Sullivan et al., 2005, Rabotyagov and Lin, 2013, Raunikar and Buongiorno, 2006). Rabotyagov and Lin (2013) found that engaging forest owners in a permanent contract was costlier than engaging them in the 50-year contract. However, in our study, forest owners required a similar amount of compensation for accepting both 60-year contract and the permanent contract. We can see that forest owners strongly dislike the permanent contract, as well as long-term contract.

Regarding the payment mode, forest owners generally preferred cash payments to the same amount of tax credits. Further, forest owners would require a smaller compensation if they could receive an annual payment in cash instead of the same monetary amount in tax credits. This differs from the results of the previous study conducted in Massachusetts by Stevens et al. (2002). The study found that family forest owners seemed to have no preference towards a mode of compensation including cost-sharing, tax benefits, and direct payments. Considering that many non-government easements only provide tax benefits through the donation of the easement and

many government incentive programs provide non-cash compensation, we could infer that providing cash payments to forest owners would be helpful in promoting PES participation among family forest owners in the region.

Furthermore, we found that forest owners expressed strong negative preferences for the requirement to maintain minimum 150-foot riparian buffers. Matta et al. (2009) found that Florida riparian forest owners require annual payment of 13 dollars per acre per year to accept the requirement to maintain at least 200-foot-SMZ. In our study, forest owners would not accept to participate in the program unless they were offered more than 17 dollars per acre per year. From this result we can gather that forest owners in southeast Georgia may be more sensitive to the minimum SMZ width requirement than forest owners in Florida.

We found that the limits on increasing pine plantation increased survey participants' WTA. The result provides useful information for the development of policies designed to protect bottomland hardwoods forests or other forested wetlands from being converted to pine plantations. For example, it is possible to make a ballpark estimate of the budget necessary for protecting bottomland hardwoods forests by utilizing the WTA compensation for limiting increasing pine plantation area, which amounts to 7 dollars per acre per year.

2. Risk attitudes

When it comes to the role of risk attitudes in forest owners' preferences for PES contractual attributes, we did not find any significant relationships between them. On the other hand, we found that those who tend to be risk averse seem to be more likely to accept PES contracts compared to risk neutral and risk seeking forest owners. Furthermore, risk averse forest owners also require substantially less compensation than less risk averse groups, ceteris paribus. We can infer that this is probably because risk averse owners prefer stable income over having unrestricted property

rights. We can also infer that forest owners' may perceive PES as a less risky forest management decision than business as usual. The result implies that to identify risk averse forest owners and to strategically target them as potential PES participants might be a cost-effective solution to promote PES participation.

3. Policy implications

We studied how the forest owners' risk attitudes affect their conservation decisions using experimental risk elicitation approach and the CE method. We found that the family forest owners' risk attitudes are associated with their propensity to participate in PES programs and their WTA for accepting PES contract. Overall, we found that forest owners in the study area seem to be willing to participate in working forest conservation easement type PES program, with 81 percent of the survey participants choosing at least once to participate in PES alternatives. Compared to the current rate of easement-type PES program participation in the region, which is currently at about 3 percent, this result is notable in terms of the potential of a long-term protection of private forests owned by family forest owners. Furthermore, our study demonstrates how information about family forest owners' risk preferences could reduce the budget required for recruiting PES participants. Risk averse forest owners not only have high propensity to participate in PES programs but also require much smaller compensation for accepting PES contracts than less risk averse forest owners. Together with many other factors such as socioeconomic characteristics, program attributes, and property characteristics, risk preference seems to affect forest owners' WTA compensation and WTP in incentive programs.

However, the study results do not explain what are the specific reasons that drive risk averse forest owners to participate in PES program are. Still, we found the evidence that risk averse forest owners require substantially lower WTA and are more likely to accept PES contracts

compared to risk neutral and risk seeking owners. Also, even though it is difficult to identify one's risk attitude, our study indicates that risk averse owners are likely to be more favourable target audience for PES programs in terms of their high WTP and low WTA. This information can be used in advertising and promoting the PES programs in the way to attract more risk averse people so that the conservation budgets utilized efficiently. For example, governments and environmental organizations may reduce incentive amounts and instead attempt to increase efforts to educate forest owners about the PES programs, which in many cases are still unfamiliar to many forest owners. Risk averse consumers tend not to choose to make an investment when there is uncertainty or they face ambiguous or novel situations. To increase outreach efforts and promote awareness of PES programs could be good strategy to target risk averse forest owners. Also, designing promotional strategy of the PES programs to attract risk averse people might be effective. For example, we can emphasize certain aspects of the PES programs, such as new source of stable incom. To investigate why participating in PES programs attracts risk averse forest owners would provide meaningful information in promoting PES participations by family forest owners and improving the design of PES programs.

Table 2.1 Adjusted Eckel and Grossman risk measure

	Choice	Probability	Payoff	CRRA ranges	Risk attitudes
Lottery 1	A	50%	$800	1.37 < r	Risk Averse
	B	50%	$800		
Lottery 2	A	50%	$560	0.68 < r < 1.37	Risk Averse
	B	50%	$1,210		
Lottery 3	A	50%	$400	0.15 < r < 0.68	Risk Averse
	B	50%	$1,530		
Lottery 4	A	50%	$240	-0.15 < r < 0.15	Risk Neutral
	B	50%	$1,740		
Lottery 5	A	50%	$120	-0.95 < r < -0.15	Risk Seeking
	B	50%	$1,820		
Lottery 6	A	50%	$20	r < -0.95	Risk Seeking
	B	50%	$1,830		

Table 2.2 PES program attributes and levels

PES program attributes	Levels in each attribute
1. Annual payment	$10, $30, $60, and $80 per acre
2. Payment mode	Cash Tax credits
3. Contract length	10, 30, 60 years and perpetual
4. Streamside Management Zone width	40, 70, 100, 150 feet
5. Restriction on increasing pine plantation area	No restriction No further increase in pine plantation area

Table 2.3 Variables used in econometric analysis

Variable	Description
	PES program attributes
Contract Years	Proposed contract length: 10, 30, or 60 years (continuously coded)
Permanent	Perpetual contract length that is perpetual (dummy coded, 1 = yes, 0 = no)
Cash	Payment is provided in cash (effect coded, 1 = cash, -1 = tax credits, 0 = otherwise)
SMZ 70	Minimum SMZ requirement of 70 feet (effect coded, 1 = SMZ 70, -1 = SMZ 40, 0 = otherwise)
SMZ 100	Minimum SMZ requirement of 100 feet (effect coded, 1 = SMZ 100, -1 = SMZ 40, 0 = otherwise)
SMZ 150	Minimum SMZ requirement of 150 feet (effect coded, 1 = SMZ 150, -1 = SMZ 40, 0 = otherwise)
Restriction	Restriction on increasing pine plantation (effect coded, 1 = limitation, -1 = no limitation, 0 = otherwise)
Payment	Proposed payment amount: $10, $30, $60, or $80 per acre per year (continuously coded)
	Risk attitudes
Risk attitude	Individual's CRRA coefficient (continuously coded)

Table 2.4 Sample characteristics

Sample characteristics (n = 253)		
Age (years)	30 to 40	5%
	40 to 50	4%
	50 to 60	22%
	60 to 70	37%
	More than 70	28%
	No answer	4%
Gender	Female	20%
	Male	77%
	No answer	3%
Highest education achieved	High school	22%
	2-year college	15%
	More than 4-year college	59%
	No answer	4%
Annual household income	Less than 150,000	57%
	More than 150,000	21%
	No answer	22%

Retirement status	Not retired	42%
	Retired	55%
	No answer	3%
Association with forestry organization	Yes	17%
	No	83%
Association with environmental organization	Yes	26%
	No	74%
Environmental education	Yes	26%
	No	74%
Tenure length (years)	<5	11%
	5 to 10	9%
	11 to 20	18%
	20+	61%
Mode of acquisition	Gift	3%
	Inherited	37%
	Other	2%
	Purchased	58%
Parcel size	20 to 49	23%
	50 to 99	34%
	100 to 499	43%
	500+	1%

Table 2.5 Proportion of respondents by risk attitudes

CRRA ranges	Risk attitudes	Proportion of choices (n = 253)
$0.15 < r < 1.37$	Risk Averse	53%
$-0.15 < r < 0.15$	Risk Neutral	20%
$r < -0.15$	Risk Seeking	27%

Table 2.6 Results from RPL estimation models (Status quo*Risk attitudes)

Variable	Coefficient	WTA in $/acre/year	95% confidence interval of WTA
Random parameters in utility functions			
Length	-0.06***	- 1.61***	(- 1.25, - 1.96)
Permanent contract	-3.40***	-97.80***	(-74.34, -121.26)
Cash	-0.39***	-11.20***	(-16.00, -6.40)
SMZ 70	-0.18		
SMZ 100	-0.11		
SMZ 150	-0.59***	-16.82***	(- 6.55, -27.08)
Restriction	-0.25***	- 7.14***	(- 2.27, -12.00)
Nonrandom parameters in utility functions			
Payment	-0.03***		
ASC	-1.14***	-32.67***	(-16.00, -49.35)
ASC*Risk attitude	-1.00***	-28.74***	(-46.66, -10.82)
Standard deviations of random parameters			
Length	-0.04***		
Permanent contract	-2.97***		
Cash	-0.52***		
SMZ 70	-0.34		
SMZ 100	-0.16		
SMZ 150	-0.95***		
Restriction	-0.64***		
Standard deviations of latent random effects			
Error component	-3.60***		
Number of observations	-1518		
Adjusted pseudo R^2	-0.33		
Log Likelihood	-1119		

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

CHAPTER 3

DO FOREST PROPERTY CHARACTERISTICS REVEAL LANDOWNERS' WILLINGNESS TO ACCEPT PAYMENTS FOR ECOSYSTEM SERVICES CONTRACTS?

Forest management decisions are determined by a combination of multiple factors such as forestland biophysical and spatial characteristics, institutional factors, landowners' socio-demographical characteristics and preferences, land management objectives, and others. Many studies found that forest owners' preferences towards their property and management objectives play a critical role in their forest management decisions among these factors. Forest owners who value amenities of their forests will manage their forests in the way that they can enjoy those benefits. On the other hand, landowners whose main ownership objective is to generate financial returns from their land will be more interested in managing land so that they can earn money from timber harvests or leasing hunting rights. Forest owners who pursue both non-timber and timber objectives will manage their land in the way they can gain most of the benefits from their property. Furthermore, some forest owners will choose not to actively manage their forestland since they are not interested in specific non-timber or timber outputs, or since they consider it meaningful to just own forestland. Consequently, current forest management on one's property may at least implicitly reveal one's preferences towards his or her property, though there will be certain limitations associated with regulation, physiographical characteristics of the property, and others.

As the importance of family forest owners as a provider of ecosystem services continues to grow, studies have attempted to find the factors that affect family forest owners' participation in conservation programs and identify the targets that are more likely to participate in those

programs. They examined a broad spectrum of factors from forest owners' objectives, socioeconomic characteristics, property characteristics, and incentive program designs. Many studies focused on forest owners' attitudes and management preferences as one of the determinants in their enrollment in payments for ecosystem services (PES) programs. One reason why they emphasize this factor is that participating in PES is a critical forest management decision. Enrolling one's land in PES programs involve various costs and benefits, but still, how a landowner wants to manage her or his property is the most important driver.

Therefore, we expect that current forest management that is expressed by forest property characteristics reveals landowners' values and objectives associated with the property. Consequently, we infer that current forest management adopted on the property may have predictive power in estimating their' willingness to participate (WTP) in PES programs and willingness to accept (WTA) compensation value for such programs depending using revealed preference information such as forest types.

We attempt to investigate the potential of using observable forest management practices through aerial images and public databases to predict forest owners' willingness to enroll their property in PES programs. We expect that the findings of the study would contribute to a more strategic and cost-effective targeting and planning of forest incentive programs for conservation. The finding could save much cost and time to conduct surveys or interviews to collect underlying preference information.

The objectives of the study are to:

1) Identify riparian forest parcels and collect stated preference information about those specific forest parcels using choice experiment.

2) Analyze current forest management approaches on the participants' properties. We use forest property characteristics as a proxy for current forest management, and assess the proportion of different forest types in each forest parcel.
3) Test correlations between forest types and forest parcel ownership objectives for the property.
4) Predict forest owners' preferences towards PES programs using forest property characteristic variables.

Background

1. Forest owners' objectives and forest management decisions

Family forest owners' objectives are more diverse compared to other types of private forest owners such as corporate forest owners and institutional forest investors who mainly seek financial returns from their forest property. A number of studies explored the family forest owners' values and objectives and found that they are motivated by various objectives from enjoying scenic beauty, generating income from timber sales, recreation, preserving a family legacy, land investment, environmental conservation, and others (Dhubháin et al., 2007, Kuuluvainen et al., 1996, Bengston et al., 2011, Karppinen, 1998, Kendra and Hull, 2005, Jennings and van Putten, 2006, Ross-Davis and Broussard, 2007, Boon and Meilby, 2007, Blanco et al., 2015, Khanal et al., 2017) .

Forest owners' objectives are also known to be critical factors that affect their management decisions (Dhubháin et al., 2007). Previous studies tried to investigate how forest owners' objectives and motivations were associated with actual forest practices they undertake. The work by Marty et al. (1988) was one of the earliest attempts to analyze the relationship between forest

owners' objectives and actual forest management. They classified the non-industrial private forest (NIPF) owners in Missouri and Wisconsin into groups with homogeneous ownership objectives that were identified in the previous studies (Marty et al., 1988, Kurtz and Lewis, 1981). Their study suggested that timber production forest owners were the group that involved active forest management such as timber stand improvement and conducted timber inventory than other groups. Kuuluvainen et al. (1996) adopted a more elaborate approach to link ownership objectives and management practices. In their study conducted in southern Finland, the quantifiable relationship between ownership objectives and actual harvesting decisions was found. The result provided the foundation for the thought that it may be possible to use forest owners' objectives to predict timber sales. Karppinen (1998) clustered Finnish forest owners into four groups depending on their long-term forest ownership objectives. They found that forest owners with multiple objectives including non-timber and economic goals and self-employment opportunities were most active forest owners among those clusters regarding recent forest management activities. The results showed that forest owners with no significant economic objectives were as much engaged in active forest management and timber production as the economically motivated group. Kendra and Hull (2005) investigated ownership motivations and management intentions of new forest owners in Virginia. They found that forest owners' motivations influenced their management intentions and forestry practices. Jennings and van Putten (2006) investigated NIPF owners in Tasmania, Australia. They found that the owner groups that were seeking income and investment from their forestlands were conducting much more intensive forest managements compared to owners that were concerned with non-timber values, agriculturalists, and multi-objective owners. Non-timber output owners were found to undertake forest management practices that could generate more non-timber goods

and services such as afforestation, wildlife habitat management, and recreational activities than other groups.

Ross-Davis and Broussard (2007) clustered family forest owners in North Central Indiana into three groups of forest managers, new forest owners, and passive forest owners based on their ownership objectives and other characteristics. The study found that these different groups used different forest management practices such as planting trees and timber harvests. Boon and Meilby (2007) classified Denmark forest owners using their ownership preferences and silvicultural practices and clustered those owners into four latent groups. The study found that different clusters of forest owners were motivated by different objectives, and consequently were motivated to choose different forest management practices. For example, the groups classified as production-oriented and classic forest owner types were more likely to engage in choosing marketable species and practices. On the other hand, the environmentalist, recreationalist, and indifferent forest owners seemed to choose close-to-nature management practices when compared to other groups. Blanco et al. (2015) analyzed private forest owners in several countries in Europe and the U.S. using the meta-analysis approach. The study found that forest owners were likely to have a different level of management intensity and management approaches depending on forest owner types they belonged to, suggesting that ownership objectives were related to management practices. According to their analysis, the profit-oriented forest owner type was more likely to undertake intensive management practices and to have plantation forests with single species than other owners. The multi-objective group tended to have more diverse stands than profit-oriented forest owners. Recreationalists were found to undertake close-to-nature or to have very low-level management practices (e.g., conducting no management or allowing natural growth). They tended to own natural forests and deciduous forests. Passive forest owners tended to conduct the least

management practices and have unmanaged stands. Khanal et al. (2017) clustered southern U.S. family forest owners into three groups whose ownership objectives were associated with seeking to achieve amenity, multi-objective, and timber goals. They found that these groups demonstrated the differences in forest management practices. They found that multi-objective and timber clusters were more likely to have pine forest than amenity cluster. Also, it was found that the amenity cluster had much more mixed forests with hardwood and pine than other groups. The study found that the timber-oriented forest owner group was more likely to have a high proportion of loblolly pine in their forestland than other groups.

2. Forest owners' objectives and PES participation

As the importance of family forest owners in the U.S. is growing in forest conservation and maintaining the sustainable provision of ecosystem services derived from the forestlands owned by them, more studies are investigating their preferences for forest ecosystem services and preferences for PES programs. Studies introduced family forest owners' objectives in the models for analyzing WTP in PES programs and WTA compensation. They found that forest ownership objectives play a major role in their decision to participate in PES programs and the amount of compensation they require (Matta et al., 2009, Mäntymaa et al., 2009, Rabotyagov and Lin, 2013, Kline et al., 2000b).

Kline et al. (2000b) investigated NIPF owners' WTA compensation for not harvesting timber for ten years on the riparian areas in western Oregon and western Washington. They introduced four different ownership clusters including: 1) timber producers, 2) multi-objective owners, 3) recreationists, and 4) passive owners in their model to predict forest owners' willingness to forego harvest. The study found that WTA of the forest owners who were classified as timber producers was the highest among those groups. Also, according to their findings, forest

owners who were more interested in non-timber values (multi-objectives and recreationists) were more willing to forego harvest and expected smaller incentives than the other groups. Mäntymaa et al. (2009) investigated Finnish forest owners WTA and WTP in a PES program. They included forest owners' objectives as explanatory variables in the model for estimating forest owners' participation in the PES program. The study found that both financial motivation and environmental preferences were positively correlated with forest owners' likelihood of participation in the program. Also, the study found that environmentally motivated forest owners' WTA was smaller than the other owners. Matta et al. (2009) investigated family forest owners in Florida and their WTA compensation for accepting PES for biodiversity conservation. They found that WTA values varied depending on forest owners' objective. Rabotyagov and Lin (2013) included forest ownership objectives in the model for predicting Washington family forest owners' participation in working forest conservation easement programs. The study found that forest owners who reported that timber revenues were the most significant ownership objective had smaller WTA than the other owners. However, they found that a dummy variable associated with environmental goals was not significant.

Overall, based upon these studies, the evidence suggests there is a linkage between landowner objectives with their forest property and preferences for PES programs, thus raising the potential for identifying and targeting PES programs. While information about landowners' objectives in managing their land and their attitudes is useful in designing and implementing PES programs, such information is typically difficult to obtain since it requires costly and time-consuming surveys or interviews. Our study started with the task of how to overcome this limitation. What if we could use proxies for forest owners' objectives, which could be relatively easily obtained? Numerous studies found that current forest management reflected through forest

property characteristics reveals forest owners' values and objectives associated with the property. Therefore, we hypothesized that it might be possible to use current forest property characteristics in predicting the landowner's WTP in PES programs and WTA compensation.

3. Potential of using current forest management for predicting PES participation

Our study starts from an assumption that if forest management decisions reflect the forest owners' preferences and ownership objectives, we may be able to predict forest owners' preferences towards PES programs using revealed preference information such as forest management types on the property. By doing so, we could reduce cost and time required to identify and target potential PES programs. This idea is in line with previous studies that suggested forest owners' current silvicultural practices and forest management decisions reveals the landowners' perceived values attached to such non-timber forest services as amenities or biodiversity. Raunikar and Buongiorno (2006) found that non-industrial forest owners who choose to manage their stands in a more natural way are willing to forego substantial profits derived from managing the same stands intensively. Their findings suggest that forest owners' WTA payments for forest amenities is reflected in the management approach they choose. Several other studies found that forest types on the property were associated with forest owners' objectives (Blanco et al., 2015, Greene and Blatner, 1986, Khanal et al., 2017). In this study, we chose the forest types and the presence of residential structure on the property as a proxy for forest management that reflects family forest owners' objectives and preferences. The common forest types in our study area include oak-hickory, oak-gum-cypress, mixed oak-pine, and loblolly-shortleaf pine forests (Brandeis et al., 2016).

Data and Methods

1. Study area and data collection

Detailed information about the study area and data collection is provided in chapter 2. It should be noted that the sample size is slightly different from chapter 2, because of the incomplete surveys. Total 250 samples were analyzed in this chapter. After collecting the riparian forest parcel information, we checked the parcels again using ArcGIS 10.4, a geographic information system (GIS) software, to ensure the forest parcels have riparian forest areas. We overlaid the parcel boundaries with National Hydrography Dataset provided by U.S. Geological Survey and filtered the parcels without intermittent streams, permanent streams, or other surface water bodies. Total 4,600 forest owners were identified, and in the late summer of 2016, we sent mail surveys to randomly selected 1,350 forest owners among them. Two weeks later, the reminder postcards were sent. Four weeks later, the final replacement surveys were sent. We also attached URL address to an online survey in mail surveys and postcards. Furthermore, we included phone numbers and email addresses of the principal investigator and co-investigator in the surveys and reminder postcards so that survey participants could ask questions associated with the survey. Since there are many forest owners who own more than one forest or non-forest property, we used the parcel tax number, which is a unique id assigned to a property in each county, as an identifier. Forest owners were asked to complete questionnaires about their ownership objectives and multiple-choice questions associated with specific forest. The questionnaire was reviewed by a group of experts and family forest owners. After the review, we revised the terms used in the survey and clarified the questions before we sent the questionnaires.

In this study, we used the following classification made based on the popular forest types in the area: 1) bottomland hardwood (BH) forests, 2) upland hardwood (UH) forests, 3) natural

pine (NP) forests, 4) planted pine (PP) forests, 5) and mixed oak-pine (OP) forests. According to this classification, oak-gum-cypress forests were considered as bottomland hardwood forests. Other hardwood forests were considered as upland hardwood forests. Pine forests were classified as PP and NP forests based on observable management. Mixed oak-pine forests, which consist of both hardwoods and substantial pine stocking are classified as OP forests.

Each forest property in the sample was analyzed based on multiple high-resolution images including the National Agriculture Imagery Program images, Google Earth historical images, and Digital Globe sub-meter images. Because forests in the same forest type groups are associated with similar species composition and site requirements, we used both aerial photo interpretation and geological information in classifying forest types in the sample parcels. For example, since it is hard to distinguish BH from UH stands, we used the National Wetlands Inventory to identify bottomland hardwood forests. We classified the hardwood stands that were overlaid with the National Wetlands Inventory maps as BH forests. When it comes to identifying PP forests, if pine stands on a parcel were recently clearcut and artificially regenerated and if visible tree rows were identifiable, the forest stands were classified as planted pine. If there is no or very low evidence of intensive management, we classified the stands as NP. We obtained the information about the proportions of different forest types, water, and the non-forested land of each property.

In addition to forest types, residential structures on the properties and the size of the properties were assessed using aerial photo analysis. In terms of the residential structures, some properties were densely forested, which made the analysis difficult. In addition to analyzing aerial photos, we also matched mailing address and property address and concluded that if both addresses are the same, there is some sort of residential structure on the property. To increase the accuracy of the forest property characteristics analysis, we asked survey participants about the presence of

intensively managed pine stands on their parcel and if the residential objective is important ownership objectives associated with the specific property. We found that our remote sensing analysis results were consistent with their responses.

2. Relationship between forest types and forest ownership objectives

We obtained survey participants' objectives for the specific property by asking them to select the proper Likert scale value from (unimportant) to 5 (very important) regarding with presented ownership objectives as following: 1) aesthetic enjoyment (*Aesthetic*), 2) personal residence (*Residence*), 3) personal recreation (*PerRec*), 4) maintaining healthy environment (*Environment*), 5) income from timber harvest (*Timber*), 6) income from recreation (*IncRec*), 7) land investment (*Investment*), 8) family legacy (*Legacy*), and 9) Privacy (*Privacy*).

To investigate the relationships between the proportion of each forest type on one's property and various forest ownership objectives, we conducted Spearman rho tests. Spearman's correlation can be employed to evaluate the strength of the correlation between interval, ordinal, or ratio variables. Using Spearman's correlation, we can discover if the strength of certain ownership objective is related to monotonic increase or decrease in the percentage of specific forest types. Spearman's correlation coefficient is constrained between −1 and +1. The closer coefficient is to −1 or +1, the stronger the monotonic relationship between two variables.

3. Econometrical analysis

A multinomial logit (MNL) model and random parameters logit (RPL) with error component specification were used to analyze the impact of forest types in family forest owners' decisions to participate in PES programs. Both models are widely used in analyzing choice experiment data, but recently RPL is becoming a dominant model. First, while MNL model specification requires the error terms to be independently and identically distributed (IID) and to

follow type 1 extreme value (McFadden, 1974a), RPL specification allows IID error terms. Therefore, RPL allows correlations among different alternatives. Also, other standard logit models including MNL assume that the coefficients for choice experiment variables are fixed across different individuals. However, by using RPL model, we can incorporate the preference heterogeneity among different respondents (Train, 2009b). We adopt RPL as the main model and use MNL for obtaining supplementary information. We specify the utility of a forest owner i for an alternative j in nth choice sequence as following:

$$U_{ijn} = \beta_i'(X_{ijn}, F_i) + \eta_j E_{ij} + \varepsilon_{ijn} \tag{3.1}$$

where X_{ijn} represents the contract attributes of PES alternatives and forest management types on the property questioned, F_i represents forest properties and managements, $E_{ij}$is random error component with zero mean, and η_j is parameter estimate for the error component. ε_{ijn} represents an error term with IID extreme value distribution. Following function demonstrates sample likelihood of respondent i to choose an alternative j in nth choice sequence for RPL model:

$$P_i = \iint \prod_{n=1}^{N} \left[\frac{exp\left(\beta_i'(X_{ijn}, F_i) + \eta_j E_{ij}\right)}{\sum_j^J exp\left(\beta_i'(X_{ijn}, F_i) + \eta_j E_{ij}\right)} \right] \phi(\beta_i)\phi(E_i) d\beta_i dE_i \tag{3.2}$$

Detailed information about the models we adopted, the random parameter logit (RPL) and multinomial logit (MNL), is presented in chapter 2. We followed the same maximum likelihood procedure as described in chapter 2. We used delta method to estimate forest owners' WTA (Hensher et al., 2015). Program attribute variables including payment mode and minimum streamside management zones (SMZ) widths were effect coded. The restriction on increasing pine plantation was dummy coded. Contract length variable was coded in two ways. The perpetual contract was dummy coded, and contract length from year 10 to 60 was continuously coded. Annual per-acre compensation amount variables were continuously coded. All the survey

participants were asked to complete six choice scenarios. Each scenario consisted of three options including two PES contracts and the Status Quo option.

Results

1. Survey results

The response rate was 22 percent. We received 296 online and mail surveys and concluded that 250 surveys were usable after excluding the incomplete questionnaires. Since all the participants were provided with six choice scenarios, total observations are 1,500. To address potential nonresponse bias, we adopted the extrapolation method suggested by Armstrong and Overton (1977), which is to make a comparison with known values for the population. As known values for the population, we used the National Woodland Owner Survey (NWOS) data, which is the official census of forest owners in the U.S. collected on an annual basis in each state. We compared the respondents' socioeconomic characteristics and forest property characteristics to the NWOS data gathered in Georgia from 2011 to 2013. We found that our sample is consistent with data collected in NWOS in terms of mode of acquisition, written management plan status, retirement status, age, gender and education (Figure 3.1).

2. Ownership objectives and forest management type

Table 3.1 demonstrates various ownership objectives and the proportion of the respondents who rated each objective. Table 3.2 demonstrates the Spearman correlation between forest types and ownership objectives. We found that the proportion of PP on the forest property is correlated with all the ownership objectives we provided other than *Investment* and *Legacy*. The proportion of BH was related to all the ownership objectives excluding *Environment, Investment, Legacy,* and *Privacy*. The percentages of UH and OP were linked to fewer forest ownership objectives than

first two forest types. However, NP seemed to have no notable correlation with any of the ownership objectives.

The proportion of PP stands in a forest parcel appeared to be negatively correlated with *Aesthetic*, *Residence*, *PerRec*, *Environment*, and *Privacy* variables. On the other hand, the PP percentage was positively related to *Timber* and *IncRec* variables. The proportion of BH forest was positively correlated with *Aesthetic*, *Residence*, and *PerRec*, and was negatively correlated with *Timber* and *IncRec.* It was notable that while the proportion of PP and BH are correlated with the same variables including *Aesthetic*, *Residence*, *PerRec*, *Timber*, and *IncRec*, but the signs of the correlations are the opposite. The proportion of PP is negatively correlated with *Aesthetic*, *Residence*, and *PerRec*, and the proportion of BH is positively correlated with those variables. On the other hand, in terms of *Timber* and *IncRec*, the proportion of PP is positively correlated with those variables and the proportion of BH has a negative correlation with them. The proportion of UH forest was positively correlated with *Environment*, *IncRec*, and *Legacy*. The proportion of OP forest was negatively correlated with *Timber* and *Investment*.

3. Estimation results

Table 3.3 demonstrates the variables used in the econometric analysis. Table 3.4 shows the estimation results of MNL and RPL models. The signs and significance of the coefficients for MNL and RPL models were consistent with each other. Both models find that forest owners were less likely to participate in a PES program with long or permanent contract lengths, a program that provided tax incentives instead of cash, a program that required participants to establish the SMZ more than 150 feet, and a program that limited expanding intensive PP areas beyond the current level. Forest owners' marginal WTA amounts were calculated using RPL results. Survey participants expected to receive about $1.70 per acre per year more as contract length increased by

one year. However, when it comes to the contract that will last in perpetuity, forest owners required $100 per acre per year. Forest owners' WTA decreased by $11 per acre per year if the compensation is paid in cash. Forest owners required $18 per acre per year if they were required to establish and maintain minimum 150-foot SMZ area. When increasing PP area on the property was limited, forest owners would require about $28 per acre every year as compensation.

The impact of forest property characteristic variables including *% of PP*, *% of BH*, *% of UH*, *% of OP*, *Residence* and *Size* were captured by ASC (Holmes and Adamowicz, 2003). The positive sign of the coefficients of property characteristic variables means that forest owners prefer to choose the status quo option, which is not to participate in any of the presented PES alternatives. The negative sign of the coefficients for these variables indicates that the indirect utility of the forest owners increases by choosing to participate in one of the two alternatives. ASCs in both models were positive and significant, which implied that forest owners' utility increased by selecting status quo option when everything else held constant (e.g., when no compensation is provided). In MNL model estimation, the coefficients for *% of PP*, *% of BH*, *% of MX*, and *ForsResi* were negative and significant. In RPL model, the coefficients for *% of PP*, *% of BH*, and *Residence* were negative and significant. If a forest owner had a large proportion of planted pine or bottomland hardwood forests on one's property and if the owner had a residence on the property, the landowner was likely to participate in PES programs with smaller compensation than the other landowners. For example, the forest owners' baseline payment requirement was $164 per acre per year, but if their property was covered by only PP, they would only require $17 per acre per year to consider participation. If forest owners' property was covered by only BH forests, they would require only $17 per acre per year as a baseline payment. Furthermore, if there was a residence on one's property, one's WTA will decrease by $33 per acre per year. The coefficients for other

variables associated with the forest types, *% of UH*, *% of OP*, and the interaction between *Restriction* and the proportion of non-pine area *(1 - % of PP)* were not statistically significant.

Discussion and Conclusions

1. Ownership objectives and forest types

Based on Spearman rho test results, we found that *% of PP* and *% of BH* had significant correlations with most of ownership variables among other forest type variables. We could reasonably infer that this might be because these two forest types, PP and BH forests, reflect forest owners' management preferences relatively well compared to the others. Furthermore, we found that although these two variables, *% of PP* and *% of BH*, were correlated with the same ownership objectives, the signs of the correlations were the opposite. This means that forest owners who valued a certain objective were more likely to own land with a high proportion of one of the forest types, and a low proportion of the other forest type. For example, forest owners who reported that earning income from timber harvest was critical were likely to have a high percentage of PP on their property and a low proportion of the BH forests. This result is consistent with the findings of previous studies. For example, it was found that the forest owners who considered the timber revenue were more likely to have a plantation with single species on their forestland than other forest owners (Blanco et al., 2015, Khanal et al., 2017). Further, forest owners who valued amenities important tended to have more diverse stands than the other types of forest owners (Blanco et al., 2015, Khanal et al., 2017). Forest owners who valued non-timber forest owners were found to have very low-level of forest management practices or close-to-nature management on their property as well. This tendency supports the potential of forest types as proxies of landowner's management objectives associated with his or her property.

2. Forest property characteristics and participation decisions

In both MNL and RPL models, the coefficient for *% of PP* and *% of BH* were negative and significant. Forest owners who had a large share of these two types of forests on their property were more likely to choose to participate in PES program and expected substantially less compensation than other forest owners. It is notable that while *% of PP* and *% of BH* seemed to reflect the different preferences on the same objectives (Table 3.2), the coefficients for these variables in RPL models had the same sign and are substantial (Table 3.4). As forest owners had either a high proportion of PP area or the high percentage of BH forests, they were more willing to enroll their property in presented PES programs. Table 3.2 shows that forest owners who valued non-timber benefits (*Aesthetic*, *Residence*, *PerRec*, and *Privacy*) were more likely to have a high proportion of BH forests on their property. On the other hand, forest owners who believed that objectives associated with generating income from timber or recreation were more likely to have the high proportion of PP. We could infer that forest owners who have high proportion of BH are more likely to participate in PES programs than the others since their opportunity costs of enrolling their property in PES is substantially smaller than for the other landowners. They appreciated non-timber benefits from their property, and naturally, they had positive willingness to pay for those benefits, which reduced WTA compensation. This result is consistent with the findings of Raunikar and Buongiorno (2006). They found that NIPF forest owners who had more close-to-nature properties were willing to forego profit from undertaking intensive forest management practices because of their positive willingness to pay for amenities. Furthermore, it is possible to infer that forest owners who have a high proportion of PP are keen to assess financial opportunities associated with their forest property and view participating in PES programs as a good source of additional income in spite of the management requirements and the loss of development right on

their property. From the results, we can see that forest owners' motivation to participate in PES programs can vary from continuous enjoyment of non-timber benefits from the property to additional income. This result supports the findings of Mäntymaa et al. (2009) that forest owners' with financial objectives, especially revenue from harvesting timber, showed positive attitudes towards a given PES contract. Forest owners who value non-timber values of their property and forest owners who pursue income from their property both are more likely to participate in PES with smaller compensation, which is consistent with previous studies (Kline et al., 2000a, Rabotyagov and Lin, 2013). To examine the impact of additionality on one's preferences towards PES designs (Vedel et al., 2015), we examined the interaction between the restriction to increase pine plantation area and the proportion of non-pine plantation areas on one's property and found that the coefficients were not significant in both MNL and RPL models. The result is different from the findings of Vedel et al. (2015), which suggests forest owners are sensitive to PES attributes with additional management requirements or restrictions. However, we cannot exclude the possibility that high costs associated with converting riparian forest to pine plantation make landowners less interested in this specific PES attribute.

3. Residence on the property and WTA

Residence was found to be significant and negative, which indicates that forest owners who use their property as a primary or vacation residence are more likely to participate in PES and also expect smaller WTA compared to those who are not. The result associated with high willingness to participate of forest owners who had a residence on the property was consistent with previous studies that found family forest owners' probability of participating in PES increase if they reside on the property, or they have a residence on the property (Nagubadi et al., 1996, Matta et al., 2009, Layton and Siikamäki, 2009). However, our finding associated with a smaller WTA of resident

owners is not consistent with the previous study. For example, Lindhjem and Mitani (2012) suggested that residence owners required a higher WTA than absentee owners since residence owners were more likely to be engaged in more active forest management and were more keen to opportunity costs of conservation. We infer that the resident owners' WTA is smaller than absentee owners since they reside on the property and consequently appreciate non-timber benefits such amenity more than those who do not. Naturally, residence forest owners' opportunity costs to enroll the property on they are residing on the conservation contract would be lower than non-resident owners.

4. Forest property size

Many studies have found that size of forest holding affected forest owners' participation in PES programs (Mäntymaa et al., 2009, Langpap, 2004, Sullivan et al., 2005, Rabotyagov and Lin, 2013). However, both the MNL and RPL model estimation results show that size of the property does not affect forest owners' willingness to participate in incentive programs. This is perhaps because our study is taking a unique approach to calculating forest owners' property sizes. For example, we first obtained information about forest properties that were interested and then asked questions specific to those forest properties to owners of them. It is reasonable to assume that since many forest owners have more than one forest property, the size of one forest property may not be a significant factor that affects landowners' decision.

5. Conclusions

We examined the potential of forest property characteristics in estimating forest owners' willingness to participate in PES programs and compensation amount. We found that the presence and proportion of certain forest types (PP and BH forests) and a residential structure were associated with forest owners' willingness to participate and WTA. Forest owners were more

likely to enroll their property in a conservation contract if there existed PP forests and BH forests, or a residential structure on the property. Furthermore, their WTA compensation to participate in PES programs significantly decreased as the proportion of PP forests or BH forests increased on the property. The presence of a residential structure also reduced one's WTA as well. Our study found that the presence of PP and BH forests, and a residential structure on one's property might be used in predicting one's likelihood of enrolling the property in conservation contracts. We expect that the findings of the study would contribute to more strategic and cost-effective targeting and planning of forest incentive programs for conservation. The finding may reduce cost and time to conduct surveys or interviews to collect underlying preference information.

However, the results of the study should be used with caution since there are some limitations. The sample size of the study is relatively small compared to other studies that investigated forest owners' preferences toward PES participation. Secondly, our study does not rule out the impact of potential attribute non-attendance (ANA). When an individual is given a choice task, instead of making trade-offs among all the attributes, the respondent ignores some attributes that are less preferred and uses simpler rules to decide for various reasons (Payne et al., 1993). In the choice experiment, ANA is caused when a respondent ignores or fails to consider some of the attributes when choosing one of more alternatives among competing alternatives with varying levels of attributes. We included an additional question to address the ANA issue using an approach suggested by Balcombe et al. (2014). We asked respondents to rank the importance of attributes after all choice experiment questions are completed. However, we found that most participants did not complete the question. Thirdly, it should be noted that we are only investigating a forest owner's preference for one specific property. It is known that many forest

owners have multiple forest properties, and it would be useful to study their preferences when considering enrolling one property among multiple holdings.

Table 3.1 Forest ownership objectives (n = 250)

Ownership objectives	**Proportion of forest owners (percent)**					**Total**
Likert scale	**1** Unimportant	**2**	**3**	**4**	**5** Very important	
Aesthetic	12	6	22	26	34	100
Residence	50	10	7	9	24	100
PerRec	18	5	18	24	35	100
Environment	8	4	18	26	44	100
Timber	10	8	21	22	39	100
IncRec	52	12	13	9	14	100
Investment	12	6	22	24	36	100
Legacy	11	7	17	16	49	100
Privacy	16	8	15	14	47	100

Table 3.2 Spearman correlation coefficients between forest types and ownership objectives (n = 250)

Variables	***% of PP***	***% of BH***	***% of UH***	***% of OP***	***% of NP***
Aesthetic	**-0.12***	**-0.11***	-0.07	-0.06	-0.01
Residence	**-0.24*****	**-0.14****	-0.07	-0.06	-<|0.01|
PerRec	**-0.11***	**-0.13****	-0.05	-0.01	-0.08
Environment	**-0.11***	-0.02	**-0.12***	-0.08	-<|0.01|
Timber	**-0.40*****	**-0.24*****	-0.03	**-0.14****	-0.02
IncRec	**-0.12***	**-0.15****	**-0.12***	-0.03	- 0.03
Investment	-0.07	-0.04	-0.03	**-0.12***	- 0.02
Legacy	-0.04	-0.10	**-0.14****	-0.02	- 0.02
Privacy	**-0.17*****	-0.10	-0.04	-0.04	- 0.07

***, **, * Spearman correlation significance at 1%, 5%, 10% level

Table 3.3 Variables used in econometric analysis (n = 250)

Variable	Description
PES program attributes	
Contract Years	Proposed contract length: 10, 30, or 60 years (continuously coded)
Permanent	Perpetual contract length that is perpetual (dummy coded, 1 = yes, 0 = no)
Cash	Payment is provided in cash (effect coded, 1 = cash, -1 = tax credits, 0 = otherwise)
SMZ 70	Minimum SMZ requirement of 70 feet (effect coded, 1 = SMZ 70, -1 = SMZ 40, 0 = otherwise)
SMZ 100	Minimum SMZ requirement of 100 feet (effect coded, 1 = SMZ 100, -1 = SMZ 40, 0 = otherwise)
SMZ 150	Minimum SMZ requirement of 150 feet (effect coded, 1 = SMZ 150, -1 = SMZ 40, 0 = otherwise)
Restriction	Restriction on increasing pine plantation (dummy coded, 1 = restriction, 0 = otherwise)
Payment	Proposed payment amount: $10, $30, $60, or $80 per acre (continuously coded)
Interaction between PES program attributes and forest property characteristics	
*Restriction *(1-% of PP)*	Interaction between restriction on increasing pine plantation and the proportion of non-planted pine area
Forest property characteristics	
% of PP	The proportion of planted pine forests on a property
% of BH	The proportion of bottomland hardwood forests on a property
% of UH	The proportion of upland hardwood forests on a property
% of OP	The proportion of mixed oak-pine forests on a property
Residence	1 if there is a residence structure on a property (1 = yes, 0 = no)
Size	Size of the forest parcel (acre)

Table 3.4 Results from MNL and RPL estimation models

Variable	MNL Coefficient	RPL Coefficient	WTA ($/acre/year)	95% confidence interval of WTA
Random parameters in utility functions				
Contract Years	**-0.03*** **	**-0.06*** **	**- 1.66**	(-2.02, -1.31)
Permanent	**-1.20*** **	**-3.48*** **	**- 100.24**	(-123.52, -76.96)
Cash	**-0.19*** **	**- 0.39*** **	**- 11.15**	(- 6.10, - 16.19)
Tax Credits	-0.19	-0.39		
SMZ 40	- 0.27	- 0.62		
SMZ 70	- 0.12	- 0.22		
SMZ 100	-0.02	- 0.10		
SMZ 150	**-0.27*** **	**-0.62*** **	**- 17.77**	(-28.86, -6.67)
Restriction	**-0.45*** **	**-0.99*** **	**- 28.41**	(-47.54, -9.28)
Nonrandom parameters in utility functions				
Restriction*(1-% of PP)	-0.39	- 0.65		
Payment	**-0.02*** **	**- 0.03*** **		
ASC	**-2.42*** **	**- 5.68** **	**- 163.57**	(- 16.35,-310.79)
% of PP	**-1.92*** **	**-5.12***	**-147.31**	(-298.64, - 4.03)
% of BH	**-1.86*** **	**-5.10***	**-146.89**	(-315.60, - 21.82)
% of UH	-0.56	-1.84		
% of OP	**-1.42** **	-4.95		
Residence	**-0.47*** **	**-1.15***	**-33.06**	(-67.41, - 1.30)
Size	-0.01	-0.01		
Standard deviations of random parameters				
Contract Years		**-0.04*** **		
Permanent		**-2.66*** **		
Cash		**-0.59*** **		
SMZ 70		-0.39		
SMZ 100		-0.22		
SMZ 150		**-1.07*** **		
Restriction		**-1.37*** **		
Standard deviations of latent random effects				
Error component		**- 3.49*** **		
Number of observations		- 1500-		
Adjusted pseudo R^2		- 0.33		
Log Likelihood		-1096		

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

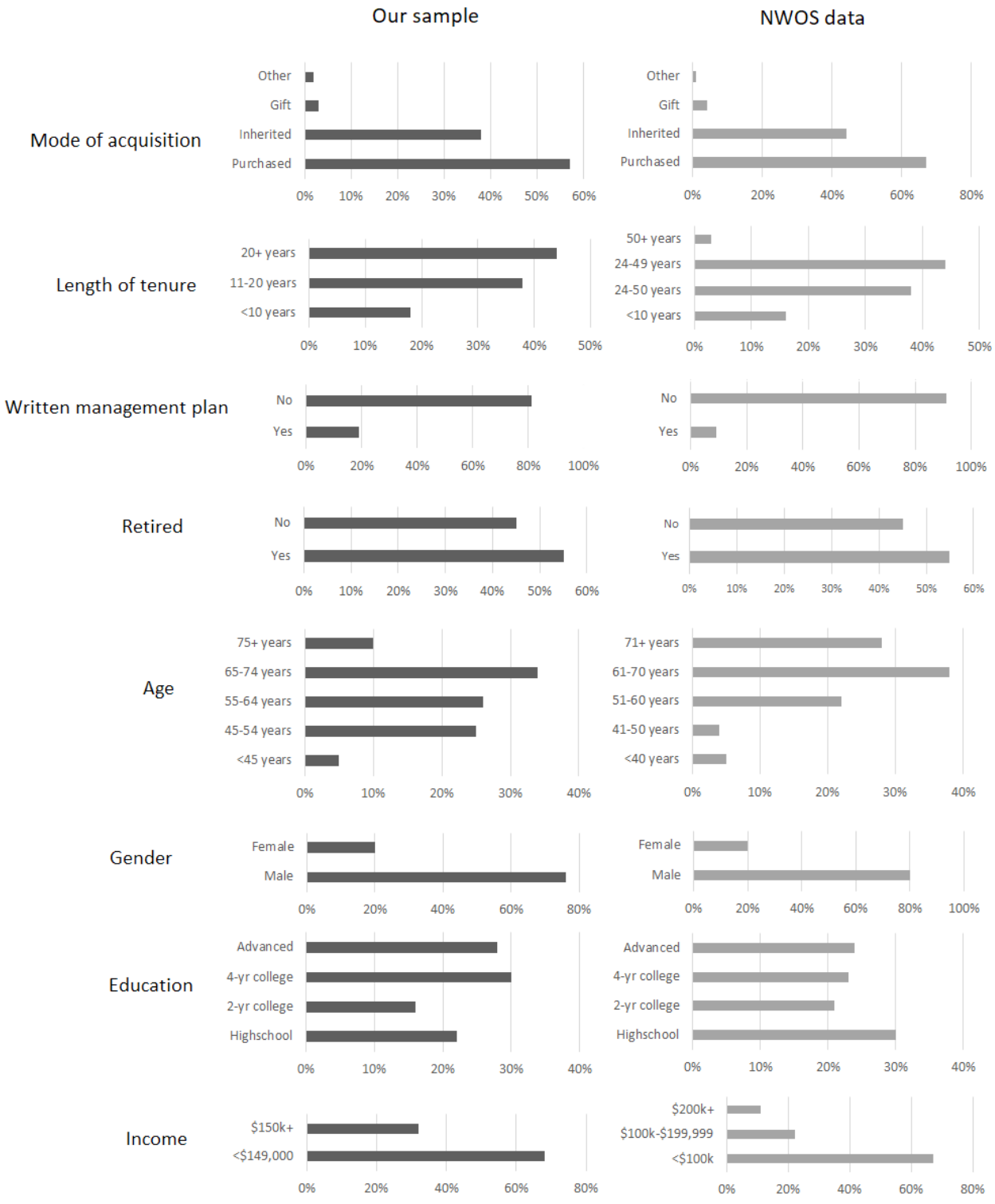

Figure 3.1 Summary of survey data

CHAPTER 4

TYPOLOGY OF RIPARIAN FOREST OWNERS IN SOUTHEAST GEORGIA

Family forest owners account for a major share of the private forests in the U.S. and their importance as a provider of essential ecosystem services from timber to diverse environmental services such as air and water protection, recreational opportunities, and wildlife habitat continues to grow (Butler, 2008). Government and environmental organizations have been trying to engage family forest owners in various incentive and conservation programs to maintain the sustainable provision of benefits derived from working family forests (Kilgore et al., 2007). The varied characteristics of family forest owners, however, make it hard for them to decide how to communicate environmental policies and how to promote those programs. Family forest owners are a very complex and heterogeneous group in terms of why they own and manage forests, what they value in their properties, and how they want their forests managed. They have diverse objectives and preferences, and it may not be reasonable to approach them as if they are a uniform group with the same goals and values.

There have been many efforts to classify forest owners into groups with similar objectives and motivations (See Background Section *1. Typology of forest owners*). Classifying forest owners into different groups with similar objectives and needs provides useful information for policy-making and targeting for forest conservation.

In this study, we classify forest owners who own forest parcels with a riparian area in southeast Georgia, which is one of the most forested areas in the state. We identify forest owner groups with similar motivations based on their objectives and compare these groups with their

socioeconomic and forest property characteristics. Furthermore, we analyze how different ownership segments affect landowners' willingness to accept (WTA) payments for ecosystem services (PES) contracts that are designed to protect water quality and to maintain the sustainable provision of ecosystem services. In doing so, we adopt market segmentation approach which has been previously applied in typology studies that study family forest owners (Khanal et al., 2017, Kuuluvainen et al., 1996, Kline et al., 2000c, Majumdar et al., 2008). Also, we collected and analyzed choice experiment (CE) data associated with forest owners' preferences toward different PES designs.

The objectives of the study are to:

1) Identify forest ownership groups using principal component analysis (PCA) and k-means clustering analysis (CA)
2) Compare forest owner groups with current forest management practices
3) Predict forest owners' willingness to accept PES programs using identified segments
4) Develop policy implications

Background

1. Typology of forest owners

Many studies focused on forest owners' objectives and motivations to identify forest owners types. Kurtz and Lewis (1981) and Marty et al. (1988) used two-step interviews to identify forest owner groups based on their common attitudes towards forests and forestry in Missouri and Wisconsin. These studies tried to find how these owner types affected forest management decisions. They found that there existed different owner types with similar objectives and emphasized the need for targeted outreach or government programs for different owner groups.

Later studies started to adopt market segmentation techniques such as PCA, CA, and factor analysis (FA) to identify forest owner typologies. Kuuluvainen et al. (1996) classified forest owners into groups using ownership objectives and estimated a timber supply model with identified forest owner groups to empirically analyze private timber supply in Finland. The study found that different forest types were associated with different timber harvest levels. Forest owners who were classified as *multi-objective owners* were found to be the group who harvested the most. Their timber sales were greater than the group who reported that they considered the income from timber sales most important.

Karppinen (1998) identified forest owner groups in Finland based on forest owners' values attached to their forest property and their objectives. The study found that ownership segmentations based on forest values and objectives were not strongly correlated with each other. The study also suggested that the multi-objective owner group was engaging in forest management and timber harvest most actively among the four forest owner groups: 1) *Multi-objective owners,* 2) *Recreationists,* 3) *Self-employed owners,* and 4) *Investors.* Kendra and Hull (2005) conducted CA to segment new forest owners in Virginia using ownership motivations. The study found that all the forest owner groups were more interested in forest benefits associated with lifestyle and amenities than economic returns derived from timber sales.

In their study on the typology of forest owners in Tasmania, Australia, Jennings and van Putten (2006) identified forest owner groups including 1) *Income and investment owners,* 2) *Non-timber output owners,* 3) *Agriculturalists,* and 4) *Multi-objective owners* and found that these groups showed differences in how they managed their properties, timber, and harvest. The study found that *Income and investment owners* were more likely to have large properties, to have harvested timber recently, and to harvest timber in the near future compared to other groups. The

study also found that *Non-timber output owners* were less likely to be engaged with both past or future timber harvests. The result of the study differed from the findings of Kuuluvainen et al. (1996) and Karppinen (1998) that forest owners who value non-timber objectives were as much engaged in timber sales as forest owners who considered income from timber sales as significant motivation to own forest properties.

Finley and Kittredge (2006) defined three forest owner segmentations based on their survey in Massachusetts. The study used reasons for owning forestland to classify forest owner groups. The results of the study emphasized targeted approaches to different segments with specific forest ownership reasons and values. Ingemarson et al. (2006) conducted a typology study of small private forest owners in Sweden. The study used ownership objectives as input factors in CA. Majumdar et al. (2008) investigated family forest owners in three southern states, South Carolina, Georgia, and Alabama. The study used the perceived importance of reasons for owning forests as inputs for CA.

Kuipers et al. (2013) segmented family forest owners in Michigan using ownership objectives and found that how these owner groups obtained forest outreach materials were different. Also, the study found that preferred communication methods for forest information were different. The results suggested segmented communication efforts to be critical in effective forest outreach.

Khanal et al. (2017) conducted a survey among family forest owners in 11 southern U.S. states to investigate how forest owner groups are conducting forest management practices and to analyze how they view climate change issues and carbon sequestration by forests. The study found that these groups differed in terms of forest management practices. The timber-oriented forest

owner group was more likely to have a high proportion of loblolly pine on property than other groups.

Other studies paid more attention to various factors beyond forest ownership objectives when they were identifying forest owner segmentations to understand family forest owners and to obtain useful insights to improve policies and forest program designs. In the study of family forest owners in Arkansas, various factors including landowner's management objectives, intention to sell timber in the future, previous timber sale experience, and a few socioeconomic variables were used in segmenting forest owners (Kluender and Walkingstick, 2000). Ross-Davis and Broussard (2007) attempted to segment Indiana family forest owners using a combination of various information including forest parcel information such as parcel acreage and forested acreage, socioeconomic variables, and management objective motivations. Emphasizing the gap between forest owners' values and actual management, Boon and Meilby (2007) included both forest owners' attitudes towards forest management practices and actual management practices in recent 5 years. Dayer et al. (2014) segmented forest owners in three different ways: behavior typology, motivation typology, and reasoned action typology. The study compared three typologies and found that all three typologies seemed to be reliable. However, the study emphasized that in selecting proper typology, the characteristics of the sample and objective of the typology should be considered. Davis et al. (2015) used forest owners' management definition to identify different owner groups in the study on family forest owners in Tennessee. Starr et al. (2015) classified forest owners in Ohio based on their outreach need. Metcalf et al. (2016) used behavioral intentions of forest owners to segment them.

Many researchers attempted to identify forest types with similar objectives, motivations, preferences, and other characteristics. Although it is hard to conclude that there is one right way

to classify forest owners, the findings of the previous studies suggest that segmenting forest owners based on criteria that fit the purposes of the studies could provide useful insights in understanding forest owners. For example, forest owners who are interested in both non-timber and timber outputs were found to be the ones who were more engaged with active forest management and timber harvests, which was different from what previously was believed to be correct.

2. Typology and forest owners' preferences towards PES

Few studies introduced typologies into predicting forest owners' preferences towards in PES programs by analyzing their willingness to participate (WTP) or willingness to accept (WTA) PES contracts based on typology. Kline et al. (2000c) investigated forest owners' preferences to manage riparian buffers for endangered species and water quality by forgoing timber harvests within riparian areas in exchange for tax benefits. The study classified forest owners into different ownership groups using CA. The study found that *multi-objective* and *recreationist owners* were more likely to participate in the suggested programs and forego timber harvests for environmental protection.

Some studies used selected forest owners' objectives to estimate or analyze their WTP and WTA for PES programs (Joshi and Mehmood, 2011, Matta et al., 2009, Mäntymaa et al., 2009, Rabotyagov and Lin, 2013). They used one or multiple dummy (1 if certain objective is important, 0 otherwise) or Likert scale variables (not important to very important) to indicate specific forest ownership objectives. Joshi and Mehmood (2011) included a timber production objective and a wildlife management objective in estimating the model for private forest owners' willingness to supply woody biomass. Matta et al. (2009) analyzed marginal WTA estimates for participating in conservation programs based on the respondents' dominant land management objectives of financial investment, timber production, recreation and aesthetics, wildlife and the other. The study

found that marginal WTA for conducting different forest practices varied depending on which objective forest owners considered important. Mäntymaa et al. (2009) introduced a Likert scale variable for the forest owners' aims for forest management in their model to estimate Finish forest owners' participation in voluntary forest conservation. They found that forest owners who considered investment objective important required more compensation than other forest owners to enroll their property in such conservation agreement. Similarly, Rabotyagov and Lin (2013) incorporated Likert scale variables associated with ownership objectives including income from timber harvest, maintaining healthy ecosystem, personal recreation, and family legacy in the model to estimate forest owners' WTP and WTA associated with a working forest conservation easement agreement. They found that marginal WTA compensation for accepting the conservation agreement and additional management requirements differed depending on forest owners' ownership objectives. Forest owners who assessed their environmental objectives high required less compensation than the other forest owners.

Several studies attempted to use forest owners' objectives in estimating their decision to participate in PES programs. However, there have not been many studies that explicitly used forest owner segmentation in the analysis. In this study, we classify family forest owners in southeast Georgia based on their ownership objectives. We directly introduce the family forest owner clusters to estimate forest owners' WTA and WTP associated with participation in PES programs.

Data and Methods

1. Study area and data collection

Detailed information about the study area and data collection is provided in chapter 2. It should be noted that the sample size is slightly different from chapter 2 because of the incomplete

surveys. Total 231 samples were analyzed in this chapter. To obtain information about survey participants' forest ownership objectives, we asked them to rate the following nine objectives: 1) aesthetic enjoyment, 2) personal residence, 3) personal recreation, 4) maintaining healthy environment, 5) income from timber harvest, 6) income from recreation, 7) land investment, 8) family legacy, and 9) privacy. Survey participants were asked to rate each objective from scale of 1 (not important) to 5 (very important).

2. Identification of different forest ownership groups

To identify different forest ownership groups, we first conducted PCA to reduce the dimension of the forest ownership data and to obtain meaningful relationships of different owenrships. We adopted PCA with Varimax rotation, which is a widely used PCA approach. The PCs are an orthogonal linear combination of variables such that much of the variability of data could be explained. The coefficients of the variables are called loadings. The number of PCs was selected based on how much variance is explained by selected principal components. The psych package for R was used for undertaking PCA (Revelle, 2017). After obtaining the PCs and loadings associated with each component and objective, PC scores were calculated by multiplying PC loadings by the target variables. The non-hierarchical k-means cluster analysis (CA) was used to segment data represented by the PC scores. By conducting k-means clustering, we can identify groups that are homogeneous within the cluster, but heterogeneous among clusters (Hair et al., 2010). Adopting the combination of PCA and CA has been used in previous studies of segmented forest owner groups (Khanal et al., 2017, Kuuluvainen et al., 1996, Kline et al., 2000c, Majumdar et al., 2008).

3. WTP in PES programs

We ran both multinominal logit (MNL) and random parameters logit (RPL) models to analyze if different forest ownership segments affect one's probability of participating in PES and WTA compensation. We used RPL as the main model for econometric analysis, and used MNL model for testing robustness of the model and obtaining supplemental information. We specify the utility of a forest owner i for an alternative j in nth choice sequence as following:

$$U_{ijn} = \alpha_j + Z_{ijn}\beta_i + \eta_j E_{ij} + \varepsilon_{ijn} \tag{4.1}$$

where α_j is an alternative specific constant (ASC) associated with each alternative, Z_{ijn} represents contractual attributes of PES alternatives (X_{jn}) and the cluster type individual i belongs to (C_i), ($Z_{ijn} = [X_{jn}; C_i]$). $E_{ij}$is random error component with zero mean, and η_j is parameter estimate for the error component. ε_{ijn} represents an error term with extreme value distribution. The following function demonstrates sample likelihood of respondent i to choose an alternative j in nth choice sequence for RPL model:

$$P_i = \iint \prod_{n=1}^{N} \left[\frac{exp(Z_{ijn}\beta_i + \eta_j E_{ij})}{\sum_j^J exp(Z_{ijn}\beta_i + \eta_j E_{ij})} \right] \phi(\beta_i)\phi(E_i) d\beta_i dE_i \tag{4.2}$$

Detailed explanation about the procedures of estimating the RPL model is provided in chapter 2. Program attribute variables including payment mode, minimum streamside management zones (SMZ) widths, and limitation on increasing pine plantation areas were effect coded. Contract length variable was coded in two ways. The perpetual contract was dummy coded, and contract length from year 10 to 60 was continuously coded. Annual per-acre compensation amount variables were continuously coded. All the survey participants were asked to complete six choice scenarios. Each scenario consisted of three options including two PES contracts and the status quo option.

Results

1. PCA results

Table 4.1 demonstrates PCA results. PCA loadings smaller than the absolute value of 0.1 cutoff are not shown in the table. Four principal components (PCs) explained about 71 percent of the total variance. PCA loadings indicate how much individual variables contribute to the PCs, in this case, variables are the ownership objectives in each row in Table 4.1. If the absolute value of a loading for a variable of a PC is high, it implies that the variable takes an important role to the PC. We adopted PCA loadings greater than 0.5 to assign ownership objectives to PCs (Hair et al., 2010). We identified the following PCs: PC 1 *Non-timber forest value and conservation*, PC 2 *Residence vs. timber*, PC 3 *Income from recreation*, and PC 4 *Investment*. PC 1 has high loadings for ownership objectives including *Aesthetic enjoyment*, *Maintaining healthy ecosystem and nature*, *Family Legacy*, *Recreation*, and *Privacy/rural lifestyle.* We named the PC 1 *Non-timber forest value and conservation* based on ownership objectives assigned to the PC. PC 2 has a high loading for *Personal residences* objective and a high negative loading for *Income from timber harvest* variable. This indicates that individual with high positive PC 2 score will be more likely to consider residence objective very important, while income from timber harvest less important, or vice versa. There exists a clear contrast between *Personal residences* and *Income from timber harvest*, and therefore we named PC2 as *Residence vs. timber*. PC 3 and PC4 have high loadings for *Income from recreation* and *Investment* respectively.

2. CA results

By multiplying PCA loadings by associated variables, it was possible to get the principal component scores, which were used as inputs in CA. As a result of k-means CA, five clusters were identified (Table 4.2). Each segment was named according to associated PCs. We compared

sociodemographic variables, property characteristics, and forest management characteristics for forest owner clusters based on ownership objectives (Table 4.3 and Table 4.4). We used chi-square or analysis of variance (ANOVA) to compare each cluster with variables of interest. Variables that were found to have statistically significant differences are marked in bold in Table 4.3 and Table 4.4.

It was found that average age of all the clusters except Cluster 3 (of which mean age was 59) was greater than 60. All the Clusters consisted of mostly male respondents. Retirement status of respondents was different depending on which cluster they fell within. For example, for Cluster 1 and Cluster 5, more than 70 percent of respondents reported that they were retired. On the other hand, more than 50 percent of respondents in Cluster 2 and Cluster 3 reported that they were still working. There was a statistically significant difference in the annual household income among clusters. For example, Cluster 1 had the least proportion of forest owners whose annual household income was high. Only 26 percent of the respondents reported that their annual household income exceeded 150,000 U.S. dollars. On the other hand, about 50 percent of forest owners in Cluster 4 and Cluster 5 reported that they earned more than 150,000 U.S. dollars in a year. Participation in forest organizations among the participants was generally low. The respondents seemed to be more engaged with environmental organizations. The average size of the forest parcel ranged from 93 acres (Cluster 3) to 150 (Cluster 2). In terms of ownership length, other than Cluster 3, more than half of the forest owners in all the clusters owned the property for more than 20 years. The most popular mode of the property acquisition was purchase, which was followed by inheritance. Most of the forest owners did not have a written management plan for the property. On the other hand, most of the respondents were conducting more than one water protection practice on their properties. It seemed that respondents had a different level of knowledge of Best Management

Practices (BMPs) according to the clusters, but it was found that they generally were not familiar with BMPs (Georgia Forestry Commission, 2015). Most of the respondents seemed to have pine plantations on their property.

1.1 Cluster 1 Multi-objective owners

We found that 20 percent of the survey respondents (n = 46) fell within this cluster. *Multi-objective owners* were likely to assess both non-timber forest objectives and timber objective important. Forest owners in this group were generally older and likely to be retired. The annual household income of the group seemed to be the lowest among the clusters. Most of *Multi-objective owners* (74 percent) reported that their annual household income was below 150,000 U.S. dollars. Forest owners in this group showed a moderate level of participation in forest organizations, but relatively high level of involvement with environmental organizations. Also, 35 percent of *Multi-objective owners* reported that they were participating or donating to environmental organizations that focus on addressing environmental issues such as The Nature Conservancy, which is one of the highest proportion among clusters. We found that 85 percent of *Multi-objective owners* reported that they owned the property for more than 20 years. Furthermore, this group has the highest proportion of forest owners who inherited the property, and the lowest proportion of forest owners who purchased the property. Also, about 80 percent of forest owners in this cluster reported that they were conducting more than one water protection practice. Forest owners in this group seem to have a moderate level of understanding about BMPs.

1.2 Cluster 2 Investors (timber)

According to our analysis, 25 percent of survey respondents (n = 50) fell within this cluster. In terms of ownership objectives, we can see that this group values both non-timber and timber forest values. Forest owners who belong to this group are likely to rank the timber objective and

investment *high*. This group consisted of relatively young forest owners. More than half of them were still working. Forest owners in this group showed relatively high participation level in forest organizations or environmental organizations. This group has the highest proportion of forest owners who purchased the property and the lowest proportion of forest owners who inherited the property. Also, 84 percent of forest owners in this groups reported that they were conducting more than one water protection practice. They seem to have a relatively good level of understanding of BMPs compared to other groups. This group has a high proportion of forest owners who reported that they have pine plantations with a moderate to high management intensity.

1.3 Cluster 3 Resident owners

We found that 24 percent of survey respondents (n = 56) fell within this cluster. In terms of ownership objectives, *Resident owners* do not place much value on objectives associated with generating income from timber, recreation or investment. Forest ownership objective associated with non-timber forest benefits and residency resonate most strongly with this group. This group is represented by young forest owners who recently purchased the property and do not have ties to forestry organizations. This group consists of young forest owners with the smallest proportion of forest owners who reported that they were retired. Also, forest owners in this group were least likely to be a member of forest organizations. Furthermore, this group has the lowest proportion of forest owners who own the property more than 20 years. This group also has the highest proportion of forest owners who own the property for less than 5 years among the clusters. Forest owners in this cluster were likely to have purchased the property from someone rather than to have inherited the property. About 90 percent of forest owners reported that they were conducting more than one water protection practice. However, only 11 percent reported that they knew BMPs well

and already were practicing them. Also, the group had the lowest proportion of forest owners who had intensively managed pine plantation on their properties.

1.4 Cluster 4 Investors (recreation)

About 18 percent of survey respondents (n = 41) fell within this cluster. Objectives associated with various investment purposes such as generating income from timber production, forest recreation, and land investment strongly resonated with this cluster. This group has the highest proportion of forest owners who reported that their annual household income is above 150,000 dollars. This group has the highest proportion of forest owners who are members of forest organizations. The most common modes of forest property acquisition were both purchase and inheritance. Forest owners in this group were most likely to conduct more than one forest practice for water protection and also seemed to have very good understanding of BMPs. Furthermore, this group has the highest proportion of forest owners who had moderate or high-intensity pine plantations on their properties. About 75 percent of forest owners in this group reported that they have pine plantations with moderate to high level of management intensity.

1.5 Cluster 5 Uninterested owners

We found that 13 percent of survey respondents (n = 30) fell within this cluster. This group was named *Uninterested,* because none of the forest ownership reasons had strong positive correlations with this cluster. This group consists of relatively older and retired forest owners. *Uninterested owners'* mean age was the highest among the clusters, which was 72. This group has a relatively low proportion of forest owners who participated in both forest organizations and environmental organizations. Also, 70 percent of forest owners in this group purchased the property and owned the property for more than 20 years. Forest owners in this group were least likely to be conducting any forest management practices for water protection. More than 40 percent

of forest owners in this group reported they were conducting no water protection practices on their property. Forest owners in this groups seemed to understand least about what BMPs are. More than half of the forest owners in this group reported that they never heard about BMPs before, and only 7 percent reported that they knew what BMPs are and were practicing them on their property.

2. WTA and WTP in PES

Table 4.5 demonstrates the results of MNL and RPL models estimated forest owners' WTA and WTP in PES program. We can see that the coefficients for both models have consistent signs and values. When it comes to the coefficients for program attributes, the coefficients for contract years, permanent contract, cash payment, SMZ 150, and the restriction on increasing pine plantations are statistically significant in both models. Also, the signs of the coefficients are consistent in both models. The coefficients for Cluster 1, 3, and 4 are statistically significant and negative in the results of MNL model. However, in the RPL model estimation, we found that only the coefficients for Cluster 1 was statistically significant. Based on the results of the two models, we can conclude that forest owners classified as Cluster 1 *Multi-objective owners* were more likely to accept PES contracts than forest owners in other clusters. We also estimated the marginal WTA of one's belong to Cluster 1 using delta method, of which theory and procedure are explained in detail in chapter 2. We found that forest owners in Cluster 1 required less compensation than other groups by about $66 per acre per year.

Discussion and Conclusions

1. Cluster and WTA

We found that *Multi-objective forest owners* were more likely to participate in PES programs and require a relatively low level of compensation compared to other groups. By analyzing their socioeconomic characteristics, forest property characteristics and management,

and ownership objectives, we would be able to explain why their WTA is significantly lower than other forest owners and why their WTP is higher.

Based on the socioeconomic information of the cluster, we can infer that this is because forest owners in this group are generally older and retired and are seeking some additional financial opportunities from their forest properties. This is supported by another characteristic of *Multi-objective owners* that this cluster has the lowest proportion of forest owners who earn high annual income (more than $150,000) among clusters. Furthermore, high level of participation in environmental organizations could be associated with their high WTP and low WTA. Forest owners in this group may be more likely to be environmentally conscious and have more interest in environmental programs compared to other groups.

Based on forest property characteristics, we could see that forest owners in this cluster were most likely to have owned the forest property for more than 20 years. Also, 87 percent of the forest owners owned the property for more than 20 years, and the most popular mode of property acquirement was through inheritance. We could infer that forest owners in this group are likely to own the forest property for their lifetime and probably would likely to pass the property to their family members, which could result in having more motivations in enrolling their forest lands in long-term conservation contracts. Enrolling one's property in easement type PES programs requires the landowner to maintain sustainable land management that does not damage ecosystem services generated from the land.

Based on the objectives, we could infer that low WTA and high WTP of forest owners' in this group could be associated with their ownership objectives. Forest owners in this group appreciated not only environmental, non-timber objectives, but also timber objectives. Previous studies found that forest owners who valued non-timber ecosystem services from the forestlands

had smaller WTA compared to those who did not appreciate the environmental benefits (Raunikar and Buongiorno, 2006). Our study results also support the previous findings that multi-objective forest owners could be a good target of environmental programs (Kline et al., 2000c).

2. Conclusions

In this chapter, we attempted the typology of family forest owners in southeast Georgia. Since forest owners have diverse motivations and objectives in their land management, identifying forest owner clusters who share similar objectives within the same groups provide useful insights to policy makers and practitioners. Our goal was to identify forest owner clusters and analyze their forest management practices, socioeconomic characteristics, as well as their WTP in PES programs and expected level of compensation. To do so, we adopted widely used customer segmentation techniques including PCA and CA, which have been utilized in segmenting forest owners in previous studies. We clustered the family forest owners into five groups based on their ownership objectives. We found that family forest owners in the region might be clustered into *Multi-objective owners, Investors (timber oriented), Resident owners, Investors (recreational business oriented),* and *Uninterested owners*.

We observed these forest owner clusters were different in terms of how they manage their property, level of management, sociodemographic characteristics. *Multi-objective owners* consist of relatively older and retired forest owners with high level of participation rate in environmental organizations. They owned the properties relatively longer than other clusters were likely to have inherited the property. *Investors (timber oriented)* and *Investors (recreational business oriented)* were likely to have purchased the property and tended to have an intensively managed pine plantation on their properties. *Resident owners,* on the other hand, were least likely to have a pine plantation on the property. Also, they were the youngest forest owners among the clusters.

Uninterested owners tended to own their forest for a long time, but their participation in a forest organization and understanding of the BMPs seemed relatively lower than other clusters.

We also investigated how one's belonging to a specific cluster affected his or her WTP and WTA associated with enrolling one's property in hypothetical PES programs. We found that *Multi-objective owners* had a high propensity to participate in PES programs compared to forest owners in other groups and their WTA was relatively lower than other groups. We analyzed the difference in WTA and WTP in terms of socioeconomic characteristics, property characteristics, and ownership objectives of *Multi-objective owners*. We found that *Multi-objective owners* might be relatively more interested in PES programs since they were seeking additional financial opportunities and they were the group who were the most engaged with environmental organization activities among the groups. Also, we infer that *Multi-objective owners* inherited their properties from family or relatives and owned the forest relatively longer than other groups, which might encourage them to enroll their lands in long-term conservation contracts which do not affect core ownership of land, but only development rights. By participating in the program, they could achieve multiple objectives including family legacy, financial outcomes, timber and non-timber outputs. The findings of the study provide useful insights to understand family forest owners based on common ownership objectives. The information can be used in improving future approaches to family forest owners encouraging their participation in PES programs and policy-making as well. However, it should be noted that the results of the study should be interpreted with caution. We adopted a unique approach to collect the sample data. In this study, forest owners were asked to answer questions associated with the specific property they own. If forest owners have only one property, this approach would not be an issue. However, it is not rare that one forest owner owns more than one property in this region.

Table 4.1 PCA loadings

Ownership objectives	Principal components			
	PC1 *Non-timber forest value and conservation*	PC2 *Residence vs timber*	PC3 *Income from recreation*	PC4 *Investment*
Aesthetic enjoyment	**0.775**	-0.211		
Maintaining healthy ecosystem and nature	**0.801**			0.116
Family legacy	**0.710**	-0.152		
Recreation	**0.673**			0.116
Privacy/rural life style	**0.639**	-0.449	0.112	0.166
Personal residences (primary or vacation)	0.306	**-0.758**	0.172	0.127
Income from timber harvest	0.108	**-0.720**	0.331	0.263
Income from recreation			**0.965**	
Land investment				**0.974**
Cumulative variance explained (%)	30.2	-46.6	58.8	70.8

Table 4.2 Cluster centers for objective based typology

		Principal components			
Clusters	N (%)	PC1 *Non-timber forest value and conservation*	PC2 *Residence vs timber*	PC3 *Income from recreation*	PC4 *Investment*
Cluster 1 *Multi-objective owners*	46 (20)	-0.44	-0.47	-0.10	-1.32
Cluster 2 *Investors (timber)*	58 (25)	-0.24	-0.59	-0.79	-0.68
Cluster 3 *Resident owners*	56 (24)	-0.27	-1.28	-0.05	-0.08
Cluster 4 *Investors (recreation)*	41 (18)	-0.13	-0.37	-1.40	-0.59
Cluster 5 Uninterested owners	30 (13)	-1.82	-0.02	-0.33	-0.23

Table 4.3 Comparison of sociodemographic characteristics for clusters

Characteristics	Clusters				
	CL1	CL2	CL3	CL4	CL5
Age ($p<0.01$)	**70**	**65**	**59**	**69**	**72**
Male ($\chi^2=4.3$, df = 4, $p=0.61$)	76%	82%	80%	71%	83%
Retired ($\chi^2=13.5$, df = 4, $p<0.01$)	**70%**	**44%**	**48%**	**54%**	**77%**
Income ($\chi^2=9$, df = 4, $p=0.05$)					
Below 150,000	**74%**	**61%**	**61%**	**44%**	**53%**
Above 150,000	**26%**	**39%**	**39%**	**56%**	**47%**
Forest organization membership ($\chi^2=14$, df = 4, $p<0.01$)	**17%**	**25%**	**7%**	**34%**	**10%**
Environmental organization membership ($\chi^2=8.3$, df = 4, $p=0.08$)	35%	35%	23%	24%	10%

Table 4.4 Comparison of property characteristics and forest management for clusters

Characteristics	Clusters				
	CL1	CL2	CL3	CL4	CL5
Size (mean/ median) (p=0.06)	104/80	150/100	93/70	127/110	120/84
Ownership length (χ^2=34, df = 12, p<0.01)					
Less than 5 years	**2%**	**16%**	**18%**	**15%**	**7%**
5 to 10 years	**2%**	**14%**	**11%**	**5%**	**0%**
10 to 20 years	**9%**	**14%**	**32%**	**17%**	**23%**
More than 20 years	**87%**	**56%**	**39%**	**63%**	**70%**
Mode of acquirement (χ^2=34, df = 12, p<0.01)					
Purchased	**30%**	**74%**	**73%**	**46%**	**57%**
Inherited	**59%**	**23%**	**27%**	**44%**	**43%**
Gift	**7%**	**3%**	**0%**	**5%**	**0%**
Other	**4%**	**0%**	**0%**	**5%**	**0%**
Written management (χ^2=5, df = 4, p=0.27)					
Have written management	24%	19%	18%	27%	7%
No written management	72%	77%	75%	63%	90%
Not sure	4%	4%	7%	10%	3%
Conducting practices for water protection (χ^2=17, df = 4, p<0.01)					
Conducting more than one water protection practices	**78%**	**84%**	**89%**	**90%**	**57%**
No practices	**22%**	**16%**	**11%**	**10%**	**43%**
Knowledge about BMPs (χ^2=42, df = 12, p<0.01)					
Never heard about BMPs before	**20%**	**37%**	**36%**	**29%**	**66%**
Heard about BMPs, but not sure	**30%**	**21%**	**21%**	**12%**	**20%**
Understand the objectives	**37%**	**14%**	**32%**	**20%**	**7%**
Know BMPs well and practicing them	**13%**	**28%**	**11%**	**39%**	**7%**
Pine plantation intensity (χ^2=15 df = 8, p=0.04)					
No pine plantation	**13%**	**14%**	**29%**	**10%**	**20%**
Low intensity	**37%**	**26%**	**25%**	**15%**	**30%**
Moderate or high intensity	**50%**	**60%**	**46%**	**75%**	**50%**

*Statistically significant variables are in bold (p<0.05)

Table 4.5 Results from MNL and RPL estimation models

Variable	MNL Coefficient	RPL Coefficient	WTA ($/acre/year)
Random parameters in utility functions			
Contract Years	**-0.02*** **	**-0.06*** **	**-1.7**
Permanent	**-1.19*** **	**-3.58*** **	**100.0**
Cash	**-0.19*** **	**-0.42*** **	**-11.7**
SMZ 70	-0.06	-0.11	
SMZ 100	-0.01	-0.11	
SMZ 150	**-0.21*** **	**-0.63*** **	**-17.5**
Limitation	**-0.11*** **	**-0.28*** **	**-7.8**
Nonrandom parameters in utility functions			
Payment	**-0.02*** **	**-0.04*** **	
ASC	**-1.14*** **	**-1.95*** **	**-54.0**
Cluster 1	**-0.90*** **	**-2.40** **	**-66.7**
Cluster 2	-0.19	-0.19	
Cluster 3	**-0.54*** **	-1.25	
Cluster 4	**-0.63*** **	-1.62	
Standard deviations of random parameters			
Contract Years		**-0.04*** **	
Permanent		**-2.95*** **	
Cash		**-0.61*** **	
SMZ 70		-0.24	
SMZ 100		-0.56	
SMZ 150		**1.14*** **	
Limitation		**-0.75*** **	
Standard deviations of latent random effects			
Error component		**-3.75*** **	
Number of observations	-1386		
Adjusted pseudo R^2	-0.32		
Log Likelihood	-1026		

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

CHAPTER 5

CONCLUSION

The overarching aim of the three studies was to examine family forest owners' preferences towards payments for ecosystem services (PES) programs. Family forest owners have become an important target of PES programs for their diverse interests and motivations compared to other private forest owners such as timber investment management organizations (TIMOS) and real estate investment trusts (REITS). Still, there are knowledge gaps about their preferences towards PES programs and underlying factors associated with their motivation to participate in such programs. We introduced family forest owners' risk preferences, property characteristics, and ownership objectives to analyze their willingness to participate (WTP) and willingness to accept (WTA) associated with PES contracts.

In chapter 2, we examined the role of individual risk preferences in family forest owners' participation in PES programs. Risk preferences have known to be one of the critical determinants of forest owners' land management decisions, but their influence on landowners' decision associated with PES participation was rarely studied. We elicited participants' risk coefficients using non-incentivized risk method and obtained their preferences towards various PES program designs using a choice experiment. We used the risk coefficients to estimate participants' willingness to enroll their forest in hypothetical PES programs. We found that one's level of risk aversion affected one's likelihood to participate in PES programs. As a forest owner's level of risk aversion increased, the landowner was more likely to participate in given PES programs. Also, risk averse forest owners tended to require smaller payments compared to non-risk averse forest

owners. The findings suggest that elaborating promotion and targeting of PES to risk averse owners has the potential to save substantial costs and raise participation. Changing the narrative of the promotion and focusing on education could result in enrolling more risk averse forest owners, who are more inclined to participate in PES programs with smaller compensation. Additional studies could examine how to identify risk averse owners who could be the cost-effective target audiences of incentive programs. Furthermore, it would be useful to investigate why risk averse owners are attracted to PES programs. Future studies could utilize post choice experiment (CE) questions asking why they chose to participate or not to participate in PES programs. Also, in our study, we could not find any significant interaction between forest owners' risk coefficients and PES program attributes. However, considering that our study examined only a few PES program attributes, it would be worth examining other program factors such as exit costs, penalties, or flexibility, which are likely to be associated with one's risk preferences.

In chapter 3, we examined whether and how forest types on one's property were related to family forest owners' preferences towards PES programs. We investigated the potential of using observable forest property characteristics including forest types and residential structures on the properties in predicting forest owners' likelihood of PES participation. We found that there were significant correlations between the landowners' objectives and the composition of forest types. Also, we found the existence of pine plantation (PP) and bottomland hardwood (BH) forests on one's property significantly increased the likelihood that the forest owner would participate in PES programs. Furthermore, forest owners' WTA was negatively related to the proportion of these two forest types. The findings from chapter 3 suggest the potential of observable forest characteristics such as forest types or residential structure on the property in predicting forest owners' preferences towards PES programs. This result suggests that the government and environmental organizations

may utilize the forest property characteristics in targeting and promoting forest incentive programs or other conservation programs. Public databases such as each the data provided by county tax assessor's offices and aerial images could be used to identify forest owners who are likely to be more favorable to PES programs, which could save time and money in identifying potential participants of incentive programs. Additional research could examine the relationship between other forest property characteristics and forest owners' WTA and WTP associated with PES participation.

In chapter 4, we investigated what types of forest owners were most likely to participate in PES programs. In doing so, we developed an empirical typology of family forest owners. We identified forest owner groups based on the reasons for owning forests. Market segmentation techniques including principal component analysis (PCA) and cluster analysis (CA) were adopted to segment the forest owners. We found that there were differences between different ownership groups and how they managed the forest. In addition, the results demonstrated that forest owners' probability of participating in incentive programs and WTA were influenced by ownership segments they belong to. Additional studies could use other variables to cluster forest owners. For example, Ross-Davis and Broussard (2007) used variables such as forest properties and ownership objectives to conduct a typology of forest owners. Forest types or residential structure on the property could be variables as they were found to be at least implicitly associated with forest owners' objectives.

It should be emphasized that our study results were derived based on forest owners' preferences towards specific parcel. Consequently, the study results do not cover the case that a single owner owns multiple parcels. Considering that it is common that forest owners have two or more forest parcels, the results of the study should be interpreted with cautions. Future studies

could fill in this knowledge gap by introducing more flexible choice scenarios in which forest owners could consider multiple parcels of him or her in CE.

Understanding family forest owners' preferences is critical to promoting, improving, and designing PES programs. The results of this dissertation provide useful addition to the knowledge of family forest owners' preferences towards PES programs. The study findings can be used in improving PES program design and communication of the incentive programs, as well as in identifying best audiences in terms of cost-effectiveness and the likelihood of participation. Future studies, as suggested earlier in this chapter, could help enhance the knowledge gained from this study and explore family forest owners' preferences that are still unknown.

We found that family forest owners in the southeast Georgia demonstrated favorable attitudes to participation in PES programs similar to working forest conservation easements with more than 80 percent of the participants choosing to participate in given PES alternatives at least one time. Although this finding was derived from CE that asked participants' preferences towards hypothetical PES programs, we believe that this result implies that family forest owners are more interested in these incentive programs for forest conservation than we expected. Future studies about the preferences (e.g., willingness to pay) of the public, who are the consumers of ecosystem services and whose well-being is affected by the quality and quantity of ecosystem services provided by the suppliers, or family forest owners, could be useful in estimating more accurate monetary value of forest ecosystem services and future policy making.

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APPENDICES

APPENDIX A. SURVEY QUESTIONNAIRE

GEORGIA RIPARIAN FOREST OWNERS SURVEY 2016

The University of Georgia
WARNELL
SCHOOL OF FORESTRY & NATURAL RESOURCES

Dear Forest Owner(s) of
Parcel Number 000 000 in Bulloch County

We are writing to ask for your help in completing a brief research survey to learn your response to potential incentive programs for conserving forests adjacent to streams, lakes, or other surface waters (referred to from now on as riparian forests) in southeast Georgia. The findings from this project may help inform the development of forest policies and incentive programs to conserve the environment and enhance sustainable forestry in Georgia.

We obtained your contact information from **Bulloch County** tax assessor's office and you are part of a randomly selected sample of private riparian forest owners in southeast Georgia. Please do not respond unless you are at least 18 years of age. Participation in the survey involves answering multiple choice and scenario questions and should only take about 10–20 minutes. Your involvement in the study is voluntary, and you may choose not to participate or to stop at any time.

Your individual responses are confidential, and only aggregated results will be reported. We do not foresee any risks associated with your participation. After collecting survey results, individually identifiable information (participant's name, mailing address, and parcel number) will be stripped off. Data will be stored in computers protected with firewall technology and only a prime investigator and co-investigator will be able to access the data. If you would like additional information about this study, please feel free to contact us—our contact information is provided below. Questions or concerns about your rights as a research participant should be directed to The Chairperson, University of Georgia Institutional Review Board, telephone (706) 542-3199, email address irb@uga.edu.

By completing and returning this questionnaire in the envelope provided, you are agreeing to participate in the above described research project. Instead of returning mail, you can also participate in the online survey through the following link:

bit.ly/gaforest16

Please note that you will be asked to enter the STUDY ID (written above) at the beginning of the online survey. Thank you for your time and consideration.

Sincerely,

Moon Jeong Kang
PhD Candidate
Warnell School of Forestry
and Natural Resources
University of Georgia
Email: mjkang@uga.edu

Jacek Siry
Professor, Principal Investigator
Warnell School of Forestry
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Email: jsiry@uga.edu

BACKGROUND

Forests provide diverse benefits including timber, food, recreational opportunities, as well as clean air and water. Approximately one-third of U.S. forests are in the South, and most of these forests are owned by private forest owners. In Georgia, urbanization, population growth, and property tax burdens are suggested as serious threats that could result in the conversion of forests to non-forest uses and undermine forest sustainability. Private forest owners are critical for conserving forestland and maintaining life-sustaining benefits provided by forests. Providing financial compensation to property owners in exchange for developing land management plans yielding conservation benefits or not conducting developmental activities on their land has been suggested as one of the solutions to encourage forestland protection and ensure the sustainable provision of numerous forest ecosystem services.

In this study, we are investigating how riparian forest owners' personal preferences influence their decision to participate in potential incentive programs. As part of this survey, we ask you to participate in an economic experiment which was designed to evaluate an individual's preferences based on the choices you make. Also, we ask about your willingness to participate in incentive programs with different characteristics. The findings from this project may help inform the development of forest policies and incentive programs to conserve the environment and enhance sustainable forestry in Georgia.

SECTION A. FOREST MANAGEMENT AND OWNERSHIP OBJECTIVES

In this part, we would like you to answer questions about your forest parcel:

Parcel Number: 000 000 in Bulloch County

If you have more than one forest parcel in the county, please note that unless stated otherwise, we are asking information about your specific forest property:

Parcel Number: 000 000 Size: About 00 acres

1. How long have you (or your family) owned this forest parcel?

   ☐ Less than 5 years ☐ 5-10 years

   ☐ 11-20 years ☐ More than 20 years

2. How did you obtain this forest parcel?

   ☐ Purchased ☐ Inherited ☐ Received as gift ☐ Other

3. Please rate your ownership objectives in the table below by selecting the appropriate value from ***Unimportant (1)*** to ***Very important (5).***

Ownership objectives	*Unimportant*				*Very important*
	1	2	3	4	5
Aesthetic enjoyment	☐	☐	☐	☐	☐
Personal residence (primary or vacation)	☐	☐	☐	☐	☐
Personal recreation	☐	☐	☐	☐	☐
Maintaining healthy ecosystem and nature	☐	☐	☐	☐	☐
Income from timber harvest	☐	☐	☐	☐	☐
Income from recreation (fishing, hunting, and wildlife-associated recreation, etc.)	☐	☐	☐	☐	☐
Land investment	☐	☐	☐	☐	☐
Family legacy	☐	☐	☐	☐	☐
Privacy/rural life style	☐	☐	☐	☐	☐

4. If you have **pine plantation stands** on this forest parcel, which of the following best describes your management intensity?

Low:	Management practices may include mechanical site preparation and planting
Moderate:	Management practices may include mechanical and/or chemical site preparation, planting, fertilization, and one thinning
High:	Management practices may include mechanical and chemical site preparation, planting, fertilization, complete vegetation control, and two thinnings

☐ Low ☐ Moderate ☐ High ☐ Not sure

5. Do you have **jurisdictional wetlands** on this forest parcel?

Jurisdictional wetlands are determined by the Army Corps of Engineers and are regulated under Clean Water Act Section 404.

☐ Yes ☐ No ☐ Don't know

6. Have you ever enrolled <u>any of your forest properties</u> in any easement, incentive, cost sharing, tax incentive, or certification programs that were designed for promoting environmental conservation and sustainable forest management? (*Check ALL that apply*)

Conservation Use Valuation Assessment (CUVA) is considered as one type of tax benefits

☐ Easements ☐ Cost-share ☐ Tax benefit

☐ Certification ☐ Others ☐ No, I haven't

7. If you **do not currently participate in** the programs mentioned in Question 6 (even if you have participated in the past), which of the following best describes your reasons for not participating in those programs? *(Check ALL that apply)*

☐ Lack of information ☐ Penalty upon violation of the contract

☐ Limited land use ☐ Insufficient benefits to you

☐ Management requirements ☐ Up-front costs to participate in those programs

☐ Contract length ☐ Other reasons

8. Do you have a **written** management or stewardship plan for <u>any of your forest properties</u>?

☐ Yes ☐ No ☐ Don't know

9. Which of the following best describes your familiarity with the **Best Management Practices (BMPs)**?

Best Management Practices (BMPs) are a set of preventative measures used during forest management activities to achieve goals related to water quality, silviculture, wildlife and biodiversity, aesthetics, and/or recreation

- ☐ I never heard about BMPs before
- ☐ I heard about BMPs, but am not sure what they are
- ☐ I understand the objectives of BMPs and know some examples of them
- ☐ I know BMPs well and am practicing BMPs on my forestlands

10. Which of the following best describes forest management practices that are currently being implemented on this forest parcel for protecting water quality and preventing soil erosion? (*Check ALL that apply*)

Streamside Management Zones (SMZs) are buffer strips adjacent to bodies of water that should be managed with special considerations to protect water quality

- ☐ Streamside Management Zones
- ☐ Minimizing the amount of the bare soil exposed
- ☐ Minimizing stream crossings
- ☐ Other voluntary forest management practices
- ☐ Stabilizing road crossings
- ☐ Separating roads and log landings from streamsides
- ☐ Preventing connection between the bare soil and stream
- ☐ No practices

11. If you are currently implementing **Streamside Management Zones (SMZs)** on this forest parcel, which of the following best describes the current average width of SMZs on **each side** of the streams or other water bodies?

- ☐ Not applicable
- ☐ 0 – 40 ft.
- ☐ 40 – 70 ft.
- ☐ 70 – 100 ft.
- ☐ More than 100ft.
- ☐ Don't know

12. How do you rate the development pressures (or development possibilities) on this forest parcel within the next 10 years?

- ☐ Low
- ☐ Moderate
- ☐ High
- ☐ Not sure

SECTION B. TIME AND RISK PREFERENCES

In this part, we ask you to participate in several economic experiments designed to help understand the role of an individual's time and risk preferences in making economic decisions.

Questions 1 to 4 ask you to make decisions involving forest management options with different incentive payments over time. Each question consists of two potential forest management options. **Option A** will generate a lower but sooner lump sum incentive payment (**in ONE MONTH**), and **option B** will generate a higher but later lump sum incentive payment (**in SEVEN MONTHS**). You are asked to choose your preferred option in each question by checking the box beside it.

Example:	A. Incentive payment in	**ONE MONTH**	☐ **$300**
	B. Incentive payment in	**SEVEN MONTHS**	☑ **$315**

1. Please choose your favorite option by checking the box beside

A. Incentive payment in	**ONE MONTH**	☐ **$1,000**
B. Incentive payment in	**SEVEN MONTHS**	☐ **$1,051**

2. Please choose your favorite option by checking the box beside

A. Incentive payment in	**ONE MONTH**	☐ **$1,000**
B. Incentive payment in	**SEVEN MONTHS**	☐ **$1,104**

3. Please choose your favorite option by checking the box beside

A. Incentive payment in	**ONE MONTH**	☐ **$1,000**
B. Incentive payment in	**SEVEN MONTHS**	☐ **$1,160**

4. Please choose your favorite option by checking the box beside

A. Incentive payment in	**ONE MONTH**	☐ **$1,000**
B. Incentive payment in	**SEVEN MONTHS**	☐ **$1,217**

In **Question 5**, you are presented with six forest management scenarios resulting in different outcomes and asked to choose the most preferred scenario. Each scenario has fifty-percent probability of generating **income A** and fifty-percent probability of generating **income B** in one year. In scenario 1, potential incomes A and B are the same. As you move down the table, the amount of income A will decrease, while the amount of income B will increase. Note that each scenario has exactly the same probability of generating income A and B. For example, if you choose plan 3, you will have the same probability of earning $400 and $1,530 at the end of the year. If you choose plan 6, you will have the same probability of earning $20 and $1,830.

5. If you have an opportunity to choose **only one** forest management scenario out of following six forest management scenarios, which one do you prefer most? Please mark **your most preferred plan** to adopt by checking the box beside.

PLEASE MARK ONLY ONE SCENARIO OUT OF SIX

	Income A (50% probability)	Income B (50% probability)	**Your Choice**
SCENARIO 1	**$800**	**$800**	☐
SCENARIO 2	**$560**	**$1,210**	☐
SCENARIO 3	**$400**	**$1,530**	☐
SCENARIO 4	**$240**	**$1,740**	☐
SCENARIO 5	**$120**	**$1,820**	☐
SCENARIO 6	**$20**	**$1,830**	☐

6. How would you rate your willingness to take risks **when making financial decisions such as investment, purchasing land, and others?** Please provide a rating from ***Not at all risky (1)*** to ***Very risky (9)***, using the following scale:

Not at all risky								***Very risky***
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
☐	☐	☐	☐	☐	☐	☐	☐	☐

SECTION C. INCENTIVE PROGRAMS FOR RIPARIAN FORESTS

In this part, we ask you to consider whether you would be willing to participate in potential easement programs for conserving riparian forests and enhancing sustainable forestry. Please assume that you are offered the following easement program:

- The purpose of the program is to conserve riparian forests in southeast Georgia and to enhance sustainable forestry and critical environmental benefits derived from the forests
- As an incentive for keeping your land forested and conducting specified management practices (Streamside Management Zones), you will receive a certain amount of annual compensation in cash or tax credits for the contract length
- You can continue forestry practices as long as you implement applicable Georgia's Best Management Practices (BMPs) guidelines for forestry that were designed to protect the state's waters and promote sound sivilcultural operations in Georgia
- However, practices that may significantly change environmental features of the forest and changing land use for other purposes such as developed or agricultural use would be limited for the duration of the contract
- Upon violation of the contract terms, you will be required to refund all the payments you received over the life of the contract and all the administrative costs involved in enrolling your forest property in the program
- The contract is binding, whether the property is sold or passed on to heirs

You will be provided with multiple choice sets, and each choice set consists of two alternatives and a "status quo" option. Each alternative consists of different levels of contract attributes. If you do not want to participate in any of the alternatives, you can simply choose the "None" option. In each round, you are asked to pick the most preferred option among them. Below is an explanation of the contract attributes:

1) Annual payment (dollars per acre):

The presented amount of compensation would be paid every year for the duration of the contract.

2) Contract length:

The program offers you an opportunity to agree to a specific contract length.

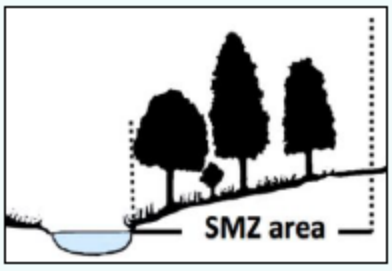
3) Payment mode:

The program offers you two payment modes of cash and tax credits. Timing of the two payments is the same. Tax credits can be used to reduce **STATE and FEDERAL property and income taxes.**

4) Minimum Streamside Management Zones (SMZs) width:

SMZs provide numerous environmental benefits including protection of water quality, biodiversity, and wildlife habitat. The program requires you to establish certain widths of SMZs on each side of **perennial (continuous flowing) and intermittent (normally flows only during wet seasons) streams and other surface waters** on your forest parcel. Different levels of minimum SMZ widths are offered.

Examples of the practices within SMZs include the following but are not limited to:



- Locating roads and logging decks outside the SMZs
- Leaving at least 50% canopy cover after a harvest to provide shade
- Limiting the use of mechanical equipment for harvesting and planting trees

5) Limitation on increasing pine plantation area:

For promoting conservation of forested wetlands and preventing change in the hydrology of the site, the program may require you **not to expand** the area of pine plantation on your property. This requirement still allows you to maintain forestry practices on already established pine plantation areas as long as they follow Georgia BMPs for forestry.

Example of choice experiment

Please carefully consider the following six scenarios and choose an alternative (A, B, or None) you most prefer in each scenario. Alternatives A and B differ in annual compensation amount, contract length, payment mode, minimum streamside management zones (SMZs) width, and limitation in expanding pine plantation area. If you do not want to participate in any of the alternatives, you can select the "None" option.

Please treat each scenario independently of each other and only compare A and B alternatives within a scenario, not across different scenarios. Also, please consider that these incentives are current opportunities for you and your forest property.

NOTE THAT THE PROGRAM REQUIRES YOU TO ENROLL YOUR WHOLE FOREST PARCEL:

Parcel Number 000 000 in Bulloch County

	Option	Annual payment	Payment mode	Contract length	SMZ width	Limitation on increasing pine plantation area
EXAMPLE	☐ A	$10/acre	Cash	10 years	70 ft.	No further increase in pine plantation area
	☑ B	$60/acre	Tax credits	30 years	40 ft.	No limitation
	☐ None					

	Option	Annual payment	Payment mode	Contract length	SMZ width	Limitation on increasing pine plantation area
SCENARIO 1	☐ A	$80/acre	Tax credits	In perpetuity	150 ft.	No further increase in pine plantation area
	☐ B	$30/acre	Cash	60 years	40 ft.	No limitation
	☐ None					

SCENARIO 2	☐ A	$10/acre	Cash	10 years	100 ft.	No limitation
	☐ B	$30/acre	Tax credits	In perpetuity	150 ft.	No further increase in pine plantation area
	☐ None					

SCENARIO 3	☐ A	$80/acre	Tax credits	10 years	150 ft.	No limitation
	☐ B	$30/acre	Cash	30 years	70 ft.	No further increase in pine plantation area
	☐ None					

SCENARIO 4	☐ A	$30/acre	Tax credits	In perpetuity	40 ft.	No limitation
	☐ B	$60/acre	Cash	30 years	70 ft.	No further increase in pine plantation area
	☐ None					

	Option	Annual payment	Payment mode	Contract length	SMZ width	Limitation on increasing pine plantation area
SCENARIO 5	☐ A	$60/acre	Tax credits	60 years	100 ft.	No further increase in pine plantation area
	☐ B	$80/acre	Cash	In perpetuity	100 ft.	No limitation
	☐ None					

SCENARIO 6	☐ A	$30/acre	Tax credits	30 years	70 ft.	No further increase in pine plantation area
	☐ B	$80/acre	Tax credits	60 years	100 ft.	No limitation
	☐ None					

7. If you selected either alternative A or B in any of the choice scenarios, please rank from **1** (**most important**) to **5** (**least important**) the attributes which affected your choices. No attributes should receive the same rank number.

☐ **Annual compensation amount**

☐ **Payment mode**

☐ **Contract length**

☐ **Minimum SMZ width**

☐ **Limitation on increasing pine plantation area**

SECTION D. SOCIO-ECONOMIC INFORMATION

In the last section, we would like to ask questions about your socio-economic information.

1. Are you a member of any forestry organization?

   ☐ Yes ☐ No

2. Are you a member, donor, or participant in any organizations that focus on environmental issues?

   ☐ Yes ☐ No

3. Have you had an environmental education (degree, major, class) or a career involving the environment in some way?

   ☐ Yes ☐ No

4. What is the highest level of education you have completed?

   ☐ Less than high school

   ☐ High school or equivalent

   ☐ 2-year college degree or equivalent

   ☐ 4-year college degree or equivalent

   ☐ Master's degree or higher

   ☐ Prefer not to answer

5. What is your age?

☐ Under 30 ☐ 31 - 40 ☐ 41 - 50 ☐ 51 - 60

☐ 61 - 70 ☐ Over 71 ☐ Prefer not to answer

6. What is your gender?

☐ Male ☐ Female ☐ Prefer not to answer

7. Are you retired?

☐ Yes ☐ No ☐ Prefer not to answer

8. Which of the following best describes your household's annual income last year?

☐ Less than $149,999

☐ More than $150,000

☐ Prefer not to answer

Thank you for completing this survey. If you have any comments or suggestions, please leave them on back of this page. Please return your completed survey in the enclosed pre-addressed postage paid envelope.

If you have misplaced the envelope, please return the survey to:

Dr. Jacek Siry, Professor
Warnell School of Forestry and Natural Resources
University of Georgia
180 East Green Street
Athens, GA 30602

Please use the space below for any additional comments.

APPENDIX B. IRB APPROVAL

Phone 706-542-3199

Office of the Vice President for Research
Institutional Review Board

APPROVAL OF PROTOCOL

July 8, 2016

Dear Jacek Siry:

On 7/8/2016, the IRB reviewed the following submission:

Type of Review:	Initial Study
Title of Study:	Family forest owners' risk and time preferences and willingness to participate (WTP) in payment for ecosystem services (PES) program
Investigator:	Jacek Siry
IRB ID:	STUDY00003648
Funding:	None
Grant ID:	None

The IRB approved the protocol from 7/8/2016.

In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103).

Sincerely,

Dr. Gerald E. Crites, MD, MEd
University of Georgia
Institutional Review Board Chairperson

310 East Campus Rd, Tucker Hall Room 212 • Athens, Georgia 30602
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