

Typology of Riparian Forest Owners in Southeast Georgia, U.S.

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Abstract

Riparian forests typically provide a richer portfolio of ecosystem goods and services than their non-riparian counterparts. This study identifies forest owner groups with similar motivations based on their objectives and compare these groups with their socioeconomic and forest property characteristics. It analyzes how different ownership categorizations affect landowner willingness to accept (WTA) payments for ecosystem services (PES) contracts that are designed to protect water quality and maintain sustainable provision of other ecosystem services. It adopted a market segmentation approach and combined it with a discrete choice experiment (CE) that elicited forest owners' preferences towards alternative PES designs. The results assist in developing more effective conservation programs by allowing cost savings and identifying forest owners most likely to participate in conservation programs.

Keywords

Payments of Ecosystem Services, Choice Experiment, Principal Components Analysis, Cluster Analysis, Forest Sustainability

1. Introduction

Family forest owners account for a major share of the private forests in the U.S. and play an essential role as a provider of a broad range of ecosystem services including timber, diverse environmental benefits such as clean air and water, recreational opportunities, and habitats for wildlife (Butler, 2008). Government and environmental organizations have been trying to engage family forest owners in various incentive and conservation programs to maintain and promote the sustainable provision of these benefits derived from working family forests (Kilgore et al., 2007). The varied characteristics of family forest owners, however, can pose

a challenge for these organizations to effectively 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 optimal to approach them as if they are a uniform group with the same goals and values.

This has led to efforts to classify forest owners into multiple internally consistent groups with similar objectives and motivations in order to facilitate the communication and design of programs to support and promote the provision of environmental benefits by family-owned forests. Already three decades ago, Kurtz and Lewis (1981) and Marty et al. (1988) demonstrated that there were different owner types with similar objectives and emphasized the need for targeted outreach or government programs for different owner groups. Recognizing the importance for policy design of identifying and categorizing forest owners, numerous studies have focused on owners' objectives and motivations as predictors of forest management decisions. A number of studies focused on developing forest owner typologies (Kuuluvainen et al., 1996; Karppinen 1998; Kendra & Hull 2005; Jennings & van Puten 2006; Finley & Kittredge 2006; Ingemarson et al. 2006; Majumdar et al. 2008; Kuipers et al. 2013; Khanal et al. 2017; Danley 2019). Other studies focused on factors beyond forest owner objectives to better understand forest owners and provide useful insights for improving policies and forest program designs (Kluender & Walkingstick 2000; Ross-Davis & Broussard 2007; Boon & Meilby 2007; Dayer et al. 2014; Davis et al. 2015; Starr et al. 2015; Metcalf et al. 2016).

Overall, these studies attempted to identify forest owner types with similar objectives, motivations, preferences, and other characteristics to explain forest management practices. Although it is hard to conclude that there is a singular way to classify forest owners, the findings of these studies suggest that segmenting forest owners based on criteria that fit the purpose of a study could provide useful insights into understanding forest owners' behavior. For example, forest owners who are interested in both non-timber and timber outputs were found to be those more engaged with active forest management and timber harvests, which was different from what previously was believed to be correct. In addition to a broad focus on forest management practices in the previous literature, several studies have used forest owners' objectives to explain their decision to participate in PES programs (Joshi & Mehmood, 2011; Matta et al., 2009; Mäntymaa et al., 2009; Rabotyagov & Lin, 2013). However, few studies have explicitly used forest owner segmentation or typologies in their analysis. Kline et al. (2000) examined forest owner typologies to explain willingness to participate in conservation programs.

This study introduces the family forest owner clusters derived from principal component analysis (PCA) and cluster analysis (CA) to estimate forest owners' willingness to participate in PES programs and their willingness to accept (WTA) compensation in such programs. It builds upon previous research efforts identifying forest owner segments with a specific focus on forest owners of parcels with

a riparian area in southeast Georgia, U.S., which is one of the most forested areas in the state. Most family forest owners harvest timber. Timber harvest is often the most important source of income. All owners have to pay annual property taxes and they will be looking for income from their forests, which will typically be generated by timber harvests and hunting leases. Riparian forests typically provide a richer portfolio of ecosystem goods and services (including nonpoint source pollution control, streambank stabilization, waterflow regulation, and flood control) than their non-riparian counterparts. The study identifies forest owner groups with similar motivations based on their objectives and compares these groups with their socioeconomic and forest property characteristics. Furthermore, it analyzes how different ownership segments affect landowners' WTA payments for ecosystem services (PES) contracts that are designed to protect water quality and maintain the sustainable provision of other ecosystem services. In doing so, it adopts a 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., 2000; Majumdar et al., 2008) and combines it with data from a discrete choice experiment (CE) that elicits forest owners' preferences for alternative PES designs. The results should assist in developing more effective programs by allowing cost savings and identifying and focusing on family forest owners most likely to participate in conservation programs.

2. Data and Methods

Data for this study come from a survey conducted in 30 counties in southeast Georgia, U.S. (see Kang et al., 2019, for full details of the study area and data collection protocols). The survey was reviewed, pretested, and revised based on feedback from a small sample of family forest owners and forest industry experts. The study area is geographically classified as the Coastal Plain Region. Private owners hold 90 percent of forest lands. Property and landowner information was collected from county tax assessor's offices yielding 4,600 riparian forest parcels greater than twenty acres with a body of water on the parcel. The identified parcels were checked using ArcGIS 10.4 and the National Hydrography Dataset by the U.S. Geological Survey to remove from the dataset parcels that did not have either intermittent or permanent streams or other bodies of surface water. For the identified riparian forest parcels with family forest owners, a random sample of 1,350 forest owners were selected and mailed a paper survey and a link to an online version in late summer of 2016. Follow-up reminders and replacement surveys were sent two and four weeks later, respectively. A total of 231 complete surveys answering all components necessary for this analysis were obtained, which is slightly different from Kang et al. (2019) due to different questions used in the analysis. The survey included questions asking about nine forest ownership 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, that survey

participants were asked to rate from 1 (not important) to 5 (very important).

To identify different forest ownership groups, a PCA was conducted to reduce the dimensionality of the forest ownership data and to obtain meaningful relationships among different ownership types. The PCs are an orthogonal linear combination of variables that explain much of the variability of the data. The number of PCs (four in this case) was selected based on how much variance is explained by selected principal components. We adopted a PCA followed by a Varimax rotation method, using the psych package for R (Revelle, 2017). After obtaining the PCs and loadings (or the coefficients of the variables) associated with each component and objective, PC scores were calculated by multiplying PC loadings by the target variables. Subsequently, non-hierarchical k-means cluster analysis (CA) was used to segment the data represented by the PC scores; k-means clustering can identify groups that are homogeneous within the cluster, but heterogeneous among clusters (Hair et al., 2010). PCA and CA are well-established methods for the study of segmented forest owner groups (see, for example, Khanal et al., 2017; Kuuluvainen et al., 1996; Kline et al., 2000; and Majumdar et al., 2008).

To assess the relationship between different forest ownership segments and willingness to participate in PES programs, a discrete choice experiment (CE) was conducted as part of the survey. The PES program would provide a certain amount of annual compensation to 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. Survey participants were presented with an example CE question to familiarize them with the decision format and each participant was asked to complete six CE tasks. Each task consisted of three alternatives: Option A, Option B, and Status Quo. Options A and B were composed of different levels of contract attributes. If the participants did not want to participate in any of these options, they were asked to select the Status Quo option.

Based upon current PES programs in Georgia, five program attributes were included in the CE including annual payment (\$10, \$30, \$60, or \$80 per acre), payment mode (cash or tax credits), contract length (10, 30, or 60 years and permanent), streamside management zone (SMZ) width (40, 70, 100, or 150 ft.), and restrictions on increasing pine plantation area (no restriction or no further increase in pine plantation area). Forest owners were informed that they should enroll the entire property (a parcel with a unique tax id number). The minimum payment corresponded with the compensation of a popular tax incentive program in the study area and the highest payment approximated the market rate for easements. Most easement type PES programs in Georgia provides tax incentives instead of cash payments; therefore, tax credits and cash payments were chosen to uncover which ones are preferred by forest owners, who were also informed that tax credits could be used to reduce state property and income taxes and the federal income tax. There were two required forest management practices for protecting water quality and maintaining riparian forests: 1) establishing specified minimum

SMZs, and 2) limiting increases in pine plantation area. To assess forest owners' WTA fulfilling additional management requirements, the SMZ width varied from 40 ft (current state mandated minimum) to 150 ft. Converting bottomland hardwood forests to pine plantations requires drainage, which can alter hydrologic features on a parcel and consequently alter the riparian ecosystem. This helps to assess how riparian forest owners respond to the limitation on increasing the area of pine plantations on the enrolled property.

Using the SAS MktEx macro, a D-optimal choice experiment design was generated with 36 choice sets that were structured in six blocks of six choice sets that were randomly assigned to each respondent. **Figure 1** provides an example of a CE choice scenario. Forest owner decisions in the CE were analyzed using a multinomial logit (MNL) model and a random parameters logit (RPL) model for robustness. The utility of a forest owner i for an alternative j in the n th choice sequence is specified as follows:

$$U_{ijn} = \alpha_j + \beta_i Z_{ijn} + \eta_j E_{ij} + \varepsilon_{ijn} \quad (1)$$

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), ($Z_{ijn} = [X_{jn}; C_i]$). This last term stems from our interest in analyzing if different forest ownership segments affect one's probability of participating in PES and WTA compensation. E_{ij} is a random error component with zero mean, and η_j is a parameter estimate for the error component. ε_{ijn} represents an error term with extreme value distribution.

	Option	Annual payment	Payment mode	Contract length	SMZ width	Limitation on increasing pine plantation area
SCENARIOS	☐ 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					

Figure 1. Example of a choice experiment question.

A detailed explanation of the procedures for estimating the RPL model is provided in Train (2009), Hensher et al. (2015) and Kang et al. (2019). Program attribute variables including payment mode, minimum SMZ widths, and limitation on increasing pine plantation areas were effect coded. The contract length variable was coded in two ways; the perpetual contract was dummy coded, and the contract length from years 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.

3. Results

Table 1 presents the PCA results. PCA loadings smaller than the absolute value of 0.1 cutoffs are not shown in the table. Four principal components (PCs) explaining about 71 percent of the total variance were retained. PCA loadings indicate how much individual variables contribute to the PCs; in this case, variables are the ownership objectives in each row in **Table 1**. A large absolute value of a PCA loading implies that the corresponding variable takes an important role in 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 *Land investment*. PC 1 has high loadings for the ownership objectives *Aesthetic enjoyment*, *Maintaining healthy ecosystem and nature*, *Family legacy*, *Recreation*, and *Privacy/rural lifestyle*. Based on those objectives, we named it *Non-timber forest value and conservation*. PC 2 has a high loading for the *Personal residence* objective and a large negative loading for *Income from timber harvest*. Given the contrast between *Personal residences* and *Income from timber harvest*, we named PC2 *Residence vs. timber*. PC 3 and PC4 have high loadings for *Income from recreation* and *Land investment*, respectively.

Table 1. PCA loadings.

Ownership objectives	Principal components			
	PC1 <i>Non-timber forest value and conservation</i>	PC2 <i>Residence vs timber</i>	PC3 <i>Income from recreation</i>	PC4 <i>Land Investment</i>
<i>Aesthetic enjoyment</i>	0.775	0.211		
<i>Maintaining healthy ecosystem and nature</i>	0.801			0.116
<i>Family legacy</i>	0.710	−0.152		
<i>Recreation</i>	0.673	0.332		0.116
<i>Privacy/rural life style</i>	0.639	0.449	0.112	0.166
<i>Personal residences (primary or vacation)</i>	0.306	0.758	0.172	0.127
<i>Income from timber harvest</i>	0.108	−0.720	0.331	0.263
<i>Income from recreation</i>			0.965	
<i>Land investment</i>				0.974
Cumulative variance explained (%)	30.2	46.6	58.8	70.8

To gather further insights, correlations between ownership objectives and forest types (planted pine—PP, natural pine—NP; oak-pine—OP; bottomland hard-

wood—BH, and upland hardwood—UH) on surveyed parcels were examined. Most notably, the proportion of PP on a forest property was correlated with all the ownership objectives other than *Land investment* and *Family legacy*. In particular, the proportion of PP stands in a forest parcel was negatively correlated with *Aesthetic enjoyment*, *Personal residences*, *Recreation*, *Maintaining healthy ecosystem and nature*, and *Privacy* variables. On the other hand, the PP percentage share was positively correlated with *Income from timber harvest* and *Income from recreation*. This forest type is very important in the study region because it commonly represents intensive forest management, signified by more frequent timber harvests (intermediate harvest—thinning and final harvest—clearcut), intensive site preparation for planting, and may involve the use of herbicides and fertilizers. Disturbance resulting from forest management and transportation operations as well as the use of chemicals may have negative impacts on the quality of adjacent water resources. The proportion of BH was negatively related to *Aesthetic enjoyment*, *Personal residences*, *Recreation*, *Income from timber harvest*, and *Income from recreation*. The remaining forest types were linked to fewer ownership objectives.

By multiplying PCA loadings by the 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 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 3** and **Table 4**). We used chi-square and analysis of variance (ANOVA) to compare each cluster along variables of interest. Variables for which differences were statistically significant are marked in bold in **Table 3** and **Table 4**.

Table 2. Cluster centers for objective based typology.

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

Table 3. Comparison of sociodemographic characteristics for clusters.

Characteristics	Clusters				
	CL1 <i>Non-market- objective</i>	CL2 <i>Investors (land oriented)</i>	CL3 <i>Resident owners</i>	CL4 <i>Investors (recreation and land)</i>	CL5 <i>Un-interested owners</i>
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. Comparison of property characteristics and forest management for clusters.

Characteristics	Clusters				
	CL1 <i>Non-market- objective</i>	CL2 <i>Investors (land oriented)</i>	CL3 <i>Resident owners</i>	CL4 <i>Investor (recreation and land)</i>	CL5 <i>Un-interested owners</i>
Parcel size in acres (mean/ median) ($p = 0.06$)	104/80	150/100	93/70	127/110	120/84
Ownership length ($\chi^2 = 34$, $df = 12$, $p < 0.01$)					
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 land acquisition ($\chi^2 = 34$, $df = 12$, $p < 0.01$)					
Purchased	30%	74%	73%	46%	57%
Inherited	59%	23%	27%	44%	43%
Gift	7%	3%	0%	5%	0%
Other	4%	0%	0%	5%	0%

Continued

Written management plan
($\chi^2 = 5$, $df = 4$, $p = 0.27$)

Have written management plan	24%	19%	18%	27%	7%
No written management plan	72%	77%	75%	63%	90%
Not sure	4%	4%	7%	10%	3%

Conducting practices for water protection
($\chi^2 = 17$, $df = 4$, $p < 0.01$)

Conducting more than one waterprotection practices	78%	84%	89%	90%	57%
No practices	22%	16%	11%	10%	43%

Knowledge about BMPs
($\chi^2 = 42$, $df = 12$, $p < 0.01$)

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
($\chi^2 = 15$ $df = 8$, $p = 0.04$)

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 ($p < 0.05$).

The average age of all the clusters, except cluster 3 (of which the mean age was 59), was greater than 60. All the clusters consisted of mostly male respondents. The retirement status of respondents was different depending on which cluster they fell within. For example, for clusters 1 and 5, more than 70 percent of respondents reported that they were retired while in clusters 2 and 3 more than 50 percent of respondents 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 smallest proportion (26 percent) of forest owners whose annual household income was high (exceeding US \$150,000). On the other hand, about 50 percent of forest owners in clusters 4 and 5 reported that they earned more than US \$150,000 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 have owned their property for more than 20 years. The most popular mode of property acquisition was purchase, followed by inheritance. Most of the forest owners did not have a written management plan for the property, however, most of the respondents were conducting more than one water protection practice on their properties. While the level of knowledge of Best Management Practices (BMPs, Georgia Forestry Commission, 2015) varied according to the clusters, respondents generally were not familiar with BMPs. Most of the respondents had pine plantations on their property.

We found that 20 percent of the survey respondents ($n = 46$) fell within cluster 1 *Non-market objective owners*. These owners were likely to assess non-timber forest objectives as more important than the timber objective (albeit the latter contributed positively to the score). Forest owners in this group were generally older and likely to be retired. The annual household income of the group was the lowest among the clusters (74 percent reported that their annual household income was below US\$150,000). This group has the highest proportion of forest owners who inherited the property, and the lowest proportion who purchased the property. Forest owners in this group showed a moderate level of participation in forest organizations, and a higher level of involvement with environmental organizations. 35 percent reported that they were participating in or donating to environmental organizations that focus on addressing environmental issues such as The Nature Conservancy, which is one of the highest proportions among clusters. 85 percent of *Non-market-objective owners* reported that they owned the property for more than 20 years. 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.

About 25 percent of survey respondents ($n = 58$) were identified in cluster 2 *Investors (land oriented)*. In terms of ownership objectives, 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 land 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 levels 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 it. In this group, 84 percent of forest owners reported that they were conducting more than one water protection practice and seemed 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.

We found that 24 percent of survey respondents ($n = 56$) fell within cluster 3 *Resident owners*. In terms of ownership objectives, *Resident owners* do not place

much value on objectives associated with generating income from timber, recreation or land investment. Non-timber forest benefits and residency objectives resonate most strongly with this group. This group is represented by young forest owners (the proportion of retired is the smallest among all clusters), who recently purchased the property (lowest proportion of forest owners owning the property for more than 20 years and highest proportion owning the property less than 5 years) and do not have ties to forestry organizations. Forest owners in this cluster were likely to have purchased the property from someone rather than to have inherited it. About 90 percent reported that they were conducting more than one water protection practice. However, only 11 percent reported that they knew BMPs well and were already practicing them. The group had the lowest proportion of forest owners who had intensively managed pine plantations on their properties.

About 18 percent of survey respondents ($n = 41$) fell within cluster 4 *Investors (recreation and land)*. 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 annual household incomes above US\$150,000. 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 a very good understanding of BMPs. This group has the highest proportion of forest owners who had moderate or high-intensity pine plantations on their properties (about 75 percent).

We found that 13 percent of survey respondents ($n = 30$) fell within cluster 5 *Uninterested owners*. 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 (72 years old on average) and retired forest owners. 70 percent of forest owners in this group reported purchasing and owning the property for more than 20 years. This group has a relatively low proportion of forest owners who participated in both forest organizations and environmental organizations. Forest owners in this group were least likely to be conducting any forest management practices for water protection. Forest owners in this group seemed to understand the least about BMPs; more than half of the forest owners in this group reported that they had never heard about BMPs before, with only 7 percent reporting that they knew what BMPs are and were practicing them on their property.

Table 5 presents estimates from the MNL and RPL models of forest owner preferences in the choice experiment for alternative designs of PES programs. The coefficients in both the MNL and RPL models have consistent signs and values. Coefficients for program attributes, the coefficients for contract years, permanent contract, cash payment, SMZ 150, and the restriction on increasing pine planta-

tions are statistically significant in both models. The coefficients for clusters 1, 3, and 4 are statistically significant and negative in the MNL model. However, in the RPL model estimation, we found that only the coefficient for cluster 1 was statistically significant. Based on the results of the two models, we can conclude that forest owners classified as cluster 1 *Non-market-objective owners* were more likely to accept PES contracts than forest owners in other clusters. We also estimated the marginal WTA for those belonging to cluster 1 using the delta method (Greene, 2012). We found that forest owners in cluster 1 required less compensation than other groups by about \$66 per acre per year.

Table 5. Results from MNL and RPL estimation models.

Variable	MNL Coefficient	RPL Coefficient	WTA (\$/acre/year)
<i>Random parameters in utility functions</i>			
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
<i>Nonrandom parameters in utility functions</i>			
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	
<i>Standard deviations of random parameters</i>			
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***	

Continued

<i>Standard deviations of latent random effects</i>	
Error component	3.75***
Number of observations	1386
Adjusted pseudo R ²	0.32
Log Likelihood	−1026

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

4. Discussion and Conclusion

We found that *Non-market-objective forest owners* were more likely to participate in PES programs and require a lower level of compensation compared to other groups. Their socioeconomic characteristics, forest property characteristics and management, and ownership objectives may help explain why their willingness to participate in PES is higher and WTA compensation is significantly lower than for other forest owners.

Forest owners in this group are generally older and retired and are seeking some additional financial opportunities from their forest properties. They are less wealthy, having the lowest proportion of forest owners with an annual income over US\$150,000 among clusters. These characteristics, combined with their high level of participation in environmental organizations, suggests that forest owners in this group may be more likely to be environmentally conscious and have more interest in environmental programs compared to other groups, resulting in a greater willingness to participate and lower WTA.

Furthermore, forest owners in this cluster are most likely (87 percent) to have owned the forest property for more than 20 years, and the most common mode of property acquisition was through inheritance. We can infer that forest owners in this group are likely to have owned the forest property for their lifetime and may wish to pass on the property to their family members (Butler et al. 2021; Tran et al. 2020), which could result in having more motivation to enroll their forest lands in long-term conservation contracts. Easement type PES programs require 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 goals, but also timber objectives. Previous studies found that forest owners who valued non-timber ecosystem services from forestlands had smaller WTA compared to those who did not appreciate the environmental benefits (Raunikaar and Buongiorno, 2006). Our study results also support previous findings that multi-objective forest owners could be a good target for environmental programs (Kline et al., 2000).

Since forest owners have diverse motivations and objectives in their land man-

agement, identifying forest owner clusters that share similar objectives within the same groups can provide valuable 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 willingness to participate in PES programs and required level of compensation. To do so, we adopted segmentation techniques including PCA and CA, which have been utilized in segmenting forest owners in previous studies.

The family forest owners were clustered into five groups based on their ownership objectives, including *Non-market-objective owners*, *Investors (land oriented)*, *Resident owners*, *Investors (recreational and land oriented)*, and *Uninterested owners*. These forest owner clusters were different in terms of how they manage their property, level of management, and sociodemographic characteristics. *Non-market-objective owners* consist of relatively older and retired forest owners with a high participation rate in environmental organizations. They owned the properties relatively longer than other clusters and were likely to have inherited the property. The cluster *Investors* 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. The impact of the cluster classification on forest owners' willingness to participate and WTA associated with enrolling their property in hypothetical PES programs was also investigated. *Non-market-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. The findings of the study provide useful insights to understand family forest owners based on common ownership objectives. The information can be used to improve future approaches to family forest owners, encouraging their participation in PES programs and policy-making as well.

Tools available to policy-makers may focus, at least initially, on *Non-market-objective owners* since they are more likely to participate in PES programs and require a lower level of compensation compared to other clusters. One would design a PES program with features and compensation levels that would lead *Non-market-objective owners* to self-select for participation in the PES program. Such an approach may be developed to limit, for example, timber harvesting in riparian forests at a reasonable expense as most owners, including *Non-market-objective* ones, will likely be inclined to harvest timber eventually to cover the cost of owning the land (property taxes, maintenance of boundary lines, protection measures), even if they do not intend to convert cutover land to pine plantations. If the goal were to limit the expansion of pine plantations, the findings may help to identify owners most likely to do it, and will help to estimate sufficient payments and other program attributes to offer a viable alternative to increasing the

area of pine plantations. The process of identifying clusters may be aided by revealed (through remote sensing) forested property characteristics in cases it is related to forest owner objectives for a particular property and thus help in targeting PES programs. These findings would help in strategic and cost-effective development and targeting of forest conservation incentive programs.

It should be noted that the results were derived based on forest owners' preferences toward a specific and uniquely identified parcel. Therefore, caution should be used in extending these results to forest owners who (often) own multiple parcels. Future studies could fill this gap by introducing more flexible choice scenarios in which forest owners could consider multiple parcels in CE.

Regarding model estimation results, both the MNL and RPL model coefficients have consistent signs and values. Coefficients for contract years, permanent contract, cash payment, SMZ 150, and the restriction on increasing pine plantations are statistically significant. However, coefficients for clusters differed, with only cluster 1 being statistically significant in the RPL model. This may result from the fact that the RPL is a more robust model. Also, a statistically significant error component (which captures an additional unobserved variance) in the RPL model may indicate an opportunity to estimate a latent class model which allows for accounting for heterogeneity in data where some parameters differ across unobserved groups.

The overall estimation procedure used in this work relied on the two-step framework. Another avenue to further this work may be to estimate increasingly popular hybrid choice (integrated choice and latent variable) models. [Vij and Walker \(2016\)](#) assessed hybrid choice models and identified circumstances where their use may be advantageous. [Budzyński and Czajkowski \(2018\)](#) further addressed the issue of endogeneity with the hybrid choice framework, and proposed solutions to this issue, further supporting the use of hybrid choice models.

The CE results presented here are likely different from similar studies, unless these were conducted in the same regional context of forest management. The greater region (US South) and the study area are characterized by predominant private ownership, very active timber markets, and virtually no forest management regulations, implying that forest owners have tremendous flexibility from a regulatory standpoint to manage their properties as they see fit. The results should be useful in developing effective policy-making tools aimed at conserving riparian forests and protecting water quality by allowing cost savings and focusing on family forest owners most likely to participate in conservation programs.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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