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## Understanding the Factors Influencing Nonindustrial Private Forest Landowner Interest in Supplying Ecosystem Services in Cumberland Plateau, Tennessee

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**Abstract:** Private forests provide a range of ecosystem services for society including provisioning, regulating, cultural, and supporting services. Sustaining the supply of such services depends on the interest of nonindustrial private forest (NIPF) landowners in managing their forests for such services. Assessing factors that influence NIPF landowner intentions would be useful in identifying potential suppliers of ecosystem services and in designing and implementing outreach and education programs to elevate the interests of less interested landowners. Using data collected from a mail survey of NIPF landowners on the Cumberland Plateau of Tennessee, this study examined how landowner interest in supplying ecosystem services was influenced by socio-demographic characteristics, economic and market factors, land management objectives, and ownership motivations. To that end, a multivariate logistic regression model was employed to analyze the supply of three types of ecosystem services: carbon storage (regulating service), water quality (provisioning service), and aesthetics (cultural service). Results revealed that landowner interest in managing forests for ecosystem services were significantly related to socio-demographic factors, management and ownership characteristics, and availability of financial incentives. These findings will improve the understanding of the market segment of landowners as related to ecosystem

services. The findings may facilitate the development of market protocols and outreach programs that promote payments for ecosystem services in Tennessee and elsewhere.

**Keywords:** ecosystem service; multivariate logistic regression; nonindustrial private forest landowners (NIPF)

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## 1. Introduction

Forests are traditionally treated as a source of timber and other wood products, but are traditionally undervalued for the provision of ecosystem services (ES). By definition, ES are benefits that people obtain (directly or indirectly) from the functions and services of natural ecosystems, and these benefits mainly refer to provisioning, regulating, cultural, and supporting services needed to maintain other services [1,2]. Common provisioning services include non-timber forest products, water quantity and quality, and production of food, fuel, and fibers. Regulating services include carbon sequestration and environmental hazard (e.g., pests and pathogens) control, with cultural services mainly referring to recreational and aesthetic benefits. Unfortunately, the Millennium Ecosystem Assessment indicated that global supply of several of these ES are in decline [2].

Recent studies have revealed that private forests play important role in providing immeasurable ES such as aesthetic enjoyment, privacy, and closeness to nature [3,4]. Approximately 63% of the forestlands in the U.S. are privately owned and most of them are classified as nonindustrial private forests (NIPFs) [3]. The USDA Forest Service estimates that 69% of the forestland in the southern U.S. is owned by NIPF landowners [5] and this percentage reaches as much as 81% in Tennessee [6]. Therefore, the interest of NIPF landowners in managing their forests for ES significantly affects the forest sector's ability to provide ES to society.

To better understand the potential supply of ES from private forests, it is important to know what factors influence landowners' decision-making in favor of ES supply. Pattanayak *et al.* [7], for example, indicated that efficient forest policy depends on an accurate understanding of the factors influencing landowner management decisions. Studies [3,8,9] have shown that personal beliefs and motivations are crucial factors in affecting private forest management decisions. Berta *et al.* [10] found that lifestyle-oriented landowners are more interested in managing their forests for cultural over regulating services. Moreover, previous studies of landowner behavior have demonstrated that landowner characteristics (e.g., age, gender, education, income, *etc.*) and ownership characteristics (e.g., ownership size, tenure, mode of acquisition, *etc.*) play important roles in forest management decisions [11–17]. Likewise, motivations of land ownership and land management objectives have also been found to be associated with landowners' attitudes regarding alternative forest management practices [18–25]. Thus, prior research demonstrates that a clear link exists between NIPF management decisions and factors such as landowner demographics, ownership characteristics, and management objectives. These factors have been used in predicting NIPF management practices [26,27]. In addition, landowner perception of risks associated with alternative management activities is a key predictor of their adoption of new management practices such as carbon sequestration [16,28].

In addition to understanding the factors that affect landowner attitudes toward ES provision, knowing how to provide appropriate incentives to motivate those owners with little interest in ES is equally important [29]. Numerous studies explored the efficacy of incentive-based programs to motivate landowners for ES supply. Jack *et al.* [30], for instance, showed that payments for ecosystem services (PES) policies increase the provision of ES such as water purification, flood mitigation, and carbon sequestration in U.S. Nevertheless, a knowledge gap still exists in fully understanding the relationship between the interest of NIPF landowners in supplying ES and the circumstances landowners face. To bridge that gap, this paper presents the results of a study to assess how NIPF landowner interests in supplying various types of ES including carbon storage, water quality, and aesthetics are related to personal characteristics, management objectives, ownership structure, and availability of financial incentives. Through identifying the characteristics of NIPF landowners associated with an interest in managing forests for ES provision, we provide useful information in understanding the potential suppliers of those services and in designing appropriate outreach programs to encourage owners to provide more services.

## 2. Conceptual Framework

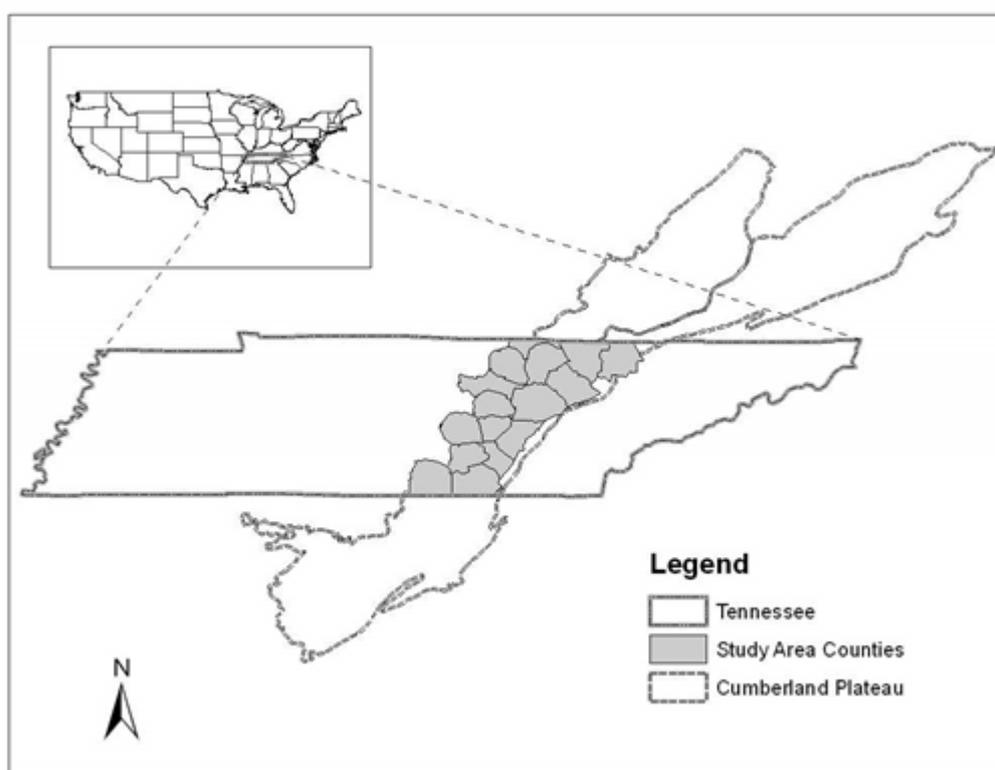
Given that the majority of forestland in the southern U.S. is under NIPF ownership, the management decisions they make are critical to future of ES supplies. According to the economic theory of utility-maximization, landowners that are also considered utility-maximizers take non-pecuniary benefits such as biodiversity, flood control, carbon sequestration, aesthetics, and recreation into consideration along with or without the timber benefits produced from their forestlands. The theory suggests that a landowner's forest management decision-making depends on both timber and non-timber benefits. Studies have demonstrated that the vast majority of NIPF landowners are generally utility-maximizers [31–33].

In addition, related theories in social psychology, including the Theory of Planned Behavior (TPB) [34] in particular, provide a basis for examining landowner management intentions. TPB “explains human behavior based on their attitudes to a behavior, subjective norms, and perceived behavioral control.” The main idea behind TPB is that the best predictor of future behavior is the intent to a specific behavior [35]. Behavioral intentions indicate one's willingness and preparedness to perform a given behavior and are assumed to be a direct antecedent of actual behavior. The TPB theory states that a landowner's attitude toward a management practice, subjective norms, and perceived risk could guide him/her in making a management decision for his/her forestland. A number of studies on landowners' behavior have been based on the TPB theory. For instance, Thompson *et al.* [16] applied TPB to explore private landowners' attitudes towards participating in carbon sequestration. Similarly, Leitch *et al.* [36] used the TPB theory to explore private landowners' intentions to supply woody feedstock.

### 3. Methodology

#### 3.1. Study Area and Data Collection

The study area covered 16 counties located in the Tennessee portion of the Cumberland Plateau (Figure 1): Bledsoe, Campbell, Cumberland, Fentress, Franklin, Grundy, Marion, Morgan, Overton, Pickett, Putnam, Scott, Sequatchie, Van Buren, Warren, and White. The Plateau is one of the “largest temperate hardwood plateau systems” and has remained largely undeveloped until recently due to the rugged terrain [37]. Most of the forests on the Plateau are under private ownership [38] and forested areas in some counties (e.g., Cumberland) have recently seen a surge of amenity migration and retiree growth. Sustaining the ecosystem and quality of life on the Plateau therefore will require cooperation of thousands of landowners in protecting and efficiently managing forests in the long run. With timber markets struggling in recent years, ES could serve as new markets for the forests.



**Figure 1.** 16-county area of the Cumberland Plateau of Tennessee.

Data required were collected with a mail survey of randomly selected forest landowners in the study area. The questionnaire was mailed to more than 1700 NIPFs in 2007 following the Total Design Method [39]. Two hundred and forty-six names were eliminated from the survey results because of the bad addresses, death, or having sold the land. As a consequence, a total of 590 completed surveys were returned, yielding an adjusted return rate of 41%. Survey questions included Likert scale items regarding their level of interest (1 = no interest at all, 4 = high interest) in managing forests for three types of ES: carbon sequestration, water, and aesthetics. Besides, other questions included in this survey were grouped into six different categories (Table 1): sociodemographic, forest ownership and management

objective, attitudes towards incentives, motivation of owning forestlands, future ownership plan, and other factors (perceived risk of damage and return from forest). Besides the survey questions, the secondary data regarding per acre return from forests in the respective county of each respondent was obtained from the *Tennessee Statistical Abstract* which was published by the Center for Business and Economic Research at the University of Tennessee. We divided the total dollar value of agriculture or forest product by the average farm size of the respective type to get the return on a per acre basis [40].

**Table 1.** Explanatory variables used to explain landowners' interest in managing forests to supply ecosystem services.

Variable	Description	Mean (S.E.)
Sociodemographic		
Age	Age of the landowner	68.99 (12.63)
Female	Dummy variable, 1 if female, 0 otherwise	0.23 (0.42)
Education	Dummy variable, 1 if landowner has more than college education, 0 otherwise	0.39 (0.49)
Income	Dummy variable, 1 if landowner has >\$75,000 in annual income, 0 otherwise	0.34 (0.47)
Occupation	Dummy variable, 1 if white-collar occupation, 0 otherwise	0.17 (0.38)
Forest ownership and management objective		
Tenure	Number of years the property has been with landowner's family	43.06 (41.92)
Acquisition	The mode of acquisition of forest by landowners. (1 if purchased, 0 otherwise)	0.72 (0.45)
Ownership size	Categorical variable, 1 if the landowner owns <10 acres of forestland, 2 if owns between 10 and 100 acres, and 3 if owns >100 acres	2.22 (0.49)
Timber harvesting	Dummy variable, 1 if the landowner recently harvested timber or planning to harvest soon, 0 otherwise	0.22 (0.41)
Advice	Dummy variable, 1 if the landowner received advice from professionals, 0 otherwise	0.04 (0.19)
Attitudes toward Incentives		
Property tax	Reported usefulness of property tax as incentive (1 = not useful, 5 = extremely useful)	3.65 (1.27)
Payment of individuals/companies	Reported usefulness of payment from private individual/company as incentive (1 = not useful, 5 = extremely useful)	2.85 (1.50)
Payment of government	Reported usefulness of payments from government as incentive (1 = not useful, 5 = extremely useful)	3.05 (1.49)
Motivations of owning forestlands		
Financial investment	Importance placed by landowner on "financial investment" as ownership motivation (1 = not important, 5 = extremely important)	3.03 (1.36)
Hunting/fishing	Importance placed by landowner on "hunting and fishing" as ownership motivation (1 = not important, 5 = extremely important)	2.71 (1.48)
Farm/Home site	Importance placed by landowner on "farm" as ownership motivation (1 = not important, 5 = extremely important)	3.53 (1.45)
Inheritance	Importance placed by landowner on "pass on to heirs" as ownership motivation (1 = not important, 5 = extremely important)	2.46 (1.67)
Peacefulness/tranquility	Importance placed by landowner on "peacefulness and tranquility" as ownership motivation (1 = not important, 5 = extremely important)	3.94 (1.20)

Table 1. Cont.

Variable	Description	Mean (S.E.)
Future ownership plan		
Inherit	Dummy variable, 1 if landowner plans to pass the forests to heirs, 0 otherwise	0.76 (0.43)
Develop	Dummy variable, 1 if landowner continues to manage the forests, 0 otherwise	0.06 (0.24)
Sell	Dummy variable, 1 if landowner plans to sell the forests, 0 otherwise	0.19 (0.40)
Donate	Dummy variable, 1 if landowner plans to donate the forests to others, 0 otherwise	0.03 (0.17)
Other factors		
Perceived risk of damage	Landowner's perception of risks of environmental damage associated with harvesting timber (1 = no risk at all, 5 = extreme risk)	3.34 (0.91)
Return from forest	Land productivity from forest use as measured by per acre value (\$) of timber products for landowner's county	10.51 (3.87)

### 3.2. Empirical Model

Researchers typically have relied on logistic regression to model forest landowner management decisions due to the categorical nature of dependent variable (e.g., harvest or not harvest) [14,36,41–44]. Since our study also involves modeling the landowner's level of interest, as measured by a Likert scale, a multivariate logistic regression was used. The dependent variable was the respondents' level of interest in managing forests to provide a given ES (*i.e.*, carbon sequestration, water quality, and aesthetic beauty). To examine whether specific factors related to NIPF landowner interest varied with different types of ES, each of the three dependent variables were separately regressed against explanatory variables. In each ES case, the dependent variable was hypothesized to be a function of the independent variables shown in Equation (1).

$$\text{Level of interest in supplying ES} = f(\text{Sociodemographics, Ownership and Management Objectives, Attitudes toward Incentives, Motivations for Owning Forestlands, Future Ownership Plans, Perceived Risk of Damage, Return from Forest}) \quad (1)$$

Mathematically, the multivariate logistic regression model is presented in Equation (2):

$$Y = \sum \beta'_k x_k + \varepsilon_k \quad (2)$$

where  $Y$  represents the level of respondents' interest in supplying selected ES,  $x_k$  is the matrix for all independent variables and  $\beta'_k$  indicates the associated parameters;  $\varepsilon_k$  is the error term of stochastic (unobserved) variation.

The sociodemographic group consisted of age, gender, education, income, and occupation. With respect to the relationship of age and gender with landowner interest in supplying ES, previous studies revealed that older and female landowners exhibit more interest in non-timber values and are more concerned for the environment [14,45,46]. Therefore, we expected a positive sign between age and landowner interest in providing ES. Moreover, income, education, and white-collar occupations were hypothesized to be positively related with landowner interest in managing forests for provisioning ES.

The second category included tenure, mode of acquisition, ownership size, timber harvesting history, and whether landowners received advice from professionals. Results regarding the relationship between tenure and forest management activities from previous studies are mixed [47,48] and therefore it is difficult for them to guide expectations for this study. In terms of mode of acquisition, we hypothesized that purchasers would be more interested in supplying ES than those who inherited forest from their parents. The reason behind this is that those who have invested resources in purchasing the land might be motivated by the potential benefit of incentives from provision of ES. In addition, compared to landowners who receive forestlands through inheritance, landowners who purchase their forestlands might be keener in managing the property with a specific interest. Previous studies also provided mixed results regarding the relationship between landholding size and interest in providing ES. Knoot *et al.* [14] and Jacobson *et al.* [49] concluded that there is no relationship between the land size and attitudes toward ES supply, whereas Thompson *et al.* [17] reported a negative correlation between increasing tract size and landowner interest in carbon sequestration. Hence, it is difficult to speculate on the relationship between landholding size and landowner interest in providing ES here. Nevertheless, we expected a negative relationship between timber harvesting and landowner intentions to supply ES because landowners who harvested or are planning to harvest timber might have less interest in non-timber products. By contrast, a positive sign for the advice variable was expected because landowners who received management advice from professionals were more motivated to manage their forests for ES. The reason is that the professional consulting could help the landowners meet their management objectives.

Attitudes toward incentives (for providing ES) of various types were also included in the model. Three types of incentives were included: payments from government, payments from private individuals/companies, and property tax incentives. Jack *et al.* [30] reported that payment for ES increases the supply of water purification and carbon sequestration. By the same token, a landowner's favorable view of incentives is expected to be positively related to landowner interest.

Ownership motivation variables included the importance placed on financial investment, hunting/fishing, farm/home site, inheritance, and peacefulness/tranquility for owning the forest. We expected that those placing higher importance on recreation (e.g., hunting/fishing), the site of their farm or home, and tranquility were more likely to manage forests for ES. On the contrary, landowners whose main purpose was to obtain financial benefits from their land would be less interested in ES. Majumdar *et al.* [8] noted that inheritors are more likely to manage forests for both timber and non-timber products than non-inheritors. Hence, we expected landowners who inherited land to exhibit more interest in ES provision.

We also expected that future ownership plans would affect landowner willingness to supply ES. Hence, variables for landowner plans to inherit, develop, sell, and donate were included. Kendra *et al.* [50] and Finley *et al.* [19] reported that "plan to sell" owners are less interested in engaging in forest management. Conversely, landowners who were willing to bequeath the forestlands to future generations are more concerned about both timber and non-timber values [31]. Thus, we expected that owners who were planning to bequeath the forests to their descendants were more willing to supply ES than those who were planning to sell or donate forestlands.

The final category was composed of two variables: perceived risk of damage by harvesting and financial return from forestland use as measured by the per-acre value of wood products sold.

The perceived risk and liability variable was developed by combining landowners' responses to seven different items characterizing the risk and liabilities that may be associated with the logging of a forest area. Using a 5-point Likert scale (1 = no risk at all, 5 = very high risk), their perception of the level of risk in terms of timber being stolen, property damage, water quality impacts, damage to residual trees, landowner liability, poor utilization of wood and waste, and beauty of the area affected were measured. Individual scores were added and then divided by seven to get the average score of perceived risk and liability. It is reasonable to expect that some landowners may not appreciate the aesthetic damage from timber harvesting [51]. Hence, the perceived risk of damage associated with timber harvesting can be significantly related to interest in non-timber services. As a result, private owners who perceived high risks from harvesting were expected to be willing to manage forests for non-timber services. Considering the Ricardian land rent theory [52], we hypothesized that landowners would be less interested in managing forests for ES if the per acre return from wood products (or the timber productivity) is high.

#### 4. Results

Summary statistics of the independent variables are presented in Table 1. The average age of respondents was 68 years. About 76% of the respondents were male, two-thirds (69.7%) reported some college education, and the reported mean annual income was \$50,000. In terms of forest ownership size, approximately 71% of the sample reported between 10 and 100 acres; 25% reported more than 100 acres, and about 4% indicated less than 10 acres. On average, the respondents owned the property for approximately 45 years: specifically, 70% of the sample owned their property less than 50 years and 23% between 50 and 100 years, as well as 7% over 100 years. Referring to acquisition, 72% of the sample reported that they purchased the land. Regarding the three incentives options, 82% preferred property tax incentives, with a relatively smaller percentage indicating that a direct payment from private individuals or companies (60%) and government (65%) would be useful. Approximately 79% of the respondents indicated that pursuing peacefulness/tranquility was the primary reason for owning their forests, whereas 76% expressed a willingness to bequeath their land to their descendants.

Collinearity among explanatory variables was tested by computing variance inflation factors (VIF) index (Table 2) and they were far less than critical threshold of 10 [53], suggesting that multicollinearity was not an issue of concern in our model. Results of the multivariate logistic regression are presented in Table 2. Both age and gender were significantly ( $p < 0.01$ ) related to respondents' interest in managing their forests for protecting water quality and storing carbon. The positive and significant coefficient on age implies that a landowner's interest in managing forests for water quality and carbon sequestration increases with their age. Similarly, female respondents exhibited a higher level of interest in managing their forests to protect water quality and sequester carbon than their male counterparts. By contrast, gender was not significant in the case of aesthetics. Similarly, those with a white-collar occupation were less likely to indicate an interest in carbon sequestration. In addition, education and income were both not significantly related with respondents' interests in providing any of the three ES examined.

The results of the forest ownership and management objective group revealed that tenure was significantly ( $p < 0.01$ ) and positively related to a respondent's interest in managing forests for carbon sequestration. Similar results were observed for aesthetic maintenance as an ES ( $p < 0.1$ ). The dummy

variable indicating whether the respondents recently harvested timber was significantly and positively ( $p < 0.1$ ) related to their level of interest in managing forests to protect water quality. Other variables in this category (ownership size, whether or not the landowner purchased the forest or received management advice from professionals) were insignificant.

**Table 2.** Results from multivariate logit model explaining factors related to landowners' interest in managing forests for selected ecosystem services ( $n = 590$ ).

Variable	Ecosystem Services			VIF
	Carbon	Water	Aesthetics	
	Coefficient (S.E.)	Coefficient (S.E.)	Coefficient (S.E.)	
Sociodemographic				
Age	0.03 (0.01) ***	0.03 (0.01) **	0.03 (0.01) ***	1.42
Gender	0.76 (0.31) **	0.80 (0.36) **	0.40 (0.33)	1.39
Education	−0.35 (0.25)	0.01 (0.29)	0.0007 (0.1)	1.38
Income	−0.29 (0.25)	0.07 (0.28)	0.52 (0.27) *	1.33
Occupation	−0.89 (0.33) ***	−0.09 (0.37)	0.005 (0.35)	1.66
Forest ownership and management objectives				
Tenure	0.02 (0.00) ***	0.01 (0.00)	0.007 (0.00) *	2.01
Acquisition	0.36 (0.35)	−0.10 (0.39)	0.17 (0.36)	2.32
Ownership size	−0.24 (0.27)	0.27 (0.30)	0.02 (0.28)	1.32
Timber harvesting	0.04 (0.27)	0.54 (0.31) *	−0.33 (0.29)	1.23
Advice	0.63 (0.63)	−0.04 (0.69)	0.89 (0.67)	1.23
Attitudes toward Incentives				
Tax property	−0.12 (0.13)	0.25 (0.14) *	0.40 (0.14) ***	2.18
Payment of individuals/companies	−0.07 (0.12)	0.11 (0.14)	0.09 (0.12)	2.82
Payment of government	0.51 (0.14) ***	0.08 (0.14)	−0.14 (0.13)	2.75
Motivations of owning Forestlands				
Financial investment	0.03 (0.09)	−0.19 (0.10) *	−0.09 (0.10)	1.34
Hunting/fishing	0.05 (0.09)	0.25 (0.10) ***	−0.05 (0.09)	1.38
Farm/home site	−0.14 (0.10)	−0.06 (0.11)	−0.18 (0.10) *	1.64
Inheritance	−0.10 (0.09)	−0.10 (0.12)	0.04 (0.11)	2.54
Peacefulness/tranquility	0.58 (0.12) ***	0.46 (0.13) ***	0.61 (0.12) ***	1.53
Future ownership plan				
Inherit	−0.71 (0.31) **	−0.18 (0.32)	−0.12 (0.31)	1.41
Develop	0.20 (0.48)	−0.21 (0.55)	0.37 (0.54)	1.11
Sell	−0.73 (0.32) **	−0.17 (0.35)	0.08 (0.32)	1.50
Donate	−0.73 (0.65)	−0.50 (0.73)	−0.88 (0.71)	1.18
Other factors				
Perceived risk of damage	0.83 (0.30) ***	0.65 (0.18) ***	0.38 (0.20) *	3.15
Return from forest	0.003 (0.03)	0.02 (0.04)	−0.06 (0.03) *	1.21

\*\*\*  $p = 0.01$ ; \*\*  $p = 0.05$ ; and \*  $p = 0.10$ . VIF: variance inflation factors.

Among the variables related to landowners' attitudes toward usefulness of incentives, a favorable view of property tax incentives or direct payment from the government were positively and significantly

related to an interest in managing forests for selected services. Specifically, coefficients for property tax incentives were significant for aesthetic beauty ( $p < 0.01$ ) and water quality ( $p < 0.1$ ). A significant ( $p < 0.1$ ) coefficient was also observed for direct payment from the government for carbon storage. Direct payments from private individuals/companies were not significantly related to interest in managing forest for any of the ES examined.

The importance placed on tranquility was significantly and positively associated with a willingness to provide carbon sequestration, water quality, and aesthetics. Additionally, the importance placed on hunting/fishing was positively related to an interest in protecting water quality. However, the importance of financial investment was negatively related to an interest in water quality. Moreover, the results revealed a negative association between the ownership motivation of farming and aesthetics.

Among the variables describing future ownership plan, respondents who plan to bequeath the forestlands to their descendants or sell their land were significantly ( $p < 0.05$ ) less interested in carbon sequestration. None of the future plan variables were significantly related to water quality or aesthetics.

As expected, a respondent's perception of the risk and liabilities associated with timber harvesting was positively related to their interest in managing for all three ES ( $p < 0.01$ ). The coefficient on the return from forests per acre was negative and significant ( $p < 0.10$ ) in the case of aesthetic beauty, and insignificant for the other two ES.

## 5. Discussion

This study demonstrates that a landowner's decision to supply ES is influenced by a wide range of ownership and land characteristics. Older and female landowners were generally more likely to manage their forests for ES, results that are consistent with previous studies [14,45,46,54]. Women are found to be more concerned than men about environmental issues, which perhaps relates to their higher level of interest in managing forests for ES [54–56]. This observation is in line with the TPB theory, which states that beliefs about environmental concern influence people's behavioral intentions, with regard to likelihood of managing forests to supply ES. The finding that higher income landowners exhibit a greater level of interest in managing forests for some ES agrees with the findings of Knoop *et al.* [14], who reported that income was positively associated with landowner interest in protecting some ES, such as bird habitat and water protection. Landowner education was not significantly related to a willingness to supply any of the ES considered in our analysis, which is in line with the results reported by Miller *et al.* [57], but Thompson *et al.* [17] reported that education positively affects interest in carbon sequestration. Such information about basic demography of NIPF landowners who are interested in sustaining the ES provision would be helpful for effective communication and outreach to those segments assistance.

Landowners who owned their forest for a longer period of time were more interested in managing it for carbon sequestration and aesthetics. It is possible that keeping the family's forests in a natural state might have been a common belief or "family norm" among some legacy- or heritage-oriented landowners, who also might have higher level of interest in non-consumptive management including carbon and aesthetics. This observation is also consistent with the relationship between norms and behavior described in the TPB framework. Earlier, Poudyal *et al.* [40] reported that tenure was negatively related to landowner intentions to convert forestlands. Furthermore, landowners who recently harvested

timber or were planning to harvest soon were more likely to be interested in managing forests for water quality protection than those who neither harvested nor were planning to harvest anytime soon. Thompson *et al.* [17] reported higher interest in carbon sequestration among landowners who planned to harvest timber. Our survey did not ask a specific question in this regard, but it is possible that interest in protecting water quality might have also been motivated by the negative impact of recent harvests. As described in TPB theory, this observation probably explains the relationship between the landowners' negative attitude towards the consequences of logging on water quality and intention to manage forest for non-timber products, which does not require logging.

Attitudes toward incentives for ES provision varied in their effects on landowner interest in supplying selected services. Landowners who thought property tax would be useful exhibited more interest in managing forests for water quality and aesthetics, whereas those who favored a direct government payment were also interested in managing forest for carbon storage. The significance of a property tax incentive in motivating landowners is not surprising considering that property tax is one of the largest financial burdens that NIPF landowners face [41]. Additionally, a landowner's previous experience with tax subsidies or exemptions (e.g., Tennessee Green Belt Program) and direct government payment (e.g., Conservation Reserve Program) may provide more familiarity and comfort with these incentives than other market-based PES mechanisms that are less common or nonexistent in the region. Landowners are probably less certain about the commitment from private individuals or companies as compared to government entities. These contrasting findings regarding the incentives could guide the design of new programs or demonstrate support for recently introduced programs that have been implemented across the nation. Such a mechanism of payment for ES exists in the form of tax credit for conservation easement (e.g., Virginia State Tax Credit, Colorado Conservation Easement Tax Credits, and Tennessee's Greenbelt Law). These programs are designed to protect the conservation values of a property such as wildlife habitat, outdoor recreation areas, and agricultural lands, as well as scenic vistas or historic lands. Considering the success of many of these tax-based programs, the government could facilitate transaction of incentives and payment for ecosystem services like carbon, water, and aesthetics through similar innovative mechanisms, where beneficiaries (e.g., companies, households) pay the government, and government in turn pays landowners for ecosystem service credit.

Landowners who highly valued tranquility were interested in managing their forests for all types of ES considered in our study. As shown in Butler *et al.* [3], enjoying tranquility is one of the most important landownership motivations among private landowners, and hence, if landowners place high importance on this motivation, they seem more interested in managing forests to provide all types of ES. Those who value recreational opportunities such as hunting demonstrated more interest in protecting water quality which arguably could benefit habitat quality. Nevertheless, Ghimire *et al.* [53] and Brenner *et al.* [58] reported that hunters are less interested in placing land in conservation easement. The inconsistency of these results may be caused by the fact that the easement involves giving up the development rights. By contrast, landowners motivated by financial returns were less likely to manage forestlands for water quality protection, possibly because returns for this ES are hard to identify in the region. Landowners' underlying values (economic, recreational *etc.*) are probably related to their evaluation of expected benefits from managing land for select ES. Even though our study does not show a formal path analysis, the evaluative belief (attitude) of benefits might in turn have influenced their intention to manage forests for alternative ES, an observation consistent with the TPB.

Future ownership plans also influenced interest in supplying ES. Landowners who plan to sell forestland were less interested in managing for carbon sequestration. This corroborates the earlier findings of Kendra *et al.* [50] and Finley *et al.* [19], who concluded that “plan to sell” owners are unwilling to participate in forest management activities involving both timber and non-timber outputs. Nevertheless, those who were planning to bequeath forests to their descendants were also less willing to manage for carbon sequestration. A casual observation behind this result is that the carbon-offset programs generally require a long-term commitment, such as the California Climate Action Registry (CCAR) program [59,60], which is not well suited to changes in ownership.

Finally, the likelihood of supplying ES was high among landowners who perceive higher risks with timber harvesting. This finding was consistent with Hardner *et al.* [28], who stated that landowners with high risk perception of forest degradation would be more willing to participate in carbon sequestration programs. According to the TPB theory, perceived risk as well as the behavioral control is an important predictor of behavioral intentions to undertake forest management practices. Therefore, TPB also explains why the landowners who have a higher risk perception of timber harvesting would be more likely to manage forests for carbon sequestration. Moreover, as indicated by Franklin *et al.* [51], harvesting forests could increase habitat fragmentation and aesthetic damage; thus, if the landowners perceive such risks, they might be more willing to manage for non-consumptive services such as ES. Returns from traditional forest management affect landowner interest in managing ES except in the case of aesthetics.

## 6. Conclusion

In conclusion, this study sheds some light on the characteristics and motivations of NIPF landowners who are interested in managing their forests for a variety of ES. First, landowners seem genuinely interested in managing their forests for provision of ES even though some difference exists in preference for incentives. Second, government agencies and conservation groups that are trying to work with landowners to promote conservation and provision of ES may benefit from our findings, particularly in identifying the market segment that might constitute the potential suppliers of ES. The findings will also be beneficial in extension and outreach programs to promote ES interest among landowners. Third, landowners seem more comfortable with government-based incentives for ES than those from private individuals or companies. This might indicate the uncertainty and trust issues among landowners in participating in private sector or market-based mechanisms for ES, and therefore some sort of government assurance might be needed to encourage landowners. Information like this would be crucial in designing market protocols and incentive mechanisms to promote ES markets.

Finally, a few limitations of this study should be noted. First, the response rate for the survey was less than desirable, although it was on par with several recent landowners’ surveys in the region. No follow-up survey was conducted due to budget constraints but considerable similarities were noticed between the sample and the population of study area in some key demographics. For instance, 22% in our sample had bachelor’s degree or higher level of education, 54% had \$50,000 or higher in annual household income. The 2013 U.S. Census QuickFacts showed that roughly 24% of the state population had a bachelor’s degree or higher level of education, and a median household income of \$44,298. Our sample had a relatively higher proportion of males (76%) compared to the Tennessee population (49%),

but this difference may also be attributable to the fact that our sampling frame included heads of the households. A second limitation is that a range of legal and logistic details surrounding ES contracts might have a great deal of impact on landowner interest and commitment to the ES project. Future studies could take an economic approach to investigate landowner interest, with the goal of estimating a minimum willingness to accept compensation for providing ES, and understanding their attitudes toward more specific details (e.g., time commitment, compliance requirement) of ES provision agreements. Finally, our regression model did not consider forest-characteristic-related variables (e.g., pine, hardwood) and site-characteristic-related variables (e.g., slope, loggability) that could arguably impact the supply and value of ES considered in this study. Future studies could combine survey data on landowners' interest with the spatially explicit land cover data of their parcels to address this.

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### Author Contributions

Nana Tian, Neelam Poudyal, Donald Hodges, and Timothy Young prepared the manuscript. Nana Tian conducted data analysis and interpretation of results. Donald Hodges and Kevin Hoyt designed the questionnaire and implemented the survey.

### Conflicts of Interest

The authors declare no conflict of interest.

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