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RESEARCH PAPER

Typology of Nonindustrial Private Forest Landowners and Forestry Behavior: Implications for Forest Carbon Sequestration in the Southern US

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Abstract To implement effective climate change mitigation and carbon sequestration activities in the southern US, nonindustrial private forest landowner (NIPF) participation is necessary because of the significant area of forest land under their ownership. For policy implementation to involve this major ownership group in climate change mitigation activities in this region, it is important to understand their forest management motivations and understanding toward carbon sequestration. This study develops a regional typology of NIPF landowners based on reasons for owning forest land in the southern US. The specific goals were to: (1) segment NIPF landowners into smaller homogeneous groups based on reasons for owning forest land; (2) identify landownership characteristics and forest management behavior by ownership groups; and (3) assess their climate change beliefs and understanding of forest carbon sequestration by ownership groups. A principal component-cluster analysis of 735 responses to a mail questionnaire distributed to NIPF landowners in the southern US revealed three groups, which were named amenity, multi-objective, and timber-oriented landowners. The amenity group included 21% of the landowners, while the timber and multi-objective groups included 40% and 39% of the landowners, respectively. These landowner groups varied in terms of owner characteristics, forest species type and management behavior, climate change beliefs and understanding of carbon sequestration. The amenity and multi-objective owners tend to have more positive belief toward climate change than the timber group, but more landowners in each group indicated having poor understanding of forest carbon sequestration. The study fills a knowledge gap in research efforts by developing a regional typology of NIPF landowners and linking it with their forestry

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resources and management strategies along with their climate change beliefs and understanding of forest carbon sequestration.

Keywords Forest management · Cluster analysis · Understanding · Climate change · Principal component analysis

Introduction

Carbon storage in forests is one of the most important strategies for climate change mitigation. Increasing sequestration of atmospheric carbon into tree components provides carbon storage and substitution benefits while providing other social and environmental benefits (Malmsheimer et al. 2008). US forests are an important carbon sink, which sequesters about 15% of total CO_2 emissions in the United States (US Environmental Protection Agency 2013). The agency estimated that conversion of some land to forest and management activities lead to an increase of net forest carbon sequestration by 13% between 1990 and 2012. US forests continue to function as a substantial carbon sink, and managing these forests for increasing carbon storage could provide a significant offset to carbon emissions and contribute to climate change mitigation. Additionally, in the southern US, forest carbon storage could be the most cost effective option with a potential to sequester 23% of the regional total CO_2 emission (Han et al. 2007).

In the southern US, nonindustrial private forest (NIPF) landowners are the predominant ownership group, owning more than 58% of the total forest land (Butler and Wear 2013). Galik et al. (2013) estimated that NIPF landowners stored 60% of the regional forest carbon under private ownership and there is a potential to further increase carbon stock in NIPF forest lands by using management strategies such as extended rotations or reduced disturbance. Assuming that all landowners are profit maximizers, US forest carbon supply models (Murray et al. 2005; Adams et al. 2011; Latta et al. 2011) found a higher potential for carbon storage in the southern US at different carbon prices.

Forest management strategies have an important role in determining carbon stocks of a forest stand (Malmsheimer et al. 2008). Forests could be both a source and sink of atmospheric carbon depending on the type of stand treatments applied; they could be managed to maximize carbon sequestration. Depending on forest type and management objectives, strategies such as increasing rotation lengths, reducing forest disturbance, and increasing productivity by fertilization can increase stored forest carbon. In general, management strategies that increase volume production often support higher forest carbon sequestration (Coeli and Stout 2007). Therefore, NIPF landowner choices of forest management strategies could have an important role in climate change mitigation and carbon sequestration in the southern U.S.

Earlier studies found that NIPF landowners often have multiple reasons for owning forest land including rural area residence, production and land investments, enjoyment of scenery, and to pass land on to heirs (Butler and Leatherberry 2006; Wear and Greis 2013). The National Woodland Owner Survey (NWOS) has found a wide variation among NIPF landowners in terms of their socio-demographic

characteristics, participation in forest management activities, and future plans for their forest land (Butler et al. 2016). An often used approach to characterize this diverse ownership group has been to segment landowners into different yet relatively homogenous groups largely based on their reasons for owning forest land (Table 1).

To characterize NIPF landowners largely based on ownership reasons, multiple studies have developed NIPF landowner typologies at state or sub-state levels (Kluender and Walkingstick 2000; Kendra and Hull 2005; Majumdar et al. 2008; Joshi and Mehmood 2011). Majumdar et al. (2008) used k-means cluster analysis to segment NIPF landowners in South Carolina, Georgia and Alabama into multi-objective, timber and non-timber oriented groups based on their reasons for owning forest land. Joshi and Mehmood (2011) used two-step cluster analysis to segment landowners in Arkansas, Florida, and Virginia into conservation oriented, multi-objective and passive landowners. Kluender and Walkingstick (2000) used k-means cluster analysis and segmented NIPF landowners in Arkansas into timber managers, resident conservationists, affluent weekenders, and poor rural residents. Timber managers were typically interested in harvesting and selling timber while affluent weekenders were less willing. Similarly, Kendra and Hull (2005) found that new NIPF landowners in Virginia could be separated into six types: absentee investors, professionals, preservationists, young families, forest planners and farmers. In this study, more landowners were associated with the forest planners and farmers group

Table 1 Selected studies using the cluster analysis to build a typology of nonindustrial private forest (NIPF) landowners in the United States by state and owner groups

Authors	State	Owner groups
Kline et al. (2000)	Oregon, Washington	Multi-objective, recreationists, passive owners, timber producers
Kendra and Hull (2005)	Virginia	Absentee investors, professionals, preservationists, farmers, forest planners, young families
Majumdar et al. (2008)	South Carolina, Georgia, Alabama	Multi-objective, timber owners, nontimber owners
Kluender and Walkingstick (2000)	Arkansas	Timber managers, resident conservationists, affluent weekenders, poor rural residents
Greene and Blatner (1986)	Arkansas	Managers and nonmanagers
Finley and Kittredge (2006)	Massachusetts	General cooperators, conservation cooperators, neutralists, noncooperators
Salmon et al. (2006)	Utah	Amenity-focused landowners, multiple-benefit landowners, passive landowners
Davis and Broussard (2006)	Indiana	Forest managers, new forest owners, passive forest owners
Joshi and Mehmood (2011)	Arkansas, Florida, Virginia	Conservationists, multiple-objective, and passive landowners
Kuipers et al. (2013)	Michigan	Consumptive, recreationists, naturalists, and multiple

than other segments. The authors found that new forest land owners were concerned more about lifestyle than timber or economic returns.

Multiple studies have analyzed NIPF landowner preference for non-timber benefits (Kulluvainen et al. 1996; Conway et al. 2003; Vokoun et al. 2006) and willingness to forego timber harvesting for those benefits (Kline et al. 2000; Raunikar and Buongiorno 2006). Their reasons for owning forest land largely affect non-timber preferences and willingness to implement alternative forest management strategies. NIPF landowners also differ in terms of their use of forest management intensities (Arano and Munn 2006; Joshi and Arano 2009). In addition, landowner values and objectives play important roles in their management decision processes or choice of forestry activities (Dhubhain et al. 2007). Lacking is an assessment of climate change and carbon sequestration related beliefs and understanding of NIPF landowners in the southern US and how policy development and educational efforts could be tailored to landowners with a variety of ownership objectives. The analysis of interconnectedness between landowner typology, forestry behavior, and understanding of carbon sequestration would be important because not every landowner would be interested or would qualify to participate in carbon programs. Such analysis would be useful to better design and implement suitable policies to involve NIPF landowners in forest carbon programs. In other words, classifying landowners into distinct and relatively homogeneous groupings based on their reasons of owning forest land is a practical approach to efficiently target landowners potentially interested in carbon sequestration programs. Such classification would help focus education and incentive programs toward potential heterogeneous target audiences.

This study developed a Southern regional typology of NIPF landowners based on their reasons of owning forest land. The specific objectives were to: (1) segment NIPF landowners based on the reasons of owning forest land; (2) analyze owner characteristics, ownership types, forest management behavior by ownership groups; and (3) identify climate change beliefs and understanding of forest carbon sequestration by ownership groups. To involve NIPF landowners in forest carbon sequestration activities in the southern US, policy instruments have to be tailored to make them consistent with landowner motivations for owning forest land.

Methods

Data

Data for this study was collected using a mail survey of NIPF landowners with forest land in 11 states[1] in the southern US. Counties without loblolly/shortleaf (*Pinus taeda/Pinus echinata)* or longleaf/slash (*Pinus palustris/Pinus elliottii*) pine forest group based on Forest Inventory and Analysis (FIA) data were excluded from the survey. A contingent rating scenario included in our survey questionnaire

[1] Alabama, Arkansas, East Oklahoma, East Texas, Georgia, Florida, Louisiana, Mississippi, North Carolina, South Carolina, Virginia.

required enough responses from NIPF landowners with pine forest types, but due to lack of such an exclusive database, counties lacking the forest types were excluded. The names and addresses of NIPF landowners were purchased from List-Giant,[2] a private database vendor that compiles forest landowner lists based on county tax roll records. Thompson and Hansen (2012) also used the same vendor database for their NIPF forest carbon sequestration study. Consistent with previous landowner studies (Olenick et al. 2005; Butler 2008; Thompson and Hansen 2013; Butler et al. 2016), our sample population did not include landowners with less than 4.05 ha (10 acres) of forest land in the selected counties.

To prepare a survey questionnaire with clearly understandable questions and elicit accurate information from landowners, a draft instrument was prepared and revised with input from US forest landowner researchers. Then, the draft survey was pretested at County Forestry Association meetings (in Jefferson Davis and Lee counties) in Mississippi and subsequently refined. The final survey questionnaire included 32 questions using 5 pages. The survey instrument included three sections: forest land characteristics, environmental preferences, and socio-economic details. Forest land characteristics addressed property size and location, ownership goals, and forest management strategies. Climate change and carbon sequestration belief and understanding related questions were in the environmental preference section and the last section included income, education, and demographic related characteristics.

The survey was sent to 5000 randomly selected landowners in the fall of 2013 following the Dillman (2000) Tailored Design Method for conducting mail surveys. The required number of landowners was selected using Dillman (2000) method to determine sample size for mail surveys. The method accounts key considerations required for overcoming sources of error in mail surveys and making an acceptable generalization of the sample results to the population from which it is drawn. There were three mailings and the time between successive mailings was approximately 3–4 weeks. Each mailing included a signed cover letter, a survey questionnaire, and a postage-paid return envelope. A reminder postcard was sent to non-responding landowners between the first and second mailing only.

Non-response Bias

To test for potential non-response bias, we conducted a telephone survey of non-responding landowners. Fifty randomly selected non-respondents were contacted by telephone and asked four key questions. Questions were related to their forest land (i.e., size of largest forested parcel), management behavior (i.e., availability of written forest management plan), climate change belief (i.e., whether human activities are contributing to climate change), and education level attended. The respondents were given the response choices used in the survey instrument. In addition, non-response bias was tested by comparing late responding landowners ($n = 100$), as proxies for non-respondents, to early responding landowners (Joshi et al. 2014).

[2] List-Giant http://www.listgiant.com.

Statistical Analysis

Respondent ratings of the objective statements in Table 2 formed the basis for developing a typology of NIPF landowners in the southern US. Landowner ratings of each statement indicated the relative importance of each benefit to the individual landowner. These statements describing landowner objectives were adopted from a study by Majumdar et al. (2008). Respondents rated each statement using a Likert scale that ranged from one (very unimportant) to five (very important) with three indicating a neutral category. Missing, invalid, or incomplete responses were not included in the analysis. All statistical analysis were conducted using SAS 9.3 statistical software (SAS Institute Inc. 2008)

By using landowner rating responses in each statement, principal component analysis transformed the set of objective statements into a smaller set of uncorrelated variables. Principal components represent reduced dimensionality of the original variables (Johnson 1998) and the new variables were named based on the original statements to which they were strongly correlated. In other words, for each principal component dimension, higher component loadings (i.e., correlation between original variables and the principal component) provided a basis for their naming and interpretation. Components with eigenvalue greater than one were retained. Then, a principal component score was computed for individual observations.

Principal component scores were used as input variables for landowner segmentation using K-means cluster analysis with Ward's minimum variance method. This segmentation approach has been used in earlier studies by Kulluvainen et al. (1996), Kline et al. (2000), and Majumdar et al. (2008) to analyze and characterize NIPF landowners. Cluster analysis groups individual observations such

Table 2 Nonindustrial private forest (NIPF) landowner ownership objectives and the associated factor loadings for the four principal components (aesthetic, recreation, investment, and non-timber) determined from principal component analysis

Objectives	Principal components			
	Aesthetic	Recreation	Investment	Non-timber
To enjoy the aesthetic appeal or scenery	0.90[a]	0.17	0.07	0.04
To protect nature or biological diversity	0.86[a]	0.14	0.13	0.09
For privacy	0.72[a]	0.33	0.11	0.12
For hunting and fishing	0.19	0.84[a]	0.15	0.13
To pass on to my children or other heirs	0.25	0.70[a]	0.35	−0.03
For recreation other than hunting or fishing	0.31	0.58[a]	−0.08	0.47
For production of sawlogs, pulpwood, and/or other timber products	0.03	0.14	0.86[a]	0.18
For investment purpose	0.20	0.14	0.86[a]	0.008
For cultivation/collection of non-timber products	0.08	0.09	0.18	0.92[a]

[a] Principal component loadings associated in each column

that there is homogeneity in observations within a cluster but heterogeneity among clusters. The analysis with two to four cluster solutions were performed, and the final solution provided the best fit in terms of i) the statistical difference among the clusters by ownership objectives and ii) the interpretability of the results from each of the cluster solutions.

Once respondents were assigned to specific clusters, landowner socio-demographic characteristics were analyzed for association with cluster membership using Chi-square analysis. In other words, Chi-square test was a measure of independence between rows and columns on n-by-n frequency tables formed by pairs of variables. Similarly, landowner forest resource status (i.e., forest acres and forest type) and management strategies (i.e., availability of a forest management plan, thinning and other stand improvement treatments, fertilization use, prescribed fire frequency, and pine forest rotation) were compared among landowner clusters. Finally, landowner climate change beliefs and understanding of forest carbon sequestration were analyzed for significant difference among clusters. Landowner climate change beliefs were adopted from Khanal et al. (2016).

Results

There were 4671 usable addresses after removing bad addresses, deceased individuals, and those with no forest land from 5000 randomly selected addresses. A total of 735 usable survey questionnaires were returned resulting in a cooperation rate of 15.8%. Thompson and Hansen (2012) also had a similar cooperation rate (15.9%) on a nationwide study of NIPF landowner attitudes toward carbon sequestration and trading. A study on forest management operations by Joshi and Arano (2009) had a 20% usable response rate. There could be several reasons for the low response rate in our study. One reason could be the complicated contingent rating scenario built into the survey instrument. In addition, the political sensitivity of the climate change issue may have contributed to the lower response rate. The survey instrument also included items that required a substantial understanding about climate change and carbon sequestration as well as detailed information about landowner forest management operations; some landowners may have lacked interest or sufficient knowledge to complete the survey. Non-response bias test results showed that there was no statistical difference ($P > 0.10$) between responding and non-responding landowners using a t test in terms of forest land, management behavior, climate change attitude and education, suggesting non-response bias was not a concern. In addition, our sample was comparable to NWOS results (Butler et al. 2015) in terms of average age, most frequently cited income category and the proportion of male and female owners in the South. Among the respondents, about 49% were older than 64 and the most frequent income category (54%) was an annual household income greater than US $75,000. The most respondents were mostly male (83%).

Typology of NIPF Landowners in the Southern US

Results of the principal component analysis are presented in Table 2. Landowner objectives were reduced to four principal components labeled aesthetic, recreation, investment, and non-timber goals. These four factors described 77% of the variation in the original data. In the first component, objectives describing aesthetic appeal, biodiversity, and privacy had loadings greater than 0.72 and was labeled aesthetic. The second component recreation included objectives describing hunting and fishing as well as bequest motives, and it had loading greater than 0.58. Similarly, the investment component represented investment and production related interests of the landowners with loadings equal to 0.86. The non-timber component represented cultivation/collection of non-timber product goal with loading of 0.92.

Subsequently, from the cluster analysis, landowners were grouped into three clusters namely amenity, multi-objective, and timber oriented owners. The three cluster solution provided the best fit because the clusters were significantly different in terms of the landowner objectives (F-ratios, $P < 0.00$) and the landowners associated with each cluster could be identified in terms of owner characteristics, forest ownership and management behavior, and climate change beliefs. Table 3 presents proportion of landowners in each cluster and their major reasons for owning forest land. There were 21% of landowners in the amenity cluster, while the proportions of landowners in the multi-objective and timber clusters were 39% and 40%, respectively. These groups were labeled based on the average Likert-scale ratings of the objectives with the strongest component loadings under each principal component in Table 1. The amenity oriented landowners highly valued aesthetics and recreation goals from their forest land, as indicated by the average Likert-scale rating of 5 (very important) and 4 (important) for the aesthetic and recreation goals, respectively. The multi-objective landowners valued aesthetics, investments, and non-timber goals from their forest land, which was indicated by the average Likert-scale rating of 5 (very important), 4 (important), and 3 (neutral) for these objectives,

Table 3 Nonindustrial private forest (NIPF) landowner cluster types based on ownership objectives, percentage of NIPF landowners by cluster type, and mean Likert-scale scores for the selected objectives (aesthetic, recreation, investment, and non-timber) by each cluster type (N = 567)

Cluster type	%	Mean Likert-scale score[a]			
		Aesthetic	Recreation	Investment	Non-timber
Amenity	21	5	4	2	2
Multi-objective	39	5	4	4	3
Timber	40	3	4	4	2
	F-ratio	211.77	11.42	118.46	74.37
	P value	<.0001	<.0001	<.0001	<.0001

[a] Mean Likert-scale score of the objectives most strongly associated with each of the four principal components in Table 2. Aesthetic (to enjoy the aesthetic appeal or scenery), recreation (for hunting and fishing), investment (for production of timber products), and non-timber (for cultivation of non-timber products). The Likert scale was 1 (very unimportant), 2 (unimportant), 3 (neutral), 4 (important), 5 (very important)

respectively. The timber oriented landowners emphasized investments, recreation, and aesthetic goals from their forest land, as indicated by the average Likert-scale ratings of 4 (important) for the investments and recreation objectives, and 3 (neutral) for aesthetic objective. There was a significant difference ($P < 0.00$) among the three groups in terms of their average Likert-scale rating to the selected objectives. The timber and multi-objective groups included 40% and 39% of the landowners, respectively, while the amenity group included only 21% of the landowners.

Owner Types, Ownership Characteristics and Management Strategies by Typology

There was significant difference among the clusters in terms of their socio-economic characteristics (Table 4). The landowner groups were different in terms of landowner age ($\chi^2 = 8.79$, $P < 0.06$) and income ($\chi^2 = 8.79$, $P < 0.06$), but not in terms of their education ($\chi^2 = 12.03$, $P > 0.14$) (Table 4). More than 67% of the landowners in the timber and multi-objective clusters were over 60 years old, but in the amenity cluster about 63% of the landowners were over age and about 15% were less than 50 years old. Less than 12% of the landowners in the timber and multi-objective clusters had income greater than US $225,000, but about 14% of the landowners in the amenity group were in the income category. However, about 46% of the landowners in each cluster had income less than US $62,500. About 32% of the landowners held a high school, GED or less education, irrespective of cluster types.

Table 4 Distribution of nonindustrial private forest (NIPF) landowner socio-demographics (i.e., age, income, education) by cluster type in the southern United States

Attributes	Cluster type (%)			Chi-square	*P* value
	Amenity	Multi-objective	Timber		
Age				8.79	0.06
<50	15.32	7.94	12.56		
50–60	21.62	24.77	16.14		
>60	63.06	67.29	71.30		
Income				8.79	0.06
Less than $62,500	45.95	56.07	47.98		
$62,500 – $225,000	40.54	32.71	44.39		
Greater than $225,000	13.51	11.21	7.62		
Education				12.03	0.14
High school, GED or less	32.43	31.78	36.77		
Associate degree	7.21	14.95	9.87		
Bachelor's degree	34.33	28.50	31.84		
Graduate degree	11.71	16.82	13.90		
Professional degree	14.41	7.94	7.62		

NIPF landowner ownership of forest characteristics was different among the groups (Table 5). There was significant association between landowner groups and forest land size ($\chi^2 = 11.10$, $P < 0.08$). The most common forest land size was between 40.47 and 202.34 ha in each landowner group, and more landowners in the multi-objective (9%) and timber clusters (13%) held larger than 202.34 ha forest property than the amenity owners (6%). Forest species types differed among the ownership clusters ($\chi^2 = 20.92$, $P < 0.00$). More than 70% of the landowners in the timber and multi-objective clusters had pine forest, but less than 58% of the landowners in the amenity cluster had pine forest. Similarly, more than 70% of the landowners in the timber and multi-objective clusters held loblolly pine (*Pinus taeda*), while less than 60% of the landowners in the amenity cluster had this species type in their forest. More landowners in the timber cluster (39%) inherited their forest land than in the amenity (28%) or multi-objective (31%) clusters.

Landowner clusters varied in terms of their forestry behavior (Table 6). Landowner clusters differed in terms of availability of forest management plans ($\chi^2 = 7.91$, $P < 0.01$). More landowners in the multi-objective (29%) and timber (27%) clusters had a forest management plan than in the amenity cluster (15%). Landowner groups were statistically different in use of forest management treatments ($\chi^2 = 11.64$, $P < 0.02$). Thinning was more common among the multi-objective landowners (40%), but the percentage of landowners thinning their forestland in the timber and aesthetic clusters was 27% and 26%, respectively.

Table 5 Nonindustrial private forest (NIPF) landowner forest characteristics (i.e., forest acres, forest type, loblolly percentage, and inheritance) by cluster type in the southern US

Attributes	Cluster type (%)			Chi square	*P* value
	Amenity	Multi-objective	Timber		
Forest size (ha)				11.10	0.08
<40.47	40.17	26.82	32.30		
40.47–202.34	52.99	64.09	56.64		
202.34–404.69	4.27	6.36	4.87		
>404.69	2.56	2.73	6.19		
Forest type				20.92	0.00
Pine	58.49	70.10	73.95		
Hardwood	19.81	18.63	18.14		
Hardwood pine mixed	21.00	10.29	6.05		
Non-type	0.70	0.98	1.86		
Loblolly Pine proportion in the forest				28.50	0.00
None	41.41	29.57	27.04		
<25%	28.28	22.58	15.52		
25–75%	17.17	29.57	23.98		
>75%	13.13	18.28	33.16		
Inherited forest land				4.96	0.08
Yes	28.83	31.31	39.46		
No	71.17	68.69	60.54		

Table 6 Nonindustrial private forest (NIPF) landowner forest management attributes (i.e., management plan, treatments, and prescribed burning) by cluster type in the southern US

Attributes	Amenity	Cluster type (%)		Chi Square	*P* value
		Multi-objective	Timber		
Availability of forest management plan				7.91	0.01
Yes	15.38	29.58	27.98		
No	84.62	70.42	72.02		
Use of forest management treatments				11.64	0.02
Thinning	26.07	40.63	27.50		
Timber stand improvement	0.63	23.44	32.55		
Chemical or fertilization	73.30	25.94	40.00		
Use of prescribed burning				8.75	0.18
Never	81.48	72.25	73.85		
Once every 1–3 years	7.41	15.31	12.39		
Once every 4–6 years	8.33	6.22	5.50		
Once every 7–10 years	2.78	6.22	8.26		

Timber stand improvement (TSI) was more frequent among the timber managers (32%) as compared to the multi-objective (23%) and aesthetic clusters (0.63%). More landowners in the amenity cluster (73%) used chemical or fertilization treatment than in the timber and multi-objective clusters. Regarding use of prescribed fire, there was no significant difference among the clusters, but more than 72% of the landowners in each cluster never used prescribed fire.

Climate Change Beliefs and Understanding of Forest Carbon Sequestration by Typology

Table 7 presents landowner climate change beliefs and the rating of their understanding toward forest carbon sequestration by ownership group. There was significant difference among the landowner groups in terms of their climate change beliefs—"human activities contribute to climate change" ($\chi^2 = 17.79$, $P < 0.02$) and "climate change is scientifically proven" ($\chi^2 = 18.85$, $P < 0.01$), but not in terms of their understanding of forest carbon sequestration ($\chi^2 = 4.27$, $P > 0.83$). More landowners in the amenity (66%) and multi-objective (71%) clusters believed "human activities contribute to climate change" than in the timber (59%) cluster. Interestingly, more than 45% of the landowners in the amenity and multi-objective clusters believed "climate change is scientifically proven", but only 30% of landowners in the timber cluster held such belief. Less than 33% of the landowners in each cluster indicated having a good or very good understanding of forest carbon sequestration.

Table 7 Nonindustrial private forest (NIPF) landowner climate change beliefs, understanding of forest carbon sequestration by cluster type in the southern United States

Attributes	Cluster type (%)			Chi square	*P* value
	Amenity	Multi-objective	Timber		
Human activities contribute to climate change				17.79	0.02
Strongly disagree	5.45	3.30	4.13		
Disagree	3.64	2.83	9.17		
Neutral	23.64	21.70	26.61		
Agree	44.55	54.25	48.17		
Strongly agree	22.73	17.92	11.93		
Climate change is scientifically proven				18.85	0.01
Strongly disagree	9.09	5.66	12.79		
Disagree	11.82	13.21	17.35		
Neutral	32.73	34.43	39.27		
Agree	34.55	35.85	25.57		
Strongly agree	11.82	10.85	5.02		
Forest carbon sequestration understanding				4.27	0.83
Very poor	17.12	14.02	17.04		
Poor	27.03	24.77	26.01		
Neutral	21.62	30.37	28.25		
Good	31.53	27.10	26.01		
Very good	2.70	3.74	2.69		

Discussion

This study developed a typology of NIPF landowners in the southern US and analyzed owner characteristics, ownership type, management behavior, and the beliefs and understanding of climate change and carbon sequestration by landowner clusters. The reasons for ownership among NIPF landowners in the southern US could be broadly grouped into four major types—aesthetic, recreation, investment and non-timber motivations. Landowner cluster results indicated that 40% of landowners in the southern US held timber goals for their forest land while the proportion of the multi-objective and amenity oriented landowners was 39% and 20%, respectively. The multi-objective landowners valued all four primary reasons for owning forestland unlike the timber and amenity group landowners. For the landowners in the amenity and multi-objective clusters, aesthetic and recreation goals were important reasons for owning forest land while the landowners in the timber cluster were neutral about the aesthetic goal. Recreation objective was an important reason for owning forestland irrespective of the cluster type. This is consistent with Butler et al. (2016) findings that aesthetic, wildlife habitat, and recreation are the important reasons for the landowners to own a forest land. The results also imply that the majority of landowners in the southern US held timber or

multi-objective goals, suggesting that although hunting or recreational management might be their primary goal they would still consider timber harvesting as long as it is in accordance with their primary goal(s). In addition, the landowners in the amenity and multi-objective clusters might find carbon sequestration strategies less conflicting with their landownership goals while the landowners in the timber cluster might find delaying harvest less profitable. This is why the timber managers might be responsive to carbon sequestration policies if it enhances their financial motive but the multi-objective landowners could be responsive to a wider variety of policy instruments including policies promoting joint management of timber and carbon. Also, environmental benefits of carbon sequestration might motive the amenity landowners.

The most common forest ownership size among southern landowners was 40.47–202.34 ha, and less than 12% of landowners held more than 202.34 ha of forest land, irrespective of the cluster type. In general, more landowners in the timber or multi-objective clusters hold larger than 202.34 ha than the amenity cluster. Less than 40.47 ha of forest land was more common in the amenity cluster (40.17%) than the multi-objective and timber cluster. The amenity landowners typically owned smaller acres of forest land than the timber or multi-objective clusters. In addition, more than 70% of landowners in the timber and multi-objective groups indicated having pine forest than the amenity cluster landowners. Hardwood or mixed forest were more common among the amenity group landowners than in the other two groups. Loblolly Pine (*Pinus taeda*) was more prevalent among the timber and multi-objective groups than the amenity group. These results indicated a positive association between forest characteristics and their reasons for owning forest land. These results are supported by Butler's (2005) findings that ownership characteristics are important variables restricting management and harvesting choices of landowners with varied reasons for ownership. This relation was more evident in the choice of forest management strategies by the three ownership groups. The amenity landowners were the most passive landowners in terms of their tendency to not have a forest management plan, infrequent use of TSI, but more frequent use of chemical or fertilization treatment as compared to the other two groups. However, most landowners in the southern US do not prepare a forest management plan nor do they use prescribed fire, irrespective of the cluster type. Since TSI has been used as a stand quality improvement tool (Nyland 2001), popularity of TSI among the timber and multi-objective groups indicates toward their regard for timber quality. The popularity of thinning among the multi-objective landowners indicates toward their tendency to manipulate the stand for multiple products or benefits. Similar to these results Joshi and Arano (2009) found that the timber and investment oriented landowners are more likely to implement harvesting and silvicultural activities than those with non-timber objectives and land size is one of the important variable associated with these decisions. In addition, this study further expands Arano and Munn's (2006) finding that there is heterogeneity among NIPF landowners in terms of their forest size and species type as well as the choice of management behavior particularly among the three ownership groups in the southern US.

Few landowners in the southern US indicated having a good understanding of forest carbon sequestration. Less than 33% of the landowners, irrespective of ownership group indicated having a good understanding of forest carbon sequestration. Though the study included a paragraph about carbon sequestration in lay terms to aid in their understanding, it could be possible that landowners' self-reported measure might be actually assessing their awareness rather than their actual knowledge given the complexity involved in explaining carbon sequestration. In this context, with carbon sequestration being a fairly new topic to include among forest management goals, a lower understanding on the part of landowners could be attributed to the limited availability of education and outreach information related to the topic. Hence, about two-thirds of the landowners in each cluster indicated a lower understanding of carbon sequestration, implying there is a need for more education and outreach activities related to carbon sequestration and climate change mitigation in the southern US.

Conclusions

From the analysis of 735 NIPF landowners' reasons for owning forest land across the southern US, this study highlights variation among the owners in terms of forest type, management strategies, and climate change beliefs and interest toward carbon sequestration. Using the principal component-cluster analysis approach, the landowners in the southern US were grouped into three segments (i.e. amenity, multi-objective, timber), which varied in terms of owner characteristics, forest size and type, and climate change beliefs. Results suggested that landowners in the southern US own forest land for multiple reasons and the landowner segments could have varied motivations and interest toward managing their forests for carbon sequestration. However, the majority of landowners indicated a lower understanding of forest carbon sequestration so more education and outreach activities were suggested for increasing participation of NIPF landowners in forest carbon sequestration.

The findings of this study have implications for design of extension and outreach services tailored to the needs of NIPF landowners in the southern US. Education programs aiming to increase participation of landowners with diverse forest values and management practices into climate change mitigation and carbon sequestration would be more effective if tailored by landowner typology. In fact, understanding of ownership reasons, forest resource status and management behavior by landowner typology could help identify target audiences for potential incentive programs. In addition, the amenity and multi-objective landowners have their ownership reasons better aligned for implementing forest carbon sequestration strategies in current climate change policy and carbon market environment. Finally, it is important that forestry educators and service professionals recognize diverse motivations and educational requirements of landowners within each typology regarding climate change mitigation and forest carbon sequestration.

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