

Social Sciences

United States Family Forest Owners' Awareness of and Participation in Carbon Sequestration Programs: Initial Findings from the USDA Forest Service National Woodland Owner Survey

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Abstract

Family forest owners (FFOs) hold a plurality of forestland in the United States, and programs and markets exist that compensate landowners for sequestering and storing increased carbon through extended rotations, improved forest management, and increased forest cover. We used USDA Forest Service National Woodland Owner Survey (NWOS) data from 2018 to estimate the number of ownerships and their associated acreage that are enrolled, that are familiar but not enrolled, and that are unfamiliar with these programs, as well as differences in attributes among these groups. As of 2018, less than 0.1% (SE < 0.1%) of FFOs are enrolled in carbon sequestration programs, and collectively they hold an estimated 400,000 ha (SE = 100,000). FFOs who are enrolled have larger holdings, are more likely to participate in other programs, and are more concerned about climate change, among other characteristics. Most FFO holdings are too small to be viable in traditional carbon programs, although new and evolving programs might enable smaller landholdings to be feasible to enroll. Knowing the characteristics of ownerships that are enrolled or aware of programs will allow for more informed design and implementation; future monitoring will be important to identify trends as these programs become more widespread.

Study Implications: Family forest owners (FFOs) hold a plurality of US forestland, making them part of a critical opportunity to help mitigate climate change through carbon sequestration and storage. A variety of programs and markets exist that compensate landowners, including FFOs, for increasing carbon storage and sequestration on their lands. Understanding characteristics of landowners who are participating in or aware of carbon programs and markets can help inform program outreach and implementation, furthering climate change mitigation goals.

Keywords: Carbon storage, carbon sequestration, climate change mitigation, landowner, non-industrial private forest landowners

Carbon sequestration through extended rotations, improved forest management, and increased forest cover is a critical opportunity to help mitigate climate change. In the United States, an estimated 9.6 million families, individuals, trusts, estates, and family partnerships (hereafter family forest owners or FFOs) hold more than a third of forested land (110 million ha, excluding interior Alaska, [Butler et al. 2021](#)), which account for 39% (5.5 billion metric tonnes) of aboveground tree forest carbon storage in the United States ([USDA Forest Service, Forest Inventory and Analysis \(USFS FIA\) 2021](#)). This study aims to provide a reflection on the current participation of FFOs in carbon programs across the United States, as well as on those who are familiar with programs but not enrolled. Specifically, the questions are (1) how many FFOs participate in carbon programs, and how many are familiar with such programs but are not participating, and (2) what are the characteristics of participating landowners, and how do they

differ from landowners who are familiar with the programs and markets (but not participating) and those who are not familiar.

Programs and markets, including regulatory programs, voluntary markets, and over-the-counter markets (hereafter programs), exist that compensate landowners, including FFOs, for increasing carbon sequestration and storage on their land. The largest regulated program available to private landowners in the United States is the California Cap-and-Trade program through the California Air Resources Board, although enrollment can involve high costs, complexity, and risk, especially for FFOs with smaller holdings ([Kerchner and Keeton 2015](#), [Wise et al. 2019](#)). Voluntary program registries include American Carbon Registry (ACR, established in 1996), Climate Action Reserve (established in 2001), and Verra (established in 2007) ([American Carbon Registry 2022](#), [Climate Action Reserve 2022](#), [Verra 2022](#)).

Although not restricted to FFOs, in 2019 the California market had an estimated \$314 million in payments, and the three registries had an estimated \$12 million in payments (Frey et al. 2021). Some newer programs specifically target small landowners; the American Forest Foundation is piloting a program for FFOs with 12–971 ha (30–2400 ac; Family Forest Impact Foundation n.d.). Other programs, such as the Natural Capital Exchange (NCX), have no acreage requirements for enrollment (Natural Capital Exchange 2021). Over-the-counter credits are sold from an offset provider to an offset buyer and can vary in the contract terms and requirements (Charnley et al. 2010, Donofrio et al. 2019).

Previous studies have found several other characteristics besides acreage that are associated with landowners' interest or enrollment in carbon programs. Absenteeism (Miller et al. 2012, Thompson and Hansen 2012), land tenure (Miller et al. 2012), and interest in preserving forest ecosystems (Alhassan et al. 2019) were all associated with higher interest in carbon programs. Some landowner goals for their wooded land, such as recreation (Khanal et al. 2016), have been positively associated with interest in participating, whereas other goals, such as timber (Markowski-Lindsay et al. 2011) and privacy (Fischer and Charnley 2010), have been negatively associated, and some goals, such as nonmarket amenities, have been found to be positively (Miller et al. 2012) and negatively (Håbesland et al. 2016) associated in different studies. Studies have found that landowners' attitudes towards climate change positively affect their interest in carbon programs (Fischer and Charnley 2010, Håbesland et al. 2016, Alhassan et al. 2019, Shin and Yeo-Chang 2019) as do their plans to bequeath their land to heirs (Thompson and Hansen 2012). Having participated in management activities in the past is associated with greater willingness to participate in carbon programs, including experience with cost-share programs (Shin and Yeo-Chang 2019) and timber harvesting (Shin and Yeo-Chang 2019, but see Håbesland et al. 2016), and whether they plan to harvest trees in the future (Markowski-Lindsay et al. 2011, Thompson and Hansen 2012). Studies have found specific demographic traits to be related to higher interest in participation, including higher education (Markowski-Lindsay et al. 2011, Thompson and Hansen 2012, Håbesland et al. 2016), being male (Miller et al. 2012), and being under 65 years old (Markowski-Lindsay et al. 2011).

Methods

The National Woodland Owner Survey (NWOS) is a survey of US private landowners conducted by the USDA Forest Service Forest Inventory and Analysis (FIA) program through the Family Forest Research Center, with the most recent data collected in 2017 and 2018 (Butler et al. 2021). Two questions on the survey ask about carbon programs and markets:

In efforts to reduce the impacts of climate change, public programs and private markets have been created that pay owners of wooded land for capturing or sequestering carbon.

a. How familiar are you with carbon capture programs or markets?

Extremely familiar, Moderately familiar, Somewhat familiar, Slightly familiar, Not at all familiar

b. Is any of your wooded land in <STATE> currently enrolled in one of these carbon capture programs or markets?

Yes, No, Don't know

We divided FFOs with 0.4 + forested hectares, the FIA minimum threshold for forestland classification, into three groups based on their reported familiarity with carbon programs and markets and whether any of their land is enrolled in such a program. Those who reported being not at all or slightly familiar with carbon programs were considered “unfamiliar”; those who were somewhat, moderately, or extremely familiar but were not enrolled in a program were considered “familiar”; and those who were somewhat, moderately, or extremely familiar and were enrolled in a program were considered “participating.”

Population-level estimates for the number of ownerships and hectares in each group, as well as the amount of nonforested acres held by FFOs, were calculated following Butler et al. (2021) and Butler and Caputo (2021). Summaries and differences among respondents in each group were calculated for selected variables using unweighted, unimputed responses. Nonparametric Kruskal-Wallis ANOVA and post hoc Dunn's tests were used to compare the groups using the Holm method to adjust for multiple pairwise comparisons across the three groups, with $\alpha = 0.05$. Some differences were found in homogeneity of variance between groups; however, Welch's ANOVA yielded similar results, and Kruskal-Wallis results are presented here for ease of interpretation. Respondents with missing values in the variables of interest were excluded. Likert-scale questions were included as ordered factors; education was binned in six categories and treated as an ordered factor variable. “Don't know” or “Not applicable” responses were combined with the lowest category (1 for Likert or 0 for binary questions). Analyses were done using R (R Core Team 2021) and the dunn.test package (Dinno 2017). The statistical power and types of analyses possible are limited by the small number of participating respondents. The study design and analyses are also not able to assign causality to relationships or patterns detected.

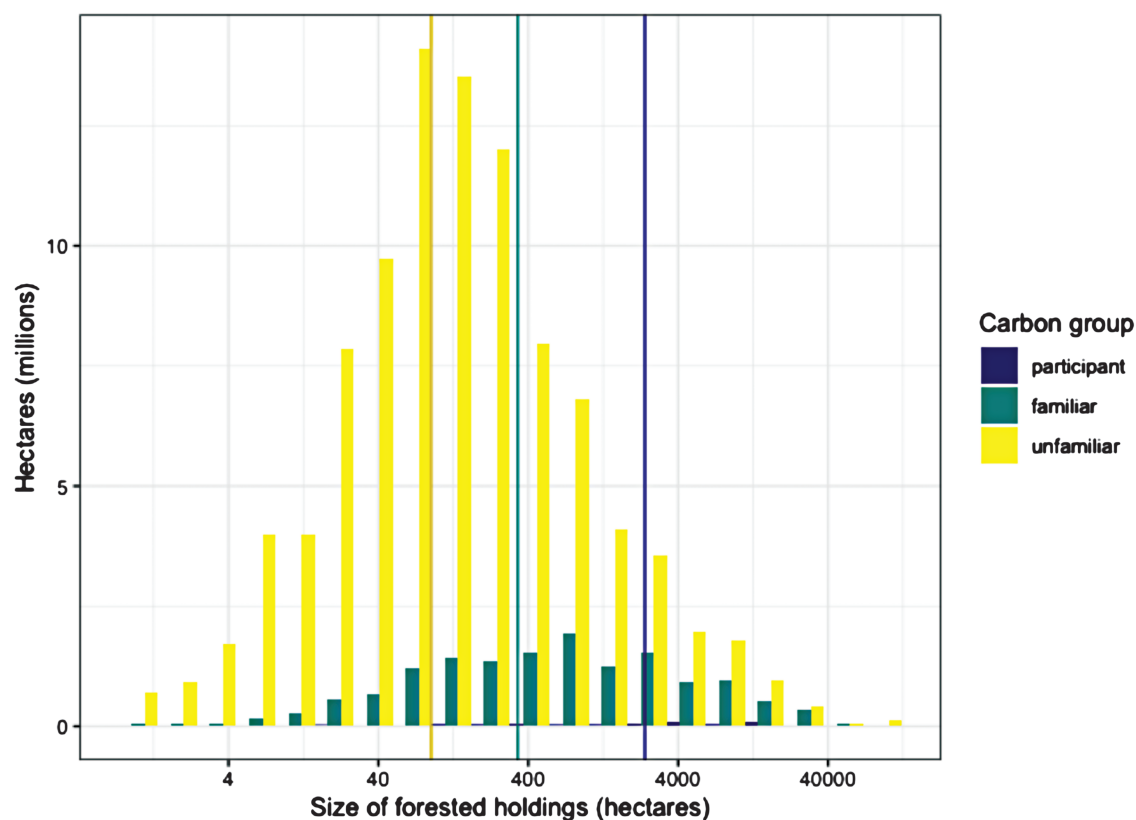
Results

Across the United States (excluding interior Alaska due to lack of data), an estimated 3,000 ownerships (SE = 3,000) are familiar with and participate in carbon programs. These ownerships hold an estimated 400,000 ha (SE = 100,000), although it is unknown whether their entire holdings are enrolled in the program. An estimated 625,000 ownerships (SE = 148,000) that hold 14.9 million ha (SE = 500,000) are familiar but not enrolled, and 9.0 million ownerships (SE = 400,000) that hold 94.7 million ha (SE = 800,000) are not familiar with carbon programs (Table 1). Most FFO holdings and their carbon storage potential are in smaller size classes, with 82% of hectares in holdings that are 400 ha or smaller (Figure 1). US FFOs also own an estimated 284 million hectares of nonforested land, some which may have potential for afforestation.

Respondents participating in carbon programs have larger wooded holdings, with a median size of 971 ha compared to 137 ha for familiar respondents and 36 for unfamiliar respondents (Table 2). Participators are also more likely to have a secondary residence or cabin on or near their wooded

Table 1. Population estimates for family forest owners (FFOs) with 0.4 + hectares and their familiarity and participation in carbon programs.

	Totals (thousands)		Percentages	
	Ownerships (SE)	Hectares (SE)	Ownership (SE)	Hectares (SE)
Participating	3 (3)	400 (100)	<1 (<1)	<1 (<1)
Familiar	625 (148)	14,900 (500)	6.5 (<1)	13.5 (<1)
Unfamiliar	9,000 (400)	94,700 (800)	93.5 (<1)	86.1 (<1)

**Figure 1.** Population estimates of family forest owner hectares by size of holdings and whether the ownership is a participant, familiar, or unfamiliar with carbon programs. Vertical lines represent the median size of holdings for each group. Note the log scale on the x axis.

land, are more likely to have an easement, and are more likely to have participated in a cost-share program in the last 5 years (Table 2). They are also more likely to be concerned about climate change affecting their forestland; to receive more of their income from their forestland; and to report that protecting nature and biological diversity, having privacy, and passing land on to their children or heirs are important reasons why they own their forestland (Table 2). Among participating landowners, 56% ($\pm 10\%$) report having a management plan and 26% ($\pm 9\%$) have an easement on their wooded land (Table 2).

Discussion

The low participation and familiarity with carbon programs highlights the potential of the large amount of FFO forestland and the importance of landowner engagement. Other programs investigated in the NWOS have higher levels of participation from this population, including tax programs (17%, SE < 1%), cost-share programs (4%, SE < 1%), and conservation easements (3%, SE < 1%) (Butler et al. 2021). Although size of holdings is an important factor for

enrollment in carbon programs, the threshold for determining project feasibility also depends on many other variables, including the requirements of the carbon program (Kerchner and Keeton 2015, Khanal et al. 2016, Kelly et al. 2017). Other barriers include the low price of carbon, the high cost of entry into markets and program requirements (e.g., developing a management plan, certification, or carbon inventories), and whether participation is consistent with other management goals (Charnley et al. 2010). Carbon programs that are simple, flexible, and low-cost for landowners to participate in while still providing permanence and additionality will be crucial to engaging smaller forest owners. In addition to their substantial forest holdings, US FFOs own more than 280 million ha of non-forested land—more than twice the amount of forested land owned by this group. Not all of this land can—or should—be forested, but planting forests on even a portion of this land (especially reforesting land where forests existed historically, including almost all of the eastern United States) could represent a substantial contribution to carbon sequestration and storage (Nave et al. 2019).

Although not causal, the differences between participating, familiar, and unfamiliar landowners offer some potential

Table 2. Response summaries from the National Woodland Owner Survey (2018) for landowners who are participating, familiar but not participating, and unfamiliar with carbon programs. Superscript letters indicate significant ($\alpha = 0.05$) differences based on Dunn's tests with Holm correction.

	Participator	Familiar	Unfamiliar
n	27	1271	8108
Wooded hectares (median)	971 ^a	137 ^b	36 ^c
Home (% yes $\pm$ SE)	35% $\pm$ 9% ^a	54% $\pm$ 1% ^a	55% $\pm$ 1% ^a
Farm (% yes $\pm$ SE)	62% $\pm$ 10% ^a	49% $\pm$ 1% ^a	39% $\pm$ 1% ^b
Secondary residence (% yes $\pm$ SE)	58% $\pm$ 10% ^a	30% $\pm$ 1% ^b	23% $\pm$ <1% ^c
Received advice (% yes $\pm$ SE)	80% $\pm$ 8% ^a	60% $\pm$ 1% ^b	27% $\pm$ <1% ^c
Management plan (% yes $\pm$ SE)	56% $\pm$ 10% ^a	47% $\pm$ 1% ^a	19% $\pm$ <1% ^b
Easement participation (% yes $\pm$ SE)	26% $\pm$ 9% ^a	13% $\pm$ 1% ^b	5% $\pm$ <1% ^c
Cost share participation (% yes $\pm$ SE)	67% $\pm$ 9% ^a	25% $\pm$ 1% ^b	9% $\pm$ <1% ^c
Harvest past (% yes $\pm$ SE)	59% $\pm$ 6% ^{ab}	47% $\pm$ 1% ^a	24% $\pm$ <1% ^b
Harvest future (% yes $\pm$ SE)	52% $\pm$ 10% ^a	51% $\pm$ 1% ^a	25% $\pm$ <1% ^b
Concern—climate change (median)*	4 ^a	3 ^b	3 ^c
Objective—nature (median)*	5 ^a	4 ^b	4 ^b
Objective—passing land on (median)*	5 ^a	4 ^b	4 ^c
Objective—timber (median)*	3 ^a	4 ^a	2 ^b
Objective—recreation (median)*	4 ^{ab}	4 ^a	4 ^b
Objective—privacy (median)*	5 ^a	4 ^b	4 ^c
Percent income from wood (median)	10 ^a	1 ^b	0 ^c
Education (median)	Bachelor's ^{ab}	Bachelor's ^a	Associate degree ^b
Tenure (years, median)	30 ^{ab}	26 ^a	23 ^b
Age (median)	66 ^a	65 ^a	66 ^a

*Likert scale ranged from 1 (not important) to 5 (very important).

insights to target landowners who might be interested in carbon programs. For example, messages that connect concern for climate change to carbon programs may resonate with FFOs, as has been suggested by other studies (Shin and Yeo-Chang 2019). FFOs who are enrolled in carbon programs are more likely to be engaged with their land in other ways, such as participating in cost share or receiving advice about their wooded land; these other forms of engagement could be an entry point for landowners interested in learning more about or enrolling in carbon programs. Interestingly, a quarter of participating respondents have an easement on all or part of their wooded land; on one hand, this can be a requirement for some programs, but it also raises questions about additionality with multiple conservation mechanisms, such as enrolling land that already has an easement on it. Just over half of participating respondents report having a management plan, also raising questions about different program requirements, as well as about how FFOs think about and plan for future management.

The small number of participating respondents prevented meaningful multivariate analyses, even when looking at non-parametric analyses, and meant the analyses had relatively low statistical power, and in some cases low precision. However, the two questions about carbon programs reported here are on the NWOS survey for the subsequent data collection cycle (2019–2023), and the identification of more participating respondents would enable more complex and powerful analyses. Augmenting data collection by directly targeting FFOs enrolled in programs would be an additional avenue for increasing the power of the analyses. Future work focusing on FFOs who are familiar with carbon programs but choose not to participate could also be informative for moving landowners into action.

Conclusions

As of 2018, very few FFOs across the United States are participating in carbon sequestration programs or markets, and the vast majority have low or no awareness of carbon programs. Most FFO holdings are too small to be viable in traditional carbon programs or markets, although new and evolving programs might enable smaller holdings to be feasibly enrolled. It will be informative to monitor landowner familiarity and involvement in these programs as they become more widespread and to identify those attributes of the programs, owners, and forests that most influence enrollment decisions.

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Conflict of Interest

B.J.B. served as an external, expert reviewer for carbon sequestration program protocols being developed by ACR and NCX but received no financial or other compensation.

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