



# Understanding Passive Forest Management on Family Forest Owned Land in New England to Further Ecological Forestry

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## Abstract

Ecological forestry seeks to sustain the diverse forest benefits we rely on via a combination of active forest management (AFM) and passive forest management (PFM) approaches across the landscape. Despite the importance of both AFM and PFM and the prevalence of family forest ownerships in the US, little is known about family forest owner attitudes toward PFM. We surveyed New England FFOs to investigate PFM interest and tool preference for adopting PFM. Over one-third of respondents would adopt PFM on their land; of these, significantly more were willing to adopt PFM on only some of their land rather than all of their land. A temporary property tax reduction program was the most popular policy tool, though different ownership characteristics were associated with increased adoption of the other policy tools tested. Foresters could play a key role in siting and monitoring PFM on family forest lands within ecological forestry.

**Keywords** Family forest owners · Reserves · Wildlands · Forest management

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**Study Implications** Family forest owners (FFOs) interested in applying passive forest management (PFM) are not indifferent owners and many plan to engage with foresters. They more often rate goals for biodiversity protection, climate change mitigation, and connection to nature as extremely or very important, and more often engage in nonmotorized recreation than other FFOs. More of them are interested in adopting PFM on only some of their land versus all their land. Foresters could engage this subset of FFOs across the landscape to aid them in siting PFM on their land within the broader landscape context and framework of ecological forestry.

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## Abbreviations

AFM	Active forest management
FFO	Family forest owner
PFM	Passive forest management

## Introduction

The benefits the public seeks from forests today expand beyond the sustained-yield timber Gifford Pinchot sought to conserve in the early 1900s. In addition to timber, forests values include an array of diverse benefits including carbon storage and sequestration, clean water and air, biodiversity, human health and wellness, sustaining cultural lifeways, and recreation opportunities. Evidence of this shift includes largescale calls for forest protection and the diversification of the management approaches to sustain these evolving values while also maintaining options for future forest values we have not yet recognized (Bengston 2020; Biden 2021; Foster et al. 2017; United Nations Environment Programme Convention on Biological Diversity 2022; Wilson 2016). To sustain these diverse benefits and future values, a diversity of forest management strategies is needed across the landscape.

As a forest management framework, ecological forestry strives to maintain or restore forests' full structure, function, and composition in order to support the broader array of ecosystem services. Ecological forestry builds on the foundation of traditional silviculture to provide continuity before and after harvest, increase structural complexity and biodiversity, adhere to ecologically appropriate management timing, and consider landscape level contexts (Franklin et al. 2018; Palik and D'Amato 2017; Seymour and Hunter 1992). To achieve these goals, ecological forestry includes a focus on retention of forest structure at a variety of scales from the individual tree to patch reserves, to large-scale landscape reserves. These forms of retention at various scales are, in essence, forms of passive forest management (PFM), which is broadly defined as one end of the forest management spectrum where an intentionally hands-off approach aims to allow natural processes to be the main driver of change. Rather than viewing PFM as opposing active forest management (AFM), ecological forestry considers them complementary components; each component implemented in the appropriate place and time, sustaining a unique set of forest benefits, and leveraging the value of the other, the whole greater than the sum of its parts (Franklin et al. 2018).

Many foresters already apply a combination of AFM and PFM to varying degrees of intensity and spatial scales. Common examples include applying streamside buffers from timber harvests, establishing patch reserves around ecologically and culturally sensitive areas while harvesting in other areas, using variable density thinning with a combination of skips and gaps, and designating some properties as actively managed while designating others as passively managed.

Applying a combination of forest management intensities across the landscape is not a new idea. Forest zoning concentrates harvesting activities and helps minimize fragmentation due to road systems (Côté et al. 2010). Though zoning had historically been discussed as a means to balance biogeographic factors, transportation

infrastructure, and economic and ecologic needs on the Pacific coast (Tappeiner et al. 1986), perhaps the most commonly cited forest zoning strategy in North America is Seymour and Hunter's (1992) Triad Approach. The Triad proposes setting aside reserve lands for biodiversity protection and intensely managed lands for wood production, leaving the matrix to be managed by ecological forestry principles that combine both AFM and PFM (Seymour and Hunter 1992). The thirty-year reflection of the Triad reinforces the importance of timber production, but not at the expense of sustaining the broad diversity of ecosystem values forests provide, and it continues to advocate for the application of ecological forestry applied in diverse and creative ways across the majority of the landscape (Himes et al. 2022).

In the US, the matrix is largely comprised of family forest ownerships (FFOs) (Butler et al. 2021). Though federal and state governments own 36% of forestland in the US and have established a strong foundation of protected lands, 60% of US forests are held privately, with FFOs being the largest private ownership group owning 39% (Butler et al. 2021). It is not sufficient to rely solely on reserves for biodiversity preservation (Lindenmayer and Franklin 2003; Seymour and Hunter 1992). Given their substantial forest ownership, FFOs are a key group within the matrix who can apply ecological forestry principles and meet recent calls for land protection and diversification of forest management (Foster et al. 2017; United Nations Environment Programme Convention on Biological Diversity 2022; Biden 2021).

Despite the importance of FFOs, decades of cost-share programs with forest engagement solely defined as AFM has attracted only a small segment of FFOs (Butler et al. 2021). In their perspective piece, "Doing Nothing" more than twenty-five years ago, Kittredge and Kittredge (1998) suggest that an informed decision by an FFO to "do nothing" is a viable decision and one that adds to important and complementary ecological and social values across the landscape. In order to engage the critical mass of landowners necessary to achieve ecological forestry goals within the matrix, it is important to understand FFO attitudes towards both AFM and PFM.

While there are myriad studies related to FFO attitudes and behaviors toward AFM (Silver et al. 2015), research on FFO attitudes toward PFM is sparse, especially in the US, though a handful of European studies provide a foundation. Mitani and Lindhjem (2015) found that non-industrial private forest (NIPF) owners are significantly more likely to participate in a biodiversity preservation program and permanently forgo AFM if they expected potential economic benefits from the program, owned less acreage, had higher education, and held an environmental attitude. They also found that NIPF owners who perceive that the conservation regulations are too strict are less likely to join the program (Mitani and Lindhjem 2015). Matilainen and Lähdesmäki (2023) suggest that passive NIPF owners are not uninterested in their forests as previous research had indicated, rather their lack of active management was due to different values for the use of the forest. Though these and other studies (e.g., Dunn-Capper et al. 2024) have begun to describe FFO attitudes toward PFM approaches and their characteristics, to our knowledge no research has investigated the attitudes and characteristics of FFOs in the US toward adopting PFM on their land.

We aim to address this gap by examining FFO: (1) scale and scope of interest in PFM (2) preference for tools used to adopt PFM (3) characteristics associated with

intent to adopt PFM, and (4) benefits and concerns related to PFM. To do so, we deployed a mail survey instrument to a stratified sample of New England FFOs.

## Data and methods

The study region includes the forested regions of the six New England states (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont), which has a high prevalence of FFOs and forestland (Butler et al. 2021). As a region, New England has seen calls and growing advocacy for increased wildlands (i.e., PFM), though FFO attitudes toward forest reserves and PFM are largely unknown (Foster et al. 2017).

Using tax assessor's data, we selected a stratified random sample of 2,600 individuals owning at least 10 acres of land across the region. Given New England's landcover composition, we assume parcels of at least 10 acres would have forest cover. We stratified our sample to ensure that each state sample was proportionate to the amount of FFO land in that state compared to New England, then split each state's sample so that half had acreages above 50 and half below. Our final sample consisted of 100 FFOs in Connecticut, 1,156 in Maine, 220 in Massachusetts, 456 in New Hampshire, 38 in Rhode Island, and 630 in Vermont.

We developed the mail survey using stakeholder and landowner involvement. We conducted seven semi-structured key informant interviews utilizing snowball sampling of landowners and conservation professionals to define PFM in alignment with current work in wildlands conservation (Goodman 1961). We referred to PFM as "wildlands" in these interviews and within the survey instrument to be consistent with language used within the region. The PFM definition for this study prohibited timber harvesting, building structures, and recreation with motorized vehicles; it allowed, but did not require, invasive plant control, collection of non-timber forest products (e.g., berries, mushrooms, and tree sap) for personal use, and non-motorized recreation (Northeast Wilderness Trust 2022). We pretested the survey instrument with cognitive interviews of six FFOs from across New England. Pre-testing led us to clarify the language in the hypothetical scenarios and refine some of the multiple-choice options provided. We administered the survey to 2,600 New England FFOs in 2023 using the Dillman Tailored Design Method via mailing a pre-notice postcard, an initial survey instrument, a reminder postcard, and a subsequent survey instrument to landowners who did not respond to the initial mailing (Dillman et al. 2009).

## Survey content

The survey included five sections of questions: general information about their land, goals for their land, past and future activities on their land, demographic information, and four hypothetical PFM scenarios (Supplement 1). Many survey items from demographic, activity, and goals sections derive from the OMB-approved National Woodland Owner Survey (Butler et al. 2021).

Across the four hypothetical scenarios, the definition of PFM remained the same but the means through which the respondent could adopt PFM changed. The tools for implementing PFM included: (1) informal voluntary adoption of PFM, (2) enrolling land in a PFM-based property tax reduction program, (3) entering into a permanent PFM legal agreement (e.g. conservation easement (CE)), or (4) selling land to a conservation organization to be managed passively (i.e., Fee Simple). The hypothetical scenarios varied in duration (permanent or temporary) and whether the respondent would maintain ownership of their land, receive a property tax reduction, and receive a one-time payment (Table 1). Respondents considered each scenario separately, indicated whether they would adopt the scenario on some or all of their land, and rated the certainty of each answer. After the scenarios, respondents provided their opinion on the benefits and concerns of PFM.

## Data analysis

### Overall PFM interest: group comparisons

To understand overall interest in PFM, we created adoption groups based on responses across all four scenarios, quantified the number of respondents in each adoption group, and posed several comparisons to see how groups differed (Table 2). We quantified overall interest and compared characteristics related to goals, past and planned activities, and demographics (Table 3) using Pearson chi-square and Wilcoxon rank sum exact tests. We also evaluated differences by region, looking at southern New England versus individual states of northern New England due to sample size.

### Scenario preference

To analyze preference for specific scenarios, we developed scenario preference categories for each scenario based on their adoption response and their level of certainty with their answer (Table 4). That is, each respondent was placed into one of five categories based on their adoption and certainty responses for each scenario. We compared scenario preference categories by scenario and geographic region using Pearson chi-square tests.

**Table 1** Hypothetical scenario variables

Scenario	Maintain ownership	Receive property tax reduction	One-time payment incentive	Permanent
(1) Voluntary	X			
(2) Property Tax Incentive Program	X	X		
(3) CE	X	X	X	X
(4) Fee-Simple		X	X	X

**Table 2** Overall interest in PFM adoption group comparisons

Comparison Name <sup>a</sup>	Adoption Groups Compared <sup>b</sup>
1. Yes to at Least One Scenario ( <i>n</i> = 640)	Responded yes on some land or yes on all land, with certainty, to at least one scenario ( <i>n</i> = 233) Vs Did not respond yes on some land or yes on all land, with certainty, to at least one scenario ( <i>n</i> = 407)
2. Yes on Some Land vs. Yes on All Land ( <i>n</i> = 233)	Responded yes on <b>all land</b> with certainty to at least one scenario ( <i>n</i> = 80) Vs Responded yes on <b>some land only</b> with certainty to at least one scenario and never responded yes on all land to any scenarios ( <i>n</i> = 153)
3. Already Doing PFM ( <i>n</i> = 640)	Report already doing at least one scenario with certainty ( <i>n</i> = 140) Vs Not already doing at least one of the scenarios ( <i>n</i> = 500)

<sup>a</sup> Comparison groups are not mutually exclusive

<sup>b</sup> Responses were deemed “with certainty” if respondent answered that they were “Certain” or “Very Certain” of their answer to the hypothetical question

## Models of scenario adoption

For each hypothetical scenario, we fit a binary logistic regression to explore how FFO and land characteristics influence adoption of PFM. The dependent variable indicates whether respondent would adopt the PFM hypothetical scenario with certainty (Table 5). We selected the independent variables for the models based on past literature on conservation-based estate planning (Ma and Kittredge 2011; Mäntymaa et al. 2009; Markowski-Lindsay et al. 2018; Mitani and Lindhjem 2015), the initial key informant interviews, and exploratory cross-tables and tests of significance between our independent variables and the combined adoption-certainty variable for each scenario (Table 3, Supplement 2). The same exogenous variables were used across the four models and include demographics, general questions about the land, planned activities, number of perceived benefits and concerns related to PFM, and goals for the land consolidated from a Principal Components Analysis (Supplement 3) into three main goals: amenity/ecological, recreational, and financial goals.

## Results

### Mail survey results

Of the 2,600 surveys mailed, 157 addresses were nonqualified (e.g., deceased, owning no forestland) and 653 surveys were returned for a cooperation rate of 26.7%, distributed across the six states: 17 from Connecticut, 282 from Maine, 58 from

**Table 3** Variable definitions

Variable	Definition	Analysis
<i>Demographics</i>		
Northern	from Maine, New Hampshire, or Vermont = 1, else = 0	Comparisons, Models
Live on Land	resides on forested land	Comparisons
ln(Acres)	logarithm of forested acres owned in their state	Comparisons, Models
Percent Income Woods	percent of household annual income from forest	Comparisons, Models
Gender	gender; male = 1, else = 0	Comparisons, Models
Bachelors or Higher	bachelor's degree or higher; yes = 1, else = 0	Comparisons, Models
Above Med. Income	household annual income above regional median income; yes = 1, else = 0	Comparisons, Models
Age	age in years	Comparisons, Models
Current Use	enrolled in current use property tax reduction program; yes = 1, else = 0	Comparisons, Models
Perceived Benefits to PFM	total number of benefits checked (range 0 to 6)	Models
Perceived Concerns to PFM	total number of concerns checked (range 0 to 9)	Models
<i>Goals for the Forested Land: "I want my land to..." Likert scale: not at all important = 0, slightly important = 1, moderately important = 2, very important = 3, extremely important = 4</i>		
Goal: Financial	provide financial security for myself and/or my family	Comparisons
Goal: Wood Products	produce wood products	Comparisons
Goal: Rural Traditions	maintain rural traditions and culture	Comparisons
Goal: Recreation	provide recreational opportunities	Comparisons
Goal: Hunting	provide hunting opportunities	Comparisons
Goal: Privacy	be a source of privacy	Comparisons
Goal: Connection to Nature	be a source of connection to nature	Comparisons
Goal: Biodiversity	protect wildlife habitat and biological diversity	Comparisons
Goal: Climate Change	reduce the impacts of climate change	Comparisons

Table 3 (continued)

Variable	Definition	Analysis
<i>Goals for forested land, Principal Component Results<sup>a</sup></i>		
PC: Amenity/Eco	scores for group including Goal: Biodiversity, Goal: Connection to Nature, Goal: Climate Change, Goal: Privacy, and Goal: Rural Traditions	Models
PC: Recreation	scores for group including Goal: Hunting, Goal: Recreation, and Goal: Privacy	Models
PC: Financial	scores for group including Goal: Financial and Goal: Wood Products	Models
<i>Planned Activities. Yes = 1, No = 0, Don't Know = 0</i>		
Plan: Nonmotorized Rec	nonmotorized recreation on the property	Comparisons
Plan: NTFPs	collect non-timber forest products for personal use	Comparisons
Plan: Invasive Insect Mgmt	engage in active forest management in response to an invasive insect	Comparisons
Plan: Active Forest Mgmt	engage in active forest management to create young forest or shrubland wildlife habitat	Comparisons
Plan: Fire Breaks	engage in active forest management to create fire breaks	Comparisons
Plan: Noncommercial Harvest	engage in a noncommercial timber harvest for personal use	Comparisons
Plan: Forester Advice	receive advice about my land from a forester	Comparisons
Plan: Commercial Harvest	commercially harvest timber	Comparisons
Plan: Motorized Rec	motorized recreation on the property	Comparisons, Models
Plan: Invasive Plant Mgmt	manage invasive plants on the property	Comparisons, Models
Plan: Firewood	collect firewood from the property for personal use	Comparisons, Models
Plan: Hunting	hunt or allow others to hunt on the property	Comparisons, Models
Plan: CE	place conservation easement on the property	Comparisons, Models
<i>Past Activities. Yes = 1, No = 0, Don't Know = 0, unless otherwise noted</i>		
Done: Nonmotorized Rec	nonmotorized recreation on the property	Comparisons
Done: NTFPs	non-timber forest products for personal use	Comparisons



Table 3 (continued)

Variable	Definition	Analysis
Done: Invasive Insect Mgmt	active forest management in response to an invasive insect	Comparisons
Done: Active Forest Mgmt	active forest management to create young forest or shrubland wildlife habitat	Comparisons
Done: Fire Breaks	active forest management to create fire breaks	Comparisons
Done: Noncommercial Harvest	noncommercial timber harvest for personal use	Comparisons
Done: Forester Advice	received advice about my land from a forester	Comparisons
Done: Commercial Harvest	commercially harvested timber	Comparisons
Done: Motorized Rec	engaged in motorized recreation on the property	Comparisons
Done: Invasive Plant Mgmt	managed invasive plants on the property	Comparisons
Done: Firewood	collected firewood from the property for personal use	Comparisons
Done: Hunting	hunted or allow others to hunt on the property	Comparisons
Done: CE	put a conservation easement on the property	Comparisons
Done: Other Harvests	know of any landowners who have done a commercial timber harvest	Comparisons
Other Harvest Satisfaction	opinion of other timber harvests (only if Done: Other Harvests is 1); “The timber harvest(s) was done well” = 3, “Some timber harvest(s) was done well and some was not” = 2, “The timber harvest(s) was not done well” = 1, “I am unsure” = 9	Comparisons

<sup>a</sup> Supplement 3 provides background on Principal Components analysis

**Table 4** Scenario preference category definitions

Scenario Preference Category	Adoption response	Certainty response
Yes, I would adopt the scenario on all my land with certainty	"Yes, on all of my land"	"Very certain" or "certain"
Yes, I would adopt the scenario on some of my land with certainty	"Yes, on some of my land"	"Very certain" or "certain"
I am already doing this on some or all of my land with certainty	"Already doing"	"Very certain" or "certain"
No, I am certain I would not adopt this scenario on some or all of my land	"No"	"Very certain" or "certain"
Uncertain	Any of the adoption responses could be chosen	"Neutral", "Uncertain", or "Very Uncertain"

**Table 5** Binary logit model samples and dependent variable coding

Model <sup>a</sup>	Survey Question	Survey Response <sup>b</sup>	Model Sample %	Coding
Voluntary Scenario ( <i>n</i> = 230)	Would you adopt this scenario on some or all of your land? How certain are you of your answer?	No. Certain	69.6%	0
		Yes, on some of my land. Certain. OR Yes, on all of my land. Certain	30.4%	1
Property Tax Reduction Scenario ( <i>n</i> = 282)	Would you adopt this scenario on some or all of your land? How certain are you of your answer?	No. Certain	53.9%	0
		Yes, on some of my land. Certain. OR Yes, on all of my land. Certain	46.1%	1
CE Scenario ( <i>n</i> = 291)	Would you adopt this scenario on some or all of your land? How certain are you of your answer?	No. Certain	74.2%	0
		Yes, on some of my land. Certain. OR Yes, on all of my land. Certain	25.8%	1
Fee Simple Scenario ( <i>n</i> = 319)	Would you adopt this scenario on some or all of your land? How certain are you of your answer?	No. Certain	82.4%	0
		Yes, on some of my land. Certain. OR Yes, on all of my land. Certain	17.6%	1

<sup>a</sup> Respondents may appear in more than one model because the scenarios are not mutually exclusive

<sup>b</sup> Only respondents certain of their answer and not already doing the hypothetical scenario were included in the models. Certain is defined as responding either “certain” or “very certain”

Massachusetts, 134 from New Hampshire, 8 from Rhode Island, and 153 from Vermont.

Non-response bias testing was conducted by comparing early and late respondents to variables relevant to our analysis (see Supplement 4 for detail). At the 1% significance level, non-respondents owned less land (median 54 acres vs. 75 acres), were younger (median 64 vs. 71), were less often male (63.0% vs. 80.3%), less often had commercial harvest plans (31.4% vs. 44.8%), and were more uncertain about their commercial timber harvest plans (26.8% vs. 16.4%). Some goals variables including goals for financial security had significant differences, though it is difficult to attribute those differences across groups.

## Respondent characteristics

FFO demographics, goals, past and future activities on the forestland, and basic information about their forestland had results similar to the northeastern state characteristics found in the National Woodland Owner Survey (Butler et al. 2021). Nearly three-quarters of respondents live on their wooded property and the mean age of respondents was 66 years old. Most respondents were male (72%), and 51%

of respondents were currently enrolled in a voluntary property tax reduction program. In terms of income and education, 61% of respondents had an annual household income greater than the regional median, and 63% had a bachelor's degree or higher. The mean percent of annual income derived from the land was 6%. Respondent state and acreage characteristics were largely shaped by our sampling procedure. The mean acreage was 130 acres with a minimum of 10 acres and standard deviation of 235. Nearly 43% of respondents were from Maine, 21% from New Hampshire, 23% from Vermont, and 13% from southern New England.

Respondents rated a variety of goals for their forestland as “extremely important” or “very important” including goals for providing a source for connection to nature (83%), protecting wildlife habitat and biological diversity (82%), providing a source of privacy (73%), maintaining rural traditions (64%), and climate change mitigation (56%) (Fig. 1). The most planned future activities for respondent forestland were non-motorized recreation (89%), collecting firewood (76%), hunting (67%), collecting non-timber forest products (NTFPs) (63%), and receiving advice from a forester (60%) (Fig. 2). These were also the most often reported past activities (Fig. 3).

### Perceived PFM concerns and benefits

Nearly 90% of respondents marked at least one concern with PFM and 80% checked at least one benefit. The two most common concerns were firewood restrictions (59%) and limited land use for future owners (53%). The two most common benefits were creating old forest habitat (61%) and letting nature take its course (58%) (Fig. 4).

### Overall PFM interest

Our three comparison groups indicating overall PFM interest (embedded in Fig. 5 shaded by comparison number) provide an extensive number of characteristic comparisons. Results of characteristic comparisons across groups reflect only statistically significant differences ( $p < 0.05$ ), unless otherwise indicated. Respondents who answered both the adoption and certainty questions for at least one of the scenarios ( $n = 640$ ) are included in this analysis. Supplement 2 contains tables for all group comparisons.

### Comparison 1: Yes to at least one scenario

Over one-third (36%) of respondents would adopt at least one of the scenarios on some or all of their land with certainty. Respondents who would adopt at least one of the scenarios with certainty were significantly different from others in that a greater proportion had incomes higher than the regional median (68% vs. 56%), less of their income coming from their forestland (4% vs. 7%), more often had a bachelor's degree or higher (75% vs. 56%), and more often rated the following goals as “extremely important” or “very important” than other respondents: connection to nature (88% vs. 81%), protecting wildlife and biodiversity (88% vs. 79%), and reducing impacts of climate change (69% vs. 49%). Those willing to adopt at least

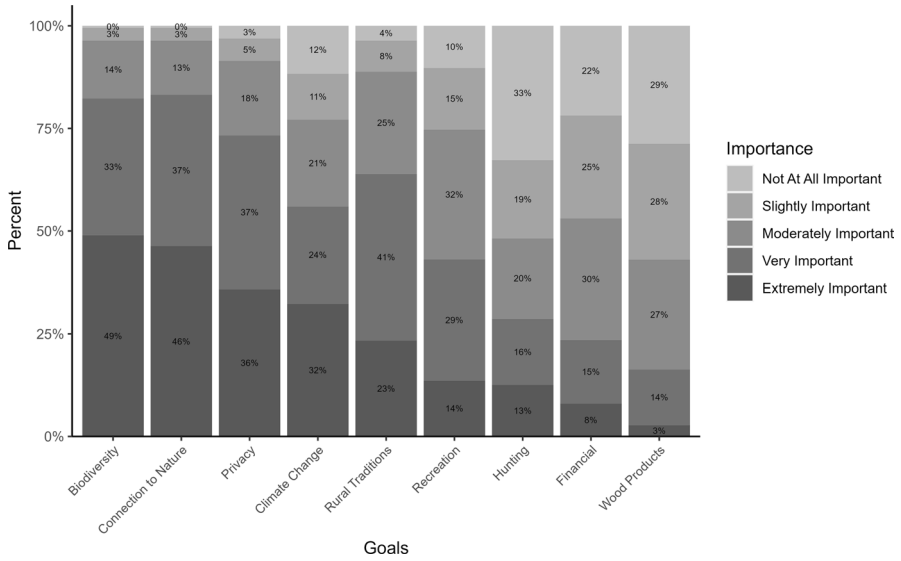


Fig. 1 Importance of goals for the forested land

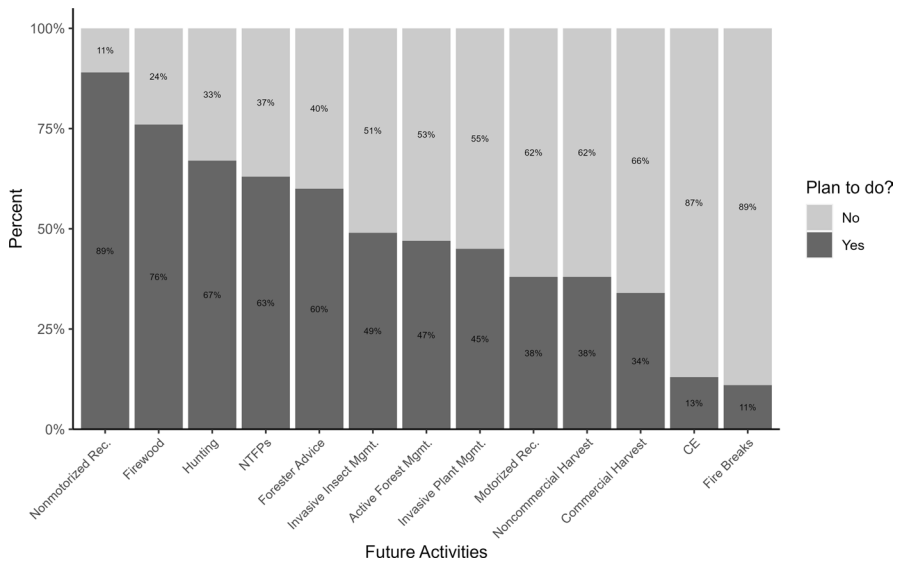


Fig. 2 Planned future activities on the forested land

one scenario more often rated goals for wood production (34% vs. 25%) and hunting (37% vs. 30%) as “not at all important” compared to others. They also selected a greater mean number of benefits to PFM (3.3 vs. 2.3, where the range was 0 to

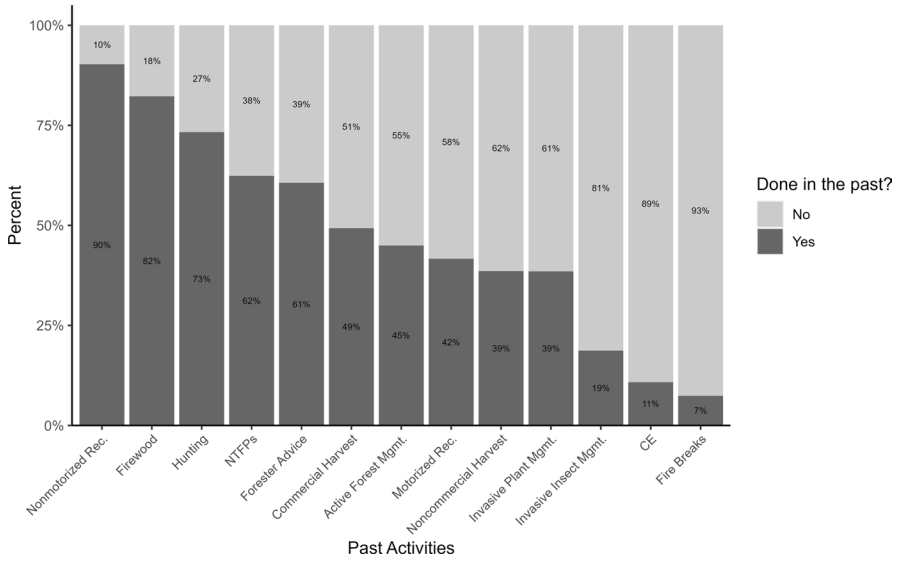


Fig. 3 Past activities on the forested land

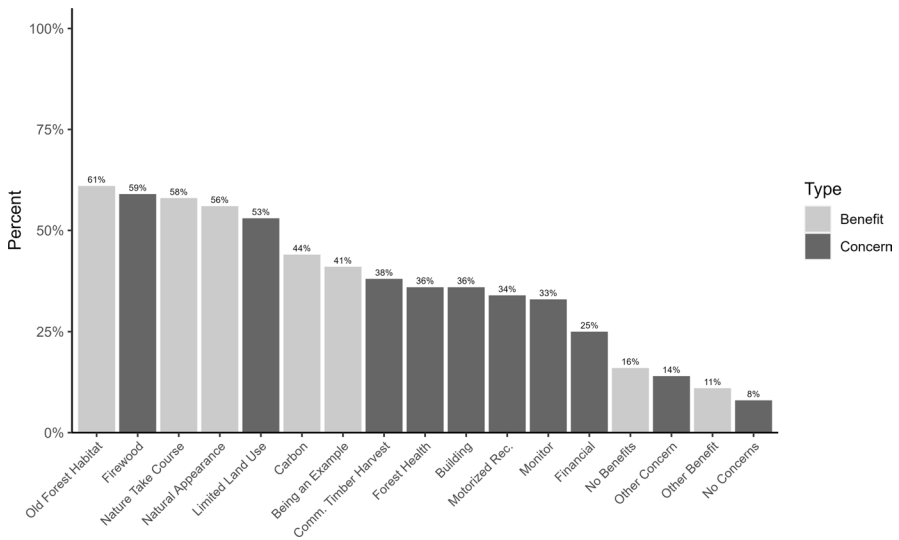
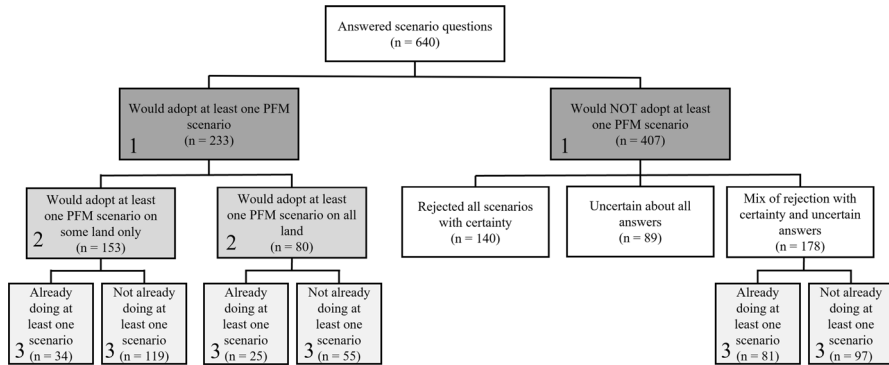


Fig. 4 Perceived concerns and benefits related to PFM

6 possible benefits) and a lower mean number of concerns (2.4 vs. 3.8, where the range was 0 to 9 possible concerns) related to PFM than others.

Those who would adopt at least one scenario report planning to do the following activities in the future more often than other respondents: nonmotorized recreation (95% vs. 86%), invasive plant management (52% vs. 42%), invasive insect



**Fig. 5** Adoption group quantities. Gray shaded boxes are adoption groups included in the group comparisons with the darkest gray shaded boxes being included in comparison 1, the middle gray shaded boxes being included in comparison 2, and the lightest gray shaded boxes being included in comparison 3. The groups with white boxes were not included in the group comparison analysis

management (56% vs. 45%), and place a CE on the property (19% vs. 9%). They less often had plans to participate in motorized recreation on their land in the future (28% vs. 43%), less often reported having done motorized recreation (31% vs. 47%) and hunting (69% vs. 76%) in the past, and more often reported participating in non-motorized recreation in the past (94% vs. 88%) than other respondents. There was also a trend ( $p < 0.10$ ) of those willing to adopt at least one scenario more often planning to seek advice from a forester (65% vs. 57%), less often having done commercial timber harvests in the past (44% vs. 53%), and less often having hunted on their forestland in the past (63% vs. 70%).

### Comparison 2: Yes on some land versus yes on all land

Significantly ( $p < 0.05$ ) more respondents would adopt at least one scenario on only some of their land with certainty rather than all of their land with certainty (24% vs. 12% of all who responded to the scenario questions). Those willing to adopt at least one scenario on all of their forestland more often were male (81% vs. 67%), rated goals for financial security from the land as “extremely important” or “very important” (27% vs. 17%), and rated goals for wood production as “not at all important” (43% vs. 29%) than those willing to adopt PFM on some land only. Those willing to adopt PFM on all of their land selected a lower mean number of concerns (1.9 vs. 2.7) regarding PFM. Those willing to adopt at least one scenario on all of their land less often had plans for non-motorized recreation (90% vs. 97%), non-commercial timber harvest for personal use (24% vs. 43%), and to seek advice from a forester (51% vs. 72%). They less often reported having engaged in non-motorized recreation (88% vs. 97%), noncommercial timber harvest (26% vs. 44%), and commercial timber harvesting (30% vs. 51%) on their forestland in the past. They also less often knew of other landowners who had done a commercial timber harvest (58% vs. 73%).

### Comparison 3: Already doing passive forest management

Nearly 22% of respondents are certain that they are already doing at least one of the scenarios on some or all of their land, and of these, 42% are certain that they would adopt an additional scenario(s) (18% on all of their land and 24% on some of their land). Those who are already doing at least one of the scenarios are significantly ( $p < 0.05$ ) different from other respondents in that they were more often female (37% vs. 26%), had less of their annual household income coming from their woodland (mean 5.6% vs. 5.8%), and more often had a bachelor's degree or higher (76% vs. 60%). Respondents that are already doing at least one of the scenarios also more often rated the following goals as "extremely important" or "very important" than other respondents: connection to nature (93% vs. 81%), protection of wildlife habitat and biodiversity (92% vs. 80%) and reducing the impacts of climate change (72% vs. 52%). They more often reported the following goals as "not at all important" than other respondents: financial security (31% vs. 19%), hunting opportunities (47% vs. 29%), and wood production (39% vs. 26%). They also selected a greater mean number of benefits to PFM (3.6 vs. 2.4) and a lower mean number of concerns regarding PFM (2.6 vs. 3.5) than those not already doing PFM.

In terms of activities, those already doing at least one of the scenarios more often reported planning to participate in non-motorized recreation (97% vs. 87%) or a CE (20% vs. 11%) and less often reported planning to engage in motorized recreation (26% vs. 41%), hunting (60% vs. 70%), and commercial timber harvest(s) (27% vs. 37%) in the future compared to others. They more often reported having previously engaged in non-motorized recreation (97% vs. 88%), invasive plant management (48% vs. 36%), and CEs (17% vs. 9%) and less often reported having previously engaged in motorized recreation (29% vs. 45%) and commercial timber harvesting (40% vs. 52%) compared to other respondents. They differed in their attitudes toward other commercial timber harvests they had seen: 20% of those already doing at least one scenario who knew of other commercial timber harvests felt that those harvests were not done well compared to 8% of respondents who knew of other commercial timber harvest and were not currently doing PFM themselves.

### Scenario preference

Across the four hypothetical scenarios, the property tax reduction scenario had the greatest adoption willingness with 25% of respondents answering they would adopt the scenario with certainty (6% on all their land, 19% on some of their land). This scenario had significantly greater agreement percentage than the voluntary (15%), CE (14%), and fee-simple (11%) scenarios. The fee simple scenario had a significantly greater percentage of "certain no" responses (57%) compared to the voluntary scenario (37%), property tax reduction scenario (36%), and CE scenario (48%). Approximately 20% of respondents report already doing PFM via voluntary adoption, 4% via a property tax reduction program, and 1% through a passive management CE on their property. For each scenario, significantly more respondents would adopt the scenario on only some of their land (7% to 19%, depending



on the scenario) rather than all of their land (4% to 6%, depending on the scenario) (Table 6).

Responses to the voluntary and property tax reduction scenarios differed significantly by state (Table 7). States did not have statistically significant differences in their overall responses to the CE and fee simple scenarios.

## Models of scenario adoption

Pearson chi-square and Wilcoxon rank sum tests indicate statistically significant differences in model independent variables between scenario adoption responses for each scenario (Tables 8 and 9).

The four logistic regression models performed well based on pseudo- $R^2$  and Hosmer–Lemeshow goodness of fit tests (Supplement 5). Multicollinearity was assessed for all four models using “Variance Inflation Factor” (VIF) testing. None of the model VIF levels were below the common threshold of 0.4 that would indicate multicollinearity issues (Allison 1999).

Variables significant in most scenario models include the number of perceived benefits and concerns and some demographic variables. In each model, the number of benefits and concerns seen by the respondent significantly increased and decreased, respectively, the respondent’s likelihood of adopting the scenario (Table 10). With each additional benefit checked, respondents were 1.3 to 1.5 times more likely to adopt the scenario and with each additional concern there is a 26–37% decrease in the odds of adopting the scenario. New England region (southern vs. northern) was significant in the property tax reduction and fee simple scenarios; those from southern New England states were 2.3 times more likely to adopt the property tax reduction and fee simple scenarios than those from northern New England (i.e., 1/0.44; 1/0.43). Respondents with a bachelor’s degree or higher are 3.9 times, 2.5 times, and 3.8 times more likely to adopt the property tax reduction, CE, and fee simple scenarios, respectively, than those without a bachelor’s degree or higher. Higher education was not significant in the voluntary model. Enrollment in a current use program was significant in the property tax reduction and CE scenarios: those enrolled in a current use program are 2.6 times more likely to adopt the property tax reduction scenario and 2.3 times more likely to adopt the CE scenario than those not already enrolled in current use. The other demographic variables including acreage, percent of income from woodlands, gender, annual income below or above regional median, and age were not significant in any of the models.

Plans for invasive plant management and for a CE were significant in some of the models. Those with plans for invasive plant management were 2.3 times more likely to adopt the fee simple scenario. Those with plans for a CE were 5.5 times more likely to adopt the CE and 2.7 times more likely to adopt the fee simple scenarios.

Goals for the land had a mixed effect on adoption of the four passive management scenarios. Those with recreation goals were less likely to consider adopting the property tax reduction scenario; this variable was not significant with the other scenarios. Amenity/Ecological goals were only significant in the fee simple scenario; respondents with these goals were less likely to adopt the scenario. Respondents

**Table 6** Hypothetical scenarios results

Adoption Group	Scenario <sup>a</sup>				
	Voluntary (n = 624)	Property Tax Reduc- tion (n = 627)	CE (n = 621)	Fee-Simple (n = 620)	
Yes, I would adopt the scenario on all my land with certainty	4%	6%	4%	4%	
Yes, I would adopt the scenario on some of my land with certainty	11%	19%	10%	7%	
I am already doing this on some or all of my land with certainty	20%	4%	1%	NA <sup>b</sup>	
No, I am certain I would not adopt this scenario on some or all of my land	37%	36%	48%	57%	
Uncertain	29%	35%	36%	32%	

<sup>a</sup> Voluntary, property tax reduction, and CE scenario responses do not add up to 100% due to rounding. Percentages are based on the sample who answered the question, not the total sample of respondents

<sup>b</sup> "I am already doing this on some or all of my land with certainty" was not a possible response for the Fee Simple scenario

**Table 7** Hypothetical scenarios with statistically significant results by state

Scenario & Response <sup>a</sup>	State <sup>a</sup>			
	(a) Southern New England	(b) ME	(c) NH	(d) VT
Voluntary Scenario	<i>n</i> = 78	<i>n</i> = 272	<i>n</i> = 129	<i>n</i> = 145
(1) Yes, I would adopt the scenario on all my land with certainty	1%	4%	4%	4%
(2) Yes, I would adopt the scenario on some of my land with certainty	5%	13%	9%	10%
(3) I am already doing this on some or all of my land with certainty	31%	18%	20%	16%
(4) No, I am certain I would not adopt this scenario on some or all of my land	26%	38%	43%	37%
(5) Uncertain	37%	27%	24%	33%
Total	100%	100%	100%	100%
Property Tax Reduction Scenario	<i>n</i> = 77	<i>n</i> = 272	<i>n</i> = 132	<i>n</i> = 146
(1) Yes, I would adopt the scenario on all my land with certainty	10%	4%	5%	9%
(2) Yes, I would adopt the scenario on some of my land with certainty	21%	18%	17%	21%
(3) I am already doing this on some or all of my land with certainty	1%	2%	9%	7%
(4) No, I am certain I would not adopt this scenario on some or all of my land	27%	40%	38%	30%
(5) Uncertain	40%	36%	30%	34%
Total	100% <sup>b</sup>	100%	100% <sup>b</sup>	100% <sup>b</sup>

<sup>a</sup> p-values for significant pairwise chi square tests are provided for each scenario, indicated by the response type (ranging 1–5) and the two states (ranging a through d) as noted in the table. Voluntary scenario: (4ac) = 0.02, (3ad) = 0.02, (3ab) = 0.03, Property tax scenario: (4ad) = 0.05, (4ab) = 0.05, (3bd) < 0.01, (3bc) < 0.001, (3ac) = 0.05

<sup>b</sup> Totals do not add up to 100% due to rounding

**Table 8** Model independent variable summary statistics for voluntary and property tax reduction scenarios

Variable	Voluntary <sup>a,b</sup>		Property Tax Reduction <sup>a,b</sup>	
	Certain No, <i>n</i> = 160	Certain Yes, <i>n</i> = 70	Certain No, <i>n</i> = 152	Certain Yes, <i>n</i> = 130
<i>Demographic:</i>				
Northern1	93%	93%	92%	** 83%
ln(Acres)	4.1 (1.1)	4.1 (1.0)	4.1 (1.1)	4.0 (1.0)
Percent Income Woods	3.2 (9.6)	5.8 (17.4)	3.0 (9.0)	2.6 (10.3)
Gender1	80%	73%	80%	** 68%
Bachelors or Higher1	56%	69%	50%	*** 81%
Above Med. Income1	68%	61%	63%	* 73%
Age	64.9 (11.4)	63.6 (11.2)	65.4 (12.0)	64.1 (10.3)
Current Use1	53%	50%	48%	56%
<i>Planned Activities:</i>				
Plan: Motorized Rec.1	52%	** 34%	51%	*** 27%
Plan: Invasive Plant Mgmt.1	41%	* 54%	44%	53%
Plan: Firewood1	83%	79%	84%	* 75%
Plan: Hunting1	73%	61%	77%	57%
Plan: CE1	6%	** 17%	7%	*** 19%
<i>PFM Benefits and Concerns:</i>				
Perceived Benefits to PFM	1.9 (1.9)	*** 3.5 (1.6)	1.9 (1.8)	*** 3.4 (1.6)
Perceived Concerns to PFM	3.9 (2.5)	*** 2.4 (1.8)	3.8 (2.5)	*** 2.4 (1.5)
<i>Goals for the Land:</i>				
PC: Amenity/Eco	-0.2 (1.1)	*** 0.3 (0.8)	-0.2 (1.1)	*** 0.3 (0.9)
PC: Recreation	0.2 (1.1)	* 0.0 (1.0)	0.3 (1.0)	*** -0.2 (0.9)
PC: Financial	0.2 (1.0)	** -0.2 (0.8)	0.0 (1.0)	-0.1 (1.0)

<sup>a</sup> Significant differences at the 1% level are indicated with \*\*\*, at the 5% level with \*\*, and 10% level with \*

<sup>b</sup> For numeric variables, mean(std. dev.) is shown, for categorical variables, the response proportion is shown

with financial goals were less likely to adopt the voluntary scenario and more likely to adopt the fee simple scenario; this variable was not significant for the property tax reduction or CE scenarios (Table 10).

## Discussion

US forests provide a wide diversity of ecological, social, and economic benefits. The application of ecological forestry can produce and sustain these benefits, but it will take foresters applying the full suite of forest management strategies, both AFM

**Table 9** Model independent variable summary statistics for CE and fee simple scenarios

Variable	CE <sup>a,b</sup>		Fee Simple <sup>a,b</sup>	
	Certain No, <i>n</i> = 216	Certain Yes, <i>n</i> = 75	Certain No, <i>n</i> = 263	Certain Yes, <i>n</i> = 56
<i>Demographic:</i>				
Northern1	88%	87%	89%	** 77%
ln(Acres)	4.1 (1.1)	4.0 (1.1)	4.0 (1.1)	4.2 (1.0)
Percent Income Woods	4.6 (13.8)	2.4 (8.0)	4.3 (14.7)	5.4 (15.6)
Gender1	80%	71%	78%	73%
Bachelors or Higher1	55%	*** 80%	55%	*** 80%
Above Med. Income1	63%	69%	64%	63%
Age	65.0 (11.5)	64.9 (12.8)	64.8 (12.0)	66.3 (11.2)
Current Use1	50%	59%	50%	59%
<i>Planned Activities:</i>				
Plan: Motorized Rec.1	49%	*** 29%	45%	*** 23%
Plan: Invasive Plant Mgmt.1	44%	* 56%	42%	*** 63%
Plan: Firewood1	82%	* 71%	82%	** 66%
Plan: Hunting1	75%	*** 57%	70%	* 55%
Plan: CE1	6%	*** 29%	8%	*** 29%
<i>PFM Benefits and Concerns:</i>				
Perceived Benefits to PFM	2.2 (1.8)	*** 3.5 (1.5)	2.5 (1.8)	*** 3.3 (1.6)
Perceived Concerns to PFM	3.6 (2.4)	*** 2.2 (1.5)	3.4 (2.3)	*** 1.8 (1.6)
<i>Goals for the Land:</i>				
PC: Amenity/Bio	-0.1 (1.1)	*** 0.2 (1.0)	0.0 (1.0)	0.1 (1.0)
PC: Recreation	0.2 (1.0)	*** -0.2 (0.9)	0.1 (1.0)	* -0.1 (0.9)
PC: Financial	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)

<sup>a</sup> Significant differences at the 1% level are indicated with \*\*\*, at the 5% level with \*\*, and 10% level with \*

<sup>b</sup> For numeric variables, mean(std. dev.) is shown, for categorical variables, the response proportion is shown

and PFM, to do so. Given the proportion of forest held by FFOs, these lands play a central role, yet no research exists exploring the attitudes of FFOs towards PFM strategies. The findings from this survey address a severe lack of understanding of FFO attitudes toward PFM in the US. In order to inform public policy and help foresters engage FFOs in integrating a diversity of PFM and AFM approaches on the landscape through ecological forestry to meet both the personal goals of FFOs and larger-scale conservation and biodiversity protection goals.

Our survey found that 36% of respondents would adopt PFM on their land; 12% on all of their land and 24% on some of their land. FFOs not engaged in AFM, USDA cost-share programs, or property tax incentive programs are often considered to be “unengaged.” Results from our group comparisons offer nuance to some of the existing typologies of passive landowners. Though some authors have described passive landowners as indifferent (Wiersum et al. 2005) or as rating all objectives

**Table 10** Regression models odds ratios and confidence intervals

Variable	Model			
	Voluntary <sup>a,b</sup>	Property Tax Reduction <sup>a,b</sup>	CE <sup>a,b</sup>	Fee Simple <sup>a,b</sup>
Northern1	n/s	0.44* (0.17, 1.13)	n/s	0.43* (0.18, 1.04)
ln(Acres)	n/s	n/s	n/s	n/s
Percent Income Woods	n/s	n/s	n/s	n/s
Gender1	n/s	n/s	n/s	n/s
Bachelors or Higher1	n/s	3.88*** (1.86, 8.08)	2.48** (1.12, 5.49)	3.77*** (1.54, 9.22)
Above Med. Income1	n/s	n/s	n/s	n/s
Age	n/s	n/s	n/s	n/s
Current Use1	n/s	2.64*** (1.31, 5.30)	2.27** (1.10, 4.70)	n/s
Plan: Motorized Rec.1	n/s	n/s	n/s	n/s
Plan: Invasive Plant Mgmt.1	n/s	n/s	n/s	2.32** (1.11, 4.84)
Plan: Firewood1	n/s	n/s	n/s	n/s
Plan: Hunting1	n/s	n/s	n/s	n/s
Plan: CE1	n/s	n/s	5.49*** (2.03, 14.80)	2.71** (1.07, 6.87)
Perceived Benefits to PFM	1.47*** (1.19, 1.80)	1.50*** (1.24, 1.81)	1.44*** (1.18, 1.76)	1.29** (1.04, 1.60)
Perceived Concerns to PFM	0.74*** (0.62, 0.89)	0.71*** (0.60, 0.85)	0.74*** (0.62, 0.89)	0.63*** (0.50, 0.79)
PC: Amenity/Eco	n/s	n/s	n/s	0.63** (0.41, 0.96)
PC: Recreation	n/s	0.66** (0.44, 0.98)	n/s	n/s
PC: Financial	0.63** (0.43, 0.92)	n/s	n/s	1.56** (1.06, 2.29)

<sup>a</sup> For each variable and model the following is shown: Odds Ratio (lower confidence interval, upper confidence interval). n/s indicates result was not significant. \*\*\* indicates significance at the 1% level, \*\* indicates significance at the 5% level while \* indicates significance at the 10% level

<sup>b</sup> The pseudo r-squared values for each model are as follows: 0.22 for Voluntary, 0.28 for Property Tax Reduction, 0.24 for CE, and 0.25 for Fee Simple

lower than other types of landowners (Ingemarson et al. 2006), our results show that FFOs willing to adopt at least one of the PFM scenarios and those already doing PFM are characterized by more frequently engaging in nonmotorized recreation on their land in the past and reporting goals for connection to nature, protecting wildlife and biodiversity, and mitigating climate change as extremely or very important more frequently than other types of FFOs. Moreover, FFOs already doing PFM and those willing to adopt PFM have plans for future activities on their land. For a segment of landowners, the passive approach is not ‘benign neglect,’ but an intentional forest management decision.

While there are certainly FFOs not making intentional decisions about any type of forest management on their land, we believe there is a small, but meaningful segment of landowners that care about their land but make an intentional choice to take a PFM approach. Interestingly, the 12% of FFOs interested in PFM on all of their land is consistent with regional calls for the establishment of wildlands in New England, helping to distribute wildland acres across both public and FFO ownerships (Foster et al. 2017; Littlefield et al. 2024). This segment is ignored in USDA cost-share programs, though these FFOs interested in PFM can play an important, complementary role within our landscapes and should be recognized and valued. That small proportion of FFOs willing to adopt PFM on all of their land play can serve as steppingstones between large existing reserves owned by the state government, federal government, or NGOs while contributing to broader landscape diversity. Rather than excluding these landowners as being "unengaged," in essence narrowing the definition of forestry, expanding the definition of forestry to include those choosing PFM will engage these landowners and help integrate PFM and AFM strategies. In fact, over 51% of those interested in PFM on all of their land plan to seek advice from a forester, demonstrating that just because a landowner decides to implement PFM, does not mean that there is not a role for foresters on those lands.

Beyond the 12% of landowners that choose PFM on all their land, across all scenarios the preference for adoption of PFM on only some land was significantly more popular than all land, which should help mitigate concerns that PFM may displace AFM on private lands. Though we did not ask FFOs directly why they preferred adoption on only some land rather than all of their land, the results of the "some land only" vs. "all land" group comparisons offer some insights. Significantly more of those willing to adopt PFM on only some land held concerns about firewood, commercial timber harvest, and building restrictions compared to those willing to adopt PFM on all of their land. Adopting PFM on only a portion of land may be more attractive to FFOs as it allows them to still engage in PFM-prohibited activities (e.g. firewood collection, timber harvesting, motorized vehicle use, and building structures) in other areas of forestland. FFO interest in applying PFM on some of their land complements ecological forestry, in which both AFM and PFM are parts of the same whole. Foresters can play an important role in helping landowners make decisions about which areas of the property may be best suited to AFM and PFM to meet landowner goals based on property characteristics and landscape context. It is also important to note that landowner attitudes in general are dynamic. FFO attitudes towards PFM may change in the future, for example if faced with an invasive insect (Simoes et al. 2019). Having an established relationship with a forester may help inform FFO decisions in an uncertain future.

For those interested in applying PFM to only some of their land, patch reserves within a certain stand(s) may be a suitable option. Applying PFM to portions of FFO properties can provide opportunities for intentional site selection including stands exhibiting existing old growth forest characteristics (including downed dead wood, large and old trees, horizontal structural diversity, and diverse age structures), minimal invasive species or deer browse impact, and areas surrounding sensitive ecological communities. Approximately 72% of those FFOs interested in adopting PFM on only some of their land, significantly more than those interested in PFM on

all land, reported planning on seeking advice from a forester. These FFOs should be engaged by foresters as they play an important role in the landscape by offering opportunities for varied management strategies and increased structural and species diversity at the property and landscape scale.

Having more FFOs interested in adopting PFM on only some of their land rather than all of their land bodes well for the adoption of ecological forestry and achieving Triad goals in the forest matrix, including increasing complexity and biodiversity and providing continuity before and after harvests (Franklin et al. 2018; Palik and D'Amato 2017). For example, at the landscape level, and entire property dedicated to PFM will provide continuity across properties. Likewise, at a smaller scale, applying PFM as a patch reserve in an otherwise AFM-managed stand will help provide continuity before and after a harvest.

The most popular PFM option was the property tax incentive scenario which provides a non-permanent program with a 90% property tax reduction. Past research supports this finding as others have found that temporary land protection tools are more desirable to FFOs than permanent ones (Markowski-Lindsay et al. 2018). The CE and fee simple scenarios were least popular which is not surprising given that past studies have found that only small selections of FFOs have a CE on their property or plan to in the future (Butler et al. 2021). Policymakers interested in increasing the amount of forest land under PFM should consider allowing some amount of PFM within existing AFM current use programs, which would incentivize the integration of AFM and PFM consistent with ecological forestry and the interest of a segment of FFOs.

The number of benefits and concerns FFOs perceive of the passive approach also significantly impacts their likelihood of adopting PFM. Given that the firewood restriction was the most common concern across all states and most adoption groups, policy makers, land trusts, and foresters may consider allowing a few cords of firewood to be harvested per year within PFM property tax incentive programs, creating use areas within PFM CEs where firewood could be harvested, and working with FFOs to designate a portion of their forest for firewood collection to help heat their homes and provide an active way to engage with their forest. The second most frequent concern was limiting the land use options of future owners which underscores the importance of having non-permanent options or working with FFOs to designate portions of their land rather than all of their land for PFM.

## Conclusion

Ecological forestry includes a spectrum of active and passive approaches applied at various scales and intensities in order to sustain a diversity of forest benefits. Our work sought to better understand FFO attitudes toward PFM in order to facilitate ecological forestry in the forested matrix between existing reserves and intensive wood production sites. We found that a property tax incentive tool was the most popular PFM option and significantly more FFOs would adopt PFM on only some of their land compared to all of their land. The majority of PFM-interested FFOs



plan to seek forester advice. Foresters can play a critical role in helping landowners make informed decisions about both AFM, PFM, and their integration within the broader landscape context, as landowners continue to look to foresters for advice as experts in forest conservation.

Given this study was of only FFOs in New England, future studies should survey FFOs in other regions to build on these findings and uncover potential regional influence on PFM option preferences. Our survey offered a small series of benefits and concerns that respondents selected from. Future studies could build upon this work with qualitative interviews to better understand the benefits and concerns of FFOs toward PFM approaches. This study was limited in precision regarding how much land a FFO would apply PFM to as we only offered the options “some” or “all” land. Future studies could consider asking FFOs what percentage of their land they would be willing to adopt PFM on and could test additional incentive tools with lower commitment levels, such as cost-share or educational programs. Since previous studies have demonstrated the importance of land ownership tenure in FFO decision making and behavior (Majumdar et al. 2009), future work could investigate FFO attitudes toward PFM in the context of length of ownership and method of acquisition (e.g. inheritance vs. purchase).

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**Data availability** The survey instrument used in this study is available in the supplemental materials, as are detailed tables resulting from non-response bias testing, group comparisons, the principal component analysis, and binary logistic regression models. Cleaned and deidentified survey data are available upon request.

## Declarations

**Ethics approval and consent to participate** The protocols of this study, ID 3636, were reviewed by the University of Massachusetts Amherst Internal Review Board who determined that the study was exempt from federal regulations that govern human subject research (45 CFR 46.104). A consent form was used to obtain informed consent from key informant interviews and pre-testing participants. Implied informed consent was gathered from participants who decided to complete the survey instrument.

**Consent for publication** Not applicable.

**Competing interests** The authors declare no conflict of interest and do not have any previous or concurring submissions to report. The submitted version of this manuscript has been seen and approved by all co-authors, and all persons entitled to authorship have been named.

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