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Factors influencing a forest landowner's choice of incentive program commitment length

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ABSTRACT

State preferential forest property tax programs (PFPTP) are commonly used to incentivize landowners to keep their land in a forested condition. For those PFPTPs that offer multiple enrollment periods, an important decision landowners face is the length of time they commit their land to the program, especially if the program's financial benefits are linked to the length of time enrolled. This study explores what factors influence the program length commitment decisions forest landowners make when choosing to participate in a PFPTP that offers multiple commitment lengths and associated financial benefits. To do so, it used enrollment data from Minnesota's Sustainable Forest Incentives Act (SFIA). The SFIA is a state PFPTP that provides annual compensation to enrollees in return for agreeing not to develop their land. It offers enrollees the choice of multiple program commitment lengths, each with a different annual payment. We developed a theoretical model of how a profit-maximizing forest landowner would choose one of several commitment length options available, given their opportunity cost of not being able to sell their forest land for development while enrolled. This model was tested using over 1100 unique SFIA enrollments from 2002 to 2021, which found the program commitment length SFIA enrollees select is not driven by their desire to maximize the financial benefit of enrolling. A second model was then developed to evaluate how owner and forest land characteristics are associated with the choice of SFIA commitment length, finding several attributes are significantly associated with their commitment length decision.

1. Introduction

Forested ecosystems provide numerous and substantial services upon which society depends such as wildlife habitat, carbon sequestration and storage, and water quality and quantity regulation. For many of these ecosystem goods and services, robust markets that encourage their provision are inadequate or nonexistent. In such instances, because forest landowners are not monetarily compensated for these ecosystem services, they have a financial disincentive to provide for them by retaining their land in a forested condition as opposed to other revenue-generating land uses such as agriculture or development.

In light of inadequate market incentives, numerous public policies and programs have been created with the goal of incentivizing private forest landowners to keep forests as forests. One common type of policy tool is preferential forest property tax programs (PFPTP), which offer lower property tax rates to enrolled forest lands as long as the owner retains them in a forest land use and, in some cases, penalizes withdrawals from forest land use (Kilgore et al., 2017; Frey et al., 2019; Frey, 2023; Chizmar et al., 2021; Chhetri et al., 2024). Separately, forest carbon offset markets are newly-emerging opportunities that incentivize the retention of forest land by allowing landowners to sell offsets based on the amount of carbon their forests sequester and/or store (e.g., Pan et al., 2022). Both types of programs have highly variable attributes regarding the rights and responsibilities of the various parties involved, as well as the dimensions of the contracts obligating each party to a program's terms.

One choice forest landowners may face when enrolling in a forest incentive program is how long they want to commit to keeping their land in the program, which can be linked to payment rates (e.g., Sun et al., 2021). Landowners may have the opportunity to choose to commit

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to a longer length of time (thus retaining the land in forest cover and forgoing alternate land uses during this longer period), often in return for receiving a higher annual payment rate, or committing to a shorter length at a lower annual payment rate. For example, the USDA Healthy Forests Reserve Program provides eligible forest owners with the option to enroll in a 10-year, 30-year, or permanent conservation easement, each providing a different level of compensation (USDA-Forest Service, 2025). Similarly, enrollment length choices abound in the carbon marketplace, where a longer forest carbon commitment length can provide landowners with a higher carbon offset price (Forest Carbon Works, 2023). Although uncommon, multiple commitment lengths also exist among PFPTPs (Kilgore et al., 2017).

Observing forest landowner choices in scenarios where multiple commitment lengths and their associated payments are available can illuminate their preferences, aid in forecasting future enrollment choices, and shape the characteristics of future forest policy tools. For example, if forest landowners systematically reject shorter commitment lengths that allow them to maximize financial returns by undertaking land development sooner in favor of accepting longer commitment lengths that offer more limited financial opportunities, this may reveal their preferences for non-financial, forest-based amenities.

To explore forest landowner commitment length choices, we analyzed Minnesota's Sustainable Forest Incentives Act (SFIA). The SFIA is a state PFPTP that provides annual compensation to enrollees in return for agreeing to certain land use restrictions and forest management obligations. The SFIA's choice of multiple commitment lengths and different annual payments associated with each is unique, making it an excellent program to better understand the relationship between the characteristics of forest landowners and their land and their commitment length preferences.

2. Review of the literature on factors influencing PFPTP enrollment and commitment length choice

Forest property taxes are often cited as a substantial on-going cost of forest land ownership that can impact returns to forest management and forest land retention decisions (Frey et al., 2019; Cushing and Newman, 2018; Greene, 1995; Stier et al., 1988). Additionally, numerous studies have documented forest landowner concerns about high property taxes (Frey et al., 2019; Butler et al., 2012; Gruver et al., 2017; Kilgore, 2014; Stone and Tyrrell, 2012; Williams et al., 2004). To address these concerns, every state has developed at least one PFPTP that reduces the tax burden of forest land ownership (Frey, 2023; Kilgore et al., 2018). The goals, enrollment requirements, and financial benefits of these programs are often a function of the owner, forest land, and property tax characteristics unique to each state. As a result, the provisions of individual state PFPTPs vary considerably (Chizmar et al., 2021; Kilgore et al., 2017; Kilgore et al., 2018). Most states have designed their PFPTP with the implicit or explicit goal of encouraging owners to keep their land in a forested condition (Frey et al., 2019; Kilgore et al., 2018).

Numerous studies have documented high landowner concern over the level of property tax levied on their forest land, and that property taxes are an important factor in forest ownership decisions (e.g., Brockett et al., 2003; Butler et al., 2010; Butler et al., 2012; Gobster and Rickenbach, 2004; Poudyal and Hodges, 2009; Mehmood and Zhang, 2001; Rossi et al., 2023; Sampson and DeCoster, 2000). Yet, research findings on the importance of reduced property taxes in influencing forest landowner decisions has been inconsistent (Frey, 2023). Overall, the available research provides moderate evidence of PFPTPs having positive, but modest success retaining forests, but insufficient evidence to determine that PFPTPs cause an increase in forest management activity (Frey, 2023).

Several studies have modeled the likelihood of forest landowner enrollment/participation in a PFPTP (e.g., Fortney et al., 2011; Bagdon and Kilgore, 2013; Frey et al., 2019; Chhetri et al., 2024). A variety of factors have been found to influence a forest landowner's enrollment decision, including landowner socio-demographic characteristics, land characteristics, tax program requirements, and landowner objectives, values, and attitudes (Frey et al., 2019; Chhetri et al., 2024). The level of property tax relief, in particular, has been found to be positively related to PFPTP enrollment in some studies (Stevens et al., 2002; Udayanganie, 2012; Udayanganie, 2013), but not others (Bagdon and Kilgore, 2013; Frey et al., 2019).

The length of program commitment is one important characteristic of many PFPTPs. In a review of PFPTPs across the United States, Kilgore et al. (2017) reported that 42 % of programs had an indefinite time length commitment (e.g., open-ended or automatic continuous renewal), another 42 % had a specified time commitment to the program (e.g., one or more years), while the remaining 16 % of programs had conditions that influenced the length of time commitment to the program (such as ownership change or land use change).

Very little research has focused on the influence of program commitment length on a landowner's decision to enroll in a PFPTP. In a national study of determinants of enrollment in PFPTPs, Frey et al. (2019) found that whether a program imposed a minimum commitment length was not an influential factor. Fortney et al. (2011) reported that forest landowners would prefer that the PFPTP in West Virginia be changed to allow a longer commitment time. Bagdon and Kilgore (2013) found forest landowner's preferred a PFPTP with a shorter commitment period and lower financial benefit.

While not addressed through research on PFPTPs, a few studies have examined conservation commitment lengths and program characteristics that are socially optimal. For example, Lennox and Armsworth (2011) researched how uncertainty in future land availability and ecological conditions influenced whether a conservation agency should offer shorter or longer commitment lengths to acquire land rights in order to optimize conservation benefits. Sun et al. (2021) examined optimal contract characteristics for carbon sequestration on forest lands, finding that landowners whose land can produce more carbon benefits will need a more ‘favorable’ conservation contract in terms of a higher payment amount, a shorter commitment length, or both.

This led us to wonder what factors influence the program length commitment decisions forest landowners make when choosing to participate in a PFPTP that offers multiple commitment lengths. We are not aware of any research that has examined the commitment lengths preferred or selected by private landowners when given multiple commitment length options associated with enrolling in a forest incentive program. Our study explores this gap in the literature.

3. Background information on the SFIA program

The SFIA program was established in 2001 by the Department of Natural Resources (DNR) as a means of encouraging Minnesota's private forest landowners to keep their forest land undeveloped, be an active forest manager, and apply good stewardship practices when conducting timber harvesting and forest management activities. To be eligible, the enrolled land needs to be at least 8.1 contiguous hectares, at least 50 % forested, not have any improvements (e.g., buildings), and not be subject to a conservation easement. The landowner is required to have a forest management (i.e., stewardship) plan for the enrolled land prepared by a DNR-approved plan writer within the past 10 years and be current on the land's property taxes.[1]

SFIA enrollees are given the choice of three commitment lengths: 8, 20, or 50 years. Annual per hectare SFIA payments are formulaic and based on current statewide average forest land values and property tax rates. They are recalculated annually and increase with increasing

[1] https://www.revenue.state.mn.us/sustainable-forest-incentive-act.

commitment length. For example, the 2023 per hectare annual SFIA payments were $24.93, $34.55, and $44.13 for 8-, 20-, and 50-year agreements, respectively. Landowners sign a contract obligating them to the terms of the SFIA program for the commitment length selected. Additionally, a covenant is required to be filed in the county recorder's office where the enrolled forest land is located, legally binding the current and any successor owners to the terms of the SFIA program while enrolled.[2]

Once enrolled, landowners may not erect any structures (except for minor, ancillary buildings such as a shed) on any SFIA-enrolled land. Enrollees are required to implement their forest management plan and follow the state's forest management guidelines when harvesting timber or conducting forest management operations. Landowners are also required to annually certify to the Minnesota Department of Revenue (DOR) they are meeting all the conditions and requirements of the SFIA program. Failure to annually certify compliance results in the property being removed from the program. Financial penalties based on a percent of the forest land's estimated market value are imposed on the owner if the forest land is involuntarily removed from the SFIA program due to noncompliance with its terms and conditions. Any SFIA enrollee who is involuntarily removed from the program is also required to pay back all annual SFIA payments received up to one-half of the commitment length. Enrollees whose land has been in the SFIA program for at least half the term of the commitment (e.g., enrolled at least 10 years for a 20-year SFIA commitment) can request to withdraw their land from the program. However, even if the land is voluntarily withdrawn, the covenant binding the landowner to the program requirements remains in effect for the duration of the SFIA commitment (Minnesota Revisor of Statutes, 2023).

All SFIA participants who enrolled in the program prior to 2018 were only given an eight-year commitment option. However, due to a change in state law, beginning in 2018 new enrollees were given the option of an 8-, 20-, or 50-year commitment (and a unique per hectare annual SFIA payment associated with each commitment length option). Additionally, pre-2018 SFIA enrollees were given the option to change their length of commitment to 20 or 50 years. To implement this policy change, in 2018 all SFIA participants who enrolled prior to 2018 were contacted by the DOR and informed they were allowed to change the length of their SFIA commitment to 20 or 50 years without penalty or cost. Enrollees had two years to increase the length of their SFIA commitment.[3] The ability of landowners to select their preferred commitment length is an aspect of the SFIA program not found in other state PFPTPs. Thus, the SFIA program provides a unique opportunity to gain insight with respect to how landowner commitment length choices relate to their preferences for and the values they associate with the monetary and non-monetary benefits derived from their forest land.

4. Theoretical model

4.1. Optimal commitment length

This section discusses a theoretical economic model of how a profit- or utility-maximizing forest landowner would choose a commitment length when given various commitment length options. The purpose of developing this model and the resulting equations is to create a framework in which we can evaluate whether landowners appear to follow a profit-maximizing rule in full or in part when choosing a commitment length.

Let us consider an extension of the Hartman (1976) model, in which a landowner chooses the timber rotation length t to maximize profits (or utility) from forested land (maintaining the land in a forest land use) where income (utility) is derived from both the periodic production of timber and continual production of other ecosystem services. For Hartman's purposes, the decision point was chosen to coincide with the time the trees were established (the beginning of a timber rotation) (Hartman, 1976; Sun et al., 2021), and establishment and other management costs ignored, yielding:

$$F(t,0) = \frac{\left[p \bullet Q(t|\, d,s) \bullet e^{-it} + \int_0^t a(x) \bullet e^{-it} dx\right]}{1 - e^{-it}} \quad (1)$$

$F(t, m)$ = present value of a forest of age m, with optimal rotation length t years.

i = discount rate.

p = price of stumpage (i.e., uncut standing timber)

$Q(t|\, d, s)$ = volume of stumpage at time t; for a given planting density d and site index s.

$a(x)$ = annual amenity (ecosystem service) value at time x.

Amenity values, $a(x)$, in principle, could reflect some type of payment for ecosystem services or personal utility derived from non-monetary benefits like the enjoyment of nature and recreation. Since these utility values vary by individual and are difficult to measure, profit-maximization is often assumed in various models and policies. Land use and program participation decisions offer a valuable lens for testing this assumption.

Let us expand the Hartman model to include a land use change decision. Without any type of conservation payment or other revenue sources, a profit-maximizing landowner would simply choose the land use that provides the highest expected value. Assume there are only two choices: keeping the land as forest under the optimal rotation indefinitely[4] or developing or selling the land for development. Define $D(t)$ as the developed value of land, at time t. The value of the land with no conservation payment, V_{nc}, would be

$$V_{nc}(t,0) = max[F(t,0), D(0)] \quad (2)$$

Now, assume a public policy or ecosystem service market program will provide the landowner an annual conservation payment, $c(n)$, to conserve the land in a forest land use, and the level of the annual payment depends on the commitment length in years, n, a landowner commits to maintain the forest. The contract negates the possibility of development of the land through time n. The present value, given interest rate i, of enrollment in an infinite series of commitments for conservation payments is defined by capitalizing the annual payment using $c(n)/i$.

$$V_c(t,n) = F(t,0) + \frac{c(n)}{i} + \frac{1}{e^{in}} max\left[D(n) - \left(F(t,n) + \frac{c(n)}{i}\right), 0\right] \quad (3)$$

The landowner maximizes V_c by choosing a commitment length n. Let us assume the future developed land value is higher than the forest land value, $D(n) - \left(F(t,n) + \frac{c(n)}{i}\right) > 0$.

Table 1
SFIA commitment length and hectares enrolled for the study sample and all SFIA enrollees.

	SFIA commitment length (%)[1]			Mean hectares enrolled[2]
	8 years	20 years	50 years	
Study sample (n-1172)	61.9	14.5	23.6	61.6
All SFIA enrollees (n = 3953)	61.2	15.4	23.5	64.7

[1] $\chi^2 = 0.775$, $p = 0.500$.
[2] F = 2.189, $p = 0.209$.

[2] https://www.revenue.state.mn.us/sustainable-forest-incentive-act.
[3] MN DOR personal communication June 27, 2023.

[4] Let us ignore the fact that development is irreversible whereas other land uses can change, which provides option value to the landowner. This would suggest that landowners would wait a bit more until the value of development is substantially higher than forest.

$$V_c(t,n) = F(t,0) + \frac{c(n)}{i} + \frac{1}{e^{in}}\left[D(n) - \left(F(t,n) + \frac{c(n)}{i}\right)\right] \quad (4)$$

Solving for the optimal choice of n (first order condition), we get.

$$\left(\frac{\partial D(n)}{\partial n} - iD(n)\right) = \left(\frac{\partial F(t,n)}{\partial n} - iF(t,n)\right) + \frac{1}{i}\left(\frac{\partial c(n)}{\partial n} - ic(n)\right) - \frac{e^{in}}{i}\frac{\partial c(n)}{\partial n} \quad (5)$$

Max development value | Max Timber Value | Max Program Payment | Adjustment factor

To maximize value, the landowner chooses the commitment length where two conditions are balanced. First, the increase in the value of developed land over time must be just enough to offset its annual development value. Second, the increase in forest land value must be similarly balanced, while accounting for the capitalized difference between program payments and annual payments, adjusted for any additional gains from extending the commitment period.

Now, let us consider a scenario in which the discount rate equals the growth of forest land value, that is $\frac{\partial F(t,n)}{\partial n} = iF(t,n)$. This is the assumption underlying the financially optimal harvest rotation (Faustmann/Hartman); i.e., assume the landowner operates using an optimal timber rotation. If this assumption holds, then:

$$\frac{\partial D(n)}{\partial n} = iD(n) - c(n) + \frac{1+e^{in}}{i}\frac{\partial c(n)}{\partial n} \quad (6)$$

The conservation payment program commitment length is optimized when the rate of change in developed land value at the end of the program commitment length is equal to the annual equivalent value of the developed land, minus the annual conservation payment and the addition payment earned with longer commitment lengths.

4.2. Choosing a discrete commitment length

Eqs. (5) and (6) describe the optimal choice of commitment length, n, assuming continuous functions, a stream of continuous payments, and continuous compounding. However, most programs are likely to offer a closed menu of discrete commitment lengths. In addition, payments are typically made on an annual basis. Thus, we substitute $(1+i)^n$ for e^{in} to better describe the landowner's discrete choice with annual compounding.

To understand the financial benefit (FB) of enrolling in the program, and thus compare a profit-maximizing landowner's tradeoff between varying commitment lengths, we subtract Eqs. (2) from (3) while substituting $(1+i)^n$ for e^{in}. Let us make simplifying assumptions that $D(0) > F(t,0)$ and $F(t,0) = F(t,n)/(1+i)^n$. This first assumption means that the value of cleared land for growing trees is less than the value of that land for development. The second assumption requires that the average rate of growth of timber value over the period from age 0 to n is equal to the discount rate. Define $G = \left(\frac{D(n)}{D(0)}\right)^{\frac{1}{n}} - 1$ is the estimated annual proportion increase in D.

$$FB = c(n)\left[\frac{1-(1+i)^{-n}}{i}\right] - \sum_{1}^{n} D(0)\left(\frac{(1+G)^n}{(1+i)^n} - 1\right) \quad (7)$$

Eq. (7) describes the financial benefit (FB) of a particular commitment length choice. A profit-maximizing landowner will select commitment length (n) from a list of options, that results in the highest FB.

4.3. Translating theoretical model to evaluate commitment length choices

Eq. (7) can be used directly to assess whether landowners are choosing the single-most financially profitable commitment length for their specific situation. This is done by estimating the financial benefit (FB) for each commitment length option and comparing them to find the profit-maximizing choice, as discussed below in Section 5 Data and Methods.

It is also possible that a landowner is "partially profit-maximizing;" that is, choosing a financially beneficial outcome is only one of several considerations. To assess whether this may be the case, we can use a regression model, as discussed below in Section 5 Data and Methods, to control for other factors that may correlate with their decision. We use Eq. (6) to identify the correlation relationship we would expect to see between development values and commitment length choices. In practical terms, Eq. (6) suggests that landowners with rapidly increasing development values will choose to wait before developing their forest land. Before converting the land to a developed use, they will maximize profits by waiting longer until the rate of increase slows to the point it is equal to the right-hand side expression in Eq. (6). This suggests that a higher rate of increase in developed land value and a lower starting level of developed land value would both be correlated with longer commitment lengths.

5. Data and methods

The Minnesota DOR provided the study team a database containing records of all properties enrolled in the SFIA program from 2002 to 2021. For each forest land property enrolled, the database includes the property location (county, township, property identification number (s)), hectares enrolled, SFIA commitment length (8, 20, 50 years), SFIA covenant number, year of initial enrollment, and additional owner-specific information. Enrollments consisting of multiple forested parcels were aggregated by SFIA covenant number, resulting in 4003 unique SFIA enrollments during this 20-year period. Because the program provides a different payment structure for enrollments of more than 777 ha, these enrollments were removed, leaving 3953 records in our SFIA database.

From this database, a random sample of approximately 30 % of SFIA enrollments was drawn, resulting in 1172 unique SFIA enrollments. Table 1 shows the relative proportion of 8-, 20-, and 50-year commitment lengths and average hectares enrolled for our sample and the population of SFIA enrollees. As this table illustrates, our sample very closely resembles all SFIA enrollees with respect to these characteristics.

Property taxes and estimated market values (EMV) for each SFIA enrollment in our sample were obtained from county property record websites. Proximate average above-ground carbon volume and urban land cover change for each enrollment in our sample were derived from the USDA Forest Service's Forest Carbon Pool and National Land Cover databases, respectively.

5.1. Maximizing the financial benefit of participation

We first examined whether a landowner's choice of SFIA commitment length maximized their financial position using the theoretical model described in Section 4. To do so, the financial tradeoff associated with each of three SFIA commitment lengths (8, 20, 50 years) was compared to the expected increase in the enrolled land's market value over the life of the commitment. A fundamental assumption is that a portion of the forest land's value reflects its use in a developed state such as a seasonal or permanent home site. While SFIA enrollees are not prohibited from selling their forest land, the covenant's terms and conditions transfer to the new owner, meaning the new owner must continue to maintain the land in an undeveloped condition. Therefore, the land's development contribution to total forest land market value cannot be realized while enrolled in the SFIA program.

Although the portion of forest land market value attributed to its use as a home site or other similar developed use is not separable from its

Table 2
Variable descriptions and hypothesized effects on choice of SFIA covenant length.

Variable	Hypothesized effect	Literature consulted in developing hypothesis
Area (continuous): Forested hectares enrolled in the SFIA program by the enrollee, obtained from the SFIA enrollment database.	**Positive:** Larger enrollments (hectares) increase the likelihood of a longer commitment due to the larger annual SFIA payment.	Butler et al., 2016; Dennis and Sendak, 1992; Fortney et al., 2011; Frey et al., 2019; Kilgore et al., 2008; Kauneckis and York, 2009; Koontz, 2001; Ma et al., 2012; Song et al., 2014; Stevens et al., 2002; Wolde et al., 2016
Stocking Density (continuous): Average above-ground carbon volume within 0.8 km of the SFIA parcel (a proxy for merchantable stocking density), derived from the USDA Forest Service's Forest Carbon Pools 2018 data.	**Indeterminate:** Merchantable stocking density was used as a proxy for the land's timber income potential. High stocking density may indicate a mature forest nearing harvest, making short-term enrollment more likely. Conversely, high stocking may increase the likelihood of a longer commitment due to the increased amenity values associated with denser forests.	Brockett et al., 2003; Butler et al., 2016; Fortney et al., 2011; Frey et al., 2019; Kilgore et al., 2007; Lennox and Armsworth, 2011; Ma et al., 2012; Snyder et al., 2008; Song et al., 2014; Wolde et al., 2016
Development (continuous): Change in urban land cover (m^2) within 1 km of an SFIA-enrolled property between 2001 and 2019. Urban land cover change, derived from the National Land Cover Database, serves as a proxy for land development potential.	**Negative:** Increasing development in the surrounding area decreases the likelihood of a longer SFIA commitment because the financial advantages of developing or selling unenrolled land become more appealing.	Bagdon and Kilgore, 2013; Brockett et al., 2003; Brockett and Gebhard, 1999; Cho et al., 2017; Dennis and Sendak, 1992; Frey et al., 2019; Hickman and Crowther, 1991; Kauneckis and York, 2009; Miller et al., 2014; Poudyal and Hodges, 2009; Rushakoff, 2021; Snyder et al., 2008; Stone and Tyrrell, 2012; Udayanganie, 2013
Market Value (continuous): Average estimated market value (EMV) per hectare the year of enrollment (2018 for pre-2018 enrollees) where the enrolled land is located, obtained from the MN Dept. of Revenue, is a proxy for the SFIA withdrawal penalty, which is based on the land's EMV.	**Negative**: Increasing market value decreases the likelihood of a longer commitment due to the increasing penalty for noncompliance with the SFIA program terms. Furthermore, higher current market value suggests short-term development is optimal since relative market value percentage growth rates will tend to decrease.	Bagdon and Kilgore, 2013; Chhetri et al., 2024; Fortney et al., 2011; Frey et al., 2019; Hickman and Crowther, 1991; Kilgore et al., 2017; Ma et al., 2012; Poudyal and Hodges, 2009; Snyder et al., 2007; Snyder et al., 2008; Stevens et al., 2002; Williams et al., 2004
Tax Liability (continuous): Net property tax per hectare (2021) paid on properties enrolled in the SFIA program, obtained from MN county on-line property tax records, is a proxy for concern about high property taxes.	**Positive**: Increasing property tax liability increases the likelihood of a longer SFIA commitment due to higher SFIA payments offsetting the land's annual property tax liability.	Butler et al., 2012; Chhetri et al., 2024; Cushing and Newman, 2018; Frey et al., 2019; Fortney et al., 2011; Greene, 1995; Kilgore et al., 2018; Koontz, 2001; Stier et al., 1988; Stevens et al., 2002; Stone and Tyrrell, 2012
Nonresident (binary): Place of residence of the primary owner of the enrolled land (1 = lives outside Minnesota; 0 = lives in Minnesota)	**Positive**: The likelihood of a longer commitment is higher for nonresident forest landowners due to a greater reliance on SFIA payments as a means of offsetting the cost of absentee forest ownership, the latter of which generally is associated with less frequent visits to and less active management of forest land.	Bagdon and Kilgore, 2013; Caputo and Snyder, 2023; Chhetri et al., 2024; Fortney et al., 2011; Floress et al., 2019; Ma et al., 2012; Miller et al., 2012; Snyder et al., 2020; Song et al., 2014, Stevens et al., 2002; Williams et al., 2004; Wolde et al., 2016
Owner Type (binary): Indicates whether the SFIA enrollee is incorporated or a limited liability corporation, based on the description of the primary owner listed on the SFIA covenant. Owners not meeting this definition were considered a family forest owner (1 = family forest owner; 0 = incorporated or LLC).	**Indeterminate**: There is no information indicating family forest owners prefer a longer commitment than other private forest owners.	
Pre-2018 Enrollment (binary): Indicates whether SFIA enrollment was prior to 2018, obtained from the SFIA enrollment database. (1 = enrollment before 2018; 0 = enrollment 2018 or later).	**Indeterminate**: There is no information indicating the choice of commitment length differs between pre-2018 (where only an 8 year commitment was offered at enrollment, with the option of a 20 or 50 year commitment in 2018) and 2018–2021 SFIA enrollees (where 8-, 20-, and 50-year commitment lengths were offered upon enrollment).	

observed market value, a framework can be developed to compare the financial tradeoffs associated with the three SFIA commitment lengths. This entails comparing the financial gain attributed to each series of annual SFIA payments over the life of the commitment to the increase in the land's market value while subject to the restricted use covenant. The commitment length selected is the one that produces the greatest present value including both financial and non-financial benefit associated with enrolling in the SFIA program.

The financial benefit of participating in the SFIA program was calculated by subtracting the discounted unrealized land value appreciation over the life of the commitment from the discounted value of the SFIA payments paid over the life of the commitment, as shown in Eq. (7) where,

i = real discount rate (1 %, 3 %, 6 %).

n = 8, 20, 50 years.

$c(n)$ = annual SFIA payment at the time of enrollment for 8-, 20-, and 50-year commitment (or 2018 SFIA payment rates for pre-2018 enrollees).

$D(0)$ = market value of forest land (EMV)[5] at the time of enrollment in the SFIA program (or 2018 EMV values for pre-2018 enrollees).

G = projected future change in EMV, as estimated by the average annual change in EMV from 2017 to 2021.

For each SFIA enrollment, Eq. (7) was calculated three times to identify which commitment length produced the greatest PV financial return to the enrollee. The financially efficient commitment length was then compared to the SFIA commitment length selected by the landowner. These calculations and subsequent comparison was performed for each of the three real discount rates.

[5] EMV is the average reported value per hectare determined by the county assessor.

Table 3
Descriptive statistics for model independent variables.

Variable	N	Minimum	Maximum	Mean	Std. deviation
Area	1172	4.0	751.5	63.1	79.7
Stocking Density	1172	< 0.10	2.37	1.25	0.34
Development	1172	0	2,386,800	217,972	213,759
Market Value	1172	803	7910	3037	1139
Tax Liability	1172	< 1	1169	32	47
Nonresident	1172	0	1	0.08	0.27
Owner Type	1172	0	1	0.88	0.32
Pre-2018 Enrollment	1172	0	1	0.72	0.45

5.2. Enrollee, forest land, and program characteristics model

A second model was developed to evaluate how owner and forest land characteristics may be associated with the choice of SFIA commitment length. Because our study is believed to be the first to evaluate factors influencing the length of a conservation commitment preferred by private forest landowners, we drew heavily from the work of Frey et al. (2019) to identify these characteristics. While Frey et al.'s work models owner, land, and program characteristics that are associated with PFPTP enrollment decisions, it is the most recent and comprehensive assessment of its kind and most closely resembles the questions we are addressing in the present work.

We employed a multinomial regression estimator[6] to establish the relationship between the landowner's commitment length choice and characteristics specific to the owner and their land. The owner and land variables selected for this second model were obtained or derived from information contained in the SFIA enrollment database. Parcel identification number(s) linked with each SFIA record were used to identify the geospatial coordinates (i.e., latitude and longitude) associated with the centroid of each tract enrolled. Proximate parcel attributes (e.g., recent land use change, tree stocking density) were developed by linking each tract's georeferenced location information to spatially explicit datasets such as the National Land Cover and USDA's Forest Inventory Analysis data. The owner and forest land characteristics associated with each SFIA enrollment record are described in Table 2, as are the hypothesized effect each has on the choice of SFIA commitment length. All analyses were performed in SPSS, version 28. (See Table 3.)

6. Results

Information about the independent variables included in the model are shown in Table 3. Applying SFIA payment and parcel data to Eq. (7) found significant differences between the predicted and actual commitment length selected by the SFIA enrollee using 1 %, 3 %, and 6 % real discount rates (Table 4). In other words, SFIA enrollees were not choosing the commitment length based on financial efficiency criteria.

Table 5 contains the results of the model examining the relationship between the SFIA commitment length selected and forest land and owner characteristics described in Table 2. No owner or forest land characteristic is significantly associated ($p \leq 0.10$) with all three pairs of commitment length choices. Two characteristics are associated with two of the paired choices. Higher urban development in the area surrounding the enrolled forest land is associated with preference for 8-year and 20-year over 50-year commitments, and higher stocking density is associated with a decreased preference for a 20-year commitment compared to 8- and 50-year commitments. Additionally, the likelihood a landowner selects a 50-year commitment over an 8-year commitment increases with greater area enrolled, lower per hectare property taxes, and if they reside in Minnesota. Higher EMV is associated with selecting a 20-year over a 50-year commitment. Landowners who enrolled in the SFIA program prior to 2018 are more likely to select an 8-year over 20- and 50-year commitments. The choice of commitment length is not associated with owner type (i.e., family versus LLC or incorporated).

Table 4
Chi-square tests for differences between the SFIA commitment length selected by the enrollee and the commitment length that maximized financial benefit (Eq. (7)) using 1 %, 3 %, 6 % discount rates (n = 1172).

	SFIA commitment length (%)		
	8 years	20 years	50 years
Predicted 1 %[1]	55.7	0.3	44.0
Predicted 3 %[2]	28.9	0.6	0.0
Predicted 6 %[3]	11.8	0.0	88.2
Actual	61.9	14.5	23.6

[1] $\chi^2 = 237.0$, $p \leq 0.001$.
[2] $\chi^2 = 563.4$, $p \leq 0.001$.
[3] $\chi^2 = 1006.4$, $p \leq 0.001$.

Given the substantial influence the initial date of SFIA enrollment had on the commitment length selected, we also ran separate models for pre-2018 and 2018–2021 enrollees. We did so to evaluate if forest and owner characteristics significantly associated with the choice of commitment length are different based on what program commitment options were available to them when they first enrolled. As Table 5 illustrates, the commitment length decisions among owners who enrolled their forest land from 2018 to 2021 are not associated with the land and owner characteristics we evaluated. In other words, our model was no better at predicting the SFIA enrollee's choice of commitment length than an intercept only model ($p = 0.600$).

In contrast, several owner and forest land characteristics of enrollees who were initially only given the choice of an 8-year commitment are significantly associated with their decision whether to extend their commitment to 20 or 50 years when given the opportunity to do so (Table 5). For these SFIA participants, higher property taxes, more developed land surrounding their forest, and being an absentee owner are associated with a greater probability of selecting an 8-year over a 50-year commitment. As the EMV increases, so too does the likelihood of selecting a 20-year over a 50-year commitment. An increase in tree stocking density decreases the likelihood of selecting a 20-year commitment relative to either 8- or 50-year commitments. Whether or not the enrollee is a family forest owner (versus a corporation or LLC) does not significantly influence the choice of commitment length.

7. Discussion

Our study did not reject the null hypothesis that enrollees are not choosing the commitment length that maximizes the financial benefit of participating in the SFIA program. Had this been the case, the commitment length selected would have been the one that produces the greatest present value when comparing the financial gain attributed to each series of annual SFIA payments to the increase in the land's market value while under covenant restrictions. Although several studies have suggested family forest owner's decision-making is driven by non-financial criteria (e.g., Frey et al., 2019; Kilgore et al., 2007; Urquhart and Courtney, 2011), ours is one of the few to empirically test whether specific forest landowner decisions are financially efficient.

The theoretical model in Section 4 (Eq. (7)) indicates that the financial benefit of enrolling in a given commitment length should be negatively related to the current development value and positively related to the rate of increase in development value. This suggests that, all else equal, landowners with high current EMV (representing

[6] An ordinal regression model was initially developed to identify statistically significant relationships between the independent variables described in Table 2 and the landowner's choice of SFIA commitment length. However, the model was rejected as the test for parallel lines assumption was violated ($p = 0.004$).

Table 5
Model results for predicting choice of SFIA covenant length for enrollments from 2002 to 2021, 2002–2017, and 2018–2021.

Covenant length	Variable	2002–2021 (n = 1172)		2002–2017 (n = 843)		2018–2021 (n = 329)	
		Estimate	Std. error	Estimate	Std. error	Estimate	Std. error
8 years	Area	**- 0.001***	< 0.001	- 0.001	0.000	< 0.001	0.001
(reference = 50)	Stocking Density	0.150	0.249	- 0.021	0.336	0.220	0.400
	Development	**< 0.001***	0.001	**< 0.001****	< 0.001	< 0.001	< 0.001
	Market Value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	Tax Liability	**0.012***	0.007	**0.029****	0.015	0.007	0.007
	Nonresident	**0.954***	0.368	**1.115****	0.483	0.712	0.617
	Owner Type	0.260	0.228	0.424	0.286	- 0.065	0.366
	Pre-2018 Enrollment	**1.928*****	0.164	–	–	–	–
	Intercept	- 1.144	0.394	0.332	0.482	- 0.398	0.619
20 years	Area	< 0.001	< 0.001	< 0.001	0.001	- 0.001	0.001
(reference = 50)	Stocking Density	**- 0.611***	0.313	**- 0.985****	0.457	- 0.238	0.432
	Development	**< 0.001***	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	Market Value	**< 0.001***	< 0.001	**0.001***	< 0.001	< 0.001	< 0.001
	Tax Liability	0.003	0.009	0.026	0.017	- 0.014	0.016
	Nonresident	0.707	0.449	0.908	0.593	0.409	0.717
	Owner Type	0.493	0.318	0.541	0.440	0.444	0.466
	Pre-2018 Enrollment	0.299	0.198	–	–	–	–
	Intercept	- 1.044	0.504	- 1.100	0.694	- 0.714	0.718
8 years	Area	< 0.001	< 0.001	- 0.001	0.001	0.001	0.001
(reference = 20)	Stocking Density	**0.761*****	0.282	**0.963*****	0.363	0.458	0.467
	Development	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	Market Value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	Tax Liability	0.009	0.007	0.003	0.009	0.021	0.016
	Nonresident	0.246	0.340	0.207	0.398	0.303	0.682
	Owner Type	- 0.233	0.304	-0.116	0.392	- 0.509	0.488
	Pre-2018 Enrollment	**1.629*****	0.189	–	–	–	–
	Intercept	- 0.001	0.476	1.432	0.589	0.316	0.766

*** ≤ 0.01.
** ≤ 0.05.
* ≤ 0.10.

developed land value) and low current Development (representing rate of change of developed land value) would tend towards shorter commitment lengths. In our models, neither variable was consistently statistically significant. However, in three of the nine commitment length comparisons the former proposition held true, namely there is a positive correlation between EMV and likelihood of commitment for a shorter length. Studies have demonstrated that the market value of Minnesota's forest land is influenced by its potential for a seasonal or permanent home (Snyder et al., 2007; Snyder et al., 2008). In the single commitment length model comparisons where development change is significant, it has the opposite sign relative to the expected negative correlation between development change and shorter commitment. In sum, these findings indicate some landowners may recognize future profit potential in commitment choice, but for most it is not the single biggest determining factor.

All our models' explanatory variables, except owner type, are significantly associated with one or more commitment length choices presented to SFIA enrollees. Our hypothesis that the likelihood a longer commitment would be selected as the area of forest land increased is partially supported. Specifically, in the All-enrollee model, the likelihood a landowner selects a 50-year commitment over an 8-year commitment increases with increasing hectares enrolled. Several studies have found that forest landowners with larger landholdings are more likely to enroll in PFPTPs than those with smaller holdings (e.g., Dennis and Sendak, 1992; Ma et al., 2012; Wolde et al., 2016; Frey et al., 2019), while others have found no statistically significant relationship (e.g., Fortney et al., 2011; Kauneckis and York, 2009; Stevens et al., 2002). Given that the SFIA payment is calculated on a per hectare basis, landowners with more hectares enrolled could be preferring the 50-year commitment over the 8-year simply because it affords them a bigger total annual payout. On the other hand, it may also imply a bigger opportunity cost in terms of foregone development. Since area enrolled is not significant when comparing commitment lengths, where the difference in commitment length is not as substantial (e.g., 12 versus 30 additional years), this may indicate landowners have a high threshold for the additional total compensation needed to extend their program commitment length. Alternatively, landowners with a large amount of forest land area might prefer the longest commitment length because they are the most likely to have timber income as a primary ownership objective (Butler et al., 2016).

Forests with higher stocking densities are associated with a decreased preference for the 20-year commitment length in both the All-Enrollee and the 2002–2017 Enrollee models. There may be two explanations for this finding. For those preferring a 50- over 20-year commitment, this could be due to the belief that higher stocking equates to having greater potential to generate timber income, thus increasing the desire to keep the land as a working forest. For those selecting 8-year over 20-year commitments, this preference for a shorter duration could be due to higher amenity values associated with highly stocked stands (e.g., large pine or hardwood forests) which could be more desirable parcels for homes and cabin sites.

Because SFIA enrollees are self-selecting, one possibility is that owners are only enrolling forest land located in areas of the state where the opportunity cost of selling is low. However, an examination of the Development variable indicates that SFIA parcels are located in areas experiencing a wide range of development pressure, with some found where more than 70 % of the surrounding forest land had been converted to a developed land use in less than 20 years.

Our analysis of all SFIA enrollees found that increasing development pressure is associated with a preference for shorter commitment lengths; specifically, a preference for 8- over 50-year and 20- over 50-year commitments. Similarly, 8-year commitments are preferred over 50-year commitments where development pressure is higher, as in the 2002–2017 model. This is consistent with our expectation that these owners do not want to tie up their land for a long period of time due to the opportunity to develop the land.

Development pressure has been explored as a potential factor influencing a forest landowner's decision to enroll in a PFPTP. It has been

operationalized in different ways in models exploring factors that influence enrollment in PFPTPs, including measures of population density, population growth, and distance to population centers. In a national assessment of factors found to be associated with forest landowner enrollment in PFPTPs, Frey et al. (2019) found that enrollment was more likely as population density increased but less likely at higher levels of population density, concluding landowners may face stiff penalties for withdrawing from the program if they desire to sell their land, creating a disincentive to enroll in a PFPTP when development is increasing or anticipated. Our analysis appears to support their finding. Our hypothesis that the monetary penalty for noncompliance with the SFIA requirements influences the choice of commitment length is only partially supported. In the All-Enrollee and 2002–2017 Enrollee models, higher EMV (which is the basis for calculating noncompliance penalties) is only significantly associated with choosing a 20-year over a 50-year commitment. It could be that enrollees are not aware of how noncompliance penalties are calculated or do not perceive the noncompliance penalties to be substantial. Similarly, landowner commitment length choices are only partially consistent with our theoretical model, which suggests that those with a high market (development) value are likely to aim for shorter enrollment because the relative annual percent increase in EMV for a high starting EMV is likely to be relatively low.

The influence of property taxes is opposite of what was hypothesized. Specifically, higher property taxes increase the probability of selecting a shorter-term commitment, but only when comparing an 8- versus 50-year commitment for the All-Enrollee and 2002–2017 Enrollee models. Previous research has found inconsistent results related to concern over taxes or the level of tax reimbursement as a factor influencing enrollment in PFPTPs. For example, Frey et al. (2019) found a variable measuring degree of concern about high property taxes to be an insignificant predictor of PFPTP enrollment, while Fortney et al. (2011) found that landowners who rated the importance of potential tax savings associated with a PFPTP to be more likely to enroll. Similarly, variables measuring the tax benefit associated with enrollment have shown inconsistent findings as a predictor of enrollment, with Chhetri et al. (2024) finding higher per hectare tax savings to be positively associated with enrollment in a PFPTP, while Frey et al. (2019) found the average annual per hectare statewide PFPTP tax reduction amount to be an insignificant predictor. Our analysis may be suggesting the level of property tax as an indicator of the land's development potential overshadows the owner's need to reduce the annual property tax burden.

Our hypothesis that out-of-state enrollees are more likely to commit to longer commitment length is not supported. We found out-of-state enrollees are more likely to select an 8-year over a 50-year commitment in the All-Enrollee and 2002–2017 Enrollee models. Absenteeism has been found to have an inconsistent influence on a landowner's decision to participate in different forest policy tools (Floress et al., 2019). Miller et al. (2012) found absentee ownership to be a positive predictor of a landowner's intention to participate in a forest carbon program. Similarly, absenteeism has been found to be a positive predictor of enrollment or participation in PFPTPs in some studies (e.g., Fortney et al., 2011; Snyder et al., 2020), and Caputo and Snyder (2023) found that participation in forest tax programs, green certification and cost-share programs was more likely when landowners lived further from their land. However, Chhetri et al. (2024) found absentee owners (i.e., owners whose mailing address is in a different county than their forest land) were less likely to enroll in Georgia's PFPTP, while Bagdon and Kilgore (2013) did not find absentee owners (i.e., parcel address different from mailing address) to be a statistically significant predictor of enrollment in the SFIA program.

Absenteeism or living further from one's land has been hypothesized to be associated with less attachment to (Huff et al., 2017) and engagement with (Kendra and Hull, 2005) one's forest land as well as greater time and financial costs to visit and steward one's land (Frey et al., 2019). Our finding related to absentee ownership may suggest that forest landowners living farther from their land (i.e., out of state) are less engaged and therefore have greater uncertainty about the use and ownership plans for their land, which could make them less likely to forego the option to develop their forest land for an extended period of time. It may also indicate absentee owners are not enjoying the amenity and other non-monetary benefits their forests provide to the extent they would be willing to make a long-term commitment to keeping their land in a forested condition.

Table 6
Distribution of commitment length (percent) among 2002–2017 and 2018–2021 SFIA enrollees. Number and (percent).

	8 year	20 year	50 year
2002–2017 Enrollees (843)	620 (74)	93 (11)	130 (15)
2018–2021 Enrollees (329)	105 (32)	77 (23)	147 (55)
All Enrollees (1172)	725 (62)	170 (14)	277 (24)

$\chi^2 = 176.997$, $p < 0.001$.

Our analysis found that factors associated with the choice of the commitment length differed among pre-2018 and 2018–2021 SFIA enrollees. Those who enrolled in the SFIA program prior to 2018 were initially given an 8-year commitment, with the option to extend the length of their commitment without cost or penalty to 20- or 50-years in 2018. In contrast, landowners who enrolled from 2018 to 2021 were given the choice of selecting an 8-, 20-, or 50-year commitment at the time of enrollment. Table 6 shows the distribution of commitment length choices for these two cohorts of enrollees.

The data suggests a strong anchoring effect for those who initially were given an 8-year commitment, with nearly three-fourths deciding not to extend their commitment when given the opportunity to do so. In contrast, only about one-third of those who were given three commitment length choices at the time of initial enrollment selected an 8-year commitment. One possible explanation for this large discrepancy is that as the 2002–2017 enrollees became more familiar with the SFIA program over time, they more fully recognized the opportunity costs associated with not being able to develop their forest land and did not want to further limit their options. Alternatively, landowners who preferred an 8-year commitment enrolled early because the program matched their desired characteristics, whereas those who would have liked a longer commitment option (e.g., 20 or 50 years) did not enroll at high rates during 2002–2017 because the program did not provide this option.

For the 2018–2021 SFIA enrollees who had three commitment lengths to choose from at the time of enrollment, our model is not useful in predicting their choice of commitment length as none of our forest land or owner variables are significant. It could be that our model does not include the factors that are important to landowners who have no experience with the SFIA program when deciding how long they want to initially commit to its terms and conditions. Alternatively, the trade-offs of enrolling in the SFIA may be so complex and the factors they consider so numerous, the choice of commitment length is largely a random decision from a modeling perspective.

In contrast, when modeling those who enrolled in the SFIA program prior to 2018, all model variables except parcel size and ownership type are significant predictors of a commitment length among one or more of the pairwise choices. The signs of these coefficients are the same as those in the All-enrollee model, meaning the effect of these variables on commitment length is consistent among those who enrolled in the SFIA program prior to 2018 and all enrollees.

8. Conclusions

To our knowledge, our exploratory research is the first to examine what influences the choice of conservation commitment length when forest landowners are given several to select from. We found that the program commitment length SFIA enrollees select is not driven by their desire to maximize the financial trade-offs that compare the present

value of SFIA payments to the lost opportunity of selling their forest land for development while enrolled.

We did find, however, that several forest land and owner characteristics are associated with their commitment length decision. None of the forest land and owner characteristics we examined helped explain the choice of commitment length among forest landowners when they initially enrolled in the SFIA program. It was only after including landowners who had been enrolled in the program for one or more years that certain landowner and forest land characteristics became statistically significant predictors of their choice of commitment length.

The landowner and forest land characteristics we evaluated came exclusively from publicly available information on the SFIA enrollees or spatially-explicit characteristics of the enrolled forest lands. Future research that incorporates additional information such as enrollee attitudes, values, reasons for ownership, current uses, bequest intentions, and socioeconomic information could provide additional insight on what drives their decision on the length of time they are willing to commit to a conservation program. Similarly, information that better describes the enrollee's forest and the associated ecosystem goods and services it provides could improve our understanding of the important drivers of their conservation commitment length decisions.

Author statement

The authors do not have any financial and personal relationships with other people or organizations that could inappropriately influence or bias our work.

CRediT authorship contribution statement

Michael A. Kilgore: Writing – review & editing, Writing – original draft, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Gregory E. Frey:** Writing – review & editing, Writing – original draft, Methodology, Funding acquisition. **Stephanie A. Snyder:** Writing – review & editing, Writing – original draft, Project administration, Investigation. **Christopher Mihiar:** Writing – review & editing, Writing – original draft, Methodology.

Declaration of competing interest

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Data availability

Data will be made available on request.

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