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Can incentives make a difference? Assessing the effects of policy tools for encouraging tree-planting on private lands

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ABSTRACT

This study uses a mail survey of private landowners in the Midwest United States to understand the characteristics of owners who have planted trees or intend to plant trees in the future. The analysis examines what policy tools encourage owners to plant trees, and how policy tools operate across different ownership attributes to promote tree-planting on private lands. Logistic regression results suggest that cost-subsidizing policy tools, such as low-cost and free seedlings, significantly increase the odds of actual and planned reforestation when landowners consider them important for increasing forest cover. Individuals most likely to plant trees, when low-cost seedlings are available and important, are fairly recent (<5 years), college-educated owners who own small parcels (<4 ha) and use the land for recreation. Motivations to reforest were also shaped by owners' planning horizons, connection to the land, previous tree-planting experience, and peer influence. The study has relevance for the design of policy approaches that can encourage private forestation through provision of economic incentives and capacity to private landowners.

1. Introduction

A major challenge in research on forest carbon sequestration relates to the potential of private lands to generate additional carbon sinks through reforestation, improved forest management, or conservation (Galik et al., 2013; Schirmer and Bull, 2014). In the United States, over half of all forest land is under private ownership and more than a third (35%) is owned by private individuals and families, collectively known as family forest owners (Butler, 2008). These individuals are key players because their actions can influence the amount of available forest land, its health, and capacity to provide environmental benefits (e.g. carbon sequestration, wildlife habitats) (Charnley et al., 2010). Research shows, however, that most forest owners have limited familiarity with carbon offset schemes or other forest conservation programs, and are generally unwilling to participate in them (Galik et al., 2013; Markowski-Lindsay et al., 2011). In this study, we focus on tree-planting activities that can lead to forest area increase on private lands. Tree-planting can contribute to carbon sequestration with or without formally meeting the requirements of carbon offset schemes. The tree-planting choices of landowners have potential to generate in-situ environmental benefits (e.g. soil conservation), regional (e.g. water quality), and global benefits (e.g. climate mitigation), thus making local reforestation of significance at multiple scales (Fisher et al., 2009). Currently, there has been minimal work regarding the decisions and willingness of landowners to undertake tree-planting, as well as the policy tools that may encourage such activities.

Using a mail survey of private landowners in Indiana, we examine whether owners had previously undertaken tree-planting or were planning to undertake tree-planting in the future. The analysis addresses the questions: (i) What are the characteristics of landowners who have planted or intend to plant trees in the future? (ii) What policy tools are likely to encourage landowners to engage in tree-planting? and (iii) How do policy tools operate across different ownership attributes to promote tree-planting on private lands? Not every owner can plant or intends to plant trees on their property. Roughly one in five family forest owners in the US

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plant trees on their land (Butler, 2008). Ownership attributes are important predictors of forest owners' management decisions, including tree-planting (Fischer and Charnley, 2010; Majumdar et al., 2009). In this analysis we explore how different policy tools, together with ownership characteristics, relate to decisions and motivations to plant trees. We focus on the role of government cost-share programs, low-cost seedlings, and tax benefits as policy incentives important to past reforestation; and direct payments, free seedlings, and free technical assistance as incentives for promoting future reforestation. As used here, reforestation behavior refers to both past and planned tree-planting activities. It can be expected that policy tools influence reforestation behavior differentially for small and large parcel ownerships, and for recent and long-term owners (Zhang and Mehmood, 2001; Hardie and Parks, 1996). These variations are important because forest ownership both in the US and in Europe is changing, and there are more parcels of small size owned by a diverse and growing number of exurban forest owners (Fischer et al., 2010; Põllumäe et al., 2014; NFF, 2014). By focusing on variations in landowner tree-planting choices and responsiveness to policy tools, this study provides insights about the potential of policy tools to harness individual motivations to generate environmental benefits on private lands.

2. Private forest owners and policy tools to encourage reforestation

Research shows that private forest owners invest in their land and trees, and that this is largely driven by a commitment to nature protection and stewardship (Knoot et al., 2010; Ross-Davis et al., 2005). For many landowners, amenity values, recreation, family legacy, and investment are dominant reasons for owning forest land (Bengston et al., 2011; Daniels et al., 2010; Fischer and Charnley, 2010). Forest owners who value their land as a family legacy are likely to undertake or plan to undertake tree-planting because it allows them to pass both economic assets and cultural heritage to their children (Fischer and Charnley, 2010). Family legacy values are generally consistent with long-term investment activities, such as tree-planting. Additionally, forest owners who frequently use their land for recreation are likely to share a commitment to conservation, and therefore be more likely to engage in tree-planting.

Property residence is another indicator associated with a greater likelihood of engagement in forest management activities, such as planting and harvesting (Joshi and Arano, 2009; Conway et al., 2003). Prior experience with tree-planting and/or harvesting is also related to active management, and owners with such experiences may be more likely to undertake or plan to undertake tree-planting. Karppinen (2005) finds that former experience with reforestation was positively associated with intentions to reforest among Finnish forest owners. As well, tree-planting by friends, neighbors, and family members may influence landowners' reforestation choices. Information from trusted peers is shown to be often more important than advice from experts (Ruseva et al., 2014; Sagor and Becker, 2014).

The management choices of forest owners are also influenced by ownership characteristics and socio-demographics (age, education) (Majumdar et al., 2009; Beach et al., 2005). Parcel and forest ownership size reflect the physical capacity of the land to support different land use decisions (Frimpong et al., 2006). Property size was the most important factor influencing the management strategies of Swedish forest owners (Eggers et al., 2014). Larger ownerships are generally positively associated with active management, including thinning and harvesting (Beach et al., 2005). Ownership length (or tenure) is negatively associated with management for nontimber values, such as recreation and wildlife habitats (Joshi and Arano, 2009; Conway et al., 2003). Higher education and income have a positive relationship with reforestation, while age and retirement status are shown to have a negative effect (Fischer and Charnley, 2010; Joshi and Arano, 2009).

Studies also show that the availability of policy tools – federal, state, and local programs designed to influence the management choices of forest owners – is significantly associated with landowner management behavior (Cubbage et al., 2007; Schaaf and Broussard, 2006; Serbruyns and Luyssaert, 2006; Beach et al., 2005). When properly designed, policy tools can facilitate extrinsic motivations by tapping into people's values and enabling the internalization of socially-beneficial behaviors, by providing incentives, capacity, learning, or symbolic rewards (Schneider and Ingram, 1990; Duesberg et al., 2014).

In private forestry, incentive tools rely on financial rewards, including cost-share programs, tax benefits, subsidies, and direct payments (Cubbage et al., 2007). Capacity tools provide information, knowledge, and resources, such as technical assistance and professional advice; and, learning tools engage landowners through educational workshops and interactions with professionals and peers (Schaaf and Broussard, 2006). A review of the empirical literature finds both technical assistance and government cost-share to be positively associated with reforestation practices (Beach et al., 2005). Zhang and Flick (2001) observe a positive relationship between reforestation and financial assistance programs, such as cost-share and tax-incentives. Kilgore et al. (2008) find that technical assistance was preferred over financial incentives among family forest owners.

This analysis focuses on cost-share, tax benefits, and direct payments as incentive tools, free technical assistance as a capacity tool, and low-cost and free seedlings as a hybrid between incentive and capacity tools. Educated and financially-motivated forest owners may be more likely to respond to incentive tools (Serbruyns and Luyssaert, 2006), while free technical assistance may be more effective with owners who are motivated and fairly well-informed (Schneider and Ingram, 1990). The provision of low-cost and free seedlings may be particularly advantageous, where owners are motivated but uncertainty exists about their endowments (e.g. parcel size), planning horizons, or land use preferences (Schneider and Ingram, 1990). In short, different policy tools have different effects depending on the context, values, and motivations of forest owners. Our analysis seeks to assess the appeal of different policy tools, and to understand how to better harness individual decisions and motivations to plant trees.

3. Methods

3.1. Study area

A random sample of private landowners was drawn from six counties in south-central Indiana, in the Midwest U.S. (Fig. 1). As one of four geographic regions in the U.S., the Midwest is known for its diverse topography, agricultural production alongside growing urbanization, and large temperate deciduous forests that underwent massive deforestation in the mid-19th century. Our study site in south-central Indiana is characterized by a mix of low hills, forest, pasture, and crop production. It is similar to other Midwestern areas experiencing residential expansion, declining agricultural land use, and peri-urban reforestation (Deller et al., 2001). Over the past century, forest area in the state of Indiana has grown from 6 to 20 percent of the state's area, with most of the regrowth occurring on small parcels owned by approximately 218,000 family forest owners (Woodall et al., 2011). Individuals own 83 percent (or 1.6 million hectares) of Indiana's forest lands (Woodall et al., 2011). The majority of them own parcels less than 40.5 ha in size and rely on

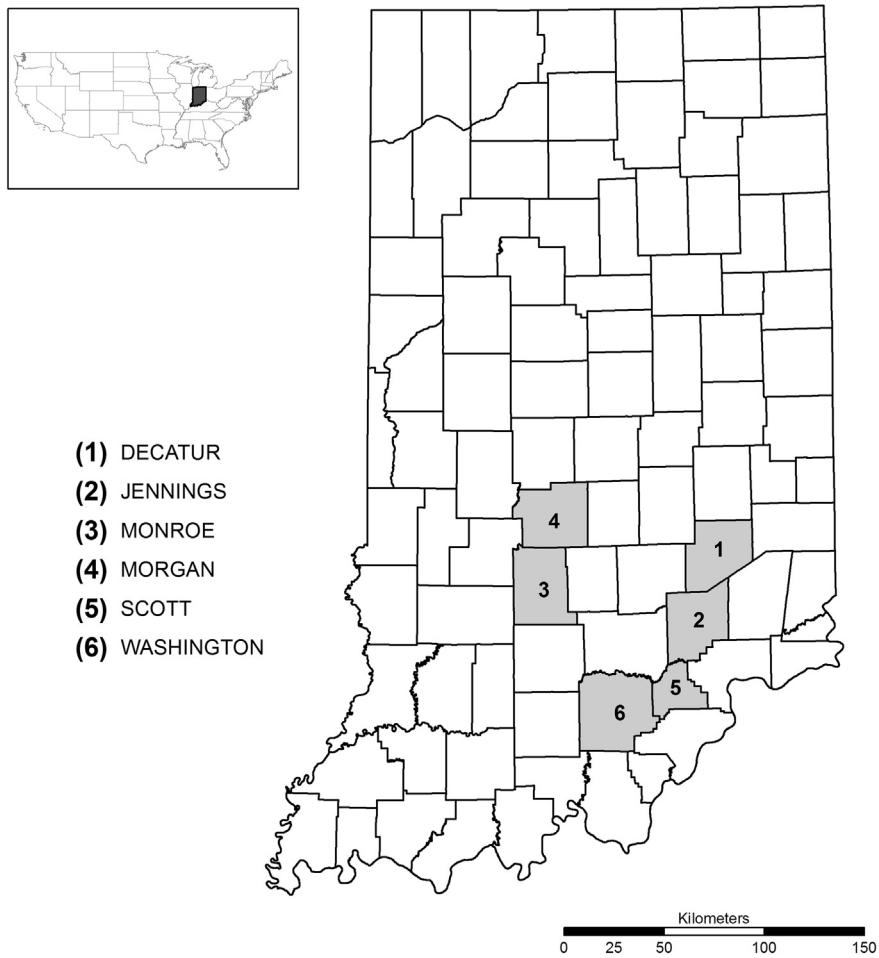

Fig. 1. Study area in south-central Indiana showing the six survey counties.

both non-farm and agro–forestry activities for income. Similar to most woodland owners in the U.S. and Europe, they have diverse motivations for land use (Bengston et al., 2011; Nordlund and Westin, 2011; Põllumäe et al., 2014).

3.2. Data collection

Following standardized survey procedures (Dillman et al., 2014), a survey of forest and land management was mailed to 6741 randomly selected landowners in our study area (Fig. 1). Due to selection of multiple parcels owned by a single owner, the total number of mailed questionnaires was lower than the initially sampled 7200 ownership parcels. Survey recipients were selected at random from a list of ownership parcels with a minimum area of 2.02 ha; only parcels outside municipal boundaries were included. The achieved response rate was 28.8% (1938 responses). We tested for response bias using the initially drawn sample, which included information about parcel acreage and percent of parcel reforested in the past five years. A statistical comparison of response and non-response groups (t-test) indicated no significant differences between the groups related to ownership size and past reforestation ($p > 0.01$).

3.3. Data analysis

Our analysis sought to identify important predictors of past and future reforestation on private lands. We undertook two separate analyses using a logistic regression model in Stata 12.1. First, we used tree-planting activities in the past 5 years (past reforestation) as a binary response variable, i.e. an owner had or had not planted trees or had planted by contracting with someone.[1] To identify whether policy tools helped explain past reforestation, we included government cost-share programs, low-cost seedlings, and tax benefits as factors reported by landowners to be important to past forest area increase.[2] Our question about availability of policy tools captures differences in perceived importance, and all landowners had equal availability to these tools (although there were likely different levels of awareness of the programs).

The second model sought to identify characteristics of landowners who would most likely plant in the future. The model for future reforestation used responses to the question, Which of the following do you think you will do with this land in the next 5 years? (Tree-planting projects: Yes/No), as a binary response variable; previous tree-planting as a control variable; and, direct

[1] The responses for "planted trees myself" and "contracted with someone to plant the trees" were combined into one because the second category had a very low frequency.

[2] Based on responses to the question: "What factors were important to the increase in forest area? - Government cost-share programs were readily available, Low-cost seedlings from the state were readily available, Tax benefits were available", each rated as 1 = Very Important/Important, 0 = Not Important.

Table 1
Descriptive statistics and definitions for variables used in the logistic regression (N = 1152).

Variable name	Mean/%	Std. dev.	Definition
Past tree-planting	0.10	0.30	Planted trees or contracted with someone to plant trees in the past 5 years (1 = yes; 0 = no)
Future tree-planting	0.23	0.42	Plans tree-planting projects in the next 5 years (1 = yes; 0 = no)
Government cost-share[a]	0.17	0.38	Government cost-share readily available and important to reported increase in forest area (1 = yes; 0 = no)
Low-cost seedlings[a]	0.44	0.50	Low-cost seedlings from the state readily available and important to reported increase in forest area (1 = yes; 0 = no)
Tax benefits[a]	0.19	0.39	Tax benefits available and important to reported increase in forest area (1 = yes; 0 = no)
Direct payments	0.35	0.48	Direct payments will encourage future increase in forest area (1 = yes; 0 = no)
Free seedlings	0.43	0.50	Free seedlings will encourage future increase in forest area (1 = yes; 0 = no)
Free technical assistance	0.29	0.45	Free technical assistance will encourage future increase in forest area (1 = yes; 0 = no)
Forest area	7.21	15.91	Size of parcel area that is forested in hectares
Parcel size (continuous)	20.71	70.61	Parcel size in hectares
Parcel size (categorical)	2.48	1.12	Parcel size by quartiles: 1 = Less than 4 ha; 2 = 4–8 ha; 3 = 8–20 ha; 4 = More than 20 ha
Landholding size	32.45	120.99	Total land owned anywhere in hectares
Ownership tenure	2.99	0.96	Time land owned (1 = Less than 5 years; 2 = 5–10 years; 3 = 11–30 years; 4 = More than 30 years)
Residence	0.69	0.46	Respondent's primary residence is on or near their property (1 = yes; 0 = otherwise)
College degree	0.32	0.47	Respondent holds a bachelor's degree or a post-bachelor's degree (1 = yes; 0 = otherwise)
Retired	0.35	0.48	Respondent is fully or semi-retired (1 = yes; 0 = otherwise)
Household income	4.69	1.88	Respondent's annual household income (1 = Under $15,000; 2 = $15,000–29,999; 3 = $30,000–44,999; 4 = $45,000–59,999; 5 = $60,000–74,999; 6 = $75,000–89,999; 7 = $90,000 or more)
Parcel income	0.37	0.48	Respondent receives income from farming, harvesting, or leasing the land (1 = yes; 0 = no)
Harvested timber	0.25	0.43	Timber harvested from the land by a timber buyer, logger or the respondent in the past 5 years (1 = yes; 0 = no)
Plans to harvest timber	0.20	0.40	Plans timber harvesting in the next 5 years (1 = yes; 0 = no)
Recreation	0.72	0.45	Land used for recreation (camping, hiking, walking, horseback riding, wildlife watching, and/or hunting) daily, weekly, or monthly (1 = yes; 0 = otherwise)
Family legacy	0.41	0.49	Whether respondent thinks children will live on the land when they are adults (1 = yes; 0 = otherwise)
Others reforesting	0.03	0.16	Neighbors, family members, or other acquaintances reforesting/considering reforesting (1 = yes; 0 = no)

[a] Sample size for these variables equals 187 valid responses.

payments, free seedlings, and free technical assistance as policy tools.[3] Both models included ownership attributes, socio-demographics, family legacy, recreation, management activities, and peer influence. These and other variables, found to be important in the literature, were first analyzed using bivariate correlation (Pearson's r, Point–Biserial correlation, Cramer's V). Variables that were highly correlated ($r > 0.4$) were removed from future analysis. The interpretation of model results relied primarily on odds ratios and predicted values (probabilities) for past and future reforestation. Probabilities are useful for understanding the relationship between a key independent variable (e.g. parcel size) and the outcome of interest, while keeping the rest of the variables in the model at their means (Long and Freese, 2014). We first examined discrete change in predicted probabilities as the value of a key independent variable changes from 0 to 1. Second, we computed the percent change in probabilities to better understand the incremental contribution of a policy tool to the reforestation choices of forest owners based on their ownership attributes (parcel size and ownership tenure). This allowed us to assess how much of a difference policy tools, together with ownership attributes, make in individual decisions and motivations to reforest.

4. Results

About one out of five respondents (433 of 1938) report an increase in forest area in the past five years. Of those, 195 individuals (45%) planted trees and 238 (55%) indicated natural regeneration; only valid responses for tree-planting were used in the analysis of past reforestation (n = 187). Another 22% of respondents (426 of 1938) said they plan to undertake tree-planting projects in the next five years; this information was used to examine future reforestation. Prior to statistical analyses missing observations were removed, resulting in a final analysis sample of 1152 responses. The characteristics of the analysis sample (n = 1152) do not deviate substantially from those of the full sample (n = 1938).

Table 1 provides summary statistics and descriptions for variables used in the analyses. Most forest owners reside on or near their property (69%; n = 1152) and have owned their land between 11 and 30 years on average. Over a third of respondents are fully or semi-retired (35%), hold a college or a post-bachelor's degree (32%), and receive farm and forest income from the land (37%). On average, sample respondents own 7 ha of forest land (median = 2.4 ha; range = 234.7 ha) and their mean parcel size is 21 ha (median = 7.3 ha; range = 2145 ha). One in four had harvested timber and one in five indicated plans to harvest in the future. A majority of respondents (72%) use the land for recreation – hiking, bird watching, horseback riding, and hunting – at least once a month.

We found significant relationships between past reforestation and policy tools (Table 2a), and between future reforestation and most policy tools (Table 2b). For owners who had planted trees in the past, the availability of low-cost seedlings was most frequently cited as important (70%), followed by tax benefits (67%), and cost-share programs (62%) (Table 2a). For respondents motivated to plant in the future, free seedlings were most commonly identified as an incentive that would encourage them to increase their forest area (42%), followed by free technical assistance (39%) and direct payments (25%) (Table 2b). Low-cost and free seedlings had the

Table 2a
Effects of policy tools on past reforestation.

		Government cost-share		Low-cost seedlings		Tax benefits		Total
		Yes	No	Yes	No	Yes	No	
Planted trees in the past 5 years	Yes	0.62	0.36	0.70	0.21	0.67	0.35	0.41
	No	0.38	0.64	0.30	0.79	0.33	0.65	0.59
	N	32	155	76	111	33	154	187
	Pearson's χ^2	7.65**		44.93***		11.25***		
	Cramer's V	0.20		0.49		0.25		

*$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$; Cell entries are column percentages.

[3] Based on responses to the question: "What incentives would encourage you to increase the forest area on this land in the next 5 years? - Direct payments, Free seedlings, Free technical assistance", 1 = Yes, 0 = No.

Table 2b
Effects of policy tools on future reforestation.

		Direct payments		Free seedlings		Free technical assistance		Total
		Yes	No	Yes	No	Yes	No	
Will plant trees in the next 5 years	Yes	0.25	0.22	0.42	0.08	0.39	0.16	0.77
	No	0.75	0.78	0.58	0.92	0.61	0.84	0.23
	N	101	163	495	657	336	816	1152
	Pearson's χ^2	1.98		186.98***		69.36***		
	Cramer's V	0.04		0.40		0.25		

*p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001; Cell entries are column percentages.

largest effect size on landowners' past and future reforestation behavior (Cramer's V = 0.49 and 0.40 respectively).

4.1. Predictors of past and future reforestation

The logistic regression results provided further support for the importance of readily available low-cost and free seedlings relative to other policy tools. In the model for past reforestation (Table 3), the variables that helped explain whether owners had planted trees were: low-cost seedlings, parcel size, education, and recreation ($p \leq 0.05$). Holding all other variables in the model constant, owners who found the availability of low-cost seedlings important for increasing forest area were about 9 times as likely to plant trees compared to those who did not find seedlings important. Owners of larger parcels were less likely to plant trees, and those who had at least a college degree were about 2 times as likely to plant or contract with someone to plant trees. Finally, respondents who frequently used their land for recreation were nearly 4 times as likely to plant trees.

In the model for future reforestation (Table 4), the variables that helped explain the likelihood that an owner would plant in the future included: policy tools, previous tree-planting, parcel size and forest area, ownership tenure, recreation, family legacy, plans to harvest, and other people reforesting ($p \leq 0.05$). All else constant, a forest owner who believed free seedlings would encourage them to increase their forest area was nearly 6 times more likely to intend to plant trees than an owner who did not believe so. Respondents who had previous tree-planting experience were also 4 times as likely to have intentions to plant trees in the next five years compared with those with no prior planting experience. Notably, direct payments, ownership tenure, and forest area size were associated with a decreased likelihood of future reforestation.

Table 3
Logistic estimates of the model for estimating tree-planting in the past 5 years.

Variables	Exp (B)
Government cost-share[a]	0.899
Low-cost seedlings[a]	8.826***
Tax benefits[a]	2.452
Landholding size	1.000
Parcel size (quartiles)	0.499**
Forest area	1.030*
Ownership tenure	1.118
College degree	2.450**
Retired	0.971
Residence	1.164
Household income	0.942
Parcel income	1.639
Harvested timber	1.237
Plans to harvest timber	0.460
Recreation	3.541**
Family legacy	1.708
Others reforesting	0.674
Constant	0.179
N	187
McFadden's R2	0.296

*p ≤ 0.10, **p ≤ 0.05, ***p ≤ 0.01.

Table 4
Logistic estimates of the model for estimating intentions to undertake tree-planting in the next 5 years.

Variables	Exp (B)
Direct payments	0.636**
Free seedlings	5.700***
Free technical assistance	1.409*
Landholding size	0.999
Parcel size (quartiles)	1.237**
Forest area	0.978**
Ownership tenure	0.745***
College degree	0.880
Retired	0.736
Residence	1.239
Household income	1.087
Parcel income	0.769
Harvested timber	1.202
Plans to harvest timber	1.669**
Planted trees in the past	4.287***
Recreation	1.781**
Family legacy	1.549***
Others reforesting	2.495**
Constant	0.049***
N	1152
McFadden's R2	0.240

*p ≤ 0.10, **p ≤ 0.05, ***p ≤ 0.01.

4.2. Probability results

From a policy perspective, it is useful to explore how policy tools operate at different size and length of ownerships to promote tree-planting activities. We calculated the probability that an owner said (i) they had planted trees or (ii) they would plant trees in the future for variables identified as significant in the regression ($p \leq 0.05$). Fig. 2 summarizes the effects of policy tools on the probability of past and future reforestation. As low-cost and free seedlings become important tools for increasing forest area, the probability of tree-planting increases from 19 to 67 percent (or by 247 percent) for past reforestation, and from 8 to 34 percent (or by 305 percent) for future reforestation (Fig. 2a and b).[4]

To better understand how interactions between seedlings and ownership size affect the likelihood of tree-planting, we examined

[4] We also computed confidence interval (CI) estimates for the predicted probabilities of planting trees when *low-cost seedlings are not important*: 95% CI = [0.11, 0.28], 90% CI = [0.12, 0.26]; *low-cost seedlings are important*: 95% CI = [0.54, 0.81], 90% CI = [0.56, 0.79]; and the predicted probabilities of intentions to plant when *free seedlings are not important*: 95% CI = [0.06, 0.10], 90% CI = [0.06, 0.10]; and, *free seedlings are important*: 95% CI = [0.28, 0.39], 90% CI = [0.29, 0.38].

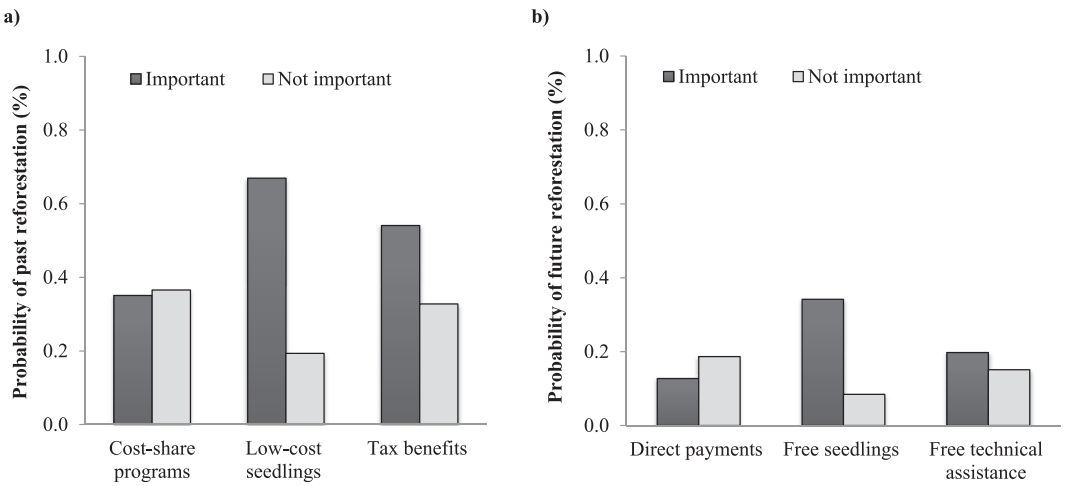

Fig. 2. The probability that an owner (a) had planted or (b) intends to plant trees as a result of reported importance of policy tools.

how the predicted values of reforestation varied across the range of parcel size in our dataset, based on the reported importance of seedlings for increasing forest cover (Fig. 3). We found that when low-cost seedlings were considered important for increasing forest area, the probability of tree-planting was higher for small ownerships (<4 ha) rather than larger ones. We also calculated the percent change in the probability of reforestation within each parcel size group, when low-cost seedlings were important for increasing forest area and when they were not. For respondents owning parcels of 20 ha or more, the probability of tree-planting increases by 455 percent (from 7 to 39 percent) when low-cost seedlings are believed to be important for forest increase, compared to an increase of 48 percent (from 45 to 88 percent) when low-cost seedlings are believed to be important for forest increase for individuals owning less than 4 ha (Fig. 3).

To understand how interactions between seedlings and ownership length affect the likelihood that an owner intends to plant trees, we examined the probability of future reforestation across the length of ownership in our dataset, relative to beliefs that free seedlings would encourage the owner to increase forest area (Fig. 4). This analysis included prior tree-planting as a control. We found a higher probability of future reforestation for shorter rather than longer ownership tenure when free seedlings are believed to encourage future forest increase. For individuals owning land for less than 5 years, who had previously planted, the probability of future reforestation increases by 117 percent (from 37 to 80 percent) when owners believe free seedlings would encourage them to increase their forest area, compared to 287 percent (from 13 to 51 percent) for individuals owning land for less than 5 years and no previous planting experience. This suggests that when free seedlings are seen as an incentive for increasing forest cover, they may have a greater impact on promoting future reforestation among relatively recent and inexperienced owners.

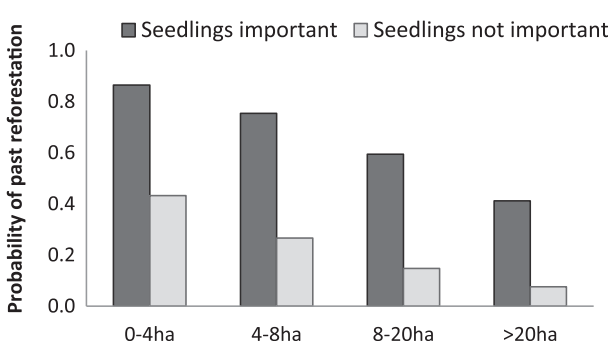

Fig. 3. The probability that an owner had planted trees as a result of the importance of low-cost seedlings, by parcel size.

Table 5 summarizes the probabilities of reforestation for specific types of landowners, when the availability of subsidized (low-cost and free) seedlings is considered important for encouraging forest increase. Our comparison of low-cost and free seedlings is based on the fact that both enable and make plantings for conservation purposes economical.[5] An average owner in our sample is likely to plant trees about 4 out of 10 times and to express intentions for tree-planting 2 out of 10 times (Table 5). When low-cost seedlings are considered important for increasing forest area and free seedlings are believed to encourage future forest increase, the likelihood of reforestation can improve substantially for specific types of owners. The odds of reforestation are 9 in 10 when the availability of low-cost seedlings is considered important for increasing forest area for fairly recent (<5 years), college-educated owners who own small parcels and use the land for recreation. The odds in favor of both past and future reforestation are nearly 6 in 10 among college-educated, recent owners of parcels greater than 20 ha, when low-cost seedlings are considered important for increasing forest cover, and when free seedlings are believed to encourage future forest increase. The fact that the probability of actual and planned reforestation for large ownerships is the same (0.58) suggests that behavioral intentions may not differ from actual behavior in the context of key factors, namely: physical capacity to allocate land for different uses (parcel size) and importance of capacity-enhancing, incentive tools (low-cost and free seedlings) (Table 5).

5. Discussion

This study aims to better understand individual decisions and motivations to plant trees. The analysis focuses on factors that are potentially important for encouraging activities that increase forest cover on private lands. We ask whether policy tools motivate forest owners to reforest, and the extent to which tools matter for

[5] Tree seedlings in Indiana average about $30–35/100 seedlings: "The price of trees from state nurseries is kept low to encourage conservation plantings. Small seedlings shipped in bales of several hundred are easy to transport and simple to plant, keeping the process as economical as possible for the landowner" (IDNR, 2014).

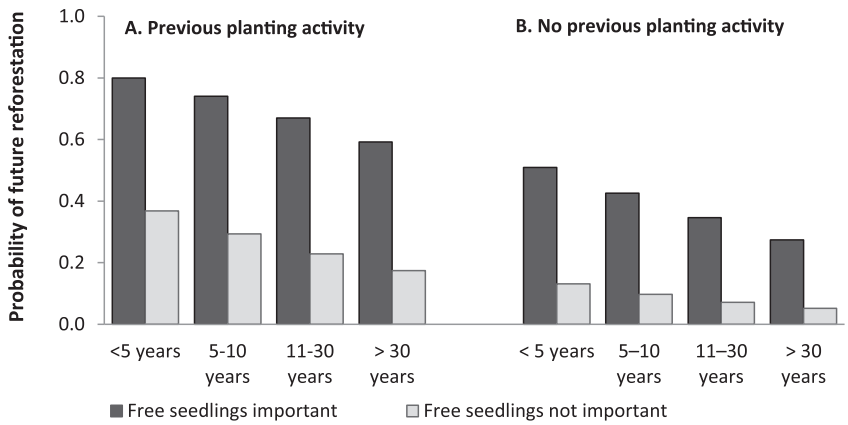

Fig. 4. The probability that an owner intends to plant trees as a result of the importance of free seedlings, by ownership length and previous tree-planting.

different ownership size and tenure.

Our findings show that some policy tools matter more than others. Policy approaches that blend characteristics of incentive and capacity tools, such as subsidized seedlings, can significantly increase the odds of past and planned reforestation when owners consider them important for increasing forest area. Individuals most likely to plant trees, when low-cost seedlings are considered important for increasing forest area, are fairly recent (<5 years), educated owners who have small ownerships (<4 ha) and enjoy the land for its recreational value (9 out of 10 times). When the availability of low-cost seedlings is not considered important for increasing forest area, these same owners are still more likely to plant trees (about 6 out of 10 times) compared to the average owner in the sample (4 out of 10 times) or to large (>20 ha) ownership-holders (1 out of 10 times) (Table 5).

We find that the availability and importance of subsidized seedlings can make a difference in the reforestation choices of forest owners. This is because seedlings effectively lower the financial cost of tree-planting. Reforestation requires significant upfront capital for site preparation and planting, and the availability of subsidy programs can reduce the cost of investment. Our results are in line with previous research underscoring the role of cost-subsidizing programs for tree-planting on private lands (Kline et al., 2002; Lee et al., 1992). The results are also similar to those reported by Karppinen (2005), who finds that attitudes about the cost of seedlings were a powerful explanatory factor in predicting Finnish landowners' choice of planting. In addition, our study adds to the literature by estimating the belief that free seedlings would incentivize owners to increase their forest area – a program not yet in actual practice, but a variation of the existing low-cost seedlings from the state.[6]

The remaining incentive tools had no significant effect on the likelihood of past reforestation and direct payments were inversely related to the likelihood of future reforestation. A possible explanation is that owners are cautious about agreements to receive payments, fearing they will lose control over decisions for future land use. This is consistent with a recent study showing that flexibility of land management can influence landowner willingness to afforest (Schirmer and Bull, 2014). Another possible explanation is that the use of a dichotomous response variable in place of a scale variable may have reduced the ability to find significant relationships. It can also be speculated that traditional private forestry programs, including financial and technical assistance, may have outlived their time, particularly as it regards new amenity-oriented or intrinsically motivated forest owners (Ma et al., 2012; Daniels et al., 2010). This echoes research showing that a majority of Irish farmers do not make decisions to afforest based on profit maximization goals (Dueseberg et al., 2014). Compensation mechanisms seem less likely to encourage tree-planting among extrinsically-motivated forest owners compared to hybrid, capacity and incentive policy tools (subsidized seedlings), which assume owners have adequate motivations to undertake tree-planting but may lack sufficient resources. Financial incentives are also less likely to influence motivations to plant trees compared to informal social influence mechanisms. As observed here, the reforestation activities of peers were positively related to motivations to plant trees. This finding is consistent with growing research showing that trusted peers are an important source of influence on forest owner decision-making (Sagor and Becker, 2014).

Another important predictor of forest management decisions is parcel size. As noted earlier, most tree-planting is likely to take place on small ownerships which tend to be managed for non-timber values, including aesthetic, conservation, and recreational values. A growing share of forest land today is owned by non-traditional rural residents and "ex-urbanites" who bring a preservationist attitude to ownership compared to traditional utilitarian perspectives. These owners may have an intrinsic motivation to undertake tree-planting, and thus, be less responsive to financial incentives. Large ownerships, on the other hand, tend to be managed for timber, crops, or other financially-motivated objectives. Large forest owners have a greater physical capacity for tree-planting projects, but they may be less flexible in allocating land to tree-planting. The management choices of large owners may be restricted by a management plan or the availability of land that is not valuable for agricultural or other uses with relatively high short-term benefits compared to the long-term benefits associated with tree-planting. In addition, owners of large parcels tend to have prior experience with government assistance programs, and thus be more responsive to policy tools. They also tend to be more sensitive to the opportunity cost of reforestation projects that require substantial capital and time upfront in return for long-term benefits. It is not surprising, therefore, that the availability and perceived importance of low-cost seedlings made the largest difference on the likelihood of reforestation among parcel ownerships greater than 20 ha, that is, on owners who have high opportunity costs of managing land for long-term benefits. This may be one explanation why the estimated odds of both past and future reforestation for large ownerships were the same (0.58) when

[6] There is no program that offers free seedlings to landowners in Indiana, but state nurseries provide low-cost seedlings. It is possible that familiarity and positive experience with low-cost seedlings can translate into support for free seedlings.

Table 5
Predicted probabilities for specific variables affecting owners' reforestation behavior.

Owner characteristics	Probability of past reforestation[a]		Probability of future reforestation[a]	
	With seedlings[b]	Without seedlings	With seedlings[c]	Without seedlings
Average respondent	–	0.36	–	0.16
College educated, owning less than 4 ha for less than 5 years, and using land for recreation (19% of sample)	0.91	0.56	0.42	0.11
College educated, owning more than 20 ha for less than 5 years, and using land for recreation (9% of sample)	0.58	0.14	0.58	0.19
No college degree, owning, 20 ha or more, for 30 or more years, and not using land for recreation (72% of sample)	0.18	0.02	0.26	0.06

[a] Probabilities computed with other variables held at their mean values. See Table 1 for descriptive statistics.
[b] With the availability of low-cost seedlings considered important for past forest increase.
[c] With free seedlings considered an incentive for encouraging future forest increase.

subsidized seedlings were considered important for increasing forest cover (Table 5).

While physical capacity (parcel size) and policy tools (seedlings) were the dominant factors influencing past reforestation, motivations to reforest were shaped by landowners' values and connection to the land (recreation), planning horizons (measured by ownership length and family legacy), as well as prior tree-planting. Our inferences about future reforestation are limited to landowners' stated intentions. Intentions to reforest may or may not lead to actions, and so our findings should be interpreted with care. Consistent with previous work (Karppinen, 2005), we found that owners with prior planting experience were more likely to have intentions to plant in the future. However, the potential effect of free seedlings, seen as having a positive effect on increasing forest cover, was greater for recent owners who lacked prior planting experience (Fig. 4). Recent forest owners (<5 years) typically have longer time horizons that reflect their willingness to accept the costs associated with activities with long-term benefits, compared to those with a long ownership tenure (>30 years). Our study supports this pattern and finds a negative association between ownership tenure and the likelihood of future reforestation. In addition, these fairly new forest owners often manage land for multifunctional forest uses, including privacy, family legacy, and recreation – with the latter being among the most frequently cited reasons for owning forest land in the US and internationally (Bengston et al., 2011; Nordlund and Westin, 2011). Since a majority of owners in our study are resident owners, it is not surprising that recreational values were highly significant to their past and future reforestation behavior. Similarly, owners who share family legacy values or have plans to harvest in the future were more likely to express intentions for future reforestation – a choice that is consistent with long planning horizons and active forest management.

6. Conclusion

This study focuses on policy tools that can promote tree-planting on private lands, using a survey of private landowners in the Midwest United States. We believe our approach is applicable to other parts of U.S. and places outside the U.S., where private forest owners collectively own a significant portion of forest land (e.g. Finland, Estonia, Sweden) (NFF, 2014). Our results are also transferrable to other contexts where the majority of forest owners own small properties (e.g. < 20 ha) and hold diverse, predominantly non-monetary values with regard to forest management (Duesberg et al., 2014; Põllumäe et al., 2014).

Several policy-relevant insights emerge from this study. First, the availability and perceived importance of cost-subsidizing policy tools, such as seedlings, may have a greater impact on promoting tree-planting when certain owner attributes are taken into consideration. Key owner attributes identified in this research, include: parcel size, ownership tenure, college education, prior tree-planting experience, and recreational use. Second, small parcel ownerships can contribute to forest area increase – and to the generation of environmental benefits – as they may be more willing to plant trees than large ownerships. Owners can engage in tree-planting outside of carbon offset schemes or other conservation programs, and it may be useful to consider ways that support and account for these practices. Third, it is important to acknowledge that owners often manage for multi-functional forest use and that tree-planting along with other forest management practices will continue to be shaped by informal channels of social influence, such as information from friends, family, and trusted peers. Programs that effectively integrate peer-to-peer learning could further encourage tree-planting on private lands, and reinforce intrinsic motivations for forest stewardship in a context where traditional forestry incentive programs have been less effective. While we draw distinctions between extrinsic and intrinsic motivations for reforestation, we lack empirical tests to support the presence or strength of such motivational drivers. Future research could consider operationalizing these constructs and testing their effects on landowner reforestation choices. Understanding what motivates owners to plant trees is important for better designing and targeting policy tools to specific forest owner groups.

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