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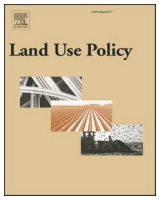

At the limit of volunteerism? Swedish family forest owners and two policy strategies to increase forest biodiversity

Brian Danley [a,*], Therese Bjärstig [b], Camilla Sandström [b]

[a] Natural Resources and Sustainable Development, Department of Earth Sciences, Uppsala University, SE 621 57, Visby, Sweden
[b] Department of Political Science, Umeå University, Umeå, Sweden

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ABSTRACT

Sweden is not on track to meet its own national 2020 environmental goals for sustainable forests. Due to the deliberate design of Swedish forest policy, private forest owners' voluntary forest and biodiversity protection efforts are required to help close the policy gap. Using survey data from Swedish family forest owners, this paper outlines how forest owner attitudes reveal challenges and opportunities for two general strategies to increasing forest and biodiversity protection. The first strategy is attempting to institute changes within *status quo* Swedish forest policy by relying on family forest owners to make such changes voluntarily. The second strategy is encouraging management changes by using policy reforms. Our qualitative results suggest that Swedish forest policy is close to the limit of what can be accomplished with volunteerism alone and likely requires policy reforms to close its forest and biodiversity protection gap on family-owned forests.

1. Introduction

Biodiversity loss is a global challenge, recognized in the UN Convention on Biodiversity (CBD, 1992) and in the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (Brondizio et al., 2019). Sweden, once viewed as a pioneer in environmental and sustainable development policy (Eckerberg and Bjärstig, 2020; Eckerberg, 2010; Hysing, 2014; Kronsell, 1997, 2002), has lately been considered less successful in terms of reaching conservation targets for biodiversity (OECD, 2014). Recent evaluations concluded that Sweden is not on track to meet its own national 2020 environmental goals for sustainable forests (SEPA, 2019). Although Sweden established the first national parks in Europe in 1909, today the proportion of protected land is second lowest in the European Union according to the European Environment Agency (EEA, 2019).

A key reason for the low proportion of formally protected land in Sweden is due to deregulations in the mid-1990s that now consider discretionary, voluntary set-asides of forests by private owners to be protected lands in calculating forest conservation targets (Lister, 2011). Forest protection targets are particularly dependent on private voluntary set-asides in sub-alpine forests, in which just over two percent of productive forestlands are officially protected via state regulation (Hedeklint and Höjer, 2017). A back-of-the-envelope calculation suggests an additional 1–2% of Sweden's actively managed forests (approx. 235,000–500,000 ha) need to be set aside from production to meet Sweden's forest protection target (Danley, 2019a). In short, Sweden is falling short of its own forest protection and biodiversity goals and is, by intentional design, dependent on private forest owners to help close its forest protection gap.

Family forest owners' voluntary contributions to forest protection are central components of Sweden's forest policy framework, often called the Swedish Forestry Model (e.g. KSLA, 2009). Individuals and families own slightly more than half of all productive forests in Sweden (SFA, 2014), which means environmental conservation measures taken on family owned forests are crucial to half of Sweden's productive forests. The Swedish Forestry Model relies on what is commonly referred to as 'freedom with responsibility' (in Swedish *frihet under ansvar*) of the private forest sector to achieve the dual goals of forest production and environmental consideration. The phrase 'freedom with responsibility' is only implicit in Swedish legislation, but is discussed as if it is official policy by actors in the forest sector (e.g. Löfmarck et al., 2017), government reports (e.g. Riksrevisionen, 2018), and the Swedish Forest Agency itself (e.g. SFA, 2017a, 2017b).

There are at least two respects in which the Swedish private forest sector, including family forest owners, are expected to behave under freedom with responsibility: one is the responsibility to follow legal

* Corresponding author.
E-mail address: brian.danley@geo.uu.se (B. Danley).

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guidelines, such as leaving retention structures at the time of felling. Another way in which freedom with responsibility functions in the Swedish Forestry Model is to encourage forest owners to take additional steps for forest conservation above and beyond what is required in legislation (SFA, 2017a, 2017b).[1] Examples of voluntary forest conservation measures family forest owners can take include voluntarily setting aside part of their productive forests for conservation,[2] entering into voluntary forest conservation agreements with the state, leaving more retention structures during felling than required by law, and certifying their forests via the Forest Stewardship Council (FSC) or Programme for the Endorsement of Forest Certification (PEFC) (Widman and Bjärstig, 2017; Danley, 2019b). Recent estimates suggest somewhere around 41% of Swedish family forest land is certified by one or both of the FSC and PEFC certification systems (SFA, 2020). How and if Sweden can achieve its forest protection and biodiversity conservation targets with such a heavy reliance on voluntary contributions is a question of great interest in a global context that has arguably seen a shift in the forest policies of many Western countries toward "governance without government" (Appelstrand, 2012; Carlsson, 2017; Wallin, 2017).

Although a variety of possibilities have been articulated in how to amend, expand, or perhaps entirely reimagine the Swedish Forestry Model (e.g. Mårald et al., 2017), there are some consistently suggested changes to the Swedish Forestry Model to address the forest protection and biodiversity conservation deficit. Felton et al. (2019) present at least three of the common suggestions for reforming Sweden's forestry practices. The first suggestion is to increase the structural diversity of managed forests by significantly increasing the amount of forest managed using continuous cover, or mixed-age forestry in a landscape dominated by clear-cut forestry (Kuuluvainen et al., 2012; Nordén et al., 2014; Peura et al., 2018). A second suggestion is increasing rotation lengths on some forests since some of the rarest forest biodiversity, as well as indigenous reindeer husbandry, are both dependent on older forests (Bostedt et al., 2015; Eggers et al., 2019; Felton et al., 2019). Finally, increasing the amount of mixed-species stands will likely increase the habitat for threatened flora and fauna and provide a wider range of other ecosystem services, particularly if more broadleaf trees are integrated into production stands (Felton et al., 2016; Lindbladh et al., 2017; Felton et al., 2019). Implementing these and other related changes on Swedish family-owned forests would arguably require far-reaching systematic change to existing forestry practices. Such fundamental changes to Swedish forestry would likely constitute "an extremely difficult task, not least when the primary mechanisms for change are influencing norms and disseminating knowledge" (Lidskog and Löfmarck, 2016, p. 182).

Our contribution to the literature is outlining how Swedish family forest owner attitudes reveal challenges and opportunities that will need to be addressed in efforts to close the gap between Sweden's biodiversity goals and existing forest conditions. In the broadest terms, we explore two general strategies to increasing forest and biodiversity protection: 1) attempt to institute changes in management practices within the *status quo* Swedish Forestry Model by further appealing to Swedish family forest owners' freedom with responsibility to do so voluntarily, or 2) encourage management changes by reforming the Swedish Forestry Model using a variety of instruments such as legal requirements, economic incentives, voluntary programs, and technological innovations. Accordingly, the aim of our analysis is two-fold. First, we investigate the willingness of Swedish family forest owners to continue acting on their freedom with responsibility to do more than the law requires for forest protection and biodiversity conservation (i.e. the *status quo* Swedish Forestry Model). Second, we explore what family forest owner attitudes reveal about policy reform as a strategy for increasing forest and biodiversity protection. With regard to family forest owner attitudes relevant for policy reform, we explore attitudes about the need for biodiversity protection in Swedish forests using existing policy instruments and the perceived effectiveness of existing environmental regulation. An important limitation of our study is that although the forest protection deficit is a quantity that can be estimated, we cannot quantify the additional forest protection that could be achieved through the two strategies we outline. Our results can only give a qualitative indication of which strategy may be best suited to bridge the quantitative gap.

The rest of this paper is organized as follows: we begin by presenting a theoretical framework for why family forest owner attitudes are relevant when considering different ways to increase forest and biodiversity protection in Swedish forestry. Next we introduce the data used for empirical analysis and the methods we apply to explore family forest owner attitudes and options. We present our results in three stages. The first stage sets the general context of Swedish family forest owner attitudes toward biodiversity protection in forestry. The second stage of our results concern which owners may be willing to take additional biodiversity conservation actions via any existing option available in the *status quo* Swedish forestry model. The third stage explores what family forest owner attitudes imply for potential policy reform to help increase biodiversity conservation on family owned forestland. After presenting how key forest property attributes, forest owner characteristics, and indicators of forestry-specific social interactions correlate with attitudes, we discuss how our results can guide policy reforms. We conclude with a summary of our findings and whether we recommend continued reliance on freedom with responsibility in the Swedish Forestry Model or policy reforms to close the gap between Sweden's forest policy goals and existing forest protection.

2. Theory

In his book "Navigating Environmental Attitudes," Heberlein (2012) states that solving environmental problems requires a scientific understanding of public attitudes. He uses a metaphor that attitudes resemble rocks in a river, often lying beneath the surface – hard to see, and even harder to move or change. Rather than trying to change attitudes, he suggests we need to design solutions and policies with attitudes in mind, addressing environmental problems with "three fixes": technological, cognitive, and structural. Each of these fixes has a different way of approaching human behavioral change. We argue that in the context of encouraging forest management change, further appeals to Swedish family forest owners' freedom with responsibility is an exclusively cognitive fix, while policy reforms to the Swedish Forestry Model would likely involve a mixture of all three fixes.

Technological fixes imply new or adapted management techniques to increase biodiversity in Swedish forests. This could be changing from clear-cut to continuous cover forestry, increasing the rotation age of ecologically valuable forests, or increasing the amount of broadleaf trees on the landscape. All changes that address the biodiversity protection deficit in Swedish forests mentioned in Felton et al. (2019) are technological fixes. The challenge for policymakers is therefore how to use cognitive and structural fixes to encourage family forest owners to adopt the technological fixes that can help close the gap in Sweden's biodiversity protection targets. Our approach is using family forest owner attitudes concerning *status quo* forest conservation and biodiversity

[1] The Swedish Forest Agency's webpage about 'freedom with responsibility' explains that in order to achieve Sweden's dual production and environmental forestry goals, forest owners and managers must do "substantially more than what the law requires" as it pertains to environmental harm mitigation efforts (SFA, 2017b).

[2] Voluntary set-asides are areas of contiguous, productive forest with one or a combination of high nature value, cultural significance, or social value and range between 0.5 and 20 ha in size. The status of set-aside areas should be recorded in a forest management plan, although the national status of voluntary set-asides on family forestland is unknown since forest management plans do not need to be filed with the Swedish state (SFA, 2012; Simonsson et al., 2016).

protection instruments to infer how Swedish family forest owners may react to new structural fixes aimed at increasing the adoption of technical fixes for biodiversity protection.

Cognitive fixes directly attempt to modify human behavior by targeting the attitudes, beliefs, and values that affect those behaviors through information or education. Using information and outreach to encourage family forest owners to change their behaviors and take additional voluntary actions, such as providing information about discretionary forest conservation set-asides and participation in voluntary conservations programs, is an example of a cognitive fix.

Structural fixes include many traditional policy instruments, but they are not necessarily restricted to state actions. Structural fixes try to modify human action by regulating the social setting, or "structures", in which these actions occur. By changing the social setting in which people make decisions, policymakers may be able to influence the choices people make. Examples of structural fixes are laws and regulations, market-based certification, voluntary stewardship management programs, economic compensation, and fees or taxes. The Swedish Forestry Model is well known for its avoidance of structural fixes for the private forestry sector, but some family forest owners may be receptive to structural fixes.

Based on Heberlein's three fixes, we argue: 1) Family forest owners who express a willingness to take additional voluntary actions for forest and biodiversity protection would likely be receptive to cognitive fixes aimed at increasing voluntary actions in the *status quo* Swedish Forestry Model. Additionally, forest owners expressing strong attitudes that more forest biodiversity protection is needed relative to the current level of protection may be receptive to cognitive fixes that emphasize the environmental benefits of revising forestry practices. 2) Forest owners with positive attitudes toward additional forest protection and environmental regulations via *status quo* forest conservation instruments would typically favor additional structural fixes in forestry practices. While the data we present does not explicitly ask family forest owners their opinions about the technical fixes outlined in Felton et al. (2019), we propose that family forest owner attitudes concerning environmental regulations in the Swedish Forestry Model in general can give an indication of how family forest owners would react to additional structural fixes per se, such as taxes, subsidies, or voluntary stewardship programs. By combining family forest owner attitudes about environmental regulations in the Swedish Forestry Model with attitudes concerning the need for biodiversity protection, we can infer how Swedish family forest owners may react to additional structural fixes to increase biodiversity.

Most attempts at making fundamental reforms to business-as-usual behaviors require a combination of the three fixes to successfully institute change. While structural fixes such as regulations constitute the backbone of forest policies, soft policy instruments such as market-based certification may provide valuable complementary measures to encourage human behavioral changes. In our case, both structural and cognitive fixes could be used to encourage family forest owners to adopt technological fixes via changes in their forest management.

3. Materials and methods

A postal mail survey was sent out to Swedish family forest owners in December 2014 with a reminder and duplicate survey sent to those who had not yet responded in January of 2015. A proportionate stratified sampling method was employed based on the county in which the forest owners' properties exist (i.e. a county containing 3% of all family forest properties received 3% of all surveys) (Frayer and Furnival, 1999). Sampling from forest owners with a registered Swedish address, 2987 unique owners were selected to receive a survey. Since most forest policy instruments in the Swedish Forestry Model assume active commercial forestry management, forest properties larger than 5 ha were selected so that policy questions would be relevant to owners. Of the 2987 recipients receiving a survey, 1296 were returned with 32 of those being blank. After removing respondents who answered fewer than half of the biodiversity policy questions we evaluate using principal component analysis (104 respondents), a total of 1192 respondents were used for analysis. Readers interested in further details of the survey are directed to Danley (2019a).

We divide our analysis into three stages and explore different survey questions in each of the three stages. The first stage of our results presents percentages of sample-level answers to some general questions that set the context of Swedish forest owner attitudes toward biodiversity protection policy in the Swedish Forest Model. In the second stage, we employ univariate analysis to explore the prospects for pursing an exclusively cognitive fix within the *status quo* Swedish Forestry Model. We identify owners who are likely to respond to an exclusively cognitive fix based on which respondents state they are willing to take additional conservation actions through any one of the existing conservation policy instruments in Sweden, including: voluntary set-asides, entering into a forest conservation contract with the state (both permanent and time-limited), and leaving more retention structures during felling than required by law. To give insight into what kind of forest owners could be targeted with a cognitive fix to increase forest biodiversity protection, we present average differences in forest property, sociodemographic, and social interaction characteristics of family forest owners based on which respondents say they are willing to take additional voluntary forest protection efforts.

In the third stage we turn to another set of attitudes questions to investigate possibilities for policy reform. We use multivariate principal component analysis to map respondents' attitudes about environmental regulation in Swedish forestry and the need for various biodiversity protection instruments. The respondent-specific principal component scores provide attitude measures relevant for additional structural, cognitive, and technical fixes to increase conservation in the Swedish Forestry Model (see Table 1). A summary of the eleven questions included in the principal component analysis is in Table 3, while the full translation of the eleven questions can be found in the Supplemental Materials Appendix.[3]

Principal component analysis is an established method used to describe relationships between data and can, among other things, reduce the dimensionality of data (Dunteman, 1989). Each variable included in principle component analysis has an imputed loading (correlation) associated with each respective component score, which is used to interpret each respective component (Jolliffe, 2002). In short, principal components can capture patterns in how survey respondents have answered various attitude questions and are often interpreted as composite attitude measures in the family forest owner literature (eg. Ficko et al., 2017).

Since we include respondents' answers to questions concerning environmental regulations in Swedish forestry and the need for various biodiversity protection instruments, we anticipate respondents' attitudes might be correlated. To allow principal components (i.e. attitude measures) to be correlated, we run a promax oblique rotation (Abdi and Williams, 2010). In obliquely rotated principal component analysis, all variables load on (are correlated with) each principal component, and each principal component is allowed to have a non-zero correlation with all other principal components. To determine the number of principal components to retain for analysis, we use the dual criteria of statistical fit from three standard tests as well as the parsimony and interpretability of the components (Bro and Smilde, 2014). Results from the three tests for how many principal components to retain are presented in the Supplemental Materials Appendix.

Respondent-level principal component scores are plotted to provide a visual representation of respondents' correlated principal component

[3] Multiple Correspondence Analysis was used to impute missing responses to the eleven attitudes questions using the missMDA package in R (Josse and Husson, 2016). About 11% of all respondents have at least one answer imputed, but only ca. 3.5% of all answers are imputed.

Table 1
Attitudes and the three fixes for environmental problems, adapted from Heberlein (2012). Both cognitive and structural fixes would be used to encourage family forest owners to adopt various technological fixes to increase forest and biodiversity protection.

	*Technological	Cognitive	Structural
What changes	Environment	Human behavior	Human behavior
How change is achieved	Technology influences the environment	Information influences human behavior	Structure of the situation influences human behavior
Examples	Adopting continuous cover forestry, increased rotation length, leaving more broadleaf trees on the landscape (seeFelton et al., 2019)	Information and education lead to changes in forest management behaviors that enhance biodiversity	Policy reform, i.e. additional legislation, voluntary stewardship programs, taxes or compensation for management that enhances biodiversity
Role of Attitudes	*Cognitive and Structural fixes cause forest owners to change technical forest management	Attitude change due to information will influence behavior	Structural change must be consistent with forest owner attitudes and values

scores (in Fig. 4). We argue that the visualization of respondent-level principal component scores shows how policymakers should consider family forest owner attitudes in formulating structural, cognitive, and technological fixes to increase forest and biodiversity protection. To complement the visualization of respondent attitudes, we calculate the average importance that selected respondents ascribe to recreation, relaxation, and family legacy. We also present the correlations between respondent-level principal component scores and the same respondent characteristics examined for forest owners who are willing to take additional voluntarily action for biodiversity protection (i.e. the same characteristics as in Table 3). Principal component analysis was conducted with the Psych package (Revelle, 2018) using the open source software R (R Core Team, 2018). We plot respondent principal component scores and tests for principal component analysis using ggplot2 (Wickham, 2016).

3.1. Results stage 1: Attitudes in overview

We begin by presenting answers to selected survey questions to set the context for how Swedish family forest owners think about biodiversity protection in Swedish forests and environmental policy in general. First, relatively few Swedish family forest owners think more biodiversity protection is needed, as can be found in Fig. 1. Almost three quarters of respondents thought the current amount of protected forest is sufficient (52.8%) or is already more than necessary (20.6%), and only about one in ten owners thought it necessary to protect more forest.

Family forest owner attitudes concerning the role of the state in environmental protection are more nuanced compared to attitudes about biodiversity protection. Aside from the matter of exactly what environmental regulations should be, approximately 3 out of 4 respondents thought forest conservation regulations should apply to both privately and publically owned forestland (Fig. 2). Fig. 2 suggests that Swedish family forest owners tend to think regulations for nature conservation should apply to privately owned forests.

Inquiring about environmental policy in general, Fig. 3 shows slightly less than two thirds of respondents disagree that the government should do more to protect the environment through structural fixes, such as legislation. Conversely, Fig. 3 also shows that slightly more than one

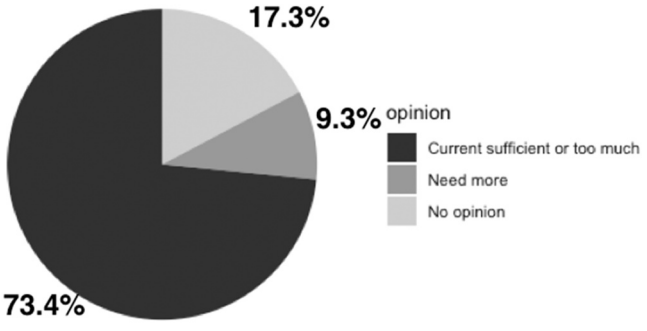

Fig. 1. Do you think Sweden needs to protect more forest for biodiversity reasons?.

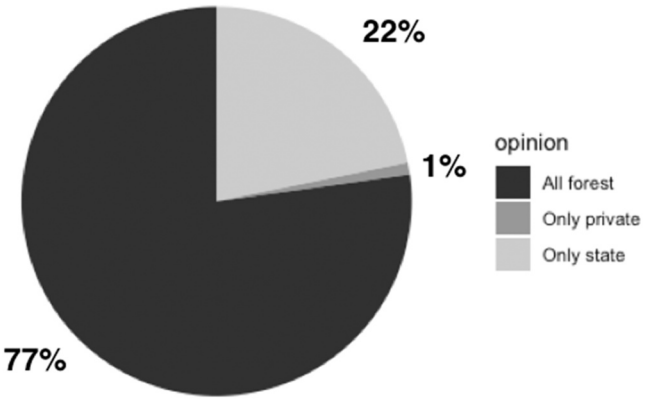

Fig. 2. What kinds of forestland by ownership class should be subject to regulations for nature conservation?.

third of respondents are not necessarily against an increase in government regulation in Swedish environmental policy, even if it may restrict some of their decision-making possibilities.

Considering respondents who were either neutral or positive to environmental regulations in general AND thought that forest conservation regulations should apply on both state and private land, the data suggest 29% of all family forest owners may not be opposed to the general idea of additional regulation. In a policy system that gives a great deal of freedom to individual landowners it is reasonable to expect an overall negative attitude toward changing the *status quo* biodiversity protection in the Swedish Forest Model. Figs. 2 and 3 show, however, that a lack of perceived need for additional biodiversity protection may not translate to a lack of interest in additional environmental regulations (i.e. structural fixes) in Swedish forestry, at least among an important minority of landowners. To put these numbers in a context directly relevant to conservation policy instruments in the Swedish Forestry Model, we now turn to owners' willingness to take additional voluntary conservation actions.

3.2. Results Stage 2: A cognitive fix within the status quo Swedish Forestry Model. Prospects for freedom with responsibility

The primary mechanism currently employed in *status quo* nature protection policy is freedom with responsibility to meet and exceed official guidelines for forest protection. An exclusively cognitive policy fix would involve providing better information and support to Swedish family forest owners so they can take additional actions without the need for further policy reforms. Approximately 1 out of 10 (9%) respondents expressed an interest in voluntarily entering into a contract for permanent or time-limited forest conservation with the state, making additional voluntary forest set-asides, or increasing the quality of the retention trees left during felling. For comparison, there are three times as many owners who are generally supportive of environmental regulations compared to those owners who are willing to take additional

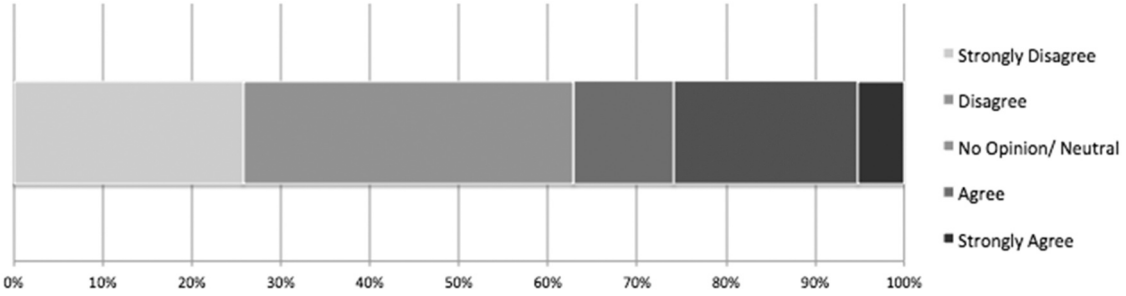

Fig. 3. Ascending agreement/disagreement with the notion that the government should do more to protect the environment through legislation even if it limits the free choice of individuals.

voluntary measures. This suggests that the potential for relying exclusively on additional volunteerism (i.e. the exclusively cognitive fix) within the current Swedish Forest Model may yield a marginal benefit.

Table 2 presents proportions of various forest owner characteristics based on which forest owners answered they were willing to take additional voluntary measures (Do more) and those who did not (Otherwise). Numbers in the table represent the proportions of respondents with each respective characteristic, except for "hectares," which is the average hectares of forest owned by respondents who answered "Do more" and "Otherwise," respectively. For example, of the respondents who say they are willing to "Do more," 0.5 (or 50%) of them live on their forest property as their full time residence, while 0.6 (or 60%) of those who are not willing to "Do more" live on their forest properties. Key forest property characteristics are respondents' forest property size in hectares (hectares), whether or not their properties are certified (Certified) via the Forest Stewardship Council (FSC) or the Programme for the Endorsement of Forest Certification (PEFC), and if the respondents' property exists in the south most part of Sweden (South). Owner characteristics are forest owner gender (Female), if respondents have their main residence on their forest properties (Residence prop), if they are over 65 years of age (Over 65), if they have owned their properties for 21 years or more (21 + tenure), if they have a university education or higher (Uni edu), and if they are sole owners of their properties (Sole owner). Investigating the possibility that family forest owner social networks may be a method of outreach for cognitive fixes to increase biodiversity protection, we look at if owners have received advice from a forest owners association in the past 5 years (Advice FOA), if they think it is important to know their neighbors' attitudes concerning biodiversity protection before making decisions about their own properties (Neigh attit), and if they think it is important to know how neighboring forest properties are managed before making decisions about their properties (Neigh prop).

To investigate the characteristics policymakers could use to focus purely cognitive policy fixes, we look for differences between the group answering "Do more" and the group answering "Otherwise" in Table 2. Overall, few differences are statistically significant between the "Do more" and "Otherwise" groups, and the absolute magnitude of the significantly different characteristics are modest. In other words, owners who are willing to take additional conservation management measures in the *status quo* Swedish Forest Model are few and they are not particularly distinct in their socio-economic characteristics. Nevertheless, a picture emerges from a few of the characteristics of Swedish family forest owners who may be receptive to cognitive policy fixes: younger absentee owners (not excluding those who may have vacation homes on their forests) with relatively smaller forest properties who are university educated and have owned their properties for less than 21 years. Keeping in mind that slightly less than 1 out of 10 respondents seemed receptive to exclusively cognitive policy fixes, it is not clear how worthwhile it would be to attempt a targeted cognitive fix to those willing to take additional measures for biodiversity protection.

3.3. Results Stage 3: Policy reforms to the Swedish Forestry Model. Prospects for cognitive and structural fixes

To explore the challenges and opportunities for broader policy reform that may involve both cognitive and structural fixes, we select 11 questions to explore family forest owner attitudes about current needs for forest biodiversity protection and attitudes on existing environmental regulations. Results of a principal component analysis with oblique rotation are presented in Table 3. We select two principal components for analysis justified by the results from three statistical tests (see Supplmental Materials Appendix) and because using two components allows for two-dimensional visualization of clearly interpretable principal components.

Principal component analysis shows how respondents tend to answer various questions, and can be thought of as a synthesis of multiple questions that reflect overarching attitudes. In a solution with two components, the first principal component (PC1) captures how much additional forest area respondents think should be preserved in Sweden via specific *status quo* protection instruments. The second principal component (PC2) captures how confident forest owners are that the *status quo* Swedish Forest Model can protect biodiversity and conversely how much support they express for additional regulations. The correlation between PC1 and PC2 is − 0.238, meaning the more respondents tend to perceive a need for additional forest protection via *status quo* policy instruments the less they tend to express confidence that the Swedish Forest model can sufficiently protect biodiversity, and vice versa.

Respondent scores for the two principal components are plotted in Fig. 4 such that dots represent a given respondent's score for each respective principal component. Dot size indicates the amount of hectares owned by each respondent, with larger properties being represented by larger dots. Black dots indicate female respondents while grey dots indicate male respondents. Based on the interpretation of each principal component given above, the farther to the right a respondent is on the horizontal (x) axis, the more s/he tends to believe that more forest should be protected via any one of the *status quo* conservation instruments in the Swedish Forest Model. Conversely, the farther to the left a respondent is on the horizontal (x) axis, the more s/he tends to believe less forest should be protected via any one of the *status quo* conservation instruments in the Swedish Forest Model. On the vertical (y) axis, as a respondent approaches the top of Fig. 4, the more s/he tends to express confidence in the effectiveness of current environmental regulations on forestry activities. Conversely, the farther down a respondent is on the vertical (y) axis, the more s/he tends to express support for additional environmental regulations on forestry activities.

Although it is common in the family forest owner literature to group respondents into discrete clusters based on their principal component scores (see review in Ficko et al., 2017), we find no indication of discrete groupings of respondents in Fig. 4. Accordingly, we interpret principal component scores directly. We indicate quadrants on Fig. 4 to facilitate interpretation of principal component scores, but we do not present the

Table 2
Differences of proportions in characteristics between respondents who are willing to take additional voluntary measures (Do more) and those who are not (Otherwise). Two-sample z tests of proportions are used to generate p values, with significant p values (i.e. $p < 0.10$) presented in bold.

Property characteristics				*Owner characteristics*						*Social characteristics*		
	hectares	Certified	South	Female	Residence prop	Over 65	21 + tenure	Uni edu	Sole owner	Advice FOA	Neigh attit	Neigh prop
Do more	82.57	0.27	0.45	0.22	0.50	0.35	0.37	0.47	0.50	0.24	0.44	0.30
Otherwise	114.87	0.29	0.44	0.23	0.60	0.46	0.49	0.32	0.58	0.22	0.40	0.33
p value*	**0.03**	0.52	0.83	0.77	**0.07**	**0.02**	**0.02**	**0.00**	0.14	0.68	0.52	0.52

Table 3
Variable loadings using promax (oblique) rotation. Variables with highest loadings on respective factor scores are in bold (≥ 0.65).

	PC1	PC2	
Agreement with the following			
The state must protect biodiversity	0.18	-0.35	
All owners must take resp. for enviro.	0.55	0.32	
Confident status quo effective	0.25	**0.75**	
Status quo too undetailed	0.19	-0.59	
Current regulations too harsh	-0.30	0.28	
Enviro. goals sufficient regulated	-0.07	**0.70**	
Need more or less of the following			
Habitat protection areas	**0.86**	-0.05	
Voluntary forest set-asides	**0.84**	0.08	
Retention standards during felling	**0.82**	-0.01	
Nature reserves	**0.78**	-0.14	
Nature protection agreements	**0.84**	0.02	
SS loadings	3.97		1.73
Cumulative Var.	0.36		0.52

Correlation between PC1 and PC2: − 0.238
PC1 concerns respondents' perceived need for additional biodiversity protection using a variety of *status quo* conservation instruments. Variables with a high loading on PC1 reflect perceived need for additional biodiversity protection in the form of additional habitat protection areas, voluntary set-asides, etc. PC2 concerns respondents' confidence in the effectiveness of *status quo* environmental regulations in Swedish forestry. Variables with a high loading on PC2 reflect confidence that current regulations are sufficient to achieve national environmental goals.

quadrants to formally group respondents into discrete groups. Respondents with scores in quadrant one (I) tend to think that there is already too much biodiversity protection via the specific policy instruments in Swedish forests but also tend to be skeptical of the current Swedish Forestry Model's ability to achieve the environmental goals outlined in "Sustainable Forests" (*Levande skogar*) and favor additional state regulation. In other words, although these respondents may tend to express more positive attitudes toward environmental regulation, they may not think the current mechanisms for forest protection in the Swedish Forestry Model are what is needed to protect biodiversity.

Respondents with scores in quadrant two (II) tend to think that there is already too much biodiversity protection in Swedish forests and tend to be confident in the effectiveness of the current Swedish Forestry Model to achieve environmental goals. Respondents with scores in quadrant three (III) tend to think more biodiversity protection is needed in Swedish forests but tend to be confident in the current Swedish Forest Model to achieve forest conservation goals. Respondents with scores in quadrant four (IV) tend to believe more biodiversity needs to be protected in Swedish forests and that more regulations are needed in the forest sector to achieve environmental goals.

Figs. 5 and 6 show how to interpret the map of family forest owner attitudes from Fig. 4 in terms of structural, cognitive, and technological fixes, respectively. Arrows in Figs. 5 and 6 indicate that as a respondent gets closer to the space indicated by the arrow the clearer the implications of their attitudes are for the three fixes. As Fig. 5 illustrates, the farther up and to the left a respondent is in quadrant II the more resistant to additional structural fixes for environmental protection the owner is likely to be. The farther down and to the right a respondent is in quadrant IV the more likely the respondent is to support further structural fixes for biodiversity protection in the Swedish Forestry Model. There exists a small but meaningful minority of forest owners in spaces that indicate clear potential opposition and clear potential support for additional structural fixes. The majority of family forest owners express attitudes relatively close to the intersection of the X-Y axis, implying a neutral attitude toward additional structural fixes in general.

As Fig. 6 illustrates, concentrations of respondents at the far right end of the x-axis implies the state should pursue cognitive fixes that mostly emphasize the environmental benefits of reforms to the Swedish Forestry Model. Concentrations of forest owners on the far left end of the x-axis imply cognitive fixes should utilize a message that avoids environmental issues entirely and instead focus on other benefits of reforming the Swedish Forestry Model, such as increased choice in forest management options. The large mass of family forest owners close to "0" on the horizontal (x) axis means the majority of owners representing the overwhelming majority of family forestland area tend to think the current level of biodiversity protection is more or less sufficient.

With such a large majority of respondents existing close to "0" on the horizontal axis, it is clear that respondents may not be enthusiastic about additional fixes for biodiversity protection, but additional data are needed to suggest what benefits could be emphasized to promote policy reforms. We therefore consider only respondents who with scores close to "0" for PC1 (+/- 0.5) and utilize a variety of ownership objectives questions related to recreation, relaxation, and family legacy to explore how interested these respondents may be in non-biodiversity aspects of forest management. Table 4 presents the average importance given to seven ownership objectives questions on a 5 point Likert scale for respondents who think the current level of biodiversity protection on Swedish private forests is generally appropriate.[4] Managing the forest for the next generation, spending time in one's forest, and appreciating the beauty of nature all have above average importance for owners who otherwise think the amount of biodiversity protection in Swedish forests in generally appropriate. Cognitive fixes should accordingly frame policy reforms in terms of the multiple benefits they can achieve, including but not limited to biodiversity, enhancing forest legacy values, and enhancing the experience of spending time on one's forest property.

To complement the qualitative map of family forest owner attitudes from the PC scores in Fig. 4, we investigate how various family forest owner characteristics correlate with both attitude measures. Table 5 presents correlations between respondent-specific principal component scores and the same forest property characteristics, owner characteristics, and social characteristics investigated in Table 2. Owners with larger properties, owners who have owned their forests for 21 years or longer, those who think it is important to know their neighbors' attitudes on biodiversity conservation, and owners whose main residence is on their forests tend to believe there is already too much biodiversity protection via *status quo* conservation policy instruments. Conversely, female forest owners and owners with a university education tend to believe more forest should be protected using the existing conservation instruments in the Swedish Forestry Model.

[4] Questions relating to recreation, relaxation, and forest legacy in Table 4 are variables that were strongly associated with a Principal Component Analysis of forest ownership objectives conducted with these data in Danley (2019b).

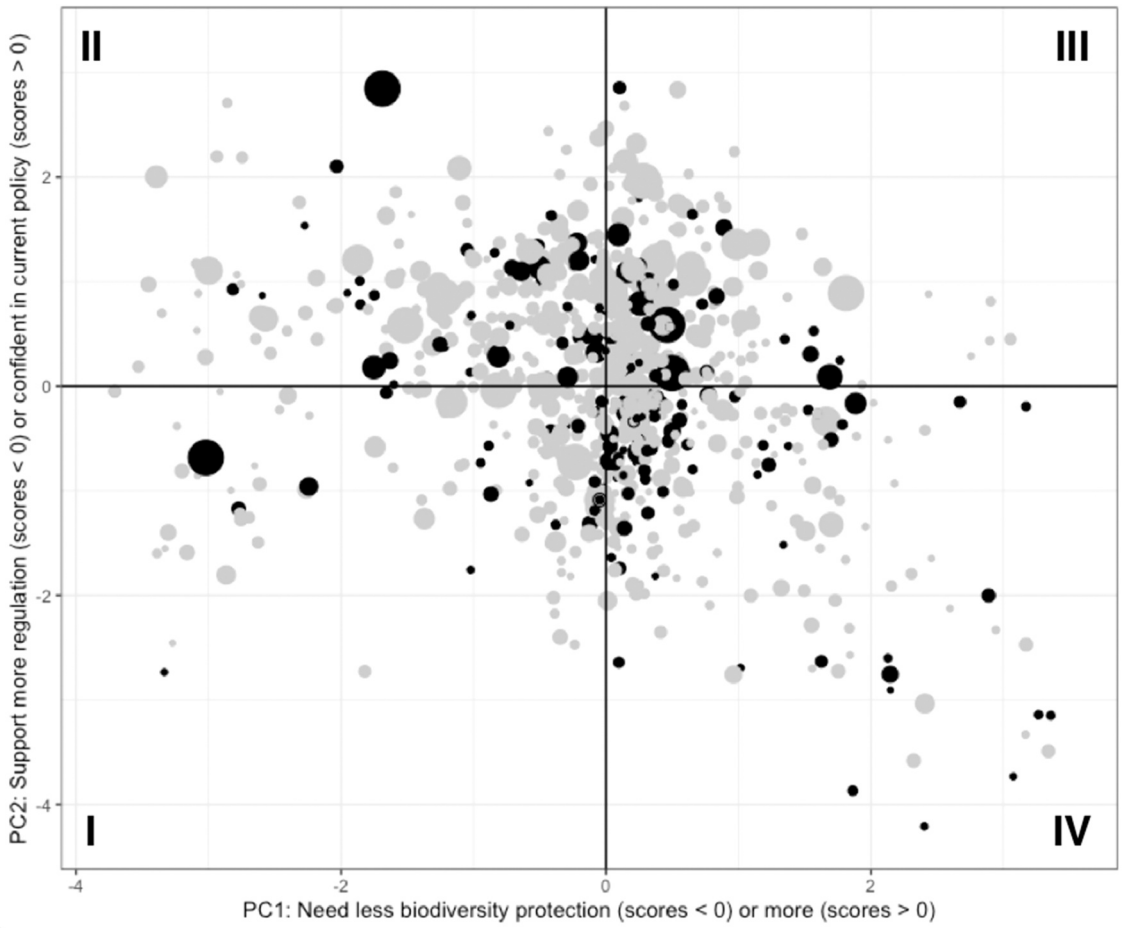

Fig. 4. Family forest owners' attitudes of the Swedish Forest Model, plotting the first and second principal component together. Black dots are female respondents and dot size represents the hectares of forest owned (largest dots are 1000 ha or more).

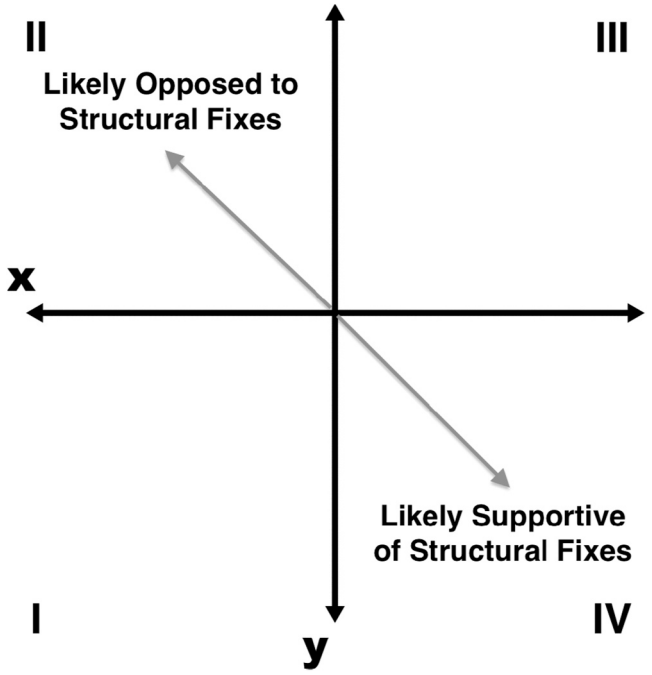

Fig. 5. Interpreting Fig. 4 in terms of the 3 fixes: Structural fixes.

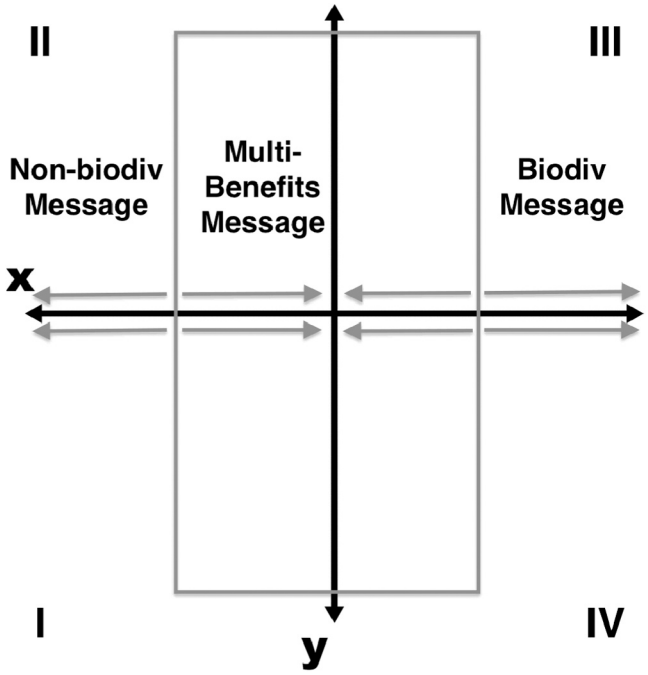

Fig. 6. Interpreting Fig. 4 in terms of the 3 fixes: cognitive fixes. What message should policymakers use to frame changes to the Swedish Forestry Model?.

Table 4
Average scores of importance given to ownership objectives concerning recreation, relaxation, and forest legacy on a 5-point Likert scale. Average scores are only for respondents close to 0 on the horizontal axis (+/- 0.5 for PC1: Perceived need for more or less biodiversity protection. This is about 2/3 of all respondents).

Average Score (between 1 & 5)	
3 indicates neutral importance	
I want to manage the forest for the next generation.	4.014
My property is part of my local environment where I spend time.	3.708
My forest property gives me the possibility to pass on a family tradition.	3.609
My property offers me possibilities to appreciate the beauty of nature.	3.523
I can relax on my property, which gives me possibilities to unwind and contemplate.	3.447
My property allows me to keep in contact with the place of my origin, where I used to live.	3.288
My property gives me recreation possibilities (e.x. hiking, outings, jogging).	3.007

When it comes to attitudes concerning the effectiveness of environmental regulations in forestry practices, owners with larger properties, owners of certified forests, and owners of forests existing in the southern part of Sweden tend to express more confidence in the effectiveness of *status quo* regulation. Owners whose main residences are on their forest properties and who are sole owners of their forests tend to express confidence in existing environmental regulation while female respondents tend to express support for additional environmental regulations. As far as variables related to family forest owner networks and the adoption of conservation behaviors, owners who have taken advice from a forest owners association in the past 5 years tend to express confidence in the effectiveness of existing environmental regulations in Swedish forestry. Owners who think it is important to know their neighbors' attitudes about forest conservation and think it is important to know how properties around theirs are managed before making forest management decisions also tend to express confidence in status quo environmental regulations.

Relating the correlations in Table 5 to implications for Heberlein's fixes, female owners, owners with relatively smaller forest properties, owners whose main residence is not on their forest properties, and owners who are less interested in their neighbor's attitudes about conservation would likely be supportive of reforms to the Swedish Forestry Model. Conversely, the opposite profile of socio-demographic characteristics (i.e. male owners, owners with larger properties, those who live on their properties, and owners who rely on their neighbor's attitudes of forest conservation) is more common among family forest owners who would likely oppose reforms to *status quo* forestry practices. The only variable in Table 5 with the same direction of correlation with both attitude measures is taking advice from a forest owner's association in the past 5 years, although the correlation is not significant for PC1. In other words, having contact with forest owner's association is unique among all characteristics we explore because it is correlated with positive attitudes toward both biodiversity protection as well as the effectiveness of existing regulations.

4. Discussion and conclusion

We have referenced three commonly suggested changes, or technological fixes, to Swedish forestry that can address the persistent deficit in forest and biodiversity protection goals: increasing the amount of forest managed using continuous cover forestry, increasing rotation lengths on ecologically important forests, and increasing the amount of broadleaf trees on the forest landscape. Our results show possibilities and challenges for implementing these and other changes to the Swedish Forestry Model using two strategies to increase forest and biodiversity protection on Swedish family-owned forestlands. It is important to repeat the caveat that our results only give a qualitative indication of how much additional forest protection can be expected from either relying exclusively on additional volunteerism or attempting reforms to the Swedish Forestry Model. Furthermore, our results make inferences based on family forest owners' general attitudes concerning environmental regulation in the Swedish Forestry Model and the need for biodiversity protection using existing conservation instruments, meaning there are some limitations in our ability to predict family forest owner attitudes about any specific prospective cognitive, structural, or technological fix.

One possibility to address the forest protection deficit is to rely on an exclusively cognitive policy fix: encouraging family forest owners to make further voluntary contributions to forest protection within the *status quo* Swedish Forestry Model. Our results suggest exclusively relying on further appeals to family forest owner's freedom with responsibility for environmental considerations in forestry practices may have limited success instituting further biodiversity and forest conservation. Only about ten percent of forest owners expressed a willingness to take additional environmental considerations, while almost three times that amount (29%) were generally supportive of environmental regulations. Younger, absentee forest owners with a university education and shorter ownership tenure tend to express willingness to take additional efforts, but whether even these owners would be willing to make technological changes as significant as increasing rotation length or changing from clear-felling to continuous cover forestry cannot be determined from these data. Although we suggest further relying on freedom with responsibility as an exclusively cognitive fix may be insufficient to achieve significant increases in forest and biodiversity protection, we argue below that volunteerism can be facilitated by reforms to the Swedish Forestry Model, such as the introduction of new voluntary stewardship programs.

A second possibility to address the forest protection deficit is to make policy reforms to the Swedish Forestry Model. Regarding structural fixes, most respondents express attitudes that imply a somewhat neutral attitude toward additional structural fixes. Swedish family forest owners who would be clearly against additional structural fixes for biodiversity protection are a relatively small minority while those who would be enthusiastic supporters of structural reforms for biodiversity protection are also a relatively small minority. Important to note is that the minority of owners who would likely be opposed to any changes in existing forestry practices may be more vocal and powerful in stakeholder forums that represent Swedish family forest owners since they tend to be

Table 5
Correlations between forest property characteristics, owner characteristics, and social characteristics of forest owners and their views on biodiversity protection (PC1) and confidence in *status quo* regulation (PC2). Significant correlations (5%) are in bold.

	Property characteristics			*Owner characteristics*						*Social characteristics*		
	hectares	Certified	South	Female	Residence prop	Over 65	21 + tenure	Uni edu	Sole owner	Advice FOA	Neigh attit	Neigh prop
PC 1												
cor	-0.051	-0.027	-0.037	0.061	-0.060	-0.035	-0.097	0.083	-0.032	0.045	-0.071	-0.041
p value	**0.086**	0.347	0.211	**0.050**	**0.037**	0.228	**0.001**	**0.004**	0.262	0.122	**0.017**	0.168
PC 2												
cor	0.120	0.177	0.093	-0.097	0.051	0.003	0.038	-0.032	0.068	0.108	0.111	0.069
p value	**0.000**	**0.000**	**0.001**	**0.001**	**0.080**	0.920	0.191	0.263	**0.018**	**0.000**	**0.000**	**0.019**

male, invested in the attitudes of neighboring landowners, and own relatively larger properties (Lidestav, 2010; Kronholm, 2016; Sténs and Mårald, 2020). Policymakers should be aware that the minority who would likely be strongly in favor of structural reforms might not be as connected to organizations that traditionally represent Swedish family forest owners and may not be equally well positioned to advocate for their attitudes as those who would oppose the reforms. Additionally, those who are likely to oppose reforms to the Swedish Forestry Model tend to have their main residence on their forest property and own large amounts of forestland, which implies these owners may more often live in rural areas that are more dependent on forestry as a source of economic livelihood (Blanco, Brown, and Rounsevell, 2015; Bjärstig and Kvastegård, 2016; Haugen et al., 2016). Policymakers should consider the use of economic compensation to address the concerns of those who stand to lose the most from policy reforms, which may have a disproportionate negative impact on rural areas.

While general attitudes suggest family forest owners may not be opposed to structural fixes in principal, the details of policy reforms and how they are communicated could make all the difference between reforms being met with general support or overwhelming opposition. Cognitive fixes to encourage change to the Swedish Forestry Model will play a central role in any reform efforts, such as how policymakers shape the message used to communicate reforms and education outreach focused on assisting family forest owners. Although most owners seem to think the current level of biodiversity protection via *status quo* policy instruments is generally sufficient, many owners are neutral or positive toward the notion of additional environmental regulations. In other words, many family forest owners may support new policy instruments or revisions to existing policies for forest biodiversity protection for reasons other than protecting biodiversity, per se. Policymakers should therefore craft information and education outreach using a message that emphasizes multiple benefits of reforming the Swedish Forestry Model, including environmental, recreational, aesthetic, and forest legacy benefits, among others.

Other research also suggests that emphasizing multiple benefits of forest protection is advisable as family forest owners often express personal and social reasons for entering forest conservation agreements as being more salient than strictly ecological reasons (e.g. Bengston et al., 2011; Häyrinen et al., 2016; Widman and Bjärstig, 2017). From a United States perspective, Fischer and Bliss (2008) find family forest owner motivations for oak conservation include the biodiversity value of the trees themselves, but also aesthetic reasons for keeping the trees, belief that the trees provide a product valued by society, and a desire for financial compensation for conservation. Investigating motivations for conservation easements, Farmer et al. (2011) show that family legacy concerns typically co-occur with financial motivations and perceived need to preserve resource lands for the public good. More generally, it is likely that any given landowner management action is actually motivated by a mixture of reasons that cannot be clearly separated from each other (Sheeder and Lynne, 2011).

Policymakers can retain freedom with responsibility as a component of forest policy by encouraging family forest owners to voluntarily take measures that imply a lower private cost or less dramatic change to existing practices. A structural fix the Swedish government can use to leverage freedom with responsibility is by establishing more voluntary, state-funded programs to facilitate family forest owner biodiversity stewardship, similar to cost share programs that are common in the United States. For example, Buffum et al. (2014) find that many family forest owners in New England express interest in supporting wildlife habitat on their forest properties, but only a small number of owners actually knew how to manage their land to establish early successional habitats for key species. Furthermore, about half of the owners who participated in a voluntary education and cost share program said the program is the key reason they implemented early succession habitat management on their properties. Likewise Rhodes et al. (2018) show how a cost share program that encourages agricultural landowners to establish and maintain forested riparian buffers is an important tool to help landowners who often do not perceive forested riparian buffers as profitable yet want to "do the right thing" on their land. It is possible to imagine a similar structural fix in Sweden that may, for example, provide family forest owners with technical education and financial assistance to establish continuous cover forestry or increase the amount of broadleaf trees on their properties.

Peer-to-peer networks are well-established mechanisms of change in the adoption of new forestry techniques (Kittredge et al., 2013; Hamunen et al., 2015; André et al., 2017), and constitute another potential cognitive fix. Our results suggest, however, that forest owner peer networks may also be more conservative about potential reforms to existing forestry practices. Those family forest owners who are more interested in what their neighbors think about forest conservation issues tend to express more support for *status quo* forest policy. Our results are consistent with findings from Sténs and Mårald (2020) who identify a discourse of concerns about the erosion of family forest owner property rights that has been mostly established and perpetuated by traditional forestry stakeholder groups (e.g. forest owners' associations and forest industry representatives). It is therefore not immediately apparent that forest owner peer networks will be useful cognitive fixes to institute changes to the Swedish Forestry Model. Additional research is needed to explore the temporal processes through which family forest owner social networks may change their attitudes about novel forestry techniques from reluctant at first to more accepting over time as the techniques become widely tested and more familiar.

Our analysis has so far assumed that family forest owners would be resistant to changes in forestry practices that would increase forest and biodiversity protection on their forests. It is possible that some family forest owners would be willing to make some changes in their forest management if, for example, the Swedish Forestry Agency gave more information, support, or detailed advice on how to implement the changes (cf. Bjärstig and Kvastegård, 2016). For example, some owners may be willing to switch from even-aged to mixed-aged management or increase the amount of broadleaf trees in their forests since those practices may enhance the aesthetic, recreational, or otherwise non-timber value of their forests (Ingemarson et al., 2006; Kreye et al., 2018).

The literature on family forest owner ownership objectives consistently shows that non-economic forest ownership objectives are prominent among family forest owners (e.g. Majumdar et al., 2008; Favada et al., 2009; Ficko et al., 2017; Kumer and Štrumbelj, 2017). While it is intuitive to expect family forest owners with non-economic ownership objectives to choose forest management alternatives that produce more environmental benefits relative to economic returns, forest ownership objectives often do not have the expected associations with forest management decisions or voluntary program participation (Urquhart et al., 2012; Dayer et al., 2014; Eggers et al., 2014; Danley, 2019b). For example, in a vote-count review of US family forest owner literature Floress et al. (2019) find that ownership objectives are more frequently insignificant than they are significant in explaining family forest owner behaviors. Family forest owners who have environmental ownership objectives may be no more likely to have taken a particular pro-environmental stewardship action compared to family forest owners without strong environmental ownership objectives because "other factors may ultimately override stated ownership objectives when it actually comes time for family forest owners to take actions" (Floress et al., 2019, page 26).

In Sweden, Nordén et al. (2017) find family forest owners to dislike some management options that yield better biodiversity conditions and have stronger preferences for production-oriented forest practices relative to the Swedish general public. Eggers et al. (2019) find that Swedish forestry experts also prefer forest management practices that favor production and economic returns over environmental benefits and conclude that policy instruments will be required to shift forest management decisions toward more ecologically friendly outcomes.

Policymakers should keep in mind that, even for environmentally oriented family forest owners, changing forest management practices likely entails difficulties such as: cognitive burdens in decision-making, fixed costs of changing forest management plans, and uncertainties of introducing deciduous trees on forests that may have been managed as coniferous monocultures for generations of ownership (e.g. Eriksson, 2018; Löfmarck et al., 2017). In summary, some Swedish family forest owners may be willing to voluntarily change their forest management to more ecologically friendly practices, but relying on volunteerism alone is unlikely to yield widespread and systematic improvements in forest and biodiversity protection (Löfmarck et al., 2017).

In summary, these results justify the exploration of some kind of policy reform to the Swedish Forestry Model that is specific to family forest owners. We draw attention to the fact that most of the potential structural fixes discussed in this manuscript can be considered as relatively modest given other proposed suggestions (e.g. Mårald et al., 2017). Exactly what structural fixes should be pursued is beyond the scope of this manuscript, but we encourage policymakers to seriously explore a wide range of possible policy alternatives that specifically consider the needs and objectives of Swedish family forest owners.

Sweden is often seen as an example of environmental sustainability, but it is falling short of its own forest and biodiversity protection goals. The Swedish Forestry Model is designed to be dependent on the private forest sector's voluntary contributions for forest and biodiversity protection, including family forest owners. A general strategy of moving away from prescriptive state regulation in favor of more voluntary policy instruments may be desirable in forest policy contexts characterized by a high degree of state regulation on private forestry. Our qualitative results, however, may indicate that the Swedish Forestry Model represents the limitations of deregulation in favor of voluntary instruments in forest policy. Specifically, we find that the Swedish Forestry Model is close to the limit of what can be accomplished with volunteerism alone and likely requires policy reforms to close its forest and biodiversity protection gap on family-owned forests. Family forest owner attitudes show policy reforms may be successful in encouraging systematic changes to forestry practices using a combination of structural and cognitive reforms if communicated with a message that emphasizes multiple benefits of forest management changes.

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Declarations of interest on behalf of all authors

none.

Research data for this article

Due to anonymity requirements, these data are not publically available. Interested readers are directed to contact the authors to request an anonymized version of the data.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.landusepol.2021.105403.

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