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Landowner participation in forest conservation programs: A revealed approach using register, spatial and contract data

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ABSTRACT

Incentive based voluntary conservation programs have gained prominence as a regulation mechanism to protect ecosystem services on private land either through the set-aside of land for reserves or by altering land management practices. A crucial challenge for voluntary approaches is however to ensure private landowner involvement and get the ecosystem services delivered where they are most demanded by society. To promote participation and ensure an instrumental design of voluntary initiatives that is coherent with this, there is a need to understand the motivations of the landowners and determinants of their participation choice. We investigate landowners' willingness to participate in protecting oak scrub sites in Denmark. Combining contract data of the landowners' actual choices, GIS information on area specific characteristics and detailed individual level register data, we develop and implement a framework for analysing revealed choice of private landowners' in voluntary conservation programs. We find that both the physical characteristics of the property and the sociodemographic characteristics of landowner in question matter, along with the information flow provided from the regulator. Results provide impetus into the design of future conservation policies, in terms of how, to whom and where to target efforts.

1 Introduction

In many parts of the world habitats, critical to the provision of biodiversity and ecosystem services, are becoming increasingly scarce. In addition, a large proportion of agricultural and forested land which hosts the habitats is privately-owned. The management of private lands therefore has significant implications for biodiversity and ecosystem services. Landowners seldom receive rewards for enhancing them on their land, and economic theory suggests that since ecosystem services constitute a public good, the amount supplied on private land will be lower than optimal. With habitat loss and degradation thought to be a main cause for the decline of biodiversity this poses a potential major threat to biodiversity if unregulated. As an alternative to regulating the provision of ecosystem services through land acquisition schemes or command and control, voluntary conservation programs are gaining prominence as a regulation mechanism that can deliver ecosystem services on private land by altering land management practices. Numerous countries are allocating considerable large funds for voluntary mechanisms to safeguard environmental benefits such as water services and erosion control, carbon sequestration, afforestation, and biodiversity conservation (Gren and Carlsson, 2012). One example is the EU expenditure on agri-environment measures from 2014–2020 which is predicted to be nearly 25 billion EUR (European Commission, 2015).

Crucial requirements for the success of voluntary incentive mechanisms are to get the ecosystem service delivered in the locations where it is most demanded by society, and to get it delivered at the least cost. Voluntary conservation will only be effective if private forest owners can be persuaded to participate in the offered programs and are able and willing to supply the demanded level of ecosystem services. To promote participation and ensure an instrumental design of voluntary initiatives that is coherent with this, there is a need to understand the motivations of the forest owners and determinants of their participation choice (Hanley et al., 2012). Linking information on owner participation and characteristics to the spatial distribution and quality of ecosystem services

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provides insight into where conservation initiatives may be successfully and effectively implemented (Knight et al., 2011). Further, these insights may reveal the potential policy limitations of voluntary conservation programs on private land. In this regard, crucial questions are: do registered participation data reveal specific characteristics of the forest owners who chose to engage in voluntary conservation? Are the programs attracting owners of land with high conservation value? And what are the consequences for the optimal design of the conservation contracts (de Vries and Hanley, 2016)

Mitani and Lindhjem (2015) group the literature on participation into two different methodological approaches. The first applies information about forest owners' actual or stated participation in existing programs and investigate the link between participation choice and forest and owner characteristics. The second method applies stated participation in a hypothetical program. Several studies have applied stated choice methods to analyse land owners motivations for entering into existing voluntary environmental payment contracts (Broch et al., 2013; Langpap, 2004; Layton and Siikamäki, 2009; Matta et al., 2009; Nagubadi et al., 1996; Vedel et al., 2015). While showing promise in analysing the underlying forest owner motivations, the hypothetical nature of these surveys can result in responses that are strategic or in some way significantly different from actual behaviour (Arrow et al., 1993; Bateman et al., 2002; Champ and Bishop, 2001). This also includes that self-selection may be an issue, in that some potential participants would never answer to surveys. Mäntymaa et al. (2009) partially circumvent the hypothetical issue by combining survey information with revealed compensation claims and Gren and Carlsson (2012) explore determinants of actual payment information at the county-level in Sweden. They convincingly demonstrate the merits of applying revealed compared to stated choice methods. However, the error variance of stated and revealed data are often different, and stated choice models may be less noisy due to the more focused nature of the choice task (Adamowicz et al., 1994).

Following the same research direction, the aim of this study is to use data from one of the most prominent forest conservation schemes in Denmark, The Oak Scrub Conservation Scheme, to identify which land and forest owner attributes determine participation. High resolution spatial data on oak scrub provision, used by the regulator at the time of implementation, is merged with revealed contract data on participation in the conservation program, and with socioeconomic characteristics of the owner at parcel and individual forest owner level. The latter is based on extensive Danish Civil Registration System data on each forest owner, with unique information about each owner. Such data access to owner characteristics from credible official statistics combined with detailed spatial data on government reported qualitative characteristics of the oak scrub allows this study to directly link owner characteristics with the probability of participation in the voluntary conservation scheme and infer about the importance of how the regulator manages the program and provides information to the forest owners. We estimate the determinants of participation and analyse the role of forest owner, physical property characteristics and information flows, and find that all matter for the participation pattern. Since we do not rely on stated choice data, we can rule out any bias due to strategic or moral motivations for not answering in accordance with actual behaviour.

2 Forest owner participation

The literature on the adoption of conservation measures has mainly been limited to modelling the discrete participation choice of the landowner (Bell et al., 1994; Kauneckis and York, 2009; Kilgore et al., 2008; Langpap, 2004; Lynch and Lovell, 2003; Matta et al., 2009; Nagubadi et al., 1996). Siikamaki and Layton (2007) and Layton and Siikamaki (2009) extends the prediction of potential participation to also include intensity of enrolment in a beta-binomial model of Finnish forest owners, while the compensation claim expressed as WTA is studied for Norwegian forest owners in (Lindhjem and Mitani, 2012) and US forest owners in Matta et al. (2009). The willingness to sell is explored for US forest owners in LeVert et al. (2009).

Studies on landowner motives for owning and managing forest find increasing evidence that not all forest management decisions are made to maximize the economic return of the forest. Financial versus non-pecuniary motivations seems to differ across owner and parcel characteristics (Koontz, 2001), with small scale and family forest owners relatively more motivated to own and manage forest for non-pecuniary benefits such as aesthetics, nature protection, bequest, and privacy (Creighton et al., 2002; Gregory et al., 2003; Maes et al., 2012; Petucco et al., 2015; Urquhart et al., 2010; Urquhart and Courtney, 2011), compared to large scale owners. Furthermore, hunting may impose a direct economic profit if not a motive itself for ownership (Meilby et al., 2006; Urquhart and Courtney, 2011). These results are supported by an examination of Danish forest owners. Boon (2003) finds that small-scale forest holders have a high emphasis on the aesthetic, recreational and nature values of their landholdings. Larger forest owner also ranked these as valuable, but placed more importance on the income and investment opportunities in owning forest. The bequest value of the forest within the family as well as possibilities for hunting either for recreational purpose or as a source of income is likewise of high interest for larger forest owners. Mitani and Lindhjem (2015) find in a related study that Norwegian nonindustrial private forest owners motivations to participate in a voluntary conservation program also depend on expectations about additional income opportunities, positive environmental attitude, but decreases if they find conservation regulations are too strict. Assumed hypotheses on how property as well as owner characteristics are expected to influence participation are further elaborated in Section 5.

Most studies have used data from questionnaires and mail surveys to the landowners asking them about their management objectives and preferences as well as property and sociodemographic characteristics to analyse their choice of whether or not to adopt conservation methods (Boon, 2003; Boon et al., 2004; Karppinen, 1998). Being able to couple survey data of motives to landowner and property attributes may leave the researcher relatively well informed about the property in question. On the downside such methodology is embedded with issues of self-selection, response rate, and probably most importantly, hypothetical bias (as also seen in the environmental valuation literature).

Two recent studies deviate from the path of using stated choice and instead focus on the revealed choices of landowners. Gren and Carlsson (2012) examine the determinants of payments accepted by Swedish forest owners in mandatory and voluntary biodiversity agreements. A county-level annual panel data set on payments and area of conserved land under the two agreements is combined with approximations for the ecological productivity, value of forest land, non-forest income, environmental preferences, climate, area of protected forest and forest land, as well as learning. Payments are found to increase in the size of the protected areas and decrease with spatial auto-correlation, indicating that there is a learning effect from cooperation between regions that may lead to lower cost of biodiversity management and ultimately lower payments. Mäntymaa et al. (2009) combines revealed choice with survey data to examine the participation choice and compensation claims for a fixed term forest conservation program in Finland. The study was based on pilot project data describing the physical characteristics of offered forest stands for protection, combined with survey data regarding forest owner attitudes, demographics, and aims for forest management. Results indicate that voluntary conservation should target forest owners who emphasize financial investment as a motive for forest ownership, have positive attitudes towards nature conservation, or own large areas of forest property.

The current study adds to the existing literature by exploring actual participation choice data at property scale level combined with detailed public records of socioeconomic data on forest owners and detailed information on the location, size and quality of the oak scrub parcels. Comprehensive data on forest owner behaviour may hold potential for improved targeting of conservation actions and implementation of future conservation policies.

3 The oak scrub program

To examine actual participation choices made by Danish forest owners, the *Oak scrub* conservation program which was implemented by the Danish Forest and Nature Agency (now named the Danish Nature Agency, DNA) is studied between 1998 and 2008. The first agreements were signed with forest owners in 1998. Oak scrubs are thought to be remnants of the primeval forest in Denmark and today cover approximately 5000 ha (Fig. 1).

It is a naturally regenerated forest containing native tree species, mainly dominated by oak (both *Quercus petraea* Liebl. and *Quercus robur* L.) and mixed with aspen (*Populus tremoloides* Michx.) and birch (*Betula pubescens* Ehrh. and *Betula Pendula* Roth). Oak scrubs are usually found on poor soils and constitute a relative unproductive forest habitat type. Over the years many of the scrub areas have been marked by grazing, coppice and the tear of wind and frost, causing the tree height to be relatively low, and trees to appear bendy and crooked. Oak scrubs represent not only a unique niche for biodiversity but also aesthetic and cultural heritage values.

In principle oak scrubs are protected by the Danish Forest Act of 1989, stating that *"oak scrub are protected and must remain as oak scrubs"*. The law is however somewhat unclear on what this entails, and no active management requirements are enforced. To ensure better protection of the oak scrubs in general and determine which areas were worthy of conservation, the Danish Nature Agency (DNA), in the late 1990s, undertook a geographical registration and monitoring of all oak scrubs areas. Local forest district officers inspected forest properties holding oak scrub areas. For each oak scrub area different characteristics (height, age, degree of crookedness, intermix of non-native trees, landscape and aesthetic value and flora of the forest floor) were recorded. Additionally, two composite measures describing the threat level and the quality of the oak scrub areas were created and scored an integer value between 1 and 3, where 1 and 3 represent the lowest and highest quality and threat level, respectively. Oak scrub areas with a quality score of 1 were deemed unworthy of conservation.[1,2] A total of 445 distinct oak scrubs were registered, of which 428 were deemed worthy of conservation.[3] Around 1700 ha were already protected through earlier conservation agreements and public ownership, while the rest was unprotected and located on private land.[4]

To support private owners in conserving the remaining area, all owners of oak scrub deemed worthy of conservation were contacted via mail by the local DNA district and offered an easement contract wherein the oak scrub would be protected permanently by judicial registration. In accepting the agreement, the owner returned a signed declaration to the local DNA district. Questions and requests in terms of compensation levels and new inspection of the area were directed to the local DNA district. However compensation levels were kept within pre-defined standard payments (between 1000–10000 DKK per hectare).[5] The highest payments were only provided in cases where the stand consisted of larger and valuable trees, e.g. on more rich soils. Any payments resulting from negotiations were within this range. Unfortunately data on start offer and the process was not available. The data shows when an owner accepted the contract and the compensation paid. Hence, this does not allow us to consider a more dynamic modelling approach including e.g. information about the numbers of years where a forest owner declines to enrol and then decide to enrol. According to interviews with the forest officers the roof of standard payments were decided centrally by the DNA. We assume that the value of waiting was small–i.e. there were no indication at the time if payments would increase in the future at a later point. Further it is not possible to renegotiate the contract. We are not able to distinguish between the characteristics of the forest owners who made a decision about not to participate, and those who ignored the choice. This is a trade-off when using revealed data compared to stated ones where you can ask follow-up questions. Finally, data on compensation levels offered to non-participants which showed interest but refused at the end was not available.

The goal of the program was to enrol all oak scrubs worthy of conservation that were not already protected. As such there was no explicit targeting goal or budget constraint faced by the local districts of the DNA and all owners of conservation worthy areas were contacted. When a contract was signed the oak scrub should be infinitely maintained as oak scrub but allowing naturally regenerated tree species, e.g. birch, aspen, lime tree and junipers, which are characteristically for this habitat. Alien tree species must be removed. All costs are incurred by the forest owner, who may in some years be able to apply for subsidies to remove alien tree species. We did not have access to data on subsequent subsidies which the owner may have received for managing the oak scrubs. If the owner wishes to harvest the stand and regenerate it, only reproductive material (seed, seedlings, and plants) from the same oak scrub stand or the material should origin from other local and nearby registered oak scrub forests. Use of other reproductive material requires the approval of the Danish Nature Agency. Further, the owner is not allowed to apply fertilizers, herbicides or insecticides, or soil preparation. Overall this means that if the owner enrols the oak scrub program the owner can still harvest the stand, but is most likely facing management costs since the owner cannot change tree species, most likely use more expensive and potentially less productive reproductive material, and the owner needs to manage alien species. The owner is allowed to apply certified products or fencing to reduce browsing. Hunting is not restricted, and the owner can apply for permission to allow cattle grazing in the forest area. Permission is needed if the owner wants to set the oak scrub aside as untouched forest reserve with no management. These requirements are amended to the private land registration. If the forest owner does not comply with the management requirements the entire payment needs to be returned, the owner will receive a fine, and may risk to be excluded from receiving any future forest subsidies.

[1] In the original data the ranking of quality goes from 3 to 1, with 1 representing the most valuable oak scrubs. For ease of interpretation the scale has been flipped here.

[2] The main requirements for a worthy oaks scrub are that the area covered should be larger than 0.5 ha, be comprised mainly of native, naturally regenerated tree species, especially oak, and show signs of exposure to e.g. grazing, coppice, frost and wind conditions.

[3] A total of 454 oak scrubs are in the data, but not all have a complete registration, and are therefore omitted.

[4] Note that there is a discrepancy on how much area was already conserved before the program was initiated. The difference is approximately 500 ha between the 2.200 ha of scrub area mentioned in publicly available DNA information (Danish Forest and Nature Agency, 2001) and the 1.700 ha of registered oak scrub data provided to the researchers from the DNA (1.700).

[5] 1 EURO equals approximately 7.4 DKK.

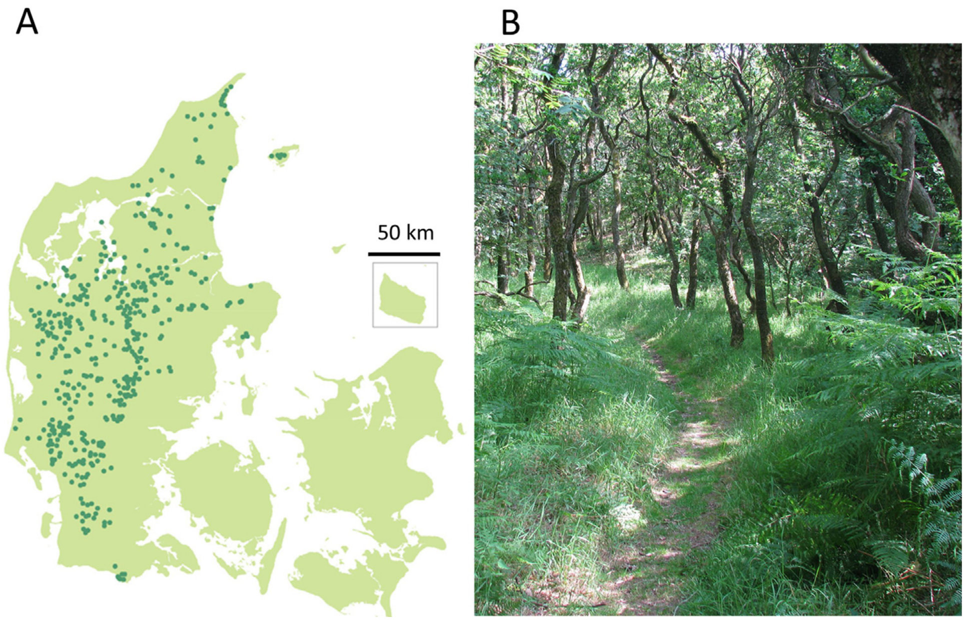

Fig. 1. Geographical location of oak scrubs in Denmark (A) (sources: © Jørgen Strunge/Naturen i Danmark). They are primarily located in the Western part of Denmark, the peninsula Jutland. Oak scrubs are remnants of the primeval forests and hosts important cultural and biodiversity values (B) (photo: www.skive.dk).

Table 1
Distribution of per ha compensation and area.

Variable	Min	1st	Median	Mean	3rd	Max
Compensation (DKK/ha)	1018.75	3500	8000	7046.4	8000	10000
Area (ha)	0.1	0.7	1.7	3.18	4.1	50.4

Note: Compensation per ha is in current prices for the given year they were granted.

Depending on the characteristics of the oak scrub, owners were paid an individually set up-front compensation between 1.000–8.000 DKK per ha (in special cases up to 10.000 DKK per ha). 719 compensations where granted during the years 1998–2008, to 701 distinct properties enrolling approximately 2285.5 ha of oak scrub. The average per ha compensation rate was approximately 7.000 DKK, with most properties receiving a rate of 8.000 DKK per ha. The size of the oak scrubs enrolled varied widely from 0.1 ha to 50.4 ha, averaging around 3 ha (see Tables 1 and 2 for further descriptive statistics and information on the timing of the enrolment). It was reported by the DNA that close to 100 per cent of the oak scrub owned by a forest owner was enrolled in each contract.

4 Model

The behaviour of the forest owners is modelled assuming utility-maximization. We present a simple model of forest owner's decision to participate in the oak scrub program, which follow Langpap (2004) and Mitani and Lindhjem (2015). We assume that the forest owner maximizes the present discounted value of the stream of expected utility from the forest land. We treat the data as cross-sectional, and therefore we assume the choice of the forest owner is a one-time decision. Notice that this is as opposed to Langpap (2004) and Mitani and Lindhjem (2015) who explicitly model when to enter the contract. Furthermore, our model differs in that we categorize the variables into physical, socio-demographic and incentive and information variables. The forest owner can choose between two actions: participation ($q = 1$) and non-participation ($q = 0$). Forest owner i's utility, U_i, consists of the present value of pecuniary as well as non-pecuniary benefits provided by the forest, see e.g. Beach et al. (2005). This may include privately gained utility from revenue, R_i, generated by timber or firewood, revenue or utility from non-timber forest products, W_i, and non-consumptive values, S_i. If he enters a contract, he may furthermore obtain a utility of the information and potential compensation obtained, I_i. R_i, W_i, and S_i and may depend on the physical characteristics of a property, p_i, and the socio-demographic characteristics of the owner $s_{i.}$ The specific variables of p_i and s_i are described in details in Section 5.2. I_i also depends on p_i and s_i but may further be affected by incentive and information campaigns, $c_{i.}$ We do not model the decisions of the DNA explicitly. Since the participation choice of the forest owner is essentially a two-step procedure, in which the effort undertaken by the DNA in informing about the program and encouraging participation comprises the first step, and the forest owner's own decision the second step, we include in c_i a variable to capture any spatial clustering of accepted contrasts within DNA forest district j. The hypothesis is that if there is a spatial effect of districts, it may indicate that more consultancy

Table 2
Number of agreements, conservation area and compensations signed annually in the period 1998–2008. Note that no data was available for 1999.

	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008
Number of agreements	1	77	124	100	170	81	24	84	54	4
Share (%)	0.14	10.71	17.25	13.91	23.64	11.27	3.34	11.68	7.51	0.56
Area (ha)										
- Mean	4	3.87	3.86	3.78	2.55	2.21	2.62	3.50	2.41	6.65
- Median	4	1.9	2.3	2.2	1.5	1.5	1.5	1.9	1.55	2.3
Compensation (DKK/ha)										
- Mean	1250	7467	7397	6498	7530	7683	6916	5790	6277	7351
- Median	1250	8000	8000	7000	8000	8000	7668	5000	5872	7452

effort and information has been successful in making DNA convince forest owners to enrol. The value of information and incentive campaigns may also be affected by whether any neighbours to forest owner i have already signed.

Letting V_i denote the present value of the forest owner's future utility, he chooses the action q which maximises V_i:

$$V_i = max_q (1-q)\left[R_i(\mathrm{p}_i, \boldsymbol{s}_i) + W_i(\mathrm{p}_i, \boldsymbol{s}_i) + S_i(\mathrm{p}_i, \boldsymbol{s}_i)\right] \\ +\mathrm{q}\left[W_i(\mathrm{p}_i, \boldsymbol{s}_i) + S_i(\mathrm{p}_i, \boldsymbol{s}_i) + I_i(\mathrm{p}_i, \boldsymbol{s}_i, \boldsymbol{c}_i)\right] \quad (1)$$

Notice, that while entering the contracts means that revenue is lost, the forest owner may still obtain non-timber benefits and non-consumptive benefits.

The forest owner's utility in the two states is not observed. However, by using the random utility framework (McFadden, 1974) we may describe the utility of landowner i as $V_i^q = \boldsymbol{x}_i\boldsymbol{\beta} + \varepsilon_i$ which constitute both an observable and an unobservable part. Here $\boldsymbol{x}_i$ is a vector of the variables p_i,s_i,c_i, affecting utility components R_i,W_i,S_i and I_i and $\boldsymbol{\beta}$ is a vector of corresponding parameters. If the forest owner has a well-defined utility function he/she will choose participation when $V_i^1 > V_i^0$ and non-participation when $V_i^1 < V_i^0$, and hence the observed choice between the two reveals which of the alternatives provides the greater utility. Thus the probability of observing of participation ($q = 1$) can be written as: $Prob(V_i^1 > V_i^0) = Prob(\boldsymbol{\beta}^{1'}\boldsymbol{x}_i + \varepsilon_i^1 > \boldsymbol{\beta}^{0'}\boldsymbol{x}_i + \varepsilon_i^0) = Prob(\varepsilon_i^1 - \varepsilon_i^0 > \boldsymbol{\beta}^{0'}\boldsymbol{x}_i - \boldsymbol{\beta}^{1'}\boldsymbol{x}_i)$ (Mitani and Lindhjem, 2015). We assume $\varepsilon_i^1 - \varepsilon_i^0$ follows a normal distribution and a probit model can be used for the estimation (Greene, 2011; Mitani and Lindhjem, 2015).

5 Data

5.1 Data sources

The data for the analysis was compiled by combining GIS information of actual participation data with detailed longitudinal socioeconomic information about the owners of the properties holding assessed scrub areas. The data was primarily collected through the DNA and Statistics Denmark (SD). The DNA delivered 3 sets of data:

1) A GIS layer containing all registered and eligible oak scrub areas. This ensured that participating forest owners were only compared to forest owners also eligible for the *Oak scrub* program. In addition the layer contained information on physical and aesthetic characteristics, quality and threat levels for each oak scrub area, see Section 3, as well as information on size, level of protection and share of public ownership. Similar information was used by the DNA when implementing the *Oaks scrub* program to determine which owners where eligible for compensation.
2) A dataset contained contract information on properties enrolled in the program, compensation size, and size and year of the enrolled area.
3) A georeferenced biodiversity data set consisting of 190 plants, 20 bird, 312 fungi and 71 insect species, which was applied as a proxy of the biodiversity richness of a given property.

The real property number is used as the identifier for the analysis. Since the GIS layer of all oak scrubs was identified by an oak scrub number and not the real property number, it was necessary to merge these data with a layer of all cadastral units in Denmark containing information on the associated real property number. Such a layer was provided for 2009 from the National Survey and Cadastre of Denmark (now named Danish Geodata Agency, DGA), and all owners were assigned a participation dummy variable ($q = 1$ in case of participation and otherwise $q = 0$).[6]

Finally, to gather socioeconomic information on the owners, the compiled data from the DNA and DGA was merged with individual-level longitudinal register data from SD in the period 1998-2008. A link between the property number and individuals was formed using an owner register also from SD from the period 1998–2008, such that information on each owner eligible for the program, their property characteristics and socioeconomic information was known. The data is a mix of longitudinal socioeconomic information and cross-sectional physical attributes. To deal with this, owners who participated in the program are merged with the corresponding socioeconomic information for the year that they agreed to participate in the scheme. For owners who did not participate we use the average of their socioeconomic information over the full period that they are in the sample. Further, for properties with more than one owner a representative owner is randomly sampled once, so that each participation choice is analysed for only one owner per property.[7] Some problems arise in the compilation process, causing the data analysed to contain slightly different numbers from what is described in Section 3. These arise as a consequence of data imprecision and different registration units of the contract (property level) and registration layer of oak scrubs (oak scrub level), hindering linkage of all contracts to the corresponding oak scrubs and effectively reducing our contract sample. Similar uncertainties prevail when connecting properties to their owners, and as a consequence, out of the initial 2041 potential scrubs we end up with a sample for estimation that covers the years 2000–2008, with 737 observations, distributed on 374 participants and 363 non-participants, representing approximately 2.000 ha of oak scrub eligible for the program.

5.2 Description of variables

The variables for p_i, s_i, and c_i are chosen based on theoretical considerations and previous empirical findings (see Section 2) as well as data availability. Table 3 shows the descriptive statistics for all owners, participants, and non-participants as well as which parameter in equation 1 it is hypothesized to affect and the expected sign of the parameter.

5.2.1 Physical characteristics

To capture the physical characteristics of the oak scrub in question we include variables on the size (AREA) and productivity of the area (PROD), the assessment scores of threat (THREAT) and quality (QUALITY) levels, biodiversity richness (SPECIES), and hunting potentials (HUNTING).

The variable AREA is calculated as the total area (ha) of oak scrub on the property. Although oak scrubs generally represent low economic use values compared to other forest land uses, the area may still provide the owner with some income related assets, e.g. fire wood and to a lesser extend timber. Since the oak scrub program in practice places no new restrictions on the management of these assets and there are economies of scale benefits from enrolling larger areas, due to assumed fixed transaction costs of participation, we expect the likelihood of participation to increase with larger areas. Larger areas are also more likely to include more ecological

[6] Changes in the property lines of forest properties tend to be relatively infrequent. Consequently, using cadastral information from a single year may be a good alternative to the computational heavy use of cadastral information for every year.

[7] Other sampling strategies were also examined when the property was owned by more than one owner. E.g. selecting the oldest owner or an owner with an agricultural education or who is working in the agricultural sector. The different sampling strategies did not impact the overall results (results not included).

Table 3
Variable description and descriptive statistics.

Parameter affected in eq. 1				All owners N = 737		Participants N = 374		Non-Participants N = 363	
	Exp. sign	Variable	Description	Mean	Std.dev	Mean	Std.dev	Mean	Std.dev
		PARTICIPANT	1=participation, 0=otherwise	0.51	0.50	1	0	0	0
		Physical attributes, p_i							
R_i	+	AREA	Oak scrub area on property (ha)	2.59	3.29	3.18	3.57	1.98	2.86
R_i	–	PROD	Area belongs to high production class = 1; else = 0	0.09	0.29	0.09	0.28	0.10	0.30
S_i,I_i	+	THREAT	Registered threat to the oak scrub (1-3)	1.80	0.57	1.77	0.57	1.83	0.56
S_i,I_i	+	QUALITY	Registered quality of the oak scrub (1-3)	2.12	0.32	2.12	0.32	2.11	0.31
$S_i,(I_i)$	+/–	SPECIES	Number of unique indicator species on the property	0.95	1.82	0.95	1.80	0.96	1.84
$W_i,$	–	HUNTING	Number of hoofed game shot in the municipality	30.81	12.34	30.10	11.42	31.53	13.20
		Socioeconomic attributes, s_i							
R_i, W_i, I_i	+	AG-EDU	Agricultural education = 1; else = 0	0.24	0.43	0.24	0.42	0.22	0.41
R_i, W_i, I_i	+	AG-OCCUP	Agricultural occupation = 1; else = 0	0.71	0.45	0.56	0.50	0.85	0.35
R_i, W_i, S_i	+/–	CHILDREN	Children in the household under 18 = 1; else = 0	0.43	0.50	0.36	0.48	0.46	0.50
I_i	–	AGE	Age of owner	53.28	12.87	53.22	13.23	53.91	12.19
I_i	+/–	OWNERS	Number of owners of property	1.26	0.56	1.21	0.46	1.32	0.64
$S_i,$	+/–	RESIDENCE	Oak scrub and residence in the same municipality = 1; else 0	0.87	0.34	0.83	0.38	0.91	0.28
		Incentive and information attributes, i_i							
I_i	+	PDIST	Prioritized district by DNA = 1; else = 0	0.49	0.50	0.51	0.50	0.47	0.50
I_i	+	NEIGHBOUR	Share of neighbours who previously signed up for the oak scrub program	0.29	0.28	0.28	0.28	0.29	0.27

Note: Income was among others a variable that was omitted from the analysis as it was insignificant and correlated with other socio-economic attributes.

values. Depending on how this is incorporated into the compensation level larger areas may increase the likelihood of participation through an increased interest from the DNA, potentially increasing the compensation level, see Section 6.1.

PROD indicates that the oak scrub is present in an area that has the highest production class.[8] Higher production classes are related to increased profitability of the area, increased management (e.g. of alien species), and higher potential opportunity cost of placing permanent management restrictions on the area, and hence we expect a lower likelihood of participation.

The variables THREAT and QUALITY were assessed by the DNA as part of their national registration of the oak scrubs areas and are included as proxies of how well the local DNA district target their contracting. THREAT indicates how large the perceived threat of the oak scrub is. The THREAT assessment is primarily concerned with negative impacts of in-growth of alien species, flooding or eutrophication from neighbouring agricultural fields if they are present. The variable ranges from 1-3 where 3 indicates an area with the highest threat level and hence also the oak scrub areas with the highest risk of losing conservation values without protection and immediate conservation management. QUALITY indicates the perceived quality or conservation value of the oak scrub area, including its cultural and aesthetic values. The variable ranges from 2 to 3, where 3 are assigned to areas of highest quality.[9] Based on interviews with officers in the DNA we expect owners of relatively high quality and threat status to be of high priority for the DNA. This could be reflected in higher campaigning efforts targeting important land owners, as well as a potentially higher compensation. Both are expected to increase the likelihood of participation.

SPECIES measures the number of unique forest biodiversity indicator species (0-16 species) on the property. The indicator species are related to birds, fungi, insects and plants, which for some owners may represent a private value (e.g. bird watching and aesthetic values), while at the same time capturing the level of heterogeneity in the landscape. Although the variable is of high policy relevance, the data we used for specifying this variable was not available to the local DNA district at the time of contract negotiation, and only few forest owners are presumed to be able to identify important species. Therefore, we hypothesize that the variable SPECIES has no, or a positive effect on the probability of participation.

The variable HUNTING is measured as the number of hoofed games shot in a given municipality and is a proxy of the hunting potential in the area. Hunting accounts for more than half of the income from forest properties in Denmark (Lundhede et al., 2015). Aside from the production value of income from game meat and hunting leases, hunting mostly represent a non-consumption and recreational value for forest owners if it is not leased out to hunters. Despite the current contract is not restricting hunting rights, setting up conservation contracts may induce a fear of future restrictions on hunting and associate an opportunity cost with the contract (Kauneckis and York, 2009). As a consequence, we expect the likelihood of participation to be smaller in good hunting areas.

5.2.2 Forest owner characteristics

Attributes concerning the forest owner characteristics are AG-EDU, AG-OCCUP, CHILDREN, AGE, OWNERS and RESIDENCE.

AG-EDU and AG-OCCUP are dummies indicating whether the forest owner holds a degree related to forestry or agriculture as his highest level of education, or if the same person has his main occupation within these fields.[10] Owners holding an occupation or education within forestry or farming are thought to be bet-

[8] We use the production class for beach as a proxy for profitability of the area (Nord-Larsen et al., 2009). Three different production classes are present for the oak scrub. PROD is binary variable which takes the value 1 if the oak scrub area is geographically located in the highest production class, otherwise zero.

[9] If there is more than one oak scrub on the property, the threat and quality variables are calculated as an area weighted average.

[10] Agriculture and forestry is defined broadly to include education and occupations related to all aspects of agriculture and forestry such that aside from the more technical functions, consulting etc. is also included.

ter informed about the available conservation programs, be more actively engaged in the land management, be better to identify ecological values and take advantage of the economic opportunities on the property, as well as incur less transaction costs related to understanding and coping with the requirements of an environmental program. Both dummies are expected to have a positive impact on the likelihood of participation.

CHILDREN is a dummy taking value 1 if there are children under the age of 18 in the household of the forest owner. The variable is included to capture bequest motivations. Participation can be a way of securing the land, but can also be seen as a restriction for future generations (Miller et al., 2010). Thus the expected sign of the variable is ambiguous. AGE indicates the age of the representative person in the household. We generally expect younger owners to be more likely to participate in the program.

OWNERS indicate the number of owners (between 1 and 12) of the property. Depending on the organization of the owners, more owners could make it more difficult to agree on management decisions (increase in transaction costs of unanimous agreement), making it less likely that they participate. More owners could however also indicate that the property is not owned for production reasons, increasing the likelihood of participation, making the expected sign ambiguous.

RESIDENCE is included to proxy that owners living close by or on the property may better capture private non-pecuniary values, e.g. recreational or aesthetic values, from the protection of oak scrub areas. This corresponds to a general finding that recreational values are expected to increase by proximity between residence and the recreational site (Bateman et al., 2006; Campbell et al., 2013). Less participation could be expected if the residence value is compromised by further restrictions and governmental interference on the land. There we expect the sign of coefficient to be ambiguous. The variable is measured as a dummy indicating whether the oak scrub and residence of the forest owner is located in the same municipality.

5.2.3 Variables affecting campaigning and information provision

As mentioned in Section 4 the forest owners' participation choice could be influenced by implicit information targeting/campaigning from the local DNA district, which actively have been approaching owners and encouraged them to participate. Further, we contemplate that an additional information flow could occur within the local community between neighbouring forest owners. To capture such potential mechanisms we include two variables related to the information flow to the forest owner. PDIST is a dummy variable measuring whether the oak scrub is located in a top 5 district that generally has oak scrubs registered as having areas which are large, of high quality, and high threat.[11] We assume that the DNA has been more active in approaching forest owners in areas of high importance, and therefore forest owners could potentially have been subject to more campaigning and received more information than districts of less importance. Unfortunately no data on campaigning intensity was available nor of the negotiation process of the contract. In any case the dummy variable captures potential unobserved differences across districts. Furthermore, areas of high importance may also receive relatively higher compensations. A second dummy NEIGHBOUR is included to try to capture the diffusion of experience and information related to the oak scrub program, and conservation programs in general, amongst the local community. The variable is formed as a spatial lag in participation, indicating the share of neighbours (excluding the forest owner in question) within a 1 km radius of the property's centroid that has entered the oak scrub program before the forest owner in question forms his participation choice.[12] Both dummy variables are expected to increase the likelihood of participation

Table 4
Regression analysis of compensation level and size, productivity, quality and threat levels of participating properties.

Variable	Coeff.	Std.
THREAT	382.30***	(113.3)
QUALITY	240.6	(197.7)
AREA	−19.18	(17.75)
PROD	−46.80	(227.1)
Constant	5079.6***	(464.2)
Observations	374	
R^2	0.038	

6 Results

6.1 Compensation and contracting

Aside from the contractual terms of a program, and the information processed to the forest owner, an important determinant of forest owner participation in conservation programs is the level of compensation received by the forest owner. The data only included information on the up-front compensations paid to the forest owners participating in the program and not the compensation levels offered to non-participating forest owners. Therefore the compensation level is not included directly in the model. Instead the variables THREAT, QUALITY, AREA, and PROD are applied as proxy variables that may have played a role in the contracting and determination of compensation. To examine a correlation between the conservation importance and compensation level a simple OLS regression was implemented (Table 4). Note that the regression is based on data on actual compensation paid per hectare, not land owned by non-participants. The compensation paid per area unit (ha) of protected land increases significantly with THREAT score (382 DKK per ha, respectively). There are no significant effects of area size, quality or productivity. This may indicate that THREAT has been an important parameter when negotiating the size of compensation.

6.2 Determinants of forest owner participation

The main model for the forest owners' participation choice is estimated using a probit model and the results and marginal effects for each of the significant variables are reported in Table 5. Other estimation strategies were also explored, however results of these did not differ substantially.[13] We took the log of AREA to reflect diminishing marginal participation effect, and it proved a better

[11] A total of 13 local forest districts were located in areas containing oak scrub at the time of the oak scrub registration process. The top 5 districts were defined as those with the highest average aggregate values of AREA, THREAT and QUALITY.

[12] To ensure that the learning process happens forward in time, not simultaneously, properties that have participated in the oak scrub program only count neighbours that have applied for participation in the program before their own application date. Since we do not observe the timing of the properties choosing non-participation, no distinction is made between them and all participating neighbours are counted.

[13] The model was also estimated using a RE panel and RE Chamberlain approach to allow for the possibility of heterogeneity not captured in the included variables. However, the panel structure is in any case questionable since we have no data on the timing of active non-participation decisions. Further a heteroskedastic version was estimated, with the heterogeneity represented by AG-EDU, AG-OCCUP, CHILDREN, AGE and RESIDENCE. The model reported no signs of heteroskedasticity. A two-stage Heckman model was also applied for testing if not only the participation choice but also the intensity of enrolment. Since most properties enrolled with close to a 100 pct. of their oak scrub area the model was discarded (of the owners to enter contracts, 90% of the area is contracted for. Finally, a logit model was also tested, which

Table 5
Probit regression of participation and physical, socio-economic and information proxy variables.

	Parameter estimates		Marginal effects
Variable	Coeff.	Std.	Coeff.
Physical attributes			
log(AREA)	0.358***	(0.0464)	0.00113
PROD	−0.140	(0.183)	
THREAT	−0.115	(0.101)	
QUALITY	−0.000648	(0.169)	
SPECIES	−0.0788**	(0.0291)	-0.0250
HUNTING	−0.00883	(0.00485)	
Socioeconomic attributes			
AG-EDU	−0.217	(0.139)	
AG-OCCUP	−1.085***	(0.124)	-0.353
CHILDREN	−0.464***	(0.135)	−0.147
AGE	−0.0252***	(0.00548)	−0.00797
OWNERS	−0.287**	(0.101)	−0.0907
RESIDENCE	−0.527**	(0.165)	−0.166
Information and campaigning			
PDIST	0.466***	(0.118)	0.145
NEIGHBOUR	−0.0110	(0.184)	
CONSTANT	3.446***	(0.582)	
Observations	737		
Pseudo R^2	0.193		
Log-likelihood	−412.16		

fit to data than a linear specification. From Table 5 we see that while log(AREA) and SPECIES are the only significant physical characteristics, the model suggests a strong influence of heterogeneous forest owner characteristics on the participation choice. Most forest owner characteristics included are highly significant and have a negative impact on the participation choice. The significant negative result for SPECIES and AG-OCCUP are unexpected. The local DNA district had no access to information on SPECIES at the time of contracting and mainly relied on the assessment scores related to the size, quality and threat level of the scrub areas. This indicates that such strategy may be counterproductive in terms of protecting species richness. We would expect occupation within forestry or agriculture to positively affect the likelihood of participation in voluntary conservation programs. Likewise we would expect higher participation among well-educated forest owners as they may be more familiar with voluntary environmental schemes and hold a higher capacity to engage them self. Among the two remaining information variables, only PDIST is significant and with the expected positive sign. No significant neighbour effect was found in the data. Overall the results suggest that a relatively younger single owner of a large oak scrub, inhabiting few indicator species, with an occupation outside of forestry and agriculture, with no children in the household, residing away from the oak scrub, who has been prioritized by the local district office of the DNA will be relatively more likely to enrol in the program.

A model of fit was run to identify if the model presents a reasonable prediction of the actual participation choice. 70% of the observations are correctly classified with almost the same ability to predict non-participation (71.6%) compared to participants (68.7%).

Since the longitudinal socioeconomic information on forest owners is not generally available to the public, and the task of linking these to contract information and physical attributes is relatively cumbersome, we test whether a model focusing only on physical characteristics performs equally well as the full model, thus testing H0: AG-EDU = AG-OCCUP = CHILDREN = AGE = OWNERS = RESIDENCE = PDIST = NEIGHBOUR=0 in a likelihood ratio test. The hypothesis is rejected at a 1% significance level.

To look further into the effects of the explanatory variables on the probability of participation we calculate the average marginal effects for the significant variables and the impact on the expected area enrolled in the program of changing PDIST. The marginal effects should be interpreted as a percentage point (pps) change in the probability of participation for a unit increase in the explanatory variables.[14] Since dummy variables only take on values of either 0 or 1 this corresponds to comparing the pps change in going from the reference group to the alternative in case of the PDIST as being in a prioritized district compared to a non-prioritized district. This has the advantage that the size of the marginal effects of dummies can be directly compared, as opposed to the marginal effects for continuous variables that only make sense interpreting against the scale and units of the given variable.

Increasing the log(area) of the oak scrub with 1 unit, increases the participation probability with 0.11 pps, while an increase in the number of indicator species decrease the participation probability with 2.5 pps. Putting this into context, an owner of 11 ha of oak scrub has a 0.11 pps higher likelihood of participation than an owner of 1 ha of oak scrub. Likewise increasing the number of indicator species on a property from 1 to 5 would decrease the participation probability with only 10 pps. In terms of forest owner characteristics the biggest influence on the participation is whether or not the owner is employed within forestry or agriculture. We observe a decrease in the likelihood of participation of 35.3 pps if he is occupied within these sectors. The influence of children and having residence in the municipality of the oak scrub causes about half the decrease in the likelihood of participation compared to occupation, with a 14.7 pps decrease for CHILDREN and 16.6 pps for RESIDENCE. A unit increase in the number of owners of a property causes a drop in the likelihood of participation by 9.1 pps, while increasing the age of the owner by a decade reduces the probability by 8 pps. Finally, being in a prioritized district increases the likelihood of participation by 14.5 pps. This variable is of considerable policy interest, as it is the only factor where the DNA is really in control and may directly affect participation. PDIST was formed to qualify in which districts the DNA may likely have asserted more effort in securing participation. By examining the aggregate share of participation, and the corresponding expected area enrolled in the program, we can evaluate how big a change in participation can be brought about, through prioritization of the DNA, without explicitly targeting the heterogeneity in the forest owner characteristics.

The aggregate participation share is calculated as the average predicted participation probability. The share of participating forest owners in the estimation sample of 737 forest owners is 50.72 per cent (374 forest owners). The aggregate share when no forest owners are prioritized is 43.64 (322 forest owners), while the aggregate share when all forest owners participate is 58.18 or 429 forest owners. With no districts prioritized the expected enrolment is 1092 ha, which increases to an expected area of 1369 ha if all districts are prioritized. As is evident from both the aggregate participation share and the expected areas enrolled, the effect of changing PDIST is relatively minor compared to the option of explicitly targeting the socioeconomic and physical characteristics of the owner.

7 Concluding discussion

This study uses a standard framework for analysing the revealed participation choice of private forest owners in the voluntary Danish Oak Scrub Conservation Scheme. We find that both the physical

confirmed the results from the probit model. The estimated coefficients differed but the marginal effects were almost similar.

[14] For log(AREA) the unit increase is estimated per 1% change in the size of the area.

characteristics of the property and the socio-demography of forest owner in question matter, along with potential indications of an information flow provided from the Danish Nature Agency. Further, we find that predicting forest owner behaviour based merely on a model with physical characteristics is inadequate.

7.1 Owner and land characteristics matters for participation

In terms of characterizing specific owner types that are more inclined to enter into voluntary nature conservation agreements, we find strong empirical support that AG-OCCUP, CHILDREN, AGE, OWNERS and RESIDENCE all decrease the likelihood of participation. The negative coefficient on AG-OCCUP is somewhat contrary to the expectation and findings from previous literature. Forest owners occupied within forestry and agriculture are thought to be more actively engaged in land management decision, and better prepared to take advantage of the economic opportunities on the land (Bell et al., 1994; Koontz, 2001; Layton and Siikamäki, 2009; Matta et al., 2009; McLean-Meyinsse et al., 1994). The result may however reflect a dis-utility of placing a permanent management restriction on the land, stemming from a general dislike of external regulator sources restricting land management choices and/or a perceived loss in market value, compared to the relatively low compensation offered. This interpretation receives some support through the negative coefficient of CHILDREN indicating that bequest based option value considerations also reduces the forest owners willingness to engage in voluntary conservation and through the negative impact on being resident in the same municipality as the oak scrub (Kabii and Horwitz, 2006; Siebert et al., 2006). Other studies on national voluntary conservation programs in Scandinavia have found similar results. Mitani and Lindhjem (2015) found that participation decreased with age and if the owner thinks regulation is too strict. Further, they found that participation decreased with how high the owner assesses the economic importance of timber. In the current study, economic return is expected to be of less importance. Oak scrub is slow growing and has little production potential. Consequently, it is less surprising that the proxy for foregone profit, PROD, is not significant. It is possible though, more detailed information on management cost and foregone profit of not growing more profitable tree species would affect this result. Unfortunately, we did not have access to such data. We would expect participation to decrease with increasing management cost and foregone profit. However, it is left for future studies to investigate such effects on participation. Aside from production related impacts of placing restrictions on the land use, many forest owners perceive their own options for use of the land for recreational purposes as important (Boon et al., 2004). Broch and Vedel (2012) find a reduction in compensation claims for afforestation if there is a withdrawing option in the contract. Placing a permanent restriction on the land reduces this option value, especially if there is uncertainty about future regulation, and what that might entail (Thorsen, 1999).

The variable AREA is the only physical variable found to have a large marginal effect on the likelihood of participation. From the forest owners' perspective, the enrolment of larger areas may impose relatively lower transaction costs per ha on the owner. On the other hand, the DNA may also have been more eager to secure larger scrub areas since they may represent relatively larger cultural and ecological values and smaller administration cost per area unit compared to smaller scrub areas.

7.2 Targeting of conservation values

We find that the *Oak scrub* program has been successful in engaging owners of large oak scrubs, but less successful in securing oak scrubs that may be small, but are of high value and threat. Transaction costs may have been a prohibitive factor. If there is a wish to protect these areas, the DNA should consider either lowering the administrative burden associated with participation or increase the compensation level to overcome transaction costs and make participation worthwhile for the owners. Further, an often used argument in the Danish nature conservation context, as seen in relation to the governmental green growth strategy in 2009, is that biodiversity will benefit from any increase in forest cover or forest protection. This study challenges that viewpoint. We find a decrease in the likelihood of participation for species rich properties, implicitly suggesting that the *Oak Scrub* program does not directly support higher conservation of biodiversity and may even perform poorer than a random sample of forest owners. This raises a need for voluntary conservation schemes to explicitly target biodiversity rich areas, if biodiversity protection is the goal.

This result is complemented by no significant relation between THREAT and QUALITY and the likelihood of forest owner participation. However, from regression results on negotiated compensation level and THREAT, QUALITY, PROD and AREA, see Table 4, it may be that THREAT has been important in determining how much compensation per ha the oak scrub was granted. With the level of compensation offered in the current program, this is not enough in itself to secure the protection of oak scrubs of high threat and quality. It is not evident from the analysis that the DNA has had emphasis on directly targeting oak scrub of high quality and threat other than through the compensation level and PDIST. The *Oak scrub* program studied here was unique in terms of the modest requirements imposed on the forest owner, the low compensation rate granted, and the lack of budget constraint and explicitly stated targeting of the DNA. As such the results shown here could be expected to alter if active management was imposed or the forest owner or the scheme became more economically attractive from the viewpoint of the forest owner. The revealed approach as well as the process decided by the DNA prohibited the inclusion of compensation data of non-participants in the analysis.

PDIST is also significant and quite large. It is the variable that the DNA most likely could influence directly and it is therefore potential useful for the future policy conservation policy design. However, despite its relatively large size the effect on the expected area enrolled in the program is expected to be relatively small. This indicates that increased success of participation cannot be achieved solely by the effort of the regulator. Rather the DNA would need to take into account a more comprehensive set of information sources. It is possible that an endogeneity problem exist in relation to the parameters THREAT, QUALITY and PDIST, as PDIST was purposely chosen to reflect areas of higher priority by the authorities, i.e. the better scrubs. If so, it would likely capture a non-linearity in the parameters THREAT and QUALITY. Reasons for such non-linearity are likely related to PDIST. So while we cannot rule out endogeneity, the results here still carry the information that regulation effort is likely to matter.

In terms of knowledge sharing between neighbours, the finding that NEIGHBOUR is insignificant indicates that local knowledge sharing is not important in framing the individual forest owners' participation choice for this program. This supports results from Frondel et al. (2012) but is in contrast with findings from Gren and Carlsson (2012) and LeVert et al. (2009), where the influence of learning from cooperation decreases compensation claims for voluntary conservation.

Our results demonstrate how observable characteristics on individuals physical and sociodemographic characteristics can help predict the likelihood of private forest owners' participation in voluntary conservation programs. The results can be used in different ways. Within the given contractual design, a more informed regulator may choose to target individuals specifically based on their physical characteristics and socio-demography, such that only owners of large areas with an occupation within forestry or agriculture are offered an easement contract, or a prioritized hierarchy of owners is created to indicate the order in which owners should be contacted. Alternatively, the regulator may modify the contractual design to target specific sociodemographic and physical characteristics of the affected owners and properties. While such approaches offer a direct implementation of our found results, ethical considerations are embedded, questioning the legitimacy of such an approach. It would be questionable to design contracts that favour e.g. owners with children or old people because they are more reluctant to go in; or vice versa to get a large area cost effectively. As a less rigid option, the information may be used to identify where to put an extra effort in the form of strengthening information provided to these owners of the importance of their oak scrubs if spatial connection of conserved area is needed. This is important as the need for spatially interconnected areas is often considered one of the main disadvantages of voluntary mechanisms. One owner choosing non-participation in a spatially integrated conservation network can hinder conservation. Another application of the results is to directly consider the spatial linkage between demand and supply as e.g. Broch et al. (2013). With the recent focus on spatial mapping of ecosystem services (Bateman et al., 2013; Maes et al., 2012) it may allow explicit consideration of the forest owners' preferences in providing information, contacting and designing contracts that ensure the participation of owners of crucial habitat in the conservation networks.

A basic premise for the success of voluntary programs is that private owners will support the initiatives through participation, and the locations ecosystems services are provided in, coincide with the highest societal demand. While this study to some extent has been able to infer about the prioritization of the DNA through access to registration data used by the DNA to implement the program, including information on QUALITY and THREAT, a natural extension in future research is to develop the link between demand and supply, and incorporate models of private forest owner participation into spatial optimization models. This would allow for a spatial analysis of whether the areas available to conservation is in fact also the areas where conservation is needed, and could help to illustrate the limitations of voluntary conservation on private land in establishing representative conservation networks. A few articles have cut the first turf on this (Guerrero et al., 2010; Knight et al., 2011; Vedel et al., 2015) but stay within the stated methodology and only examine willingness-to-sell.

Finally it should be noted that there are pros and cons of both revealed data and choice data approaches. Considered in a similar decision context the results of revealed and stated choice analysis may be similar (Carlsson and Martinsson, 2001). The current study also confirms the results from similar revealed as well as stated choice studies (Boon et al., 2010; Horne, 2006; Langpap, 2004; Mitani and Lindhjem, 2015). The stated choice data approaches are often criticized for being biased as they are measuring hypothetical actions. In settings like landowner participation, a particular emphasis can be on strategic answers and self-selection bias. Using revealed data typically involves data merging where observations are lost when data cannot be merged. When this is subject to systematic differences, it may cause selection bias. In our case, the reasons for the loss of data through merging, is expected to be uncorrelated with preferences and consequently not an issue. In stated choice studies, self-selection may be a large reason for differences to revealed studies. Consequently, selection bias may be present in both types of studies.

One main reason to use stated choice data is that revealed data from participation in implemented programs may be outside the range of data relevant for predicting participation in new programs where the decision context has changed (Adamowicz et al., 1994). Despite, the hypothetical nature of stated choice questionnaires you may be able to reveal non-use values or other types of values which are otherwise hard to observe. While the focus of these values is often discussed for public good provision, they may also have a private value (cf. discussion in Section 2 and in Boon, 2003). Nevertheless, one important limitation of stated choice data is that they reveal behavioural intentions, not actual behaviour.

7.3 Selection bias and perspectives for use of register data in future research

While the data foundation for this analysis included access to high resolution data at forest owner level, the data revealed some restrictions in linking the geographical information and contract data to the entire population of oak scrub owners. The final sample used for the estimation only represents about half the population of oak scrub owners. These missing data linkages may cause our sample to over-represent non-participants, as properties that may not contain oak scrub are counted as eligible for participation. This means that properties with conserved oak scrub areas in some cases are counted as non-participants. As a consequence, the group of non-participants may be more representative of the average forest owners in general, than the population of non-participant oak scrub owners. Although we avoid issues of self-selection, response rate and hypothetical bias by using revealed data, the approach forces us to rely on proxies for motivations, e.g. children is applied as proxy of the owner's bequest value. The data only includes information on number of children younger than 18 years who are part of the household. Defining the presence of children as children in the household, means effectively excluding any children who has moved away from home and are older than 18. This contrasts with simple logic which would suggest that these are relevant in the context of bequest motivations. Further we face limitations in imprecise knowledge on factors such as the timing of the participation decision and our knowledge of site specific information is limited to what is available through different GIS sources. More detailed information on the production value of the oak scrubs for each site to better assess the opportunity cost of participation would strengthen the analysis. These types of trade-offs can be difficult to avoid when estimating revealed choices due to the dependence on observable outputs that are available to planners. Likewise, revealed analysis is restricted to focus on already implemented instrumental design and program objectives. For areas with poor data registration and little variation in the implemented program, these challenges pose a major methodological restriction. The problems encountered in carrying out this analysis are likely to also be prevalent when examining other programs. This analysis benefits from having relatively precise information on the location of eligible non-participants. Such information is not commonly found, which could confound analysis for other programs and increase uncertainty in the over representation of non-participants.

The discovered issues of data compilation must be seen in the light of combining an array of different datasets, from different sources, that to a large extent was created for administrative purposes, not analysis and program evaluation. If however, this was to become a mainstay in planning, implementing and evaluating conservation efforts through voluntary private ecosystem supply, data would be actively used, and hence more actively managed, meriting optimism in terms of future use. We suggest that revealed data and potentially in combination with stated choice data could potentially be a cost-effective way to predict which forest owners to target in future conservation programs. With an increased focus in governmental bodies on evaluating the performance and participation in implemented voluntary conservation programs, we encourage the Danish Nature Agency and similar institutions in other countries to setup a coherent data registration strategy to enhance spatial targeting of conservation efforts. Further, it would contribute to an increased learning about private forest owners' motivations for conservation.

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References

Adamowicz, W., Louviere, J., Williams, M., 1994. Combining revealed and stated preference methods for valuing environmental amenities. J. Environ. Econ. Manage. 26, 271–292, http://dx.doi.org/10.1006/jeem.1994.1017.
Arrow, K., Solow, R., Portney, P.R., Leamer, E.E., Radner, R., Schuman, E.H., 1993. Report of the NOAA Panel on Contingent Valuation. Report to the General Counsel of the US National Oceanic and Atmospheric AdministrationResources for the Future, Washington D.C., U.S.A.
Bateman, I.J., Carson, R.T., Day, B., Hanemann, M., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Özdemirog–lu, E., Pearce, D.W., Sugden, R., Swanson, J., 2002. Economic Valuation with Stated Preference Techniques: a Manual. Edward Elgar Publishing, Cheltenham, UK.
Bateman, I.J., Day, B.H., Georgiou, S., Lake, I., 2006. The aggregation of environmental benefit values: welfare measures, distance decay and total WTP. Ecol. Econ. 60, 450–460, http://dx.doi.org/10.1016/j.ecolecon.2006.04.003.
Bateman, I.J., Harwood, A.R., Mace, G.M., Watson, R.T., Abson, D.J., Andrews, B., Binner, A., Crowe, A., Day, B.H., Dugdale, S., Fezzi, C., Foden, J., Hadley, D., Haines-Young, R., Hulme, M., Kontoleon, A., Lovett a, A., Munday, P., Pascual, U., Paterson, J., Perino, G., Sen, A., Siriwardena, G., van Soest, D., Termansen, M., 2013. Bringing ecosystem services into economic decision-making: land use in the United Kingdom. Science 341 (80), 45–50; 10.1126/science.1234379.
Beach, R.H., Pattanayak, S.K., Yang, J.-C., Murray, B.C., Abt, R.C., 2005. Econometric studies of non-industrial private forest management: a review and synthesis. For. Policy Econ. 7, 261–281, http://dx.doi.org/10.1016/S1389-9341(03)00065-0.
Bell, C.D., Roberts, R.K., English, B.C., Park, W.M., 1994. A logit analysis of participation in Tennessee's Forest Stewardship Program. J. Agric. Appl. Econ. 26, 463–472, http://dx.doi.org/10.1017/S1074070800026389.
Boon, T.E., 2003. Hvad mener de danske skovejere. Spørgeundersøgelse blandt private skovejere i Danmark. Skovbrugsserien nr. 33. Skov & Landskab, Miljøministeriet, Hørsholm, Denmark.
Boon, T.E., Broch, S.W., Meilby, H., 2010. How financial compensation changes forest owners' willingness to set aside productive forest areas for nature conservation in Denmark. Scand. J. For. Res. 25, 564–573, http://dx.doi.org/10.1080/02827581.2010.512875.
Boon, T.E., Meilby, H., Thorsen, B.J., 2004. an empirically based typology of private forest owners in Denmark: improving communication between authorities and owners. Scand. J. For. Res. 19, 45–55, http://dx.doi.org/10.1080/14004080410034056.
Broch, S.W., Strange, N., Jacobsen, J.B., Wilson, K.A., 2013. Farmers' willingness to provide ecosystem services and effects of their spatial distribution. Ecol. Econ. 92, 78–86, http://dx.doi.org/10.1016/j.ecolecon.2011.12.017.
Broch, S.W., Vedel, S.E., 2012. Using choice experiments to investigate the policy relevance of heterogeneity in farmer agri-environmental contract preferences. Environ. Resour. Econ. 51, 561–581, http://dx.doi.org/10.1007/s10640-011-9512-8.
Campbell, D., Vedel, S.E., Thorsen, B.J., Jacobsen, J.B., 2013. Heterogeneity in the WTP for recreational access: distributional aspects. J. Environ. Plan. Manag., 1–20, http://dx.doi.org/10.1080/09640568.2013.793173.
Carlsson, F., Martinsson, P., 2001. Do hypothetical and actual marginal willingness to pay differ in choice experiments? J. Environ Econ. Manage. 41, 179–192, http://dx.doi.org/10.1006/jeem.2000.1138.
Champ, P.A., Bishop, R.C., 2001. Donation payment mechanisms and contingent valuation: an empirical study of hypothetical bias. Environ. Resour. Econ. 19, 383–402, http://dx.doi.org/10.1023/A:1011604818385.
Creighton, J., Baumgartner, D., Blatner, K., 2002. Ecosystem management and nonindustrial private forest landowners in Washington State, USA. Small-Scale For. 1 (1), 55–69, http://dx.doi.org/10.1007/s11842-002-0005-z.
Danish Forest and Nature Agency, 2001. Den biologiske mangfoldighed i skove–status for indsats og initiativer. Danish Forest and Nature Agency, Ministry of Environment and Energy, Copenhagen, Denmark.
de Vries, F.P., Hanley, N., 2016. Incentive-based policy design for pollution control and biodiversity conservation: a review. Environ. Resour. Econ. 63, 687–702, http://dx.doi.org/10.1007/s10640-015-9996-8.
European Commission, 2015. EU Agriculture Spending Focused on Results [WWW Document] (Accessed 12 December 16) http://ec.europa.eu/agriculture/sites/agriculture/files/cap-funding/pdf/cap-spending-09-2015_en.pdf.
Frondel, M., Lehmann, P., Wätzold Frank, F., 2012. The impact of information on landowners' participation in voluntary conservation programs–theoretical considerations and empirical evidence from an agri-environment program in Saxony, Germany. Land Use Policy 29, 388–394.
Greene, W.H., 2011. Econometric Analysis. Prentice Hall, New Jersey.
Gregory, S.A., Christine Conway, M., Sullivan, J., 2003. Econometric analyses of nonindustrial forest landowners: Is there anything left to study? J. For Econ. 9, 137–164, http://dx.doi.org/10.1078/1104-6899-00028.
Gren, I.-M., Carlsson, M., 2012. Revealed payments for biodiversity protection in Swedish forests. For. Policy Econ. 23, 55–62, http://dx.doi.org/10.1016/j.forpol.2012.06.003.
Guerrero, A.M., Knight, A.T., Grantham, H.S., Cowling, R.M., Wilson, K.a., 2010. Predicting willingness-to-sell and its utility for assessing conservation opportunity for expanding protected area networks. Conserv. Lett. 3, 332–339, http://dx.doi.org/10.1111/j.1755-263X.2010.00116.x.
Hanley, N., Banerjee, S., Lennox, G.D., Armsworth, P.R., 2012. How should we incentivize private landowners to 'produce' more biodiversity? Oxford Rev Econ. Policy 28, 93–113, http://dx.doi.org/10.1093/oxrep/grs002.
Horne, P., 2006. Forest owners' acceptance of incentive based policy instruments in forest biodiversity conservation–a choice experiment based approach. Silva Fenn. 40, 169–178.
Kabii, T., Horwitz, P., 2006. A review of landholder motivations and determinants for participation in conservation covenanting programmes. Environ. Conserv. 33, 11–20, http://dx.doi.org/10.1017/S0376892906002761.
Karppinen, H., 1998. Values and objectives of non-industrial private forest owners in Finland. Silva Fenn. 32, 43–59.
Kauneckis, D., York, A.M., 2009. An empirical evaluation of private landowner participation in voluntary forest conservation programs. Environ. Manage. 44, 468–484.
Kilgore, M.A., Snyder, S.A., Schertz, J., Taff, S.J., 2008. What does it take to get family forest owners to enroll in a forest stewardship-type program? For Policy Econ. 10, 507–514, http://dx.doi.org/10.1016/j.forpol.2008.05.003.
Knight, A.T., Grantham, H.S., Smith, R.J., McGregor, G.K., Possingham, H.P., Cowling, R.M., 2011. Land managers' willingness-to-sell defines conservation opportunity for protected area expansion. Biol. Conserv. 144, 2623–2630, http://dx.doi.org/10.1016/j.biocon.2011.07.013.
Koontz, T.M., 2001. Money talks? But to whom? Financial versus nonmonetary motivations in land use decisions. Soc. Nat. Resour. 14, 51–65, http://dx.doi.org/10.1080/08941920117246.
Langpap, C., 2004. Conservation incentives programs for endangered species: an analysis of landowner participation. Land Econ. 80, 375–388, http://dx.doi.org/10.2307/3654727.
Layton, D.F., Siikamäki, J., 2009. Payments for ecosystem services programs: predicting landowner enrollment and opportunity cost using a beta-binomial model. Environ. Resour. Econ. 44, 415–439, http://dx.doi.org/10.1007/s10640-009-9293-5.
LeVert, M., Stevens, T., Kittredge, D., 2009. Willingness-to-sell conservation easements: a case study. J. For. Econ. 15, 261–275, http://dx.doi.org/10.1016/j.jfe.2009.02.001.
Lindhjem, H., Mitani, Y., 2012. Forest owners' willingness to accept compensation for voluntary conservation: a contingent valuation approach. J. For. Econ. 18, 290–302, http://dx.doi.org/10.1016/j.jfe.2012.06.004.
Lundhede, T.H., Jacobsen, J.B., Thorsen, B.J., 2015. A hedonic analysis of the complex hunting experience. J. For. Econ. 21, 51–66, http://dx.doi.org/10.1016/j.jfe.2015.01.001.
Lynch, L., Lovell, S.J., 2003. Combining spatial and survey data to explain participation in agricultural land reservation programs. Land Econ. 79, 259–276, http://dx.doi.org/10.2307/3146870.
Maes, J., Egoh, B., Willemen, L., Liquete, C., Vihervaara, P., Schägner, J.P., Grizzetti, B., Drakou, E.G., La Notte, A., Zulian, G., Bouraoui, F., Luisa Paracchini, M., Braat, L., Bidoglio, G., 2012. Mapping ecosystem services for policy support and decision making in the European Union. Ecosyst. Serv. 1, 31–39, http://dx.doi.org/10.1016/j.ecoser.2012.06.004.
Matta, J.R., Alavalapati, J.R.R., Mercer, D.E., 2009. Incentives for biodiversity conservation beyond the best management practices: are forestland owners interested? Land Econ. 85, 132–143, http://dx.doi.org/10.3368/le.85.1.132.
McFadden, D., 1974. The measurement of urban travel demand. J. Public Econ. 3, 303–328, http://dx.doi.org/10.1016/0047-2727(74)90003-6.
McLean-Meyinsse, P.E., Hui, J., Joseph, R., 1994. An empirical analysis of Louisiana small farmers' involvement in the conservation reserve program. J. Agric. Appl. Econ. 26, 379–385, http://dx.doi.org/10.1017/S1074070800026304.
Meilby, H., Strange, N., Jellesmark Thorsen, B., Helles, F., 2006. Determinants of hunting rental prices: a hedonic analysis. Scand. J. For. Res. 21, 63–72, http://dx.doi.org/10.1080/02827580500463813.
Miller, A.D., Bastian, C.T., McLeod, D.M., Keske, C.M., Hoag, D.L., 2010. Factors impacting agricultural landowners' willingness to enter into conservation easements: a case study. Soc. Nat. Resour. 24, 65–74, http://dx.doi.org/10.1080/08941920802684146.
Mitani, Y., Lindhjem, H., 2015. Forest owners' participation in voluntary biodiversity conservation: what does it take to forgo forestry for eternity? Land Econ. 91, 235–251.
Mäntymaa, E., Juutinen, A., Mönkkönen, M., Svento, R., 2009. Participation and compensation claims in voluntary forest conservation: a case of privately

owned forests in Finland. For. Policy Econ. 11, 498–507, http://dx.doi.org/10.1016/j.forpol.2009.05.007.
Nagubadi, V., McNamara, K., Hoover, W., 1996. Program participation behavior of nonindustrial forest landowners: a probit analysis. J. Agric. Appl. Econ. 2, 323–336.
Nord-Larsen, T., Johannsen, V.K., Vesterdal, L., Jørgensen, B.B., Bastrup-Birk, A., 2009. Skov og plantager 2008 [Forests and Plantations 2008]. University of Copenhagen, Faculty of Life Sciences, Skov & Landskab, Hørsholm.
Petucco, C., Abildtrup, J., Stenger, A., 2015. Influences of nonindustrial private forest landowners' management priorities on the timber harvest decision—a case study in France. J. For. Econ. 21, 152–166, http://dx.doi.org/10.1016/j.jfe.2015.07.001.
Siebert, R., Toogood, M., Knierim, A., 2006. Factors affecting european farmers' participation in biodiversity policies. Sociol. Ruralis 46, 318–340, http://dx.doi.org/10.1111/j.1467-9523.2006.00420.x.
Siikamaki, J., Layton, D.F., 2007. Potential cost-effectiveness of incentive payment programs for the protection of non-industrial private forests. Land Econ. 83, 539–560, http://dx.doi.org/10.3368/le.83.4.539.
Thorsen, B.J., 1999. Afforestation as a real option: some policy implications. For. Sci. 42, 171–178.
Urquhart, J., Courtney, P., 2011. Seeing the owner behind the trees: a typology of small-scale private woodland owners in England. For. Policy Econ. 13, 535–544, http://dx.doi.org/10.1016/j.forpol.2011.05.010.
Urquhart, J., Courtney, P., Slee, B., 2010. Private ownership and public good provision in English woodlands. Small-scale For. 9, 1–20, http://dx.doi.org/10.1007/s11842-009-9098-y.
Vedel, S.E., Jacobsen, J.B., Thorsen, B.J., 2015. Forest owners' willingness to accept contracts for ecosystem service provision is sensitive to additionality. Ecol. Econ. 113, 15–24, http://dx.doi.org/10.1016/j.ecolecon.2015.02.014.