Incentivising participation and spatial coordination in Payment for Ecosystem Service schemes: forest disease control programs in Finland.

Oleg Sheremet, Enni Ruokamo, Artti Juutinen, Rauli Svento, and Nick Hanley*

Abstract

This paper considers the problem of designing PES-type contracts to encourage participation and spatial coordination amongst private forest owners in Finland. The aim of the policy is to increase efforts to mitigate risks from invasive forest pests and diseases. Such control actions yield spill-over benefits to other landowners and to wider society, meaning that the level of privately-optimal disease control is likely to be less than the socially-optimal level. The policy designer may wish to encourage spatial coordination in the uptake of such PES-type contracts, as spatial coordination delivers an increase in the effectiveness of control measures on disease risks. We conducted a choice experiment with private forest owners in Finland in October 2016. The study elicited the preferences of woodland owners with respect to the design of forest disease control contracts, and gauged their willingness to cooperate with neighbouring forest owners within the framework of such programs.

Keywords: *choice experiment; Payments for Ecosystem Services; forest pests and diseases; disease control measures; spatial coordination.*

JEL classifications: *C35, Q23, Q57.*

*corresponding author. Email Nicholas.Hanley@glasgow.ac.uk.

1. Introduction

Invasive diseases are becoming more common world-wide, due to expansions in global trade, increasing specialisation of production, and climate change (Florec et al, 2013: Freer-Smith and Webber, 2015). For forests, invasive pests and diseases such as emerald ash borer, oak processionary moth, sudden oak death (*Phytophthora ramorum*) and red band needle blight (*Dothistroma septosporum)* are capable of greatly reducing the flow of benefits from ecosystem services such as timber production, recreation amenities and carbon sequestration (Boyd et al, 2013). In most cases, costly control actions are available which either reduce the risks of a disease arriving, or reduce its rate of spread or survival once arrived. These control action include for example thinning, clear-felling, public access restrictions (some diseases are spread by recreational users), and the spraying of biocides.

Where such pests and diseases (diseases, from now on) affect privately-owned land, it is likely that the extent of control actions which private landowners find it profitable to undertake are less than that which would be socially optimal. This is because such control actions, which incur costs to the private landowner, generate public good benefits, including maintaining recreation and aesthetic values enjoyed by forest visitors, and reduced risks of disease to other forest owners, as well as private benefits to the forest owner (Epanchin-Niell, 2017). Since the social benefits of disease control in forests can outweigh the private benefits of disease control to the landowner, there is an argument for implementing a Payment for Ecosystem Service-type scheme to incentivise landowners to engage in more disease control, and using general tax revenues to fund payments under such a scheme (Hanley et al, 2012).

As with any Payments for Ecosystem Service (PES) scheme, an important question is how exactly to design contracts offered to landowners (Engel, 2016). The policy designer is likely to be concerned with a range of criteria including how many landowners are incentivised to participate in the scheme (given that participation is voluntary), and the ecological benefits from participation. Participation in turn has been shown to be related to contract design details such as the length of contracts offered, the level of monitoring required, and what management changes a landowner is required to make (Kuhfuss et al, 2016; Broch and Vedel, 2011).

This paper employs the Choice Modelling approach to investigate the willingness of forest owners in Finland to participate in a PES-type programme to promote actions to reduce the expected economic costs of invasive pests and diseases. In particular, we are interested in how spatial coordination amongst those choosing to participate can be enhanced, since such spatial coordination is thought to result in more effective landscape-level disease risk reductions in this specific instance of forest pest and disease control. Moreover, economists have become increasingly interested in the general question of how to motivate spatial coordination in the provision of environmental benefits from land management (Banerjee et al, 2017).

2. Previous work

2.1. Choice modelling and PES design

Choice Modelling has been widely used to estimate the relative importance of contract design factors influencing the potential up-take of PES-type schemes, both by farmers and foresters (Christensen et al, 2011). Choice modelling is commonly implemented in a stated preference format[1], asking land managers how they would respond to different PES contracts differentiated in terms of their contract attributes. Villanueva et al, (2017), for example, list 54 existing studies which use a stated preference approach to estimate how much landowners demand to participate in PES-type schemes; and how stated participation varies with other contract design features. Our paper contributes to this literature by studying potential participation in a programme designed to reduce risks from invasive pests and diseases; and by considering the ways in which an agglomeration bonus influence predicted participation. The advantages of a stated preference choice modelling approach in this context are that (i) a wide variety of scheme designs can be studied (ii) new schemes

[1] Note that it is possible to apply choice modelling to revealed preference data. In the current context, this would imply the need to describe variation in uptake of actual PES schemes for invasive pests and disease control as a function of scheme characteristics.

which have not yet been implemented can be evaluated in terms of their potential effectiveness; and (iii) farmer or forest manager heterogeneity in response can be modelled. The disadvantages of choice modelling include any systematic differences between stated (hypothetical) decisions by land managers and their actual decisions should such a scheme be offered (Johnston et al, 2017), although the determinants or the size of any such hypothetical bias has yet to be determined in a PES uptake context.

Choice modelling in a stated preference context has also been implemented to understand public preferences for invasive species control. For example, Sheremet et al (2017) quantify the public benefits of forest disease control using choice modelling. They find that the UK general public are, on the whole, willing to pay for government funding of actions to reduce the spread of invasive pests and diseases in UK forests, but that this willingness to pay depends strongly on which ecosystem benefits from forests are most affected, who owns affected forests, and which specific control measures are implemented.

2.2. Spatial coordination in PES

The efficiency of measures aimed at controlling the spread of forest pest and pathogens depend partly on whether the disease-controlling efforts of different forest owners and managers are coordinated in time and at specified locations (Epanchin-Niell and Wilen, 2012). For example, failing to take effective control actions at a neighbouring forest may mean a plot becoming re-infected after being treated. This reflects a more general finding on the desirability of spatial coordination in responses to invasive species, in terms of improving the effectiveness of control measures (Sims et al, 2017).

The importance of coordinating the efforts of participants in environment protection programs has been extensively discussed in the literature on payment for ecosystem services (PES) schemes. Merckx et al., 2009; Dallimer et al., 2010; Wätzold et al., 2010 show that spatially coordinated uptake of PES contracts results in greater biodiversity conservation benefits on farmland, and Windle et al., 2009 finds that it improves prospects for restoration of native vegetation in Australia. Mattsson and Vacik (2017), in their survey of managers of several European protected areas, find that although invasive species is the second most important threat to maintaining biodiversity and ecosystem services over the next decade (preceded by only climate change), the managers are not inclined to view stakeholder coordination of conservation efforts as a very effective instrument against this threat. They are also rather pessimistic regarding mitigation of invasive species in smaller protected areas. On the other hand, cooperation with adjacent protected areas is perceived as more effective against human-related threats, such as forest conversion or illegal hunting and collecting. Such cooperation will have more chances if coordinated at the regional level, by municipalities or local communities.

However, Banerjee et al. (2012; 2014) found that spatial coordination using PES-type incentives can be challenging, partly due to the coordination game created by offering potential scheme participants an agglomeration bonus[2] (Parkhurst et al, 2002; Parkhurst and Shogren, 2007). The agglomeration bonus is a 2-part payment scheme, whereby a participation payment is offered to any landowner joining the scheme, with an additional bonus paid if one or more of that landowner's neighbours also participate. Experimental studies have shown that, whilst the agglomeration bonus can achieve target levels and patterns of spatial participation, the performance of such a scheme depends on factors such as the number of landowners in a neighbourhood, information flows between neighbours, and transactions costs. In the choice experiment described below, we included an agglomeration bonus in the contract design, to examine its effect on predicted participation levels.

3. Experimental design

3.1. General design

The survey consists of three parts. Part A contains the description of four tree diseases that are most prevalent in Finnish forests and several questions about the respondents' perceptions of their positions and powers in relation to control of forest diseases, as well as preferred roles for the national government in such control activities. The respondents were

[2] An alternative incentive design to encourage spatial coordination in PES-type schemes is a conservation auction where extra points are awarded to bids from neighbours (Krawczyk et al, 2016).

also prompted to reveal their expectations about the possible spread of existing and new diseases in their own forests and across Finland.

Part B is the choice experiment. Its initial design was defined in discussion with forest experts in the UK and Finland and then pretested with a small group of Finnish forest owners in order to select both the attributes and attribute levels that would be most relevant for a possible disease management scheme in Finland. This pre-test also examined the most understandable way to present the choice situations to respondents.

At the end of the choice experiment the respondents were asked either to specify their reasons for choosing the opt-out option in all cards (if that was the case), or to rank the attributes of the choice situations according to their perceived importance and to identify any attributes that were not attended while making decisions in choice situations. Finally, respondents were asked what part of their forest they would be willing to enrol in a forest disease control program that would be similar to one of the programs offered in the choice situations.

In Part C the respondents were asked several questions about their background and demographic details. A separate group of questions aimed to assess their experience and involvement with agriculture and forestry, their goals in woodland management, and the extent of their existing interactions and cooperation with their forest neighbours.

3.2. Attributes used in the choice experiment

In the choice experiment the respondents were presented with several sets of possible forest disease management schemes and prompted to choose one in each set. An example choice card is shown in Figure 1. The underlying assumption behind the proposed schemes is that the government would be willing to offer forest owners monetary incentives for them to undertake disease control actions which go beyond current regulatory requirements for disease and pest management, and beyond actions which are privately profitable. The choice situations in our stated preferences experiment do not correspond to any actual disease control scheme which the government will implement, but are rather described in terms of the most likely features such schemes might consist of in the future.

There are five attributes (shown in Table 1) that characterize each choice situation and thus the contracts which could be offered under such a scheme: disease management options, contract length in years, inspection and reporting frequency, annual grant (participation) payment per hectare per year, and an agglomeration bonus payment per hectare per year if at least one neighbouring forest owner also enrols.

The disease management options are described as preventive actions implemented to reduce spread and potential damage from tree diseases and pests. Respondents are reminded that all management options are costly for forest owners. Each disease control option affects the spread of the tree diseases or pests differently. The first two options, 'avoiding timber harvesting during summer' and 'avoiding thinning', reduce the risk of spreading the diseases by preventing mechanical impact of the harvesting actions on soil and injuries to the remaining trees, which would otherwise make the forest stand more susceptible to diseases. Timber harvesting actions conducted in wintertime inflict much less damage to the stand compared to similar actions during the summer. The 'avoiding thinning' option has also an advantage of maintaining a diversified forest, which helps in keeping disease outbreaks under control. The next disease control action, 'removing damaged and dead trees from forest stands', prevents future damages caused by pests (e.g. spruce bark beetles) and diseases before the next tree generation emerges. And the last option, 'stump treatment with protectants'[3] after tree felling in summertime, is an effective management option especially against butt and root rot.

The contract length was varied from 5 to 30 years, which is based on the following considerations. On one side, from the ecological perspective long contracts are preferable to short ones for controlling the spread of tree diseases and pests. On the other, the average length of forest ownership in Finland is around 23 years (Finnish Forest Association, 2017), and forest owners may not be willing to make inter-generational commitments, thus preferring short contracts.

[3] To prevent the spread of the butt and root rot, the Finnish government in spring 2016 established a requirement for forest owners to apply stump treatments in spruce- and pine- dominated forests located in the specific risk areas, harvested during the May-November period.

The inspection and reporting frequency attribute was set to either once every year or once every second year. Such a choice is based on the considerations that inspections are not possible during winter and that the size of forest holdings can be quite large for more frequent survey visits to be feasible.

The levels of the annual grant payment are determined based on previous studies (e.g. Juutinen et al. (2008)) and comments from experts. We can argue that a possible grant support for the disease control schemes is justified because actions taken to reduce the risks of tree pest and diseases will provide monetary and non-monetary benefits for both the forest owners and the general public. And because joint actions of neighbouring forest owners might be more efficient in reducing the tree diseases risks, the agglomeration bonus payment for bringing in a neighbour forest owner into the proposed tree disease control scheme is considered as another important monetary attribute describing our choice situations.

3.3. Design of the choice cards

For the choice experiment we generated a Bayesian D-efficient design[4] consisting of 36 choice situations, or cards, divided further into six blocks. Each card contains two alternative disease control schemes and an opt-out option. The design was generated in Ngene software using the multinomial logit as the base model. The priors for the model's parameter were taken from an earlier pilot study of UK forest owners undertaken by the authors, and in addition the parameters for two attributes, the disease control measures and the bonus for inviting neighbours, were modelled as random parameters with normally distributed priors.

During the experiment, each respondent is randomly assigned to one of the design blocks and asked to make choices over each of six cards in that block. Prior to answering actual choice cards, the respondents are provided with an example choice card (see Figure 1) and with interpretations of each of the alternative disease control scheme presented in that card.

[4] A design that has a sufficiently low D-error (which is equal to the determinant of the asymptotic variance-covariance matrix of a model estimated from simulated choices) is called a D-efficient design. In the efficient designs parameter prior values are assumed to be known and fixed. However, there is always some uncertainty surrounding true parameter values. To account for this uncertainty, we used a Bayesian D-efficient design, which assumes random rather than fixed priors (see Scarpa and Rose (2008); Ferrini and Scarpa (2007)).

We explained that the respondents will see a series of choice cards that included two hypothetical disease control contracts (contract A and contract B) and an opt-out option. Then we ask them to consider a forest stand where clear felling or thinning could be done, and a situation when a new forest disease would likely inflict some damage on their woodland in next five years (as the choice experiment was not specific to a particular disease, we could not provide more detail on expected damages). The respondents were requested to choose the best disease control alternative in every card independently of others, or to select the opt-out option if they were not willing to select either of the offered contracts in some cards.

4. Sample description

The questionnaires were mailed in October 2016 to 1510 Finnish non-industrial private forest owners who were randomly selected from the Finnish Forest Centre's database. We received back 243 completed questionnaires, which is 16.1 percent response rate. There was only one mailing round without any subsequent reminders. An internet survey was not thought to be a good option, due to previous experience in surveying private forest owners in Finland.

4.1. Socio-demographic characteristics

The socio-demographic characteristics of the respondents in our sample are reported in Table 2. As there is no census information available regarding Finnish forest owners, for comparison we provide the results from a regularly conducted and extensive Finnish forest owner survey, the most recent edition of which covers the period 2007-2009 (see Hänninen et al. (2011)).

In our sample, the average age (58 years) and gender structure (72.5 percent males) are similar to those reported in Hänninen et al. (2011). Although the reference study used somewhat different income grades compared to our questionnaire, we still can conclude that that high income households are to some extent overrepresented in our sample (almost 28 percent of respondents have income higher than 6,000 €/month), while the low income households are relatively underrepresented. Similarly, our sample has disproportionally more respondents with a university degree (about 24 percent) at the expense of the respondents who completed only basic education, compared to the education distribution in the reference study[5]. In terms of the professional status of forest owners in our study, the sample adequately represents employees (32 percent of respondents) and entrepreneurs (17 percent), although the proportion of pensioners (44 percent) is slightly lower than their share in the reference sample. In addition, 19 percent of respondents indicated that their job is connected to agriculture or forestry.

4.2. Forest management – objectives and experience

The average forest area owned by the respondents (56.5 ha) in our sample is about 26 percent higher compared to the forest area in Hänninen et al. (2011). The woodlands in the possession of the respondents are mainly either coniferous (47 percent) or mixed (44 percent). There are predominantly two forms of forest ownership, which is forests belong to either families (43 percent) or estates or unions (44 percent). Respondents in our sample seem to have accumulated considerable experience with forests, as on average the respondents own their forest estates for about 25 years, whilst 71 percent stated that they undertake silvicultural actions in their woodlands themselves. This finding is in line with previous research (Parviainen et al., 2014).

When asked about their forest management objectives (see Table 3), 80 percent of respondents stated timber production as one of their goals, and 56 percent named it as the most important objective. Notably, timber was considered either as a source of firewood (31 percent) or as an additional small (i.e. 5-20 percent of the total) source of income (38 percent of respondents). Other frequently mentioned purposes of managing a forest are preservation of wildlife or biodiversity (54 percent, including 20 percent considering this as the top-most

[5] It is important to remember that the reference sample describes the profile of Finnish forest owners in 2007-2009, and therefore, quite some changes could have happened in the past years. For example, the average age of Finnish forest owners is quite high. Hence the then-oldest forest owners may not own their forests anymore or many of them might have died. Those individuals likely had low education and low income levels, compared to a younger generation. Similarly, they were often agricultural entrepreneurs or pensioners. The differences indicate, however, that our sample might not be fully representative, so may create difficulties for generalizing the survey's results.

management objective), provision of recreational possibilities (mentioned by 37 percent), and maintaining the visual attractiveness of the landscape (40 percent).

The respondents were also asked a series of questions about their willingness to discuss issues related to forest management with neighbours, or to cooperate in fight against forest diseases, or to share equipment in the process of maintaining their forests (Table 4). Based on their answers, we conclude that the respondents only rarely discuss forest-related questions or share their equipment with their neighbours. Furthermore, the majority of respondents prefer to cooperate in their efforts to control disease spread at the regional level only (as opposed to local cooperative actions) or to take the relevant measures independently. However, there could be a natural explanation for these findings: the average distance to a house of the nearest neighbour is 56km, which might make it rather difficult to frequently interact with neighbour forest owners.

4.3. Tree diseases – knowledge and expectations

There is a clear split in the sample with respect to self-evaluation of respondents' tree diseases knowledge (Table 5). About 38 percent somewhat agree or strongly agree with a statement that they know tree diseases well, but on the other side, a somewhat larger proportion, 44 percent, disagree with such a statement. Some 61 percent think that there is enough information about tree diseases available.

Another interesting finding is that while the respondents at large (65 percent) are ready to change their forest management practices in response to increased threat of forest diseases, it should be the government that determine which actions should be taken and which pays for these actions, according to the views of 70-78 percent of respondents. Only one third of respondents think they have enough decision-making power over the issue of forest diseases. Further, a large share of respondents (one quarter) did not have any opinion on this matter, which might indicate that forest owners are not aware about the required practices related to forest disease management.

The impact of existing diseases in Finnish forests (Table 6) seems to be relatively small so far. Only about 25% of respondents say their woodlands are already affected by tree diseases, and a further 5-16 percent of the affected forest owners notice any visible damage from the diseases. In their projections about the future, about 40 percent of the respondents believe their forests will unlikely be affected by the existing diseases in the next 10 years. On the other hand, people are significantly more concerned about the potential risk of new diseases, as 59-65 percent think that it is likely that a new disease affecting either conifers or broadleaves will arrive in Finland in the near future. However, expectations of the resulting damage are not very high, even if there will be no grant-supported disease control schemes: 72 percent think that the diseases will damage less than one third of their forest stand, and moreover, 30% of respondents think the damage will not exceed 10 percent of the stand.

5. Choice modelling results

5.1. Econometric model

The modelling of preferences elicited through choice experiments is based on the assumption that a respondent maximizes their utility through their choices over the alternatives presented in a series of choice cards. The standard reference for the application of utility theory to discrete choice experiments is Train (2009).

One of the most widely used models to analyse choice data is the random parameters logit (RPL) model, also called the mixed logit (MXL) model, as its specification is versatile enough to represent a wide spectrum of respondent choice behaviour. The model formulation is similar to the multinomial logit model (MNL), in which the utility to an individual i from selecting an alternative j in a choice situation t described by K observed attributes $\boldsymbol{x}_{ijt} = \{x_{ijt}^1, \ldots, x_{ijt}^K\}$ is defined by the formula:

$$U_{ijt} = \alpha_j + \boldsymbol{\beta}'\mathbf{x}_{ijt} + \varepsilon_{ijt} / \sigma$$

where α_j is an alternative-specific constant, β are attribute weights, ε_{ijt} is the i.i.d. extreme value idiosyncratic error, and σ is its scale, normalized to 1 in the MNL model.

The probability for such a choice is then defined as:

$$\Pr(y_{it} = j) = \frac{\exp(\alpha_j + \boldsymbol{\beta}'\mathbf{x}_{ijt})}{\sum_{q=1}^{J} \exp(\alpha_q + \boldsymbol{\beta}'\mathbf{x}_{iqt})}.$$

In the RPL model the individual-specific preference parameters β and choice-specific constants α are no longer fixed for all respondents, but vary around means and are modelled as follows:

$$\beta_{ik} = \beta_k + \boldsymbol{\delta}_k'\mathbf{z}_i + v_{ik},$$
$$\alpha_{ij} = \alpha_j + \boldsymbol{\delta}_j'\mathbf{z}_i + v_{ij},$$

and where α_j is an alternative-specific constant, and v_{ij} is normally distributed (with zero mean) heterogeneity of the choice-specific constants; β_k is the population mean of *k*-attribute coefficient, v_{ik} is the individual specific heterogeneity of a taste parameter, which in this paper is assumed to follow the normal distribution with zero mean. The means of the parameter distributions of α_{ik} and β_{ik} are also allowed to be heterogeneous with respondents' individual characteristics z_i, which enter the formulas for taste parameters and constants with vectors of weights δ_k and δ_j, respectively. These characteristics include two subsets: first, *M* observed demographic characteristics g_i (such as age, gender, education, and income), and second, *N* variables that reflect self-reported experience and expectations of the respondents and their knowledge about forest pests and diseases as well as their willingness to cooperate their efforts to control disease spread.

In our experiment, choice situations are characterized by attributes that can be best represented as categorical variables with several levels. To account for this, each attribute with L_k levels is modelled as a set of $(L_k - 1)$ dummies, where each dummy corresponds to one level of a categorical variable.

5.2. Description of respondent choices

The full sample of 243 respondents who completed the survey is reduced for the analysis of choice experiment data, as 57 respondents (24% of the full sample) preferred to choose the opt out in every choice situation. For this group of people, analysis shows that their decisions are mainly based on two reasons: either unwillingness to sign up for such forest disease control schemes, or unwillingness to consider forest diseases as significant threats to their forests. The remaining subsample of people who did not choose the opt out in *every* choice card provides us with 1060 choice data points for preference analysis. Choices between two alternative disease control programs included in each choice card are symmetric, as each contract is selected in 39% of choice situations. In the remaining 22% of choices, the respondents preferred the opt-out option.

The post-experiment ranking of the importance of choice situation attributes (Table 7) indicates that two attributes, 'frequency of inspection visits', and 'bonus for inviting your neighbour', are rated as the least important. These attributes are not only ranked the lowest on average, but also are by far the least likely to be named as the most important attributes by any respondent: only 5-6% of respondents would do so, compared to e.g. 62% of respondents placing disease control measures at the top of the rank. Similarly, these two attributes are mentioned as being most frequently non-attended during the choice-making process. However, the degree of attribute non-attendance seems to be rather low, as even the two most frequently non-attended attributes are excluded during decision making by only 10-15 percent of the respondents. We thus do not explicitly model attribute non-attendance in what follows.

5.3. Estimation results

We estimated a number of models over respondent choices, starting from a multinomial logit to a simple attributes-only mixed logit to different models that include interactions with demographic, disease knowledge, and behavioural variables. Three of these models are presented in Table 8. The best statistical fit is reported by a MIXL model with interactions related to the respondents' evaluation of the current disease situation and their expectations about future developments in disease risks. Interestingly, other possible interactions of the Status Quo (SQ) utility level or 'bonus' attribute weight with demographic, disease knowledge, or counter-disease cooperation variables are not significant. We have also estimated a number of models that allow for scale heterogeneity, but results do not statistically outperform the non-scaled models and so are not reported here.

The first model that we report is a multinomial logit (MNL) model. The estimate of the alternative-specific constant (ASC) has negative sign, which means that the respondents derive higher utility from subscribing to some grant-financed disease control scheme. In addition, it can also indicate possible dislike for the 'no thinning' disease control option. The estimates of other control measures have positive signs, so they are more preferred relative to 'no thinning' option, which is the omitted level for this attribute. The highest ranked control option is 'remove damaged and dead trees', followed by 'chemical treatment of stumps', and 'avoiding summer logging'. This relative ranking of the disease control measures is retained in other, more sophisticated models. The 'length of contract' coefficient is negative and significant, which means that the respondents dislike longer disease-control programmes. A possible explanation for this can be that a longer contract is perceived as an unwanted constraint on a forest owner's freedom to manage her forest, i.e. for a possibility to cut and sell or hold her stand untouched depending on the timber market conditions and not on the prescriptions of the disease control contract. In this model, the 'neighbour bonus' coefficient is significant, but has a negative sign, which can be a reflection of dislike or at least considerable variability of respondent preferences about disease control contracts that depend on actions of many other participants. We study this issue in detail in more advanced models below. And as expected, the 'grant payment' coefficient is positive and highly significant.

In an attribute-only mixed logit (MIXL) model, which accounts for individual variability of attribute coefficients, the utility of the opt-out option is not significantly different from zero. Other utility weights, with the exception of 'neighbour bonus', are much higher than the coefficients in the MNL model. The 'neighbour bonus' coefficient estimate is not significant, but the attribute's distribution has a statistically significant variance across the sample.

The estimate for the ‘inspection frequency’ utility coefficient is not significantly different from zero. We observed the same outcome for other parametrizations of this attribute in all estimated models. Moreover, the estimated standard deviation of the parameter’s individual values around the sample mean is also not statistically significant. We thus conclude that the frequency of inspection visits is not important for the respondents.

The last mode we report in Table 8 is a MIXL model in which choice attributes are interacted with variables that reflect the respondents’ demographic characteristics as well as their experience and expectations about forest diseases. Only three interaction terms are significant and thus reported in the table.

The first term shows that the respondents whose forest stands are already affected by a disease are less sensitive to the size of the neighbour bonus offered in a disease control contract. Second interaction term tells us that the respondents who expect the existing forest diseases to spread rapidly in the coming 10 years are also less sensitive to the size of the neighbour bonus, as their bonus coefficient estimate is lower than the estimate for the rest of the sample. That is, for the respondents who are more aware of the risks of forest diseases other characteristics of a disease control contract (e.g. contract length) become more important.

The last interaction term indicates that the grant payment has a relatively larger weight in the utility functions of those respondents who prefer local-level cooperation with their neighbours. Perhaps, those forest owners have already good working relations with the owners of neighbouring forests, and so for them the complementary neighbour bonus looks almost as certain as the contract payment.

5.4. Simulation of probabilities for different disease controls

We studied what impact possible changes in the neighbour bonus and a disease control contract’s duration have on the probability of forest owners selecting a contract that requires a particular disease control measure. We plot several curves for different combinations of neighbour bonus (0€ and 80€) and contact length (5 years and 30 years).

First, let us have a look at contracts for different disease control measures, i.e. no thinning, removing dead trees, avoiding tree cutting during summer, and chemical treatment. Figure 2 shows choice probabilities based on the estimates that do not include the interactions terms for bonus attribute, i.e. on the model estimates for the respondents who do not expect an increase in the spread of existing tree diseases in the next 10 years or whose woodlands are not yet affected by tree diseases. The effect of changes in the neighbour bonus attribute on the choice probabilities is rather limited, while the effect of changes in the contract length attribute is much more pronounced. In particular, a contract with large bonus and short duration is the most likely to be accepted for any disease control measure and grant payment, while a long contract with small bonus has the lowest chances to be chosen. Such a high impact of the contract duration is most clearly observed for the contracts with the 'no thinning' control measure. We can also see that the 'no thinning' contract would require the largest monetary compensation for any given probability of signing such a contract.

Curves in Figure 3 show the probabilities for contracts with 'no thinning' disease control measure based on the estimates for the model that includes two interaction terms. The first panel shows the probability curves without interactions, the second panel shows the probability curves for those respondents who indicated that an increase in spread of current diseases is very likely, and the third panel demonstrates the curves for the respondents whose woodlands are already affected by tree diseases. Overall, these respondents require higher grant payments compared to the respondents who are neither affected by the current diseases nor expecting rapid further spread. As before, the evidence of a strong negative impact of the contract length attribute on the simulated choice probabilities is clearly visible. The role of neighbour bonus in the decisions of the respondents already affected by a disease is reduced, and furthermore, the neighbour bonus attribute seems to have no impact at all on the decisions of the respondents who expect an increase in the spread of the existing diseases. Especially in the model with interaction terms, for contracts with 'no thinning' control measure and with grant payments exceeding 100-150€ it is mostly the duration of contract that defines whether the contract will be likely accepted (simulated probability is close to one) or rather rejected (simulated probability is less than 0.5).

Finally, Figure 4 shows the probability curves for the contracts with the option of 'removing dead trees' as the main disease control measure. As in the previous case, the impact of the neighbour bonus is either very limited or non-existent. Notably, the effect of the contract length is counterweighed by the contract payment: for small payments (below 100€) the length of the contract seems to be the single most important factor, while for large payments (above 200€) the contract length factor plays a very limited role in the respondent decisions. Overall, the contracts with the 'remove dead trees' option are more readily chosen. First, for any given probability of choosing a disease control contract the respondents require much smaller monetary payments compared to contracts with other control measures. Second, short contracts have very high probabilities of acceptance even for the lowest payment rates. This phenomenon can perhaps be explained by the fact that removing dead trees is often undertaken as a forest management operation, and is the lowest cost of the disease management options presented to the forest owners.

6. Discussion and Conclusions.

In this paper, we have analysed the willingness of forest owners to participate in a PES-type scheme aimed at reducing the spread of invasive pests and diseases. We motivated this from a recognition that privately-costly actions by forest owners to reduce disease risks generate benefits to other forest owners and to the wider public, and maintain the flow of ecosystem benefits in the face of invasive diseases and pests (Sims et al, 2016). Using choice modelling, we found that a large fraction of those forest owners who decided to participate in the survey were willing to participate in such a PES scheme. Most respondents preferred some contract to no contract. This could, to some degree, reflect a selection bias, in that people most willing to engage in such a scheme were more likely to return their surveys. Unfortunately, it is not possible to quantify the size of any such bias in this instance. But the finding might also reflect the positive experiences of forest owners in Finland with innovative contract-based schemes aimed at protecting and enhancing biodiversity in Finnish forests (Juutinen et al, 2010).

In terms of which aspects of a contract would increase stated participation, we found that shorter contracts with larger per-hectare payments increase participation. The latter has obvious implications for the budgetary cost of such a scheme to the government, and no estimate is provided here on the expected economic benefits of reductions in disease spread which could be compared with budgetary costs. That landowners prefer shorter PES contracts has been found in other studies (eg Broch and Vedel, 2011), and probably reflects a desire to maintain flexibility in management response and a concern with the resale value of farm or forest properties, but does reduce the likely environmental benefits of scheme; since environmental benefits generated whilst the contract is in force may be lost when the contract ends (although see Kuhfuss et al, 2016b).

In terms of which management options for disease risk reduction are most likely to be accepted by landowners, we found highest levels of support for the removal of dead/diseased trees and the use of chemicals. Actions which restrict timber harvesting are less accepted; moving to a “no thinning” regime as part of a PES contract is the least popular option, as thinning both provides current-period revenues and impacts on future revenues, due to the effects on forest growth rates.

We also found very mixed evidence on the performance of an agglomeration bonus, which has wider implications for the design of PES schemes. As argued above, the agglomeration bonus is one of the main mechanisms which economists have developed to incentivise spatial coordination in uptake of PES schemes, where such coordination is desirable from an ecological viewpoint. Most studies to date have used context-free lab experiments to study the effectiveness of the AB in producing spatial coordination (eg Banerjee et al, 2017). In our choice experiment, actual forest owners made choices over realistic future policy options designed to encourage spatial coordination in disease and pest control. We found that the effects of the AB on intended participation depended very much on (i) whether a forest owner was already affected by a disease (ii) their expectations over how rapidly disease would spread in the future and (iii) their attitudes to the desirability of local cooperation in disease risk reductions. This makes the impacts of an AB introduced as part of a Payment for Ecosystem Service scheme much harder to predict, and also shows that motivations for uptake of a contract including an AB are much broader than those modelled to date in lab experiments.

This also shows that the likelihood of local cooperation over responses to invasive pests and diseases seems very context-specific, and to be embedded in wider attitudes to cooperation with neighbours, as well as expectations over future production risks. Forest ownership in Finland is very fragmented (mean distance to nearest forest neighbour was 56km in our survey) and ownership is being increasingly concentrated in cities. Respondents in our survey revealed that they rarely cooperated with neighbours in terms of sharing equipment, and infrequently discuss forest management issues with neighbours. This cultural context necessitates the development of new co-operation enhancing instruments.

Finally, it would seem to be important to consider the synergies and trade-offs between actions which reduce the risks/expected costs of invasive pests and diseases in forests with multiple objectives of forest management. There is some evidence that the willingness of the general public to fund the kinds of PES scheme modelled here depend on which benefits from a forest (recreational use, commercial, carbon storage, timber production…) are most impacted by a particular disease. Actions taken to reduce risks from a given disease may reduce or enhance the ability of a forest to supply some ecosystem services (eg if access restrictions are imposed), or may decrease or increase forest biodiversity (eg Monkkonen et al, 2014) . This implies that any PES scheme for forest invasive pests and diseases should be designed in a manner which (i) is consistent with maximising the net social benefit flows from a forest and (ii) which makes economic sense to forest owners in terms of how compensation matches the opportunity costs of participation.

FUNDING:

OS and NH acknowledge funding from the UK Research Councils under the Tree Health and Plant Biosecurity initiative under the project “Foremod”.

References

Banerjee, Simanti, Anthony, M. Kwasnica, James, S. Shortle, 2012. Agglomeration bonus in small and large local networks: a laboratory examination of spatial coordination. *Ecological Economics* 84 (12), 142–152.

Banerjee, Simanti, Hanley, Nick, deVries, Frans P., van Soest, Daan P., 2014. The impact of information provision on agglomeration bonus performance: an experimental study on local networks. *American Journal of Agricultural Economics* 96 (4), 1009–1029.

Banerjee, Simanti, Timothy N. Cason, Frans P. de Vries, and Nick Hanley, 2017. Transaction Costs, Communication and Spatial Coordination in Payment for Ecosystem Services Schemes. *Journal of Environmental Economics and Management* 83, 68–89.

Boyd I.L., P. H. Freer-Smith, C. A. Gilligan, H. C. J. Godfray, 2013. The Consequence of Tree Pests and Diseases for Ecosystem Services. *Science* , 15th November, Vol. 342, Issue 6160, 1235773.

Broch, S. and Vedel, S., 2011. Using Choice Experiments to Investigate the Policy Relevance of Heterogeneity in Farmer Agri-Environmental Contract Preferences. *Environmental and Resource Economics* 51(4), 1-21.

Christensen, T., Pedersen, A.B., Nielsen, H.O., Mørkbak, M.R., Hasler, B. and Denver, S., 2011. Determinants of farmers' willingness to participate in subsidy schemes for pesticide-free buffer zones-A choice experiment study. *Ecological Economics* 70(8), 1558-1564.

Dallimer, M., Gaston, K.J., Skinner, A.M., Hanley, N., Acs, S., Armsworth, P.R., 2010. Field-level bird abundances are enhanced by landscape-scale agrienvironment scheme uptake. *Biology Letters* 6 (5), 643–646.

Engel, S., 2016. The devil is in the detail: a practical guide on designing Payments for Environmental Services. *International Review of Environmental and Resource Economics* 9, 131-177.

Epanchin-Niell R. and Wilen J., 2012. Optimal spatial control of biological invasions. *Journal of Environmental Economics and Management* 63, 260–270.

Epanchin-Neill R., 2017. Economics of invasive species policy and management. *Biological Invasions*, https://doi.org/10.1007/s10530-017-1406-4.

Ferrini, Silvia, and Riccardo Scarpa, 2007. Designs with a Priori Information for Nonmarket Valuation with Choice Experiments: A Monte Carlo Study. *Journal of Environmental Economics and Management* 53(3), 342–363.

Finnish Forest Association, 2017. Finnish forest ownership. Available from: https://www.smy.fi/en/forest-fi/forest-facts/finnish-forests-owned-by-finns/ (accessed 25.10.2017.)

Freer-Smith, P. H., & Webber, J. F., 2015. Tree pests and diseases: the threat to biodiversity and the delivery of ecosystem services. *Biodiversity and Conservation,* doi:10.1007/s10531-015-1019-0.

Florec V., Sadler A., White B and Dominiak B., 2013. Choosing the battles. *Food Policy* 38, 203-213.

Hanley N, Banerjee S., Lennox G, and Armsworth P., 2012. How should we incentivise private landowners to "produce" more biodiversity? *Oxford Review of Economic Policy* 28 (1), 93-113.

Hänninen, Harri, Heimo Karppinen, and Jussi Leppänen, 2011. Suomalainen Metsänomistaja 2010 [Finnish Forest Owners in 2010]. 208. Metlan Työraportteja. http://www.metla.fi/julkaisut/workingpapers/2011/mwp208.htm.

Johnston, Robert J. Kevin J. Boyle, Vic Adamowicz, Jeff Bennett, Roy Brouwer, Trudy Ann Cameron, W. Michael Hanemann, Nick Hanley, Mandy Ryan, Riccardo Scarpa, Roger Tourangeau, and Christian A. Vossler, 2017. Contemporary Guidance for Stated Preference Studies. *Journal of the Association of Environmental and Resource Economists* 4 (2), 319-405.

Juutinen, Artti, Erkki Mäntymaa, Mikko Mönkkönen, and Rauli Svento, 2008. Voluntary Agreements in Protecting Privately Owned Forests in Finland — To Buy or to Lease? *Forest Policy and Economics* 10 (4), 230–239.

Juutinen, A., Ollikainen, M., 2010. Conservation contracts for forest biodiversity. Theory and experience from Finland. *Forest Science* 56, 201-211.

Krawczyk, M., Bartczak, A., Hanley, N.D., Stenger, A., 2016. Buying spatially-coordinated ecosystem services: an experiment on the role of auction format and communication. *Ecological Economics* 124, 36–48.

Kuhfuss, L., Préget, R., Thoyer, S., Hanley, N., 2016a. Nudging farmers to enrol land into agri-environmental schemes: the role of a collective bonus. *European Review of Agricultural Economics* 43(4), 609–636.

Kuhfuss, L, Preget, R, Thoyer, S, Hanley, N, Le Coent, P & Desole, M., 2016b. Nudges, social norms and permanence in agri-environmental schemes. *Land Economics* 92(4), 641-655.

Mattsson, B. J., Vacik, H., 2017. Prospects for stakeholder coordination by protected-area managers in Europe. *Conservation Biology*, doi: 10.1111/cobi.12966.

Merckx, Thomas, Ruth, E. Feber, Riordan, Philip, Townsend, Martin C., Bourn, Nigel A.D., Parsons, Mark S., Macdonald, David W., 2009. Optimizing the biodiversity gain from agri-environment schemes. *Agriculture, Ecosystems and Environment* 130(4), 177–182.

Mönkkönen, M., Juutinen, A., Mazziotta, A., Miettinen, K., Podkopaev, D., Reunanen, P., Salminen, H., Tikkanen, O-P., 2014. Spatially dynamic forest management to sustain biodiversity and economic returns. *Journal of Environmental Management* 134, 80-89.

Parkhurst, Gregory M., Jason F. Shogren, Chris Bastian, Paul Kivi, Jennifer Donner, and Rodney B.W. Smith, 2002. Agglomeration Bonus: An Incentive Mechanism to Reunite Fragmented Habitat for Biodiversity Conservation. *Ecological Economics* 41(2), 305–328.

Parkhurst, Gregory M., and Jason F. Shogren, 2007. Spatial incentives to coordinate contiguous habitat. *Ecological Economics* 64(2), 344-55.

Parviainen, M, Pellinen, R, Salminen, MR and Sauranen, T., 2014. Kevyet koneet metsänhoidossa, Opas metsänomistajille. Available from: https://www.jamk.fi/globalassets/tutkimus-ja-kehitys--research-and-development/tki-projektien-lohkot-ja-tiedostot/kevyet-koneet-metsanhoidossa/kevmet-kasikirja-web.pdf (accessed 25.10.2017.)

Scarpa, Riccardo, and John M. Rose, 2008. Design Efficiency for Non-Market Valuation with Choice Modelling: How to Measure It, What to Report and Why. *Australian Journal of Agricultural and Resource Economics* 52(3), 253–282.

Sheremet O., Healey J., Quine C and Hanley N., 2017. Public preferences and willingness to pay for forest disease control in the UK. *Journal of Agricultural Economics,* doi: 10.1111/1477-9552.12210

Sims C., Finnoff D., and Shogren J., 2016. Taking one for the team. *Environmental and Resource Economics,* doi: 10.1007/s10640-016-0099-

Train, Kenneth E., 2009. *Discrete Choice Methods with Simulation*. 2nd ed. Cambridge: Cambridge University Press.

Wätzold, Frank, Mewes, Melanie, van Apeldoorn, Rob, Varjopuro, Riku, Chmielewski, Tadeusz Jan, Veeneklaas, Frank, Kosola, Marja-Leena, 2010. Costeffectiveness of managing natura 2000 sites: an exploratory study for finland, germany, the netherlands and poland. *Biodiversity and Conservation* 19(7), 2053–2069.

Windle, Jill, Rolfe, John, McCosker, Juliana, Lingard, Andrea, 2009. A conservation auction for landscape linkage in the southern desert uplands, Queensland. *Rangeland Journal* 31 (1), 127–135.

Villanueva, A. J., Glenk, K. and Rodríguez-Entrena, M., 2017. Protest Responses and Willingness to Accept: Ecosystem Services Providers' Preferences towards Incentive-Based Schemes. *Journal of Agricultural Economics* 68, 801–821.

Figure 1. An example choice card.

CHOICE CARD 1	**Contract A**	**Contract B**	
Disease management option	removing damaged/dead trees	avoiding timber harvesting in summer	I would not want to sign either of these two contracts
Contract length	5 years	30 years	
Inspection and reporting frequency	once every year	once every second year	
Grant payment rate *(€/ha/year)*	70€	120€	
Bonus payment for bringing in neighbor forest owner *(€/ha/year)*	80€	0€	
YOUR CHOICE:	◯	◯	◯

Figure 2. Simulated probabilities of subscribing to a disease control scheme for different control measures (the effect of interaction terms is not included)

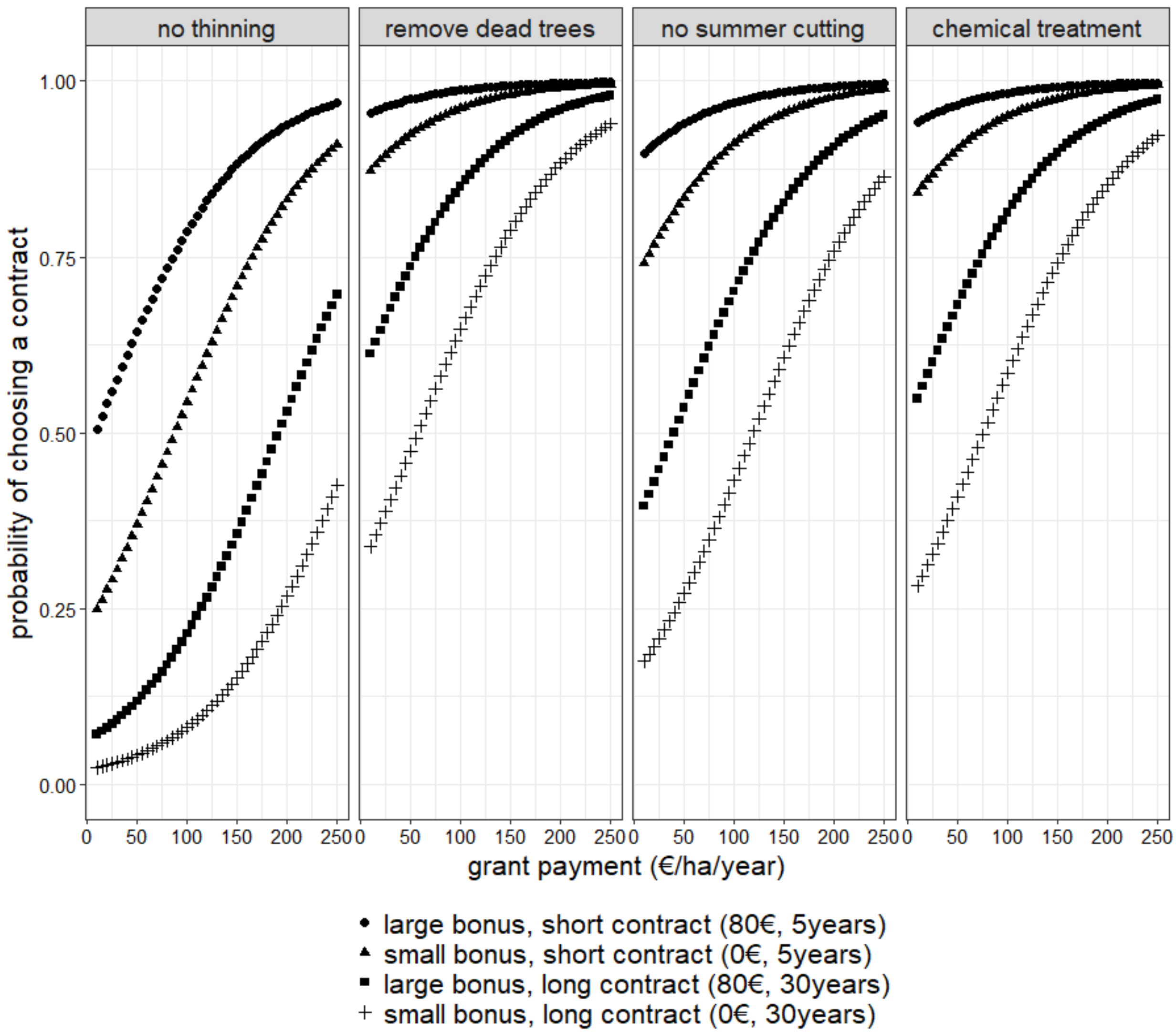
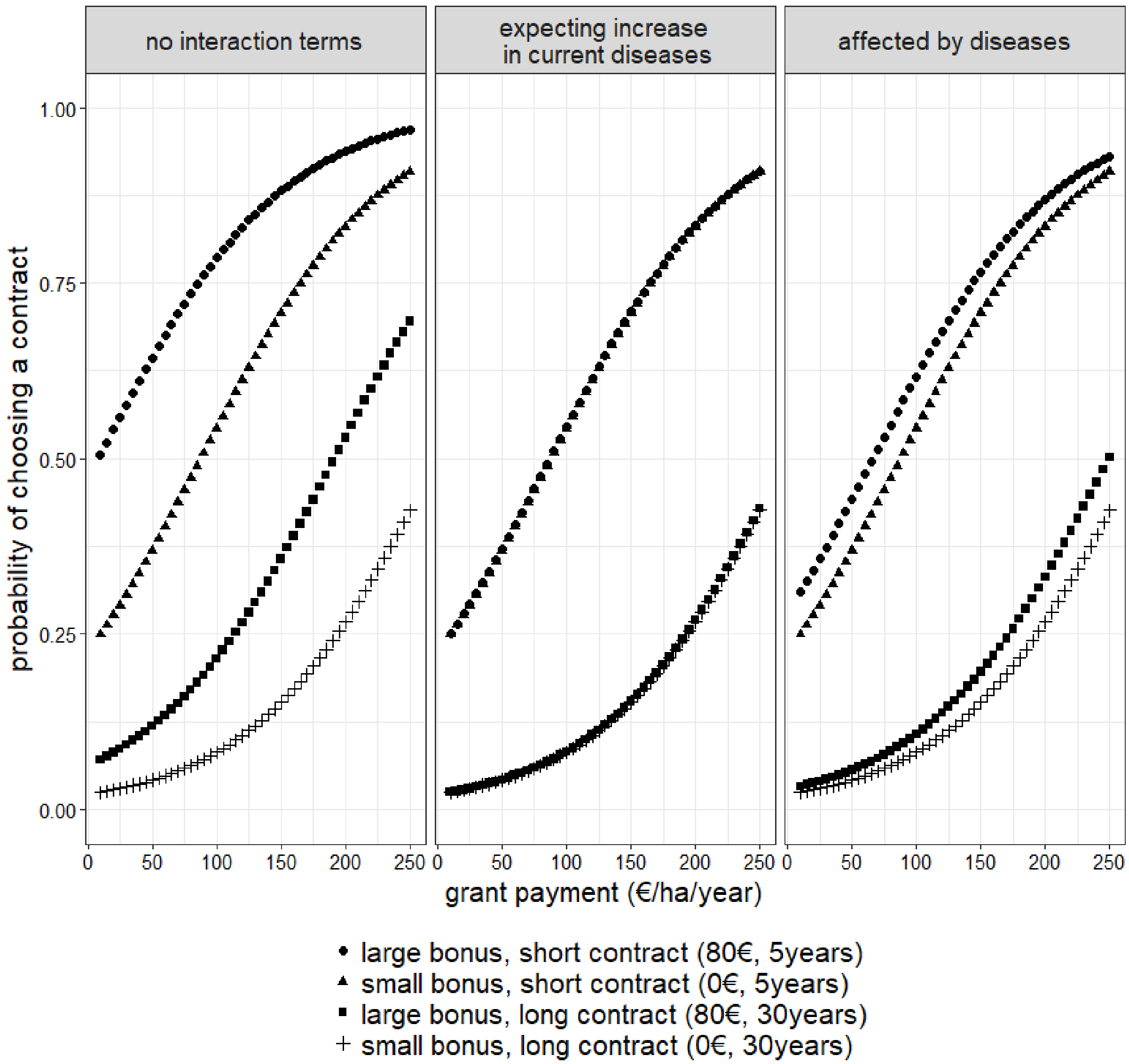
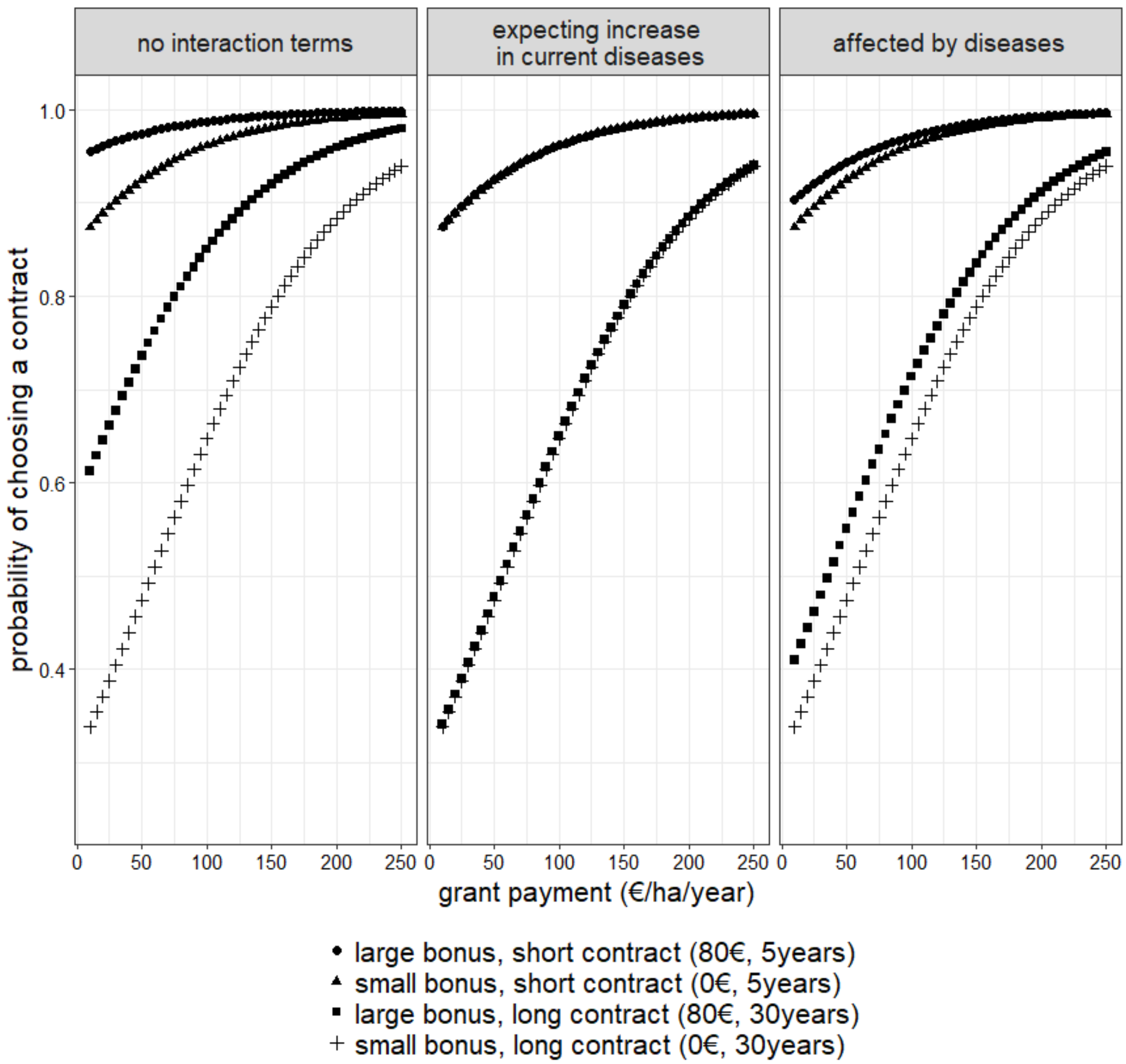


Figure 3. Simulated probabilities of subscribing to a disease control scheme with 'No thinning' control measure (with different interaction terms)



Note: In the middle panel, two top and two bottom curves are merged.

Figure 4. Simulated probabilities of subscribing to a disease control scheme with 'Remove dead trees' control measure (with different interaction terms)



Note: In the middle panel, two top and two bottom curves are merged.

Table 1. Attributes used to describe choice situations

Attributes	Levels
Disease management options	Avoiding timber harvesting during summer Avoiding thinning Stump treatment with protective chemicals during the summer tree felling Removing damaged and or dead trees
Contract length (years)	5, 10, 20, 30
Inspection and reporting frequency	Once every year Once every second year
Annual grant payment rate (€/ha/year)	10€, 30€, 70€, 120€, 180€, 250€
Bonus payment to you for bringing in neighboring forest owner (€/ha/year)	0€, 10€, 20€, 40€, 60€, 80€

Table 2. Socio-demographic characteristics of the sample.

	Sample	Reference study
Sample averages		
Age (years)	58.2	60.6
Household size	2.3	
Total forest area owned (ha)	56.5	34.5
Sample shares (percent)		
Gender:		
Female	27.5	25
Male	72.5	75
Household's gross income (€/month):		
less than 2000	9.2	21
2000-3999	37.1	36
4000-5999	26.2	23
more than 6000	27.5	20
Education:		
Basic education	23.3	32
Matriculation examination or/and vocational degree	29.2	35
Polytechnic degree	23.7	21
University degree	23.7	12
Professional status:		
Employee	32.3	31
Entrepreneur	17.4	19
Pensioner	44.3	47
Other status	6.0	3

Notes: 1. The reference study is Hänninen et al. (2011) Suomalainen metsänomistaja 2010, Metlan työraportteja 208. Accessible via: http://www.metla.fi/julkaisut/workingpapers/2011/mwp208.htm. ISBN 978-951-40-2317-0.
2. Our sample consists of 243 respondents, while Hänninen et al. (2011) counts 6318 respondents, though the number of observations varies between questions.
3. The annual income from Hänninen et al. (2011) for year 2007 was multiplied by index of wage and salary earnings to update it to 2016 and then divided by 12 to get a monthly figure.

Table 3. Forest ownership and management data

Characteristics	Sample
General information	
Average duration of forest ownership (years)	25
Total forest area owned (ha)	57
Distance to nearest neighbour's house (km)	56
Sample shares (percent)	
Forest composition:	
conifers	47
mixed	44
Forest ownership:	
individual	9
family	43
estate or union	44
Forest management objectives:	
timber production	80
preservation of wildlife or biodiversity	54
provision of recreational possibilities	37
visual attractiveness of the landscape	40
carbon storage	23
other	10
Top-ranked forest management objectives:	
timber production	56
preservation of wildlife or biodiversity	20
provision of recreational possibilities	4
visual attractiveness of the landscape	7
Timber production goals:	
no specific goal	19
small-scale (e.g. firewood)	31
timber revenues are 5-20% of income	38
timber revenues are 21-40% of income	5
timber revenues are >40% of income	2

Notes: Respondents were allowed to select multiple forest management objectives.

Table 4. Two-way tables on willingness to discuss, cooperate, or to share equipment

(percent)	*Cooperate*				*Share equipment*		
	locally	regionally	locally + regionally	stay independent	never	sometimes	often
Share equipment							
never	7	37	7	20			
sometimes	4	12	2	3			
often	0	0	0	0			
Discuss							
never	3	17	5	13	37	1	0
sometimes	8	30	3	9	34	19	0
often	0	3	1	1	3	2	0

Notes: 1. The breakdown numbers are in percent, relative to the entire sample.

2. There are some missing data (about 4 percent), so the shares do not sum up to 100 in sub-tables.

3. The questions are formulated as follows:

A. How often do you discuss forest management issues with your neighbours?
B. To what extent are you willing to cooperate in fight against forest diseases?
C. How often do you share forestry equipment?

Table 5. Self-assessment of disease-related knowledge and powers

(percent)	Don't know	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Perceptions about themselves						
I know forest diseases well	4	11	33	12	34	4
Sufficient information is available	5	2	13	17	42	19
Forest owners should change their management practices due to the proliferation of forest diseases	7	2	8	14	41	24
Forest owners have enough decision-making power w.r.t. forest diseases	24	3	14	22	25	9
Perceptions about the state						
The state should determine how forest owners act on disease issues	2	4	8	14	41	29
The state should pay for costs of forest diseases prevention	1	3	4	11	34	44

Note: 1. The numbers are in percent relative to the entire sample.
2. About 4 percent answers are missing.

Table 6. Perceptions about the risk of existing and future diseases

(percent)	Already affected	No or little visible damage*	Don't know	Very unlikely	Quite unlikely	Quite likely	Very likely
Existing diseases							
pine blister rust (*Cronartium flaccidum*)	25	95	12	16	26	14	2
spruce bark beetle (*Ips typographus*)	21	84	14	12	29	16	3
root and butt rot (*Heterobasidion annosum*)	26	91	13	17	22	17	0
Havununna (*Lymantria monacha)*	5	58	30	16	27	16	1
New diseases							
A new disease affecting conifers will arrive			9	1	21	44	21
A new disease affecting broadleaves will arrive			10	2	24	40	19

Note: 1. The numbers are in percent relative to the entire sample.
2. About 5 percent answers are missing.
3. The numbers in the second column "No or little visible damage" are in percent relative to the sub-sample of respondents whose woodlands are already affected by tree diseases.
4. About 72 percent of respondents think the disease-related damage will not exceed 30 percent of their woodland stand. Moreover, about 30 percent of respondent actually expect the damage to be under 10 percent of their stand.

Table 7. Attribute ranking and non-attendance.

(percent)	*Ranking*			*Non-attendance*	
	Modal ranking	Average ranking	Top ranked* (subsample)	Ignored (sample)	Ignored* (subsample)
Disease management options	1	1.8	62%	7%	2%
Contract length	3	2.7	18%	29%	7%
Inspection frequency	4	3.5	6%	42%	10%
Grant payment	2	2.5	16%	18%	4%
Bonus payment	5	4.2	5%	64%	15%

Note: 1. Lower ranking numbers indicate higher importance of an attribute
2. The numbers in columns marked with asterisk (*) are in percent relative to the subsample of respondents who ignore at least one attribute in making their decisions.

Table 8. Estimation results for Multinomial and several Mixed Logit models

	MNL	MIXL	MIXL + interact.
Means			
ASC = U(SQ) + no thinning	-1.263*** (0.070)	0.427 (0.418)	0.743* (0.435)
Remove dead trees	1.862*** (0.141)	2.983*** (0.357)	3.035*** (0.346)
No summer logging	1.552*** (0.139)	2.246*** (0.293)	2.154*** (0.288)
Chemical treatment	1.806*** (0.140)	2.620*** (0.357)	2.771*** (0.373)
Length of contract	-0.047*** (0.005)	-0.096*** (0.014)	-0.104*** (0.015)
Inspection frequency	0.014 (0.075)	-0.034 (0.151)	0.016 (0.150)
Grant payment	0.002*** (0.001)	0.016*** (0.003)	0.014*** (0.003)
Neighbour bonus	-0.004** (0.002)	0.004 (0.003)	0.014*** (0.004)
Interactions			
Bonus * (affected by a disease)			-0.010** (0.005)
Bonus * (high expectations of worse current diseases)			-0.014*** (0.005)
Grant * (prefer local cooperat.)			0.011*** (0.004)
Std Dev			
SD (ASC)		2.340*** (0.345)	2.483*** (0.367)
SD (Remove)		1.760*** (0.309)	1.662*** (0.316)
SD (No Summer)		1.347*** (0.336)	1.673*** (0.359)
SD (Chemical)		2.861*** (0.456)	2.754*** (0.397)
SD (Length)		0.103*** (0.017)	0.119*** (0.018)
SD (Inspection)		0.264 (0.257)	0.011 (0.242)
SD (Grant)		0.009*** (0.003)	0.011*** (0.003)
SD (Bonus)		0.010** (0.005)	0.004 (0.006)
N.obs	3180	3180	3180
AIC	3647.5	1717.0	1702.0
Loglik	-1815.7	-842.509	-831.998
McFadden R^2	0.103	0.151	0.153

Notes: 1) ***, **, * indicate significance at 1%, 5%, and 10% levels, respectively. Std errs are in parentheses.
2) Other models (not included here) indicate that the estimates for Inspection frequency are similarly not statistically significant if modelled via dummies per attribute level.
3) The omitted dummy for Disease management attribute level corresponds to Avoiding thinning.