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Contributing to healthy forests: Social preferences for pest and disease mitigation programs in Spain

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ABSTRACT

In a scenario of global change, with increasing temperatures and extreme climatic events, healthy forests are at risk. Forests have to fight several types of biotic and abiotic stress. Prospective scenarios warn of the negative effects that forests will suffer in upcoming decades (drought, fires, pests, diseases, etc.), consequently making it necessary to implement actions that can not only prevent the attack of biotic agents such as fungi and insects but also improve the resilience of forest systems. Such warning scenarios transcend the scientific sphere, and as such, Spanish society has previously expressed considerable concern about the appearance of pests and diseases caused by biotic agents. This article therefore analyzes the social preferences for pest and disease mitigation programs in Spanish forests. A discrete choice experiment was consequently carried out, and the willingness to pay was estimated for various characteristics of mitigation programs. The results show that society positively values these programs, mainly when they are applied in relatively nearby forests, when they are targeted at mixed forests, and when there is low uncertainty about their effectiveness. Conversely, the self-management of subsidies by forest owners is rejected, with a preference for funds being managed by regional public authorities.

1. Introduction

Forests provide human society with critical and diverse ecosystem services. In addition to contributing to economic development through the production of timber and non-timber products, forests provide refuge for terrestrial biodiversity, they are an important component of the water cycle, and they take part in mitigating climate change by acting as sinks of carbon dioxide (Boyd et al., 2013).

The influence of the climate on the structure and function of forest ecosystems is widely recognized (Desprez-Loustau et al., 2007). The climate not only plays an essential role in forest species distribution, but also in the distribution of insect pests and microorganisms that tree species can host, as well as in the dynamics of such interactions (Hawkins et al., 2003; Curtis et al., 2002). Thus, the climate is relevant to forest health, and a changing climate may alter patterns of biotic disturbances (Ayers and Lombardero, 2000). Outbreaks of forest pests and diseases are predicted to be more frequent and severe (Desprez-Loustau et al., 2016), caused in part by new biological invasions interacting with drought and other abiotic stressors affecting trees subject to climate change (Sturrock et al., 2011). Moreover, other contemporary issues such as international trade, land use patterns, connectivity, and management practices also increase the risk of exotic insects and fungi becoming introduced (Sikes et al., 2018; Linnakoski and Forbes, 2019; Roberts et al., 2020). These disturbances could have a significant impact, especially when the dominant tree forest species is affected and its presence is reduced, thereby initiating a cascading effect on the ecology of that forest (Lovett et al., 2016; Swei et al., 2011), as well as on its function and value (Chornesky et al., 2005). In other cases, forests might recover from such disturbances.

Climate change scenarios are useful for understanding the risks that will be faced by forests in the upcoming decades (IPCC, 2021; Moss et al., 2010). In the case of a European country of the Mediterranean such as Spain, climate risks are particularly relevant (Ciscar et al., 2011). In addition to numerous natural disturbances, Spanish forests will also be seriously stressed by biotic and abiotic agents in the upcoming decades (Serra-Varela et al., 2017). Temperature is expected to increase and precipitation to decrease, but more importantly, a change in extreme events is predicted (IPCC, 2021). At the same time, increasing global trade is often at the origin of an unprecedented number of biological invasions that are taking place in Europe (Brasier, 2008; Dehnen-

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Schmutz et al., 2018), subsequently causing new threats to forests (Santini et al., 2013). There are notable cases of biotic disturbances, which are already increasing in number and causing major damage to Spanish forests. For example, the Asian chestnut gall wasp, *Dryocosmus kuriphilus*, has spread throughout Spain since it arrived in the northeast of the Iberian Peninsula in 2014 (Gil-Tapetado et al., 2020), and it is considered to be the most important chestnut pest in the world, highly limiting fruit production; Phytophthora root rot, originating from *Phytophthora cinnamomi*, is causing oaks to decline on the Iberian Peninsula and is responsible for high tree mortality, likely aggravated by climate change (Resco De Dios et al., 2007); pine wilt disease, caused by *Bursaphelenchus xylophilus*, the pine wilt nematode, is now found in Portugal and some areas of Spain (Abelleira et al., 2011), and it is considered to be one of the most dangerous diseases to Pines.

Pest and disease management programs are usually implemented to reduce the negative impact that such biotic disturbances have on the ecological, social, and economic value of forests and plantations (Jactel et al., 2009; Boyd et al., 2013). Once a biotic agent is established in an area, management actions that might be used are included in silvicultural, biocontrol, and plant resistance categories (Gonthier, and Nicolotti, G. (Eds.)., 2013). Silvicultural practices refer to cleaning, fertilization, and weed control, as well as thinning and pruning and the selective felling of trees (Jactel et al., 2009). They are routinely applied in stands, but they can also be used to prevent outbreaks and the dispersal of biotic disturbances, as well as to release healthy trees (Roberts et al., 2020). Biological measures involve the use of living organisms to suppress populations of pest insects and pathogens, and they are successfully used to cope with some pests and a reduced number of diseases (Prospero et al., 2021). Biological measures include preventive actions such as the conservation or augmentation of the natural enemies of a pest, the use of mycorrhizas, and promoting defensive bacteria when planting. Breeding for plant resistance to a particular pest or disease is another approach that is gaining importance, but it is still in the initial stages compared to agricultural crops (Desprez-Loustau et al., 2016). Another control option is to change the species mix in plantations. In this sense, Macpherson et al. (2017) developed a bioeconomic model that assesses the effect of tree disease on the optimal planting strategy for mixed forests, and they showed that planting a mixture of tree species increases the overall net benefit.

This article presents novel research that delves into biotic disturbances and the social preferences for pest and disease mitigation measures. There are few related studies that deal with social preferences for reducing disturbances caused by biotic agents. Some examples include the following: Rosenberger et al. (2012) performed a literature review of economic valuation research on the impacts of forest insect pests. Meldrum et al. (2013) and Meldrum (2015) analyzed the social preferences for managing a disease caused by the fungus *Cronartium ribicola* in the United States. Drake and Jones (2017) elicited the public's willingness to pay to protect against the spread of two forest diseases caused by *Phytophthora ramorum* and *P. kernoviae* in England and Wales. Sheremet et al. (2017) analyzed the public's preferences and willingness to pay for forest disease control in the UK. Sheremet et al. (2018) analyzed the preferences of Finnish private forest owners for mitigating the risks derived from invasive pests and diseases. Finally, Adams et al. (2020) estimated the willingness to pay for a monitoring and prevention program to protect urban forests from invasive pests in Florida, USA.

This article provides novel insights regarding the social preferences for adopting specific tactics related to mitigating pests and diseases, thereby contributing to the sustainable management of healthy forests in areas threatened by climate change. Mitigation programs can contribute to preventing changes from biotic disturbance regimes and reducing the related social, ecological, and economic effects. This paper seeks the following objectives: (1) analyze how technical issues are perceived, considering the hypothesis that the population gives little importance to the technical characteristics of disease and mitigation programs; (2) analyze preferences for elements related to disturbances and their effects, considering the main hypothesis that the likelihood of occurrence of a disturbance is the key issue with respect to paying for a program; (3) analyze the reaction to the administrative considerations of a program, considering the hypothesis that the population reacts to the type of entity that is responsible for managing the collected funds; and (4) determine if people are willing to pay more taxes for a given period in exchange for defraying the expenses (or part of them) in order to maintain a healthy forest. The novelty of this article lies in the analysis of these four objectives as a whole and in the fact that this is the first time that such an analysis has been conducted in relation to Spanish forests.

2. Materials and methods

A total of 660 Spanish inhabitants over the age of 18 years were interviewed between the 3rd and 17th of July 2021. The survey was conducted online using TickStat® software, and the average time taken to complete the survey was 13 min. The questionnaire had three parts: (i) perception of the ecosystem services provided by forests and of the risks to forests in upcoming decades, (ii) valuation scenario and choice experiment, and (iii) socioeconomic characteristics. The individuals of the sample were randomly recruited from an online panel managed by Cint™. The distribution of the respondents is presented in Fig. 1. The sample is representative of Spanish society with regard to the geographic distribution of the population, urban and rural habitats, age structure, and gender. However, a higher education level is overrepresented in our sample. This figure is typical when using web-based panels (Nielsen, 2011). Women make up 51.8% of the sample, the average age is 46 years, 45% have completed secondary studies, 49% have a university education, and 27% of the people in the sample are forests owners, although 83% of these do not manage their lands.

The individuals' preferences for pest and disease mitigation programs were explored using a discrete choice experiment (DCE) (Carson and Louviere, 2011; Johnston et al., 2017). The mitigation programs were described according to their characteristics (the stated attributes and levels). The utility that an individual derived from a program was determined by the utility they obtained from each of the characteristics. The attributes (Table 1) were defined according to three dimensions.

The first dimension is related to technical issues such as the causal agents of pests and diseases (fungi and insects) and the type of preventive actions (genetic breeding and biological control). The second dimension includes elements about the disturbance: the likelihood of pests and diseases, the type of affected forest (deciduous, conifers, and mixed forests), and the distance between the home and the affected forests. Finally, an administrative dimension was considered, given that the population could react to the type of entity that is responsible for managing the collected funds (regional authorities, local authorities, and self-management by forest owners). The monetary attribute was an increase in taxes, and various durations of these payments were considered (10, 20, and 30 years).

Previous results from another study conducted in Spain revealed that Spanish inhabitants show intense preferences for programs related to the resilience of forests and that they are especially concerned about reducing the biotic risks that trigger pests and diseases (Soliño et al., 2020). These preferences led us to include the pests and diseases in the choice experiment that are respectively caused by insects and fungi (which contain most of the biotic threats) and to exclude other causal agents of disease such as drought, an important abiotic stress in the Mediterranean region (IPCC, 2021). Regarding management measures, we considered genetic breeding and biological control as the specific options to be incorporated for reducing the effect of a biotic agent, while assuming that silvicultural practices are routinely being applied. We excluded quarantines and eradication measures, which involve regulatory norms of mandatory compliance aimed at preventing the introduction and establishment of a biotic agent in a region or area. For the attribute related to the occurrence of pests and diseases, once preventive measures are adopted, we established the level of a 30% likelihood as

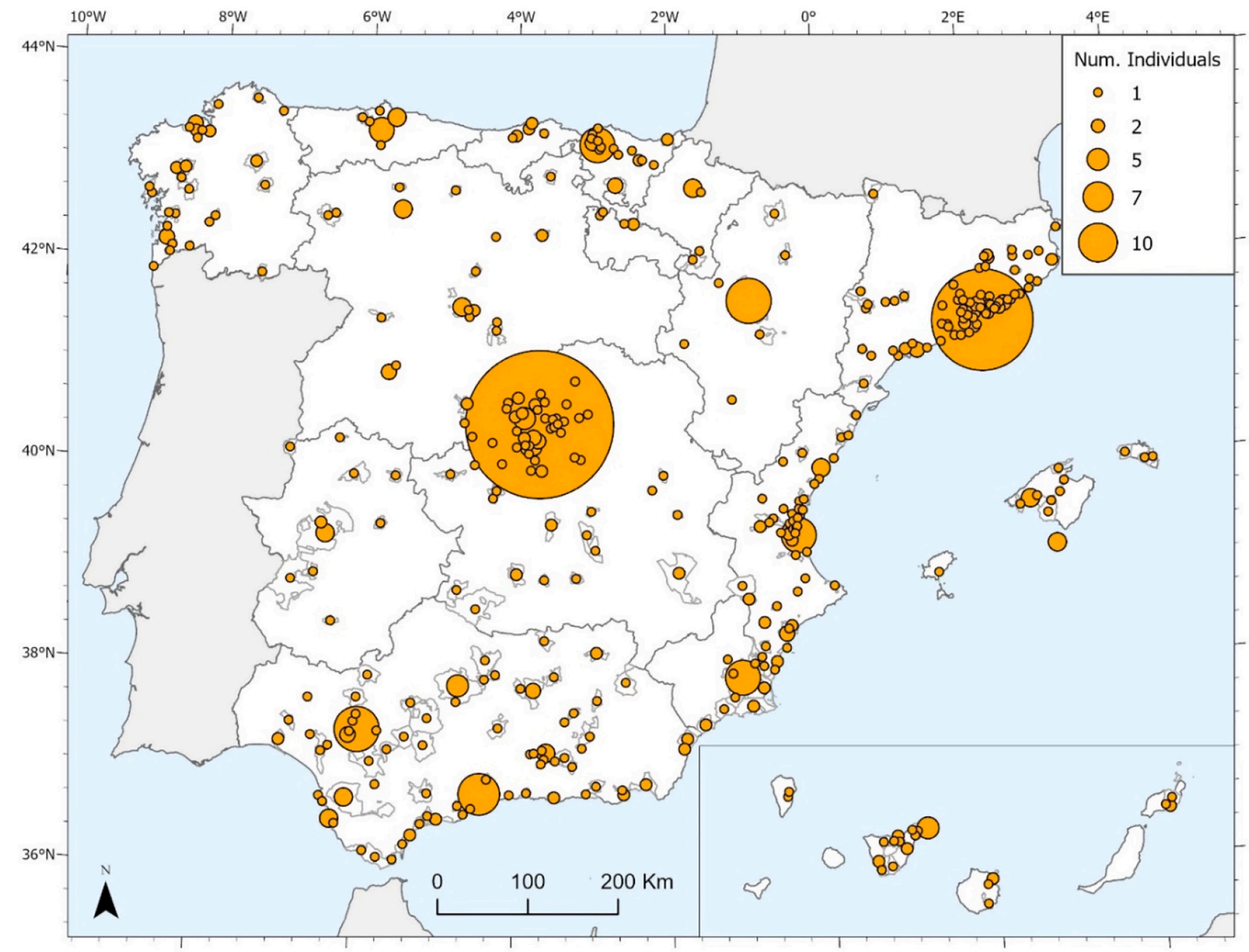

Fig. 1. Distribution of the sample.

high (Serra-Varela et al., 2017) and a likelihood of occurrence of less than or equal to 10% as low. Other issues related to a disturbance, such as the type of affected forest (deciduous, conifers, or mixed forests) and the distance between the home and the affected forests, were also considered, similarly to Sheremet et al. (2017). Mixed forests have been shown to be more resilient than monocultures and are usually preferred over broadleaves and conifers (Bravo-Oviedo et al., 2014; Giergiczny et al., 2015). Finally, an administrative attribute was considered according to the destination of the collected funds. This attribute measures the preferences for different levels of decentralization, from regional governments to forest owners (through management at the local level), and it provides relevant information for the design of Payment for Ecosystem Services (PES) schemes.

In the DCE, individuals chose their preferred program from among several alternatives presented in a choice card. They looked at several choice cards resulting from an optimal orthogonal choice *design (*Domínguez-Torreiro, 2014*)*. The experimental design was implemented using ngene® 1.2.1. software (ChoiceMetrics, 2018). A total of 36 choice cards were designed with a D-optimality of 97.23%. Using a blocking strategy, 12 choice cards were presented to each of the 660 individuals participating in the study. Each choice card contained three alternatives (two mitigation programs and an opt-out for no choice). An example of a choice card is shown in Fig. 2. Therefore, a total of 7920 observations were used to estimate the econometric model, assuming that the underlying individual decision heuristics were the same for all 12 choices.

The discrete choice data were analyzed using a Mixed Logit model (Train, 2009). The preferences for all non-monetary random attributes were assumed to be independently normally distributed, i.e., individuals could either like or dislike them. A lognormal distribution was tested for the monetary attribute (TAX), but the result was not statistically significant at the 90% level, and the pseudo R^2 and AIC favored considering TAX as a fixed parameter. Moreover, this homogeneity assumption of TAX facilitates the interpretation of the resulting willingness to pay (WTP) measures. A fictitious variable – the Alternative Specific Constant (ASC) – was also created to specify if an individual chose a mitigation program (A or B) or the opt-out. The ASC captures a portion of the unobservable influences beyond attributes, i.e., it represents the preferences for a program per se. Qualitative attributes were coded using effects codes instead of dummies to avoid confounding effects with the ASC (Bech and Gyrd-Hansen, 2005). WTP measures were calculated as the negative ratio between each of the adjusted estimated coefficients and the TAX coefficient (Hanemann, 1984), thereby considering their coding as a dummy (ASC), as a continuous (DURATION), or as effect codes (all other attributes) (Lusk et al., 2003; Domínguez-Torreiro and Soliño, 2011; Talpur et al., 2018). Consequently, Table 2 presents the results of the adjusted estimated coefficients considering this coding approach.

Before the choice exercise, participants were informed that “Maintaining healthy forests requires significant investments by landowners, whether private or public. One of the key long-term issues is to be

Table 1
Summary of attributes and levels.

Attribute	Level	Variable	Coding
Defense against pests and diseases caused by…	Fungi Insects	FUNGI INSECTS	Effect codes
Preventive measures	Genetic breeding Biological control	GENETIC BIOLOGICAL	Effect codes
Likelihood of pests and diseases	30% - High 20% - Medium 10% - Low	HIGH-PROB MED-PROB LOW-PROB	Effect codes
Type of affected forest	Conifers Deciduous forest Mixed forest	CONIFERS DECIDUOUS MIX-FOREST	Effect codes
Distance from the affected forest to the home	More than 50 km Between 21 and 50 km Less than 20 Km	DIST-HIGH DIST-MED DIST-LOW	Effect codes
Funds are managed by…	Forest owners Municipalities Regional authorities	OWNERS LOCAL REGIONAL	Effect codes
Annual tax increase	€25€, €40, €55, €70	TAX	Continuous
Timeframe	10, 20, 30 years	DURATION	Continuous
Alternative Specific Constant	Choice of any program (A or B) Choice of none of the programs	ASC	Dummy

prepared in order to combat pests and diseases caused by insects and fungi. To achieve this objective, several action schemes are being designed. These schemes are partially or even entirely funded by the public sector, so they require an increase in the taxes that taxpayers currently pay". Moreover, other informative issues about the valuation scenario were included: "In this questionnaire, we are seeking to learn society's opinion about these programs. We want to consult society because, in the end, it is society that finances these programs and that will ultimately benefit, directly or indirectly, from the results of the programs. Below we provide you with information about various programs. We ask that you choose among the programs shown to you on each card. You will be given 12 cards with 2 options or performance programs on each one. In addition, you always have the option to check 'No program', which means that none of the proposed programs should be carried out, therefore not involving any payment". Finally, the participants were informed that society as a whole would pay for these programs through an increase in national taxes and that payments would continue for several years: "The programs have a cost that must be borne by all citizens. The formula for everyone to contribute to these programs is through an increase in annual taxes. Keep in mind that not only you but all other citizens will have to assume that tax increase, consequently reducing your savings or your consumption of other goods and services. Payments will also have to continue for several years. Considering that the programs are related to forests, they are long term and could require maintaining payments for 10, 20, or 30 years."

3. Results

3.1. Ecosystem services and risks for forests

Individuals were asked about their perceptions regarding the relevance of several ecosystem services (ESs) provided by forests, according to a scale from 1 to 10, where 1 represented no relevance and 10 a very high relevance. Individuals rated the following ecosystem services: economic revenue (timber, firewood, resin, etc.), outdoor recreation and landscapes, biodiversity conservation, genetic resources conservation, ecological functions (climate regulation, soil erosion, etc.), heritage conservation, and legacy for future generations. The most relevant ES was the conservation of biodiversity (average of 9.04; ~Std.Dev. 1.380), followed by the maintenance of ecological functions (8.95; ~1.451). Provisioning services (economic revenue) were the least-valued ES (7.33; ~2.277). Other highly valued ESs were as a legacy for future generations (8.78; ~1.566) and the conservation of genetic resources (8.74; ~1.574). Thus, ESs related to regulation and culture are more relevant for the interviewed Spanish population than ecosystem services related to the supply of products.

People were also asked about their perception of forest risks in the upcoming decades. A list of potential risks was presented: plantations with unsuitable species, bad management practices, a lack of management, diseases and pests, droughts, other extreme weather events (winds, floods, etc.), abandonment of the rural environment, intentional and unintentional fires, and a lack of definition of property rights.[1] All of these risks were rated highly. The most important ones were related to intentional forest fires (9.39; ~1.382), water stress (8.77; ~1.684), and pests and diseases (8.64; ~1.667). Therefore, abiotic and biotic stresses represented a major concern for the respondents, and the main objective of this study – pests and diseases – was rated as one of the most relevant risks. Conversely, the correct definition of property rights was identified as the risk with the lowest rating (7.90; ~1.877), although bad management practices (8.61; ~1.631), the absence of management (8.60; ~1.617), and the abandonment of forest lands (8.35; ~1.900) were identified as worrisome risks for Spanish forests.

3.2. Preferences and willingness to pay

Attempts to decrease the impact by pests and diseases in forest systems are not always successful. Even when early detection systems are available, as well as monitoring and surveillance programs, the mitigation measures taken to reduce damage may not achieve the desired results. Individuals were likely to react to this fact, and they showed a clear preference for programs that guarantee a low probability of occurrence (LOW-PROB) and a dislike for those programs with a high probability of occurrence (Table 2).

The type of causal biotic agent (FUNGI and INSECT) and the type of measures implemented to prevent pests and diseases (GENETIC and BIOLOGICAL) do not influence the preferences of individuals (Table 2). Nevertheless, the interviewed population prefers taking action in mixed forests (MIX-FOREST) located at a mid-distance from their homes (DIST-MED). It is noteworthy that if preventive actions are carried out in forests that are far away, individuals would prefer not taking action. Finally, the self-management of funds by forest owners (OWNERS) is negatively valued, and individuals would prefer that regional public authorities (REGIONAL) be responsible for managing funds.

The results show an inverse relationship between the choices and the tax amount (TAX) and the duration of payments (DURATION), i.e., higher taxes and longer programs are preferred less by individuals. Considering the intensity of preferences for the different characteristics of the pest and disease mitigation programs, and assuming the linear additivity of preferences and following the compensating surplus formula of Hanemann (1984), we estimated several simulated management options. Consequently, the minimum aggregate WTP for a program is €47.11/year, while the maximum is €128.59/year. There are slight differences when the programs are focused on conifers, deciduous trees, or mixed forests. For example, in a highly effective program managed by regional authorities over 30 years, the range would be from €100.23/year for conifers to €107.52/year for mixed forests.

4. Discussion

Fighting biotic risks in forest systems is going to be a challenge in upcoming decades, and society positively values taking action in this regard. Individuals show a high preference for the assurance that

[1] Property rights can be defined as a set of rights and obligations related to resources over time. These property rights can be private, public, or even hybrid, and they are characterized by their specific rights of access, withdrawal, exclusion, management, and alienation (Caballero, 2015).

CHARACTERISTICS OF THE PROGRAM	**Program A**	**Program B**	**None of the programs**
Defense against pests and diseases caused by…	 Fungi	 Insects	
Preventive measures	Genetic breeding	Biological control	
Likelihood of pests and diseases	30% - High	10% - Low	
Type of affected forest	Conifers	Mixed	
Distance from the affected forest to the home	20 km Less than 20 km	50 km Between 21 and 50 km	
Annual tax increase	55 € 30 years	70 € 10 years	
Funds are managed by…	 Forest owners	 Regional authorities	
Check your favorite option →	☐	☐	☐

Fig. 2. Example of a choice card.

Table 2
Results (Random Parameters Logit Model using 500 replications for simulated probabilities and Halton draws; Log likelihood function = −6533.172; Restricted log likelihood = −8701.009; McFadden Pseudo R-squared = 0.2491; Inf.Cr.AIC = 13,114.3; AIC/n = 1.656; n = 660 individuals and 7920 observations; Willingness-to-pay estimates using the Wald procedure and the delta method for confidence intervals; calculations based on effect coded attributes and linear effects for continuous variables).

Attribute	Mean coefficients		Normal distribution of random parameters		Willingness to Pay		
	Adjusted Coefficient	Std. Err.	Mean Coefficient	Std. Err.	Mean (€)	Std. Err.	95% Confidence Interval
FUNGI	−0.06081	0.03973	0.21107***	0.03593	−2.285	1.486	(−5.198; 0.628)
INSECT	0.03040	0.01986	Base level		1.142	0.743	(−0.314; 2.599)
GENETIC	−0.02776	0.04107	0.30225***	0.02757	−1.043	1.539	(−4.059; 1.973)
BIOLOGICAL	0.01388	0.02053	Base level		0.521	0.769	(−0.987; 2.030)
HIGH-PROB	−0.04373	0.05019	0.21479***	0.02809	−1.643	1.890	(−5.347; 2.061)
MED-PROB	−0.04824*	0.02894	Base level		−1.812*	1.088	(−3.944; 0.320)
LOW-PROB	0.18845***	0.04851	0.04665	0.04697	7.080***	1.844	(3.466; 10.694)
CONIFERS	−0.12399***	0.04778	0.06907	0.09530	−4.658**	1.814	(−8.214; −1.103)
DECIDUOUS	−0.08647*	0.05071	0.26207***	0.04652	−3.249*	1.926	(−7.023; 0.525)
MIX-FOREST	0.07015**	0.02891	Base level		2.636**	1.102	(0.476; 4.795)
DIST-HIGH	−0.11279**	0.04695	0.06381	0.06523	−4.238**	1.769	(−7.705; −0.770)
DIST-MED	0.05232*	0.02713	Base level		1.966*	1.022	(−0.037; 3.968)
DIST-LOW	−0.04416	0.04717	0.09823	0.07303	−1.659	1.774	(−5.136; 1.817)
DURATION	−0.02542***	0.00488	0.10800***	0.00447	−0.955***	0.187	(−1.321; −0.589)
OWNERS	−0.80184***	0.09272	0.95626***	0.04948	−30.127***	3.755	(−37.487; −22.767)
LOCAL	0.01422	0.06465	0.33563***	0.04714	0.534	2.427	(−4.223; 5.291)
REGIONAL	0.26254***	0.04889	Base level		9.864***	1.910	(6.120; 13.609)
TAX	−0.02662***	0.00141	Fixed		–	–	–
ASC	3.10324***	0.10113	Fixed		116.594***	4.305	(108.157; 125.031)

***, **, * Significance at the 1%, 5%, 10% level.

programs will be effective and will protect forests from attacks by biotic agents. Meldrum et al. (2020) highlight the importance of presenting outcome uncertainty in applications of stated preference methods. Uncertainty is a key issue when designing pest and disease mitigation programs. Our sample reacts to the outcomes of the programs, thereby showing that only low uncertainty is linked to an increase in well-being. In fact, the interviewed respondents negatively value a program that does not guarantee a low risk of occurrence of pests and disease.

People do not show a preference for any of the programs when differentiated by the technical aspects of biotic threats. Similarly to political systems, the population passively observes the technical options and leaves decision-making to the experts (Font et al., 2015). They are indifferent as to whether a disturbance is caused either by insects or pathogens, as well as if the prevention measures used are biological or involve plant breeding. The lack of preference for either type of measure suggests that people are more concerned about the outcome of the measure that is applied than about the actual measure itself. Both types of proposed measures (biological and breeding) can be used as a complement to each other in an integrated program to effectively manage forest health, but it is interesting to learn that the efforts for mitigating a specific biotic disturbance do not have to be included in either of those specific categories. Furthermore, the results of this study show that any intervention carried out to mitigate forest damage should maintain or enhance the biodiversity of a forest, given that the most relevant ES defined by the interviewed respondents was the conservation of biodiversity, followed by maintaining a forest's ecological functions.

People prefer taking action in mixed forests, i.e., in more resilient forests compared to monocultures of conifers or broad-leaved trees (Bravo-Oviedo et al., 2014). They are also in favor of implementing actions within a mid-distance from their homes. While distance is not the same as use, this result could indicate that use values are more important than option and non-use values (Pearce, 2001; Croitoru, 2007) or perhaps that people do not have appropriate knowledge regarding the spread of diseases across a certain space. It is also surprising that DIST-LOW and DIST-MED are not statistically significant. Unfortunately, we do not have data to go beyond these hypotheses, given that we have no information about how the respondents make use of forests and that none of the individuals in the sample were subject to any impact by diseases or pests in their local environment. Nevertheless, distance is an important geographic variable for exploring the spatial dimensions of the stated preferences, and further research should be conducted along this line (Badura et al., 2020; Glenk et al., 2020; Olsen et al., 2020).

Spaniards are concerned about more than just the outcomes of programs. Our results show that one of the most influential characteristics of a mitigation program is related to the management of funds. Individuals would prefer that funds be managed by regional public authorities, i.e., they prefer a centralized system over a decentralized one. This result is relevant for a co-sharing discussion on the financial costs of environmental schemes. Bate et al. (2021) point to the role of public incentives for improving biosecurity. Not only did the respondents react positively to a more centralized level, they expressed a clear rejection of self-management by forest owners, perhaps due to distrust with respect to owners applying the corresponding measures when they receive funds in advance. Nevertheless, no data are available to reach a conclusion in this regard, and future research should be conducted in collaboration with sociologists and policy analysts to properly interpret this aspect.

Sheremet et al. (2017) found that disease control programs in private forests of the UK were less likely to be supported by society than equivalent control programs in public forests. In our case study, the funds collected for public forests would be directly administered by public entities at every territorial level. Similarly, Font et al. (2015) discussed the tensions between direct citizen engagement and governance via elected representatives using an expert-based governance model, therein highlighting the need for efficiency and expertise in decision-making. In this sense, centralized fund management could be interpreted as a type of expert-based governance or a more efficient management approach. In our case study, the design of Payment for Ecosystem Services schemes could be socially supported if they were based on subsidies for forest owners after having inspected compliance with the requirements of a program. One way to implement PESs in the future could be through the reformulation of environmental advisory councils, which are one of the most common participatory institutions in many countries but are currently weak in Spain (Alarcón et al., 2020).

5. Conclusions

In a scenario of global change, expenditures on protecting our forest ecosystems and the ecosystem services they provide (timber and non-timber resources, biodiversity, landscape, etc.) are expected to increase over the next few decades. Considering that in most cases this is a public expenditure, either because the property is public or because the actions are implemented based on subsidies or PESs for private forest owners, citizens will be the ones ultimately paying to maintain healthy forests through taxes. Thus, it is essential to ask people how these actions can contribute (or not) to their well-being.

Pest and disease mitigation programs contribute to reducing the negative impact that biotic disturbances have on the ecological, social, and economic value of forests, and society gains when these programs are implemented. This article shows that Spanish inhabitants are willing to pay in order to implement these programs. The technical issues related to programs, such as the causal agents of pests and diseases or the preventive measures to be taken, are not relevant for people. Conversely, the type of infected forests and the distance between them and the homes of individuals are the attributes that have an influence on their willingness to pay. Mitigation programs with a low likelihood of occurrence are more highly valued, i.e., people are willing to pay for effective programs. Fund management is especially important to people. To maximize social well-being, the role of public authorities is crucial. As shown by the preferences of individuals, collected funds should be managed by regional public authorities, and there is a clear preference for a high degree of centralization. It seems that this centralized structure contributes to generating greater trust in and the credibility of programs. Therefore, these preferences of the public reinforce the role of the governance structure as a key issue for the management of natural resources.

Declaration of Competing Interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.forpol.2022.102754.

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