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Contingent valuation of landowner demand for forest amenities: application in Andalusia, Spain

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Abstract

We applied discrete choice contingent valuation to the amenities consumed by non-industrial private forest owners in Andalusia (Spain) in a survey of 765 landowners. The landowners' median willingness to accept compensation from an alternative investment for giving up land amenity consumption is EUR 387.8 per hectare yearly. The preferred model shows diminishing marginal values of amenity consumption with property size, negative effects of eucalyptus and Aleppo pine presence and positive effects of distance to urban centres. We discuss the performance of the question formats and models employed and recommend the single-bounded format in this valuation context.

Keywords: non-market values, stated preferences, willingness to accept

JEL classification: Q51, Q56, Q57

1. Introduction

Private land ownership provides the opportunity to consume a variety of amenities from the working landscapes where properties are located (Campos *et al.*, 2009; Kallio, 1999; Martin and Jefferies, 1966; Pope, 1985; Samuel and Thomas, 1999; Torell *et al.*, 2005). These amenities cover the consumption of services such as open space, recreation, landscape, bequest options, social status, lifestyle and the opportunity to engage in rural land activities (e.g. ranching or hunting) by private landowners. Studies conducted in forests and rangelands of several different countries (e.g. Spain, United States, Portugal, Wales and

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Finland) reveal that these amenities are important to explain the underlying motivations for keeping, buying and managing a piece of land and that private landowners obtain benefits from land ownership that go beyond income from marketed goods. This is associated with landowners characterised by land management which is not entirely ruled by commercial profit maximisation. These landowners, often referred to as non-industrial owners, are willing to forego commercial profits based on their land management and ownership preferences, in contrast to industrially oriented management (e.g. plantations and intensive livestock operations), in which commercial profit maximisation prevails (Pattanayak, Murray and Abt, 2002; Raunikar and Buongiorno, 2006; Scarpa *et al.*, 2000).

This preference for amenity consumption could create a dichotomy in the land market. Landowners (potential sellers) who want to keep these amenities demand a higher price from potential buyers, pushing the land price up. At the same time, if potential buyers expect to consume these amenities when acquiring the property, they will increase their bid to match the price demanded by sellers and to compete with other potential amenity consumers. Thus, part of the land market price would internalise the value given to the consumption of amenities when the forestland is sold, representing the discounted value of the future consumption of amenities (Pope, 1985; Torell *et al.*, 2005). The dichotomy appears because, while the monetary value of this discounted consumption (its capital value) could be observable as part of the land market price, the non-monetary value of the yearly consumption by the landowner is not subject to a market transaction once the land is owned and is not directly observable in the market of forest products (Campos *et al.*, 2009). Thus, the private consumption of forest amenities is marketed on the capital side but is outside the market on the production side.

The literature has paid little attention to directly quantifying the economic flow value given by landowners to the yearly consumption of these amenities. This has implications not only in terms of the undervaluation of ecosystem contribution to economic production if the value of private amenity consumption is overlooked, but also from a management and conservation perspective. It is expected that managed forestlands will be shaped according to landowner preferences, which may include the consumption of amenities (Pattanayak, Murray and Abt, 2002). Omitting them could lead to the policy-maker or analyst reaching misleading conclusions about the drivers of economic values in forestlands. For example, when all land market price is assessed according to income from traditional market commodities (e.g. timber and grazing), we can conclude that either forestlands are overvalued assets or that the market prices of commercial forest products are undervalued. Similarly, an incomplete analysis could conclude that potential land buyers and current landowners are behaving irrationally: the former for paying a premium price for an investment that provides relatively low returns and the latter for keeping it immobilised at a high market value and opportunity cost.

This is relevant for any type of economic analysis, but particularly in national accounts-based systems where output and stocks are interrelated through production and capital accounts (Campos *et al.*, 2019a; United Nations, 2021). In this context, several papers supporting the recently approved System of Environmental Economic Accounting–Ecosystem Accounting (SEEA–EA) acknowledge the possibility of using non-market valuation methods to estimate the demand for non-market products in order to value the contribution of nature to economic production (Barton *et al.*, 2019; Caparrós *et al.*, 2017; United Nations, 2019). Since the transaction value of the private amenities consumed by landowners is not directly observable, we can use this type of valuation methods to simulate their demand, which can be elicited from real and simulated landowner investment and consumption decisions.

In this article, we propose the use of contingent valuation (CV) to directly measure the yearly demand of amenity consumption by non-industrial forest owners and present a regional application in Andalusia (southern Spain). We used a single CV question with a *follow-up* (double-bounded) in a survey of 765 landowners. Our analysis focuses on the single-bounded model results because the double-bounded models did not provide the expected gains in efficiency. We used a market simulation where respondents had to decide between their current land asset and amenity consumption and an alternative investment that gives them greater financial profits, but which would imply giving up land amenities. Based on this, we estimate the demand for private amenities by calculating the yearly amount of money that non-industrial forest owners would be willing to accept from an alternative investment in order to give up their land and its amenities. Our proposal complements the hedonic pricing approach, which would focus on observed forestland market prices. Hedonic pricing would identify how much of the land market price is explained by amenities, which could then be transformed into an amenity flow income by applying the standard capitalisation formula and using a discount rate associated with amenity consumption. This discount rate could be assumed *ad hoc* or estimated through combined field and laboratory experiments with landowners.

The contribution of this research is twofold. First, we propose a procedure to estimate the demand for yearly consumption of amenities by landowners, aimed at resolving the valuation gap between output and capital values when landowners' preferences for amenities are significant in an area or region. Second, we empirically quantify, in a regional application, this demand through the forest landowners' willingness to accept compensation (WTA) for giving up private amenity consumption. Our design is based on a well-known non-market valuation method that can be adapted and applied to other areas where land amenities are important for landowners and that can be used to complement hedonic pricing or when the aim is to directly estimate the demand of private amenity consumption. We also discuss the performance of the question formats used and the values estimated using the different models presented. Our research is partly motivated by the current debate on the estimation of non-market product demand and its potential integration in ecosystem accounting (Campos *et al.*, 2020; Edens and Hein, 2013; Hein *et al.*, 2020).

In the following sections, we describe the study area and the methodology used. We then present and discuss the main results and close by outlining the main conclusions.

2. Background

The capital value of a forest property (K) can be expressed as a function of future resource rents (Caparrós, Campos and Montero, 2003):

$$K_j = \int_j^{\infty} e^{-r(t-j)} \left(R_t\right) dt \tag{1}$$

where R_t is the resource rent obtained in year t, j is the base year for the valuation of K and r is the discount rate. Expected forest commercial products (e.g. from timber) and private amenity consumption are internalised in K, so that R_t can be separated into commercial resource rents (R_{Ct}) and amenity resource rents (R_{At}), where a C subscript refers to commercial and an A to private amenity, each with their corresponding r (r_C and r_A). Thus, K can be expressed as:

$$K_j = K_{Cj} + K_{Aj} = \int_j^{\infty} e^{-r_C(t-j)} R_{Ct} dt + \int_j^{\infty} e^{-r_A(t-j)} R_{At} dt \tag{2}$$

For simplicity, we omit the value of infrastructures and buildings, which would also determine the market price of the forest (Caparrós, Campos and Montero, 2003). R_{At} would be determined by private amenity consumption c_{At} (the output component) minus the costs z_{At} incurred to provide the amenity service consumed, i.e. $R_{At} = c_{At} - z_{At}$. However, to simplify the exposition further, we assume that there are no costs involved in the production of the amenity and that c_A is constant over time ($z_{At} = 0$ and $c_{At} = c_A$ for all t). Hence, Section 4 focuses on the estimation of c_A.

Equation (2) establishes the relationship between private amenity consumption and its capital value reflected in K. Caparrós, Campos and Montero (2003) propose the calculation of K by discounting the future resource rents to the corresponding capital stock, but their proposal focuses on market goods and on pure public goods. In the case of landowner amenity consumption, if we estimate R_{At} and assume that it remains constant over time, we can calculate the share of K corresponding to amenity returns (K_A) by applying a value r_A in equation (2). Alternatively, with hedonic pricing, we could also directly estimate this share of K. Our approach would provide values for R_{At} that are independent of the estimation of r_A, this approach being more suitable when the goal is to estimate R_{At} (or c_{At}). For example, although both K_A and R_{At} are relevant in ecosystem accounting, estimates of R_{At} are probably more relevant as national accounts focus mainly on flow values, such as gross domestic product, and are less concerned with capital values.

The analysis of landowner private amenity consumption c_A (the output component of R_{At} in equation (2)) in forests and rangelands has been addressed and referred to in many ways in the literature (e.g. consumptive use, quality-of-life values or rural and environmental amenities). Many studies in the western United States have classified landowners based on their motivations, in most cases finding that amenities play an important role in explaining landownership (Gentner and Tanaka, 2002; Huntsinger *et al.*, 2010; Rowe, Bartlett and Swanson, 2001). Economic approaches have often used the hedonic pricing technique to estimate the effect of amenities on forest and rangeland prices (e.g. Bastian *et al.*, 2002; Pope, 1985; Torell *et al.*, 2005; Wasson *et al.*, 2013). Other authors have focused on the opportunity costs incurred by non-industrial landowners in their forest management versus profit maximising industrial owners (Scarpa *et al.*, 2000; Raunikar and Buongiorno, 2006). Recent publications on income analysis of forest properties in Andalusia (southern Spain) point to evidence of foregone profits in the management of commercial activities (Campos *et al.*, 2019b, 2020; Oviedo, Huntsinger and Campos, 2017). Questionnaire-based approaches have also been used to capture and identify the value of these 'unpriced' forest products (Kallio, 1999; Samuel and Thomas, 1999), and Campos *et al.*'s (2009) study is the first to make use of stated preferences to value private amenity consumption. This study, however, was only applied at a local scale, using small study areas and limited samples. In addition, it used an open-ended valuation format, which has incentive compatibility problems (Carson and Groves, 2007; Johnston *et al.*, 2017).

These previous studies show that private amenity consumption by landowners may play an important role in the market of forestlands and that amenity motivations can drive non-industrial landowners to assume voluntary opportunity costs in their decision to keep, manage or buy a piece of land. In this context, stated preferences can be used to investigate the willingness of non-industrial landowners to accept lower commercial benefits (opportunity costs) in order to enjoy the private amenities of their forestlands.[1] Although there have been significant advances in stated preferences methods over the years (Carson and Groves, 2007), certain controversies and open issues still surround these approaches. Hausman (2012) highlights three main issues: (i) hypothetical bias, (ii) willingness to pay (WTP)–willingness to accept (WTA) disparity and (iii) the embedding effect, although this author focuses on the latter as the most problematic, linking it to the absence of well-defined preferences. Despite these issues, the lack of information on economic values in the absence of markets leads to a demand for these methods and for increased efforts to provide best practice recommendations that improve the validity and reliability of the estimated values (Carson and Groves, 2007; Hanley and Czajkowski, 2019; Johnston *et al.*, 2017). Our application is not free of the hypothetical bias and embedding effect, although the deep familiarity of the consumers (landowners) with the good valued (the amenities from their properties) may have minimised their impact.

1 Spanish Land Law recognises the existence of these private amenities in rural lands and, in order to consider them, proposes the application of a weighting factor to the net present value of the commercial resource rents, but the determination of this factor is not based on any market or landowner preference information (BOE, 2011).

3. Study area

The region of Andalusia (delimited by the *Comunidad Autónoma* figure, an administrative unit for territorial organisation) is located in the south of Spain, covers 8,726 thousand hectares and has a population of around 8.4 million inhabitants. Forests represent around 50 per cent of the region (4,386 thousand hectares). Native oak and pine forests coexist with extensive stockbreeding and historic government conifer and eucalyptus plantations. Cork oak (*Quercus suber*) and Holm oak (*Quercus ilex*) are the main oak species in the region. The former is mainly found in the southwest, covering 248 thousand hectares, and the latter is spread throughout the entire region, covering 1,408 thousand hectares. Oak forests are mainly managed open woodlands with a canopy cover of between 5 and 75 per cent and a well-developed understory of grasses to favour livestock grazing. There are also a variety of pines throughout the region such as the Stone pine (*Pinus pinea*), the Aleppo pine (*Pinus halepensis*) and the Maritime pine (*Pinus pinaster*). Treeless pasture and shrubland facilitate extensive stockbreeding and hunting activities, and cropland is sometimes used for cattle feeding, although it has a marginal role in the properties.

This variety of vegetation and land uses provides a wide range of commercial products such as timber, forage, cork, charcoal, acorns, hunting and crops, along with environmental amenities such as landscape, recreation, wildlife species preservation, rural lifestyle and bequest values. The provision of these amenities may vary over the territory, and some of them are associated with cultural values and tradition. Recreation is either privately enjoyed by landowners and their families in their properties or is provided in the form of free access in some public properties. Landscape values depend on vegetation and steepness, with higher values expected to be attached to native oaks and protected areas. Species biodiversity is higher in pasture and shrubland, followed by oak forests (Díaz *et al.*, 2020).

Our study focuses on forest properties that belong to individual private owners. Properties owned by institutional owners, both private (e.g. corporations or private foundations) and public (e.g. public administrations), are not considered. Amenities cannot be consumed by private institutions, and the public consumption of forest amenities differs from that of the private owners. Although both public and private properties provide amenities, their provision and values may differ as they depend on the management of the environmental assets and the expected consumption by active and passive users. While private landowners pay for the amenities of their properties both directly in the land market to acquire the exclusive rights over the land and implicitly through the voluntary opportunity costs assumed for keeping these amenities, the general public pay for them through taxes and are likely to be willing to pay more. This may also include amenities of private lands in the form of externalities generated by the preferences of non-industrial owners for amenity consumption.[2]

2 Another difference between privately and publicly owned properties is that the latter cannot be sold in the market, except under very specific conditions (BOE, 2011). This implies that the value

Both approaches are not substitutes but complementary, each needing different valuation designs. Our interest in amenity consumption by private forest landowners is motivated by the implications it has for the economic valuation of forestlands and because privately owned properties represent 73 per cent of forestlands in Andalusia. Results on public consumption of non-market forest products in Andalusia can be found in Campos *et al.* (2019a, 2019b, 2020) and Caparrós *et al.* (2017).

Our unit of analysis (which we will refer to as the forest 'property') is a group of land parcels owned or leased by a single owner and which are under common management. Although a property generally comprises a single land parcel, there are cases where several parcels form a single management unit, even though they are registered as different properties. Therefore, our unit of analysis follows a land management criterion. It can be difficult to determine the exact population of these properties in Andalusia based on available information. From a management perspective, there is no standardised, official census of forest properties in Andalusia. Even from a legal perspective, the information is fragmented and imprecise. The only official information is the Spanish *Catastro* (land registry), but this refers to parcels that do not necessarily match the properties and, less still, the management units. Thus, we had no precise *a priori* information on the properties in 73 per cent of privately owned forestland area.

4. Methods

We designed a CV questionnaire with the aim of estimating a simulated demand function for the consumption of non-market private amenities by forest owners in Andalusia. We chose CV instead of other stated preference techniques (e.g. choice experiments) because we were interested in the consumption of amenities as an indivisible whole (Johnston *et al.*, 2017). In addition, breaking down the different attributes of this amenity consumption and presenting several alternatives would have implied a more complex design that might have reduced the credibility of the scenario as landowners are used to buying and selling land as a whole.

The valuation scenario is based on the premise that forestland assets in our study area provide profitability rates below normal market returns (Campos *et al.*, 2019a, 2019b, 2020), so that forest owners may frequently face the decision of whether to sell their property in order to invest in an alternative asset that would give them higher profits but would mean a loss in land amenity consumption. We assume that there is a direct link between this opportunity cost and the willingness to keep consuming land amenities (this is shown later in our results). The different components of land amenities are explored through attitudinal and self-assessment questions in our survey, but our analysis focuses on the aggregate value of all these components linked to the voluntary opportunity costs of owning a forest property.

of amenities would be internalised in the land price only in the few cases where these properties are sold to buyers who expect to consume amenities.

Immediately prior to the CV questions, we formulated a series of questions that helped to create the valuation context. We asked respondents to rate from 1 to 5 (1 being 'not important at all' and 5 being 'very important') the different reasons for which they keep their land and to apportion (in percentage) the contribution of different benefits from their forestland to its potential land market price. We also asked them whether they thought that by selling their property and using the money to invest in a non-agroforestry investment (with the same risks and length of time), they would obtain more yearly profit than that which they get in the form of money (including subsidies) and increase in land value from their forest property. We then asked respondents to consider the possibility of an alternative non-agroforestry investment that would increase their yearly profit by a specific amount €*A* and whether they would sell their property in order to make this investment and obtain this increased yearly profit (this being the CV question per se). This first CV question is based on the closed-ended format proposed in Bishop and Heberlin (1979). We then asked a follow-up (second question) where the amount €*A* was increased if the answer to the first question was 'no' or decreased if the answer to the first question was 'yes' (see the Appendix for the wording of these questions).

This CV question focuses on the yearly profit that the respondent would be willing to forego from an alternative investment (potential opportunity cost), which depends on the landowner preferences. The landowner needs to know whether they would accept an increase of €*A* in their current commercial income in order to give up the property and the associated land amenities. This €*A* value may be partly determining the value of land, that pertaining to amenity consumption, although it is not the only factor that determines this value. These amenities represent part of the services produced by the forest environmental assets and may differ and have different drivers from the economic values associated with pure market products. Through our design, we intend to obtain a separate valuation of the demand for private amenity consumption by making landowners choose between amenity consumption or an increase in their commercial income. We expect the responses to the CV question to only refer to the yearly amount of money they would exchange for amenities.

The wording of the CV question (see the Appendix) was developed based on a meeting with experts and two focus groups. We originally considered the possibility of providing examples for potential alternative investments with similar risks and length of time within the text of the question itself. The two examples put forward were housing investment and long-term financial bonds. However, it was decided from the meeting with experts and the focus groups that this made the question too 'wordy' and that it would be better to leave these additional explanations to the interviewer (as explained later, the questionnaires were conducted face-to-face with an interviewer).

We have used a WTA wording instead of WTP. The latter could have been obtained if we had worded the question in terms of whether the forest owner would be willing to assume a specific increase €*A* in their current opportunity cost in order to maintain land amenity consumption. Potential differences between WTA and WTP measures have been analysed, in theoretical terms (Willig, 1976; Randall and Stoll, 1980; Hanemann, 1991), in the context of behavioural economics (Tversky and Kahnemann, 1991) as well as empirically (Horowitz and McConnell, 2002). More recently, Kim, Kling and Zhao (2015) have extensively reviewed (in theoretical and empirical terms) the sources of differences between WTP and WTA estimates. Although initial studies (Willig, 1976; Randall and Stoll, 1980) showed that WTA and WTP should be close, Hanemann (1991) argued that in the context of public goods, theory predicts that differences can be large, especially if there are no substitutes. There is enough empirical evidence showing the disparity between WTP and WTA, which is explained by different factors, such as income and substitution effects, loss aversion or bounded rationality (Brown and Gregory, 1999; Kim, Kling and Zhao, 2015). The decision between these two measures often depends on which one is more appropriate in each specific valuation context, and although there are often practical challenges associated with WTA, the recommendation is that it should be used when it is conceptually appropriate and feasible (Johnston *et al.*, 2017).

In our case, we chose the WTA wording because (i) it is more suitable when the good is private and the respondent has the right to consume it (Brown and Gregory, 1999; Mitchell and Carson, 1989), which is consistent with private landowners having the right to consume its amenities *in situ*; (ii) the WTP wording was cognitively more challenging because respondents would have to consider a potential increase in their opportunity cost and (iii) the WTP wording proved problematic both in the focus groups and in previous applications (Campos *et al.*, 2009), causing confusion for some respondents. In any case, as the good considered in our application is private and may have substitutes, differences between WTP and WTA estimates should not be too large (Horowitz and McConnell, 2002; Kim, Kling and Zhao, 2015).

To design the bid vector, we constructed a log-normal distribution (Alberini, 1995; Cooper, 1993) of values based on the answers to CV questions from previous Spanish case studies (Campos *et al.*, 2009) and from the pre-test ($n = 135$). For the first question, we used the four quintiles of this log-normal distribution. For the second question, we used the median of the log-normal distribution truncated at the initial value from above if the answer to the first question was ‘yes’ and from below if the answer to the first question was ‘no’. This design, which follows Kanninen (1993) and Alberini (1995), represents a good compromise between efficiency and information for the shape of the distribution of values and avoids the tails of the assumed distribution. Thus, the bid vector expressed in euros per hectare for the first question was [€75, €140, €240, €450]. For the second question, the increased bid vector was [€240, €320, €450, €720] and the decreased bid vector was [€45, €75, €105, €140]. These values were designed in euros per hectare, but we also presented the amount in total euros. The software used multiplied the per hectare amount randomly selected by the total hectares of the property.

Although our valuation scenario design meets most of the best practice recommendations by Johnston *et al.* (2017) (a well-defined baseline, pretesting, a bid vector design based on the pre-test and the literature, and other aspects explained later as an incentive compatible question format or a random sampling), consequentiality has not been explicitly addressed in our design. However, the questions presented previous to the CV question may have enhanced respondents' perceptions about the existence of amenity consumption and the possibility of exchanging them for a higher monetary income from an alternative investment. As the consequentiality condition refers to the probability of an individual perceiving that their responses will lead to an actual outcome (Carson and Groves, 2007; Vossler, Doyon and Rondeau, 2012), respondents in our survey may have perceived that their decisions regarding amenity consumption or higher monetary income could eventually come to pass. In any case, this is an issue that should be considered more explicitly in future applications.

4.1. Econometric analysis

We assume that WTA for individual *i* (WTA_i) estimated from the CV questions equals c_{Ai} (see Section 2). We discuss this assumption in Section 6. Since respondents did not know in advance that there would be a follow-up, the first CV question (single-bounded) can be analysed independently of the second one (double-bounded). The analysis of the single-bounded question is based on Cameron (1988, 1991). We follow this approach because it allows a flexible specification of explanatory variables and a direct interpretation of the coefficients of the valuation function. We assume an underlying valuation function of private amenity consumption defined as:

$$c_{Ai} = x_i'\beta + u_i \tag{3}$$

where c_{Ai} is unobserved but can be derived from the binary choice question described earlier in which forest owners are confronted with a threshold value s_i of c_{Ai}, x_i is a vector of explanatory variables for which observations are available, β is a vector of coefficients to be estimated and u_i is an error term distributed according to a logistic distribution with mean 0, standard deviation b and scale parameter $k = b\sqrt{3}/\pi$ (Cameron, 1988). Making use of s_i, the probability of a negative answer to the CV question, that is, the probability that the respondent's i underlying valuation of private amenity is greater than s_i, is:

$$\begin{aligned} Pr(c_{Ai} \geq s_i) &= Pr(x_i{}'\beta + u_i \geq s_i) = Pr(u_i \geq s_i - x_i{}'\beta) \\ &= Pr[u_i/k \geq (s_i - x_i'\beta)/k] = Pr[\varphi_i \geq (s_i - x_i'\beta)/k] \\ &= 1 - Pr[\varphi_i < (s_i - x_i'\beta)/k] \end{aligned} \tag{4}$$

where φ_i is a standard logistic random variable with mean 0 and standard deviation $b = \pi k/\sqrt{3}$. Similarly, the probability of a positive answer, that is, the probability that the respondent's i underlying valuation of private amenity consumption is lower than s_i, is:

$$Pr\left(c_{Ai} < s_i\right) = Pr\left[\varphi_i < \left(s_i - x_i'\beta\right)/k\right] \tag{5}$$

Although the log-likelihood associated to equations (4) and (5) can be written and optimised directly using a non-linear iterative optimisation algorithm, Cameron (1988) proposes a 'shortcut', which involves including the value threshold offered to respondents (s_i) among the explanatory variables, thus allowing us to estimate $1/k$ and $-\beta/k$ from a conventional binary logit. This logit will include an augmented vector of variables x^* and coefficients γ^* so that $-\left(x', s\right)\begin{pmatrix} -\beta/k \\ 1/k \end{pmatrix} = -{x^*}'\gamma^*$. Once γ^* is estimated from the binary logit regression, we can recover k from the coefficient $1/k$ and β for equation (3) by using k and the coefficient $-\beta/k$. For confidence intervals, we follow the procedure from Cameron (1991), where the point estimates for γ^* and the associated variance–covariance matrix ($\sum_{\gamma^*}$) yield the coefficient variance–covariance matrix ($\sum_{\beta}$) after some manipulations of $\sum_{\gamma^*}$ and its related information and transformation matrix.

For the conventional binary logit, we use a log-logit specification where we use the log of s, as in the example presented in Cameron (1988). This functional form precludes negative values of c_{Ai} and gives a better fit for our data. In our model, s_i is entered in euros per hectare values. The variables in x^* include an intercept and several property characteristics that act as proxy variables of the quantity and quality of amenities consumed by forest owners. Amenities include a range of benefits such as open space, recreation, scenic values, lifestyle or social status that are intended to be captured by these variables. Using a model only with the intercept would allow us to estimate an aggregate value of amenity consumption, but adding additional variables can separate out the contribution of individual components to this aggregate value.

The double-bounded data (first and second questions) were analysed following the traditional approaches of Hanemann, Loomis and Kanninen (1991) and Cameron and Quiggin (1994). We also tried an alternative approach that takes advantage of recent developments in discrete choice modelling (Train, 2009) by estimating a mixed logit model with repeated choices that pools the responses to the first and second valuation questions. However, for reasons explained later on in Section 5, our analysis focuses on the single-bounded data. The methodological developments of the double-bounded models are described in the online supplementary material (supplementary data at ERAE online) to this paper.

4.2. Sampling

We conducted a random sampling, drawing 11,500 random points from a geographical information system (GIS) layer of forestland in Andalusia. Using the parcel information from the Spanish *Catastro* (land registry), we removed

5,896 points that belonged to (i) parcels owned by public institutions; (ii) parcels owned by private institutional owners; and (iii) parcels with less than 10 per cent forest area. We also discarded 1,988 points corresponding to the same landowner and property. This left us with 3,618 points corresponding to properties owned by non-industrial private owners. For these properties, we obtained the contact information from the Spanish *Catastro*.

Our initial target was 800 questionnaires, each corresponding to one property and owner. We set this target under the assumption that we needed a minimum of 400 valid answers to the CV question and we were expecting a conservative 50 per cent rejection and protest response. This criterion was adopted because we expected some forest owners to be reluctant to respond to this type of survey and to be more likely to reject the market simulation scenario presented in the CV question. The expected sample size would give a maximum sampling error of ±5 per cent for the proportion (yes/no answers to the CV question) for a 95 per cent confidence interval in the case with the higher standard deviation (both 'yes' and 'no' answers equal to 50 per cent). With this sample size, proportions of answers and an assumed margin of error of ±5 per cent, we have approximately an 80 per cent statistical power of correctly rejecting the null hypothesis that the population proportion is within the confidence interval of the estimated proportion.

4.3. Survey logistics

We trained a team of 16 interviewers in two 5-hour sessions previous to the field implementation of the questionnaire. The training covered all aspects of the questionnaire, but special emphasis was given to the CV questions. We insisted that the interviewers made it clear to the respondents that the hypothetical alternative investments were non-agrarian, with similar risks and lengths of time to those of the forestland assets, and that they provided the two examples discussed in the meeting with experts and the focus groups. All interviewers had a college degree in either forestry or environmental sciences and were working at the AMAyA agency of the regional government at the time the survey was implemented. The list of 3,816 landowners and properties resulting from the sampling process was divided among the eight provinces of Andalusia, and for each province, the corresponding interviewers contacted landowners randomly. The division of the sample into provinces after completing the sampling process was a practical way of distributing the team of interviewers over the territory to avoid unnecessary commuting. Each interviewer was assigned to one province and was in charge of interviewing landowners with properties in that province. In the end, 843 questionnaires were completed, for which 1,298 contacts were necessary (65 per cent success rate). The total number of completed questionnaires was a little higher than the original target sample because a preliminary analysis of the first questionnaires completed (March 2010) revealed that some of the properties did not qualify as part of our target population and this could have led to a reduced valid sample size.

Thus, of the 843 questionnaires completed, 78 were discarded because we identified these properties as being more oriented towards agriculture, despite having some forestland use. The criterion used to discard these observations was based on the percentage of forest land use area in the property. To select this criterion, we analysed the percentage of land uses in the properties, the responses to land management questions as well as the comments annotated by the interviewers during the completion of the questionnaires. We concluded that properties in which less than 30 per cent of the area was forestland were oriented towards agriculture. In accordance with this, we avoided the inclusion in our sample of properties with marginal forestry uses but primarily oriented towards agriculture and we also avoided the exclusion of large properties with extensive areas of both forest and crop uses. Thus, our final valid sample was made up of 765 questionnaires. Since the initial sampling of points was random and the selection of landowners to be contacted was also random, we expect our final sample to be uniformly distributed throughout the region.

During November and December 2009, we held the meeting with experts, created the two focus groups comprising three forest owners and conducted a pre-test with 52 landowners. In the pre-test, we validated the questionnaire and tested a preliminary CV design. The final survey was conducted between January and May 2010. All interviews were conducted face-to-face with the forest owner. The pre-test and the final survey were programmed and designed digitally, and the interviewers conducted the questionnaire using a laptop computer.

5. Results

Table 1 shows the statistics for the main variables, describing the forest owners and their properties. The most frequent situation is that the forest owner directly manages the property (78.0 per cent), while about a third of them lease out part or all of the property (36.6 per cent). The average owner is 58 years old and 26.9 per cent of the family income comes from activities undertaken on the property (self-reported response). 41.5 per cent of the respondents have a college degree. The average size of the properties is 463.2 hectares, with 86.3 per cent of their area being forestland. The average distance of the properties from the capital of the province is 85.7 km. The dominant vegetation is oak (mainly holm and cork oak), present in 69.7 per cent of the properties, followed by pasture and shrubland (60.8 per cent). Cropland uses are present in almost half of the properties, although these uses tend to be marginal, representing on average 10.6 per cent of the property area (std dev. = 38.2 per cent). Among pine species, the Aleppo pine is the most common. Eucalyptus plantations are less frequent although they account for an average 30 per cent of the area of the properties in which they are present. A third of the properties are within some type of land protection area (e.g. natural park). A comparison of these characteristics among the subsamples from the different Andalusian provinces is presented in the online supplementary material (section SM.1 (supplementary data at ERAE online)).

Table 1. Descriptive statistics of forest owners and properties ($n = 765$)

Variable	Mean	Std dev.
Forest owner		
Direct management (%)	78.0	41.4
Lease land to third parties (%)	36.6	48.2
Age (years)	58.4	13.0
Contribution of property to respondent's income (%)	26.9	36.1
College degree (%)	41.5	49.3
Forest property		
Size of property (management unit) (hectares)	463.2	779.3
% area of forestland in the property[a]	86.3	19.8
Distance from property to the provincial capital (km)	85.7	38.7
% of properties with oaks	69.7	46.0
% of properties with treeless pastureland–shrubland	60.8	48.9
% of properties with Aleppo pine	9.2	28.9
% of properties with eucalyptus	2.7	16.4
% of properties with cropland	49.8	50.0
% of properties within a protected area	33.2	47.1

[a] Wooded land, pastureland and shrubland.

As regards the questions previous to the CV scenario, we found that the highest rated reason for keeping the property is 'the possibility of leaving the property as inheritance' (mean = 3.7; std dev. = 1.5), followed by 'the enjoyment of recreational and landscape features by the family' (mean = 3.1; std dev. = 1.5) and by 'commercial uses' (mean = 3.1; std dev. = 1.6). 'The possibility to experience a rural lifestyle/live in the countryside' was also rated above 2.5 (mean = 2.7; std dev. = 1.5). All other reasons presented and those reported as 'others' were rated below 2.5.[3] Overall, amenity-related reasons were rated higher (mean = 1.9; std dev. = 0.5) than commercial-benefit-related reasons (mean = 1.4; std dev. = 0.3).

On average, landowners attribute 54.9 per cent (std dev. = 30.7 per cent) of the potential land market price of their property to amenity benefits, with bequest options (mean = 20.8 per cent; std dev. = 24.1 per cent) and recreation and scenic enjoyment (mean = 15.1 per cent; std dev. = 18.2 per cent) being the two factors with the greatest weight in this allocation. Furthermore, most respondents (81.0 per cent; std dev. = 35.3 per cent) stated that they would obtain more profit through an alternative non-agroforestry investment (with the same risks and length of time), while 14.2 per cent (std dev. = 13.2 per cent) stated that they obtain more profit from their current land investment considering both money and increase in land value. The remaining 4.8 per cent (std dev. = 4.6 per cent) think that the activities of the property alone are

3 These include 'the enjoyment of managing the commercial uses', 'keeping a safe investment', 'social prestige (the possibility of inviting friends and/or clients)', 'love for nature', 'tradition', 'hunting' or 'subsidies'.

more profitable (not considering the increase in land value) than the alternative investments.

For the first CV question (single-bounded), we obtained 458 valid answers (60 per cent response rate). The 307 discarded responses were identified as 241 protests, 26 'do not know/do not answer' and 40 questionnaires that were not answered by the forest owner but by the land manager. To identify protest responses, we used a follow-up open-ended CV question after the second CV question and a subsequent follow-up (see the Appendix) asking why they would not accept any amount to move to an alternative, more commercially profitable investment. This follow-up was presented to those giving a negative answer to both the first and the second CV questions and not stating any amount for the open-ended CV question. The responses showed that the main pattern of protest was associated with redundant or imprecise answers (e.g. 'I do not want to answer this') and with answers related to the rejection of the scenario (e.g. 'I would not even think about this situation' and 'I do not want to put myself in this situation'). In these cases, we considered the answers of this respondent as a protest response.

The questionnaire also included three control questions. Immediately after the valuation scenario, respondents completed a follow-up where they had to rate their understanding of the CV questions (1–5 scale from very confusing to very clear). The mean rating was 4.0 (std dev. = 0.9). In addition, having finished the questionnaires, interviewers were asked to complete a series of questions which included rating the respondent's attitude and understanding during the questionnaire (1–5 scale from very bad to very good). The mean rating for these questions were 4.3 (std dev. = 0.8) and 4.2 (st dev. = 0.7), respectively. These results indicate a good understanding and attitude from respondents when answering the questionnaire.

Table 2 shows the results of the selected log-logit regression estimated with the single bounded data and of the censored log-logistic regression obtained after reparameterisation. The reparametrised coefficients can be interpreted as the coefficients of a log-linear function. We present this model as the preferred one here because all explanatory variables are significant (p-value < 0.10) and are not correlated (p-value > 0.10). Furthermore, it allowed for spatial variability in c_A estimates. We tested other models including additional explanatory variables, although some of these variables were either not significant, were correlated to each other or resulted in other variables becoming non-significant. Nevertheless, and to further illustrate drivers of private amenity consumption, we present in the online supplementary material (supplementary data at ERAE online) three additional models including each different groups of variables and one model including all variables considered (section SM.2 (supplementary data at ERAE online)). These models are (i) a model adding property and vegetation characteristics to those presented in Table 2, (ii) a model with dummy variables for the eight Andalusian provinces, (iii) a model including landowner socioeconomic characteristics and self-reported amenity assessments and (iv) a model including all the explanatory variables from the previous models. All these additional models include correlated

Table 2. Log-logit and censored log-logistic regressions for the valuation of forest owner private amenity consumption

	Log-logit regression		Log(c_A[a]) censored logistic regression	
Variable	Coefficient	*p*-Value	Coefficient	*p*-Value
Intercept	−2.7975**	0.0162	3.8629***	0.0012
Log of the bid	0.7242***	<0.0001		
Eucalyptus (=1 if there is eucalyptus vegetation in the property)	1.1926*	0.0650	−1.6468*	0.0836
Aleppo pine (=1 if there is Aleppo pine vegetation in the property)	0.9695***	0.0027	−1.3387***	0.0091
Log of the distance to the provincial capital	−0.3832**	0.0457	0.5292**	0.0607
Property size in hectares	0.0003*	0.0918	−0.0004	0.1124
k			1.3809***	<0.0001
Log likelihood	−287.70			
McFadden R^2	0.0629			
Restricted McFadden R^2[b]	0.0330			
Akaike Information Criterion (AIC)	587.39			
AIC/*n*	1.29			
n	455			

Notes: Single-bounded model. Asterisks (e.g.*,**,***) denote significance at the 10 per cent, 5 per cent and 1 per cent levels, respectively.
[a]The dependent variable is the log(c_A) in euros per hectare for 2010.
[b]Following Herriges (1999), and to make it comparable with the Hanemann, Loomis and Kanninen's (1991) double-bounded models presented in the online supplementary material (supplementary data at ERAE online), we also show a restricted McFadden R^2 where the restricted log-likelihood in the formula corresponds to a model with only a constant term and the log of the bid as explanatory variables.

explanatory variables within the same model and/or across models. The online supplementary material (supplementary data at ERAE online) presents the correlation analysis of these variables (section SM.1 (supplementary data at ERAE online)).

The log-logit regression in Table 2 shows that the log of the bid coefficient is significant and with a positive sign, indicating that the probability of accepting the bid (answering 'yes') and giving up amenity consumption increases as the amount offered increases. In other words, the probability of consuming amenities drops if the implicit price (land investment opportunity cost) paid by forest owners for keeping them increases. This establishes a demand relationship between the implicit price paid and the consumption of amenities. This variable does not appear in the censored regression, only the reparameterised coefficient *k*, for which the implied standard deviation of error distribution (*b*) is 2.5047.

Two vegetation variables, the presence of eucalyptus and Aleppo pine in the property, are also significant with a negative sign in the censored regression. The eucalyptus is an exotic species, historically introduced through plantations in the study area for pulp production, while the Aleppo pine is a native species that has been artificially expanded. Both species compete for land use with the iconic native oak species in the region, the holm oak and the cork oak. It is likely that both the eucalyptus and the Aleppo pine are acting as proxies of negative scenic and landscape values, driving the c_A downwards.

Another variable, the log of the distance from the property to the provincial capital, shows in the censored regression that the further the property from the provincial capital, the higher the value of private amenities. We can interpret this as landowners being more likely to consume forest amenities in remote areas, more isolated from urban centres. In general, more remote forests in Andalusia are located in natural parks, which were designated as such, among other reasons, because of their higher scenic, natural and environmental values. Our survey data show a significant positive correlation ($r = 0.203$; p-value < 0.01) between the distance to the provincial capital and whether the property is located within a natural park. Although being closer to a large urban area may have advantages in terms of communications, it also brings with it the risk of having more people in the surroundings or even trespassing on the property. In addition, distances in Andalusia are not large enough for decreasing amenity value linked to excessive remoteness and isolation to occur. The maximum distance from a property to the provincial capital in our sample is 175 km. We tested a model with a linear and a quadratic term for this distance, but neither of these coefficients was significant.

The sign in the censored regression was also negative for property size, that is, the c_A per hectare decreases as property size increases. This implies that total c_A remains relatively constant from a certain property size upwards and, eventually, it starts decreasing. This effect is derived from the implied quadratic function for total c_A in our model of c_A per hectare. The marginal changes in total c_A become negative when a property reaches 2,406 hectares. The extension of the flat area for this function previous to reaching this point, which can be interpreted as an area of saturation in the consumption of amenities, depends on the values of the other explanatory variables. For example, if we define this flat area as the space where marginal changes are less than EUR 10 per hectare, this occurs between 2,282 and 2,405 hectares for properties without eucalyptus and Aleppo pine and located 85.7 km from the provincial capital. For properties with eucalyptus and Aleppo pine, the flat area ranges from 980 to 2,405 hectares. Figure 1a (c_A per hectare) and b (total c_A) illustrate the former case. Property size here represents a proxy of the quantity of amenities consumed (more land and more amenities to be consumed). Interestingly, it seems that this consumption gets saturated at a certain quantity. This effect has previously been hypothesised by Pope (1985) for land values related to amenities (what he called 'consumptive' value), but his hedonic pricing application to rural land values in Texas could find no empirical evidence of this effect due to lack of data. Our application provides empirical evidence of this effect in monetary and physical terms.

The single-bounded models presented in the online supplementary material (section SM.2 (Section in supplementary data at ERAE online)) show that the presence of cork oaks (an iconic oak species in the region) and of a hunting reserve in the property increase c_A, while the presence of cropland decreases it. Interestingly, although cropland usually increases the commercial production value of a property, this does not occur with the part of the land value linked to amenities, as forest landowners in our sample demand lower levels of compensation in exchange for amenity consumption when properties include cropland. This result may be specific to our regional case study and should not be taken as a generalisation of amenity drivers in other regions. It should be borne in mind that our target population is that of forest properties, some of which include some cropland (generally marginal) while others do not. Furthermore, our c_A estimates refer exclusively to amenity values and do not include any value associated with commercial production, which may account for a large difference in aggregated land values between crop and forest/rangelands. We do not know the overall effect of different combinations of these land uses on the total value of a forest property in Andalusia. This is beyond the scope of our paper. Analysing this aspect would imply an interesting step forward in the valuation of forest and agricultural land where both commercial production and amenity consumption are present.

The model with variables for the Andalusian provinces shows some significant results, pointing to higher amenity values in Almeria and lower values in Granada, Huelva and Jaen. The model with landowner characteristics and self-reported amenity assessments shows that landowners owning more than one property have a significantly lower c_A, probably because having multiple properties implies a larger area of managed land; thus, the effect is similar to that of property size. The three other variables in this model reveal a higher c_A for landowners with a higher level of education as well as for landowners who award a higher rating to amenity motivations for keeping the land and those attributing a higher share of the potential land market price of their property to amenity benefits. The two latter effects show a direct link between c_A, amenity motivations and self-assessment of amenities.

Using the estimated β and the values of the explanatory variables x^* (except the bid) in equation (3), we estimated the median[4] c_A (Cameron, 1988) for each respondent who provided valid values for x^*. Table 3 shows the main statistics of the distribution of these values for all single-bounded models presented (values are in euros per hectare for 2010). For the preferred model (Table 2), we obtained a mean of EUR 387.8 per hectare and a relative margin of error of ± 3.0 per cent. The slightly higher median than the mean, along with the negative signs of the asymmetry and kurtosis coefficients, indicate that the distribution of these values is slightly skewed to the left.

4 We present the median c_A because this metric is favoured by statistical arguments as it avoids outliers or unusual observations (Hanemann, 1984). In addition, the mean c_A in our model gave unrealistic values as the parameter $k > 1$ (Alberini, Longo and Veronesi, 2007).

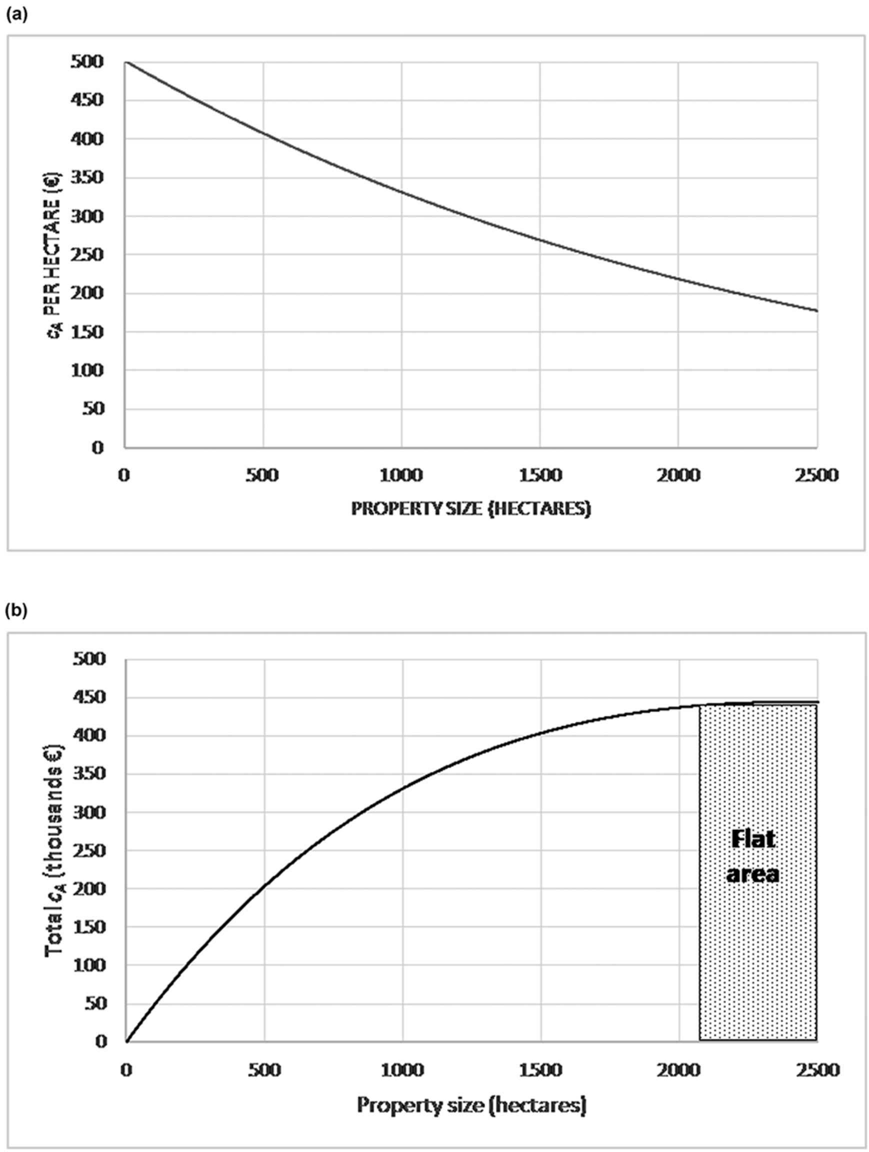

Fig. 1. (a) c_A per hectare (€) as a function of property size for forest properties without eucalyptus and Aleppo pine and located 85.7 km from the provincial capital. (b) Total c_A (thousands €) as a function of property size for forest properties without eucalyptus and Aleppo pine and located 85.7 km from the provincial capital. The shaded area (flat area) indicates that marginal changes in total c_A are less than EUR 10.

We initially focus on the results from this model (Table 2) because they avoid the effects of correlation on the estimated regression coefficients as well

Table 3. Statistics for the distribution of median c_A values from the $\log(c_A)$ censored regression models

Model	Mean	Std dev.	Margin of error (%)	Median	Kurtosis	Asymmetry
	Confidence interval (95%)					
Valid values for x^*						
Table 2 model ($n = 761$)	387.8 [376.2, 399.3]	162.5	±3.0	409.9	−0.6	−0.3
Table SM.3 model (n = 761)	511.0 [477.9, 544.2]	466.9	±6.5	375.4	6.0	2.3
Table SM.4 model (n = 765)	451.6 [434.0, 469.2]	248.9	±3.9	500.8	−1.5	0.0
Table SM.5 model (n = 726)	585.0 [540.6, 629.4]	610.9	±7.6	394.9	15.0	3.2
Table SM.6 model (n = 723)	846.1 [738.8, 953.3]	1471.4	±12.7	430.4	84.3	7.3

Note: Single-bounded data.

as the risk of double-counting the same effect on c_A captured by correlated variables. For example, this potential double-counting could arise if we included the dummy variables for Andalusian provinces in the model. As the presence of eucalyptus is positively and significantly correlated with Huelva province, we could find that the negative effect of eucalyptus vegetation on c_A would be accounted for twice, both in the vegetation variable and in the province variable. A similar analysis can be made with the model in Table SM.3 (Table in supplementary data at ERAE online), which adds three additional explanatory variables to the model from Table 2. The correlation analysis for the variables in this model shows not only that the presence of cork oak trees and the presence of cropland in the property are negatively correlated, but also that cork oak trees are positively correlated with property size and negatively correlated with Aleppo pine, while cropland is positively correlated with Aleppo pine and negatively correlated with hunting. These multiple correlations suggest that the values estimated using this model must be interpreted with caution. We illustrate this with two examples. On one hand, the positive effect of cork oak trees may reflect landowner preference for iconic native oak species, usually linked to traditional open forest landscapes in the region which are more likely to be part of hunting reserves. Since cork oak trees and hunting reserves are positively correlated, there is a risk of double-counting the same effect of landowner preference for amenities in this model. On the other hand, as cork oak trees and cropland are negatively correlated, we wonder whether the above-mentioned effect found for cropland is a negative effect resulting from the absence or reduction of oak woodland area in properties with more cropland. If this were the case, we would be considering the same amenity preference twice in the model.

When comparing the c_A statistics from the different models (Table 3), we find that mean values are less robust across models and that they increase with the number of correlated explanatory variables in the model (models from Table SM.3, SM.5 and SM.6 (Table in supplementary data at ERAE online)). For example, the mean from the model in Table SM.6 (Table in supplementary data at ERAE online) is more than twice that from the model in Table 2. The same occurs with the standard deviation, the margin of error, and the coefficients of kurtosis and asymmetry. However, the median values remain relatively similar across models (Table 3). These results suggest that the distribution of values presents a longer right tail in the models with more correlated variables, implying a greater proportion of outliers. This is confirmed in Figure SM.1 (Figure in supplementary data at ERAE online) in the online supplementary material (supplementary data at ERAE online), which shows the graphical distribution of these values for each model. This may be a result of the double-counting of amenity preferences from correlated variables. For example, 98 per cent of outlier c_A values from the model in Table SM.3 (Table in supplementary data at ERAE online) (e.g. above percentile 95: EUR 1,505.63 per hectare) correspond to properties where positively correlated variables with positive coefficients are present (e.g. cork oak trees and a hunting reserve) along with an absence of variables with negative coefficients that are negatively correlated with positive coefficient variables (e.g. presence of Aleppo pine and cropland uses).

It could be argued that there is no need to use models with explanatory variables in order to obtain point estimates of c_A (or, alternatively, WTP measures). However, the use of explanatory variables related to locational and physical characteristics of the ecosystem service valued is of interest for ecosystem accounts. The SEEA–EA is a spatially based, integrated statistical framework that 'places considerable focus on recording data on the stocks and flows at sub-national and finer spatial scales' (United Nations, 2021: 25). The analysis of spatial units is key to understanding and tracking individual ecosystem assets, flows of ecosystem services and production changes in smaller areas (Campos *et al.*, 2020; Edens and Hein, 2013; Remme *et al.*, 2015), in addition to aggregated information from national accounts. In our application, we estimate differentiated values across a spatial area by combining the Cameron's (1988) approach with the explanatory variables of the preferred model.

This requires different models to be tested, each with different explanatory variables, and raises the issues of model choice, multicollinearity and potential double-counting of correlated explanatory variables. Our results have illustrated some of these challenges and, based on these results, we draw two main recommendations. First, we recommend using a parsimonious model without correlated explanatory variables to estimate c_A, although we acknowledge that this risks the omission of relevant variables influencing amenity preferences. Our results show that the proposed model is less likely to generate outliers in the distribution of estimated values in the sample. Second, if the aim is to present aggregated values, we recommend using the median of the distribution of values estimated, which has proved to be more robust. However, in the context of ecosystem accounts, this should not be seen as a substitute for the estimation of individual values differentiated according to spatial- and ecosystem-based attributes (e.g. vegetation type or locational characteristics).

Finally, we also acknowledge that each valuation context as well as the characteristics of the study area will differ; hence, we may find cases where correlation among explanatory variables is unavoidable or is not as strong as in our application. For example, in valuation studies where the information on attributes of the ecosystem service valued is more controlled (e.g. choice experiments), there may not be correlation problems, although there may be other issues such as unrealistic scenarios. Thus, although our recommendations are based on our specific application, they could be relevant to future case studies that may face similar or related valuation issues.

6. Further analysis and discussion

As regards the double-bounded results (sections SM.3, SM.4 and SM.5 in the online supplementary material (supplementary data at ERAE online)), the Cameron and Quiggin's (1994) models produce inferior results, with no significant coefficients for the second valuation function and little gain in efficiency[5] for the first valuation function, while the Hanemann, Loomis and Kanninen's (1991) model gives a modest gain in efficiency. When using the mixed logit model with repeated choices, we also obtain a modest gain in efficiency or none at all, and the significance level of some coefficients drops. Overall, we find little improvement in the double-bounded models, while we still face the problems of endogeneity, incentive incompatibility or strategic response associated with the second question (Johnston *et al.*, 2017). For this reason, the double-bounded results are only briefly mentioned here (see the online supplementary material for more details (supplementary data at ERAE online)).

We have also considered unobserved heterogeneity in our analysis by specifying mixed logit models (Train, 2009). For the single-bounded data, we did not obtain significant standard deviation parameters, and the fixed parameters became non-significant in these models. For the double-bounded data, the mixed logit models with repeated choices presented in the online supplementary material (supplementary data at ERAE online) consider unobserved heterogeneity, but these models do not perform better than the single-bounded models with fixed parameters and only a few standard deviation parameters are significant. It is possible that the explanatory variables included in the models are already capturing preference heterogeneity for forest amenities across landowners.

The number of protest responses ($n = 241$) obtained from the CV question led us to conduct a logit analysis to identify the drivers of protest. This analysis is presented in section SM.6 in the online supplementary material (supplementary data at ERAE online). The results show that the occurrence of protest responses is positively associated with higher amenity values and motivations.

5 Measured with the McFadden R^2, the Akaike Information Criterion (AIC) and the standard deviation of error distribution (b).

Cropland has a negative effect, while hunting and having livestock have a positive effect on the probability of protest response. The self-reported rating of amenity motivation also explains the occurrence of protest. There is no straightforward interpretation of the positive effect of age, although it is possible that older landowners are more attached to tradition and lifestyle values and therefore are driven by them when expressing protest.

Before concluding, we will briefly discuss two of our main assumptions. First, we have assumed that the WTA_i estimated from the CV questions equals c_{Ai}. This is equivalent to assuming that each individual WTA_i would be internalised in the land market price if the land were sold and that it already represents an exchange value that can be used in ecosystem accounting (Campos *et al.*, 2019a). Two conditions would favour this assumption holding (i) that each forest property is a unique asset, as are the amenity services consumed by landowners and (ii) that the landowners selling have all the bargaining power in the land market. This would imply being close to a market with property-specific demand. Our results partly support the first assumption as several location- and property-specific variables determine c_A and therefore would be affecting the potential land market price of the property. Our survey also indicates that 23 per cent of the properties in the sample were transacted between 1990 and 2009, that is, 1 per cent of forest properties sold yearly in Andalusia. Using an estimate of about 10,000 forest properties in Andalusia, based on the average property size (436 hectares) and the total forestland area in Andalusia (4,386 thousand hectares), we obtain 100 transactions every year in the region. Although this is a rough estimate, it illustrates that the forestland market in Andalusia may be narrow and opaque, which partially reinforces the idea that landowners who are selling may have a substantial share of the bargaining power in the forestland market and can demand a property-specific market price. Nevertheless, this is an issue worth further investigation, for example, by combining our CV results with those obtained from hedonic pricing to analyse the proportion of land market price explained by amenities or through laboratory experiments to identify landowners' discount rate for amenity consumption.

Second, to simplify the analysis, we have assumed that there are no costs involved in providing c_A, the consumption of the amenity. However, from an ecosystem accounting perspective, it is important to incorporate the costs incurred (Edens and Hein, 2013: 45). In that respect, the concept of resource rent, R_A, defined above is consistent with the resource rent concept proposed by the SEEA Central Framework (United Nations *et al.*, 2014). As shown in Campos *et al.* (2019a), there are in fact costs involved in the production of c_A, so that the values presented in this article should not be interpreted as resource rents. When c_A is integrated as an output value in ecosystem accounts, the private amenity activity represents 41 per cent of the total product consumed and 47 per cent of the net value added generated in the forests of Andalusia by 16 activities (Campos *et al.*, 2019a: 227–228).

7. Concluding remarks

We have used CV to quantify the voluntary opportunity costs that forestland owners from Andalusia would assume for keeping their properties. Our results show that amenity consumption is one of the main reasons why landowners would assume this opportunity cost and that landowners consider that amenities are an important component of the potential land price of their property. The CV method, usually employed for valuing public goods, has been used here to estimate the demand for amenity consumption by private forest owners, expressed through their WTA compensation for giving up amenities, that is, their WTA commercial profit losses associated with retaining amenity consumption. Most of the results from our models are significant, although the poor fit and high variability of mean values across the different models, possibly linked to the presence of correlated variables, suggest that further research is needed to improve the modelling approaches in which the estimated values are used in ecosystem accounting.

Of the two valuation formats used, the single-bounded format gives better indicators of model performance. Overall, and given the sample sizes used, there are no relevant advantages in using the double-bounded data in our case. The double-bounded data provide little to no gain as regards the statistical efficiency of the models, while the associated potential problems of incentive compatibility and strategic response due to the second question remain. Since the valuation methods discussed could potentially be applied to other regions worldwide, opting for the simplest possible CV format has the additional advantage of minimising training requirements and methodological complexity. Based on our results, we recommend that the values estimated using the single-bounded model be used for policy analysis and/or ecosystem accounting in this valuation context. Although our models show a relatively low restricted McFadden R^2, this statistic is presented for comparison purposes, and its low value can be explained by the fact that we have purposely chosen a model with few explanatory variables in order to avoid correlation. We have also encountered a considerable number of protest responses, which seem to be associated with higher amenity preferences, suggesting that the estimated c_A values may be undervalued with respect to the true c_A values of the population.

It is possible that private amenity consumption is also important in other ecosystems (e.g. wetlands) or agricultural lands, as well as in other regions, although we expect it to be more predominant in developed countries where owning a forest combines consumption and investment motivations. *A priori*, any rural landowner of cropland, rangeland, wetland or forestland, with the right to exclude access, can enjoy and consume amenities from the properties. The key question is to identify whether there is an economic consumption of these amenities and if it has a significant impact on the land market. Our valuation proposal can be used as a starting point to study or analyse other ecosystems and amenity consumption preferences in other study areas. It would be necessary to undertake more pilot applications that could use the valuation scenario proposed here as the baseline for identifying non-market values associated with land ownership private amenity consumption.

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Supplementary data

Supplementary data are available at *ERAE* online.

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Appendix: Scenario for the contingent valuation questions

44. Rate from 1 to 5 the reasons that explain why you maintain the ownership of your forest property (1 being 'no importance' and 5 'very important'):

Mark with a X:	1	2	3	4	5
Commercial uses					
The enjoyment of recreational and landscape features by the family					
The enjoyment of managing the commercial uses					
The possibility of leaving the property as inheritance					
The social prestige (the possibility of inviting friends and/or clients)					
The possibility to experience a rural lifestyle/live in the countryside					
Others (specify: ____________________________)					

45. Do you think that if you sold your property and invested the money in a non-agroforestry investment (with the same risks and length of time) you would obtain more **YEARLY** profit than that which you get now in the form of money (including subsidies) and increase in land value?

☐ Yes, I would obtain more profit through a non-agroforestry investment
☐ No, I obtain more profit with the money that my property gives me
☐ No, I obtain more profit with the money that my property gives me and the increase in land value

46. Imagine that you were offered the possibility of an alternative non-agroforestry investment that would increase your **YEARLY** profit by [€*A* per hectare; total €*B*]. Would you sell your property in order to make this investment and obtain this increase in **YEARLY** profit?

☐ Yes (*go to q. 47*) ☐ No (*go to q. 48*)
☐ Don´t know/don´t answer (*go to q. 49*)

47. And if your profit increased by [€*A* per hectare; total €*B*], would you sell your property in order to make this investment and obtain this increase in **YEARLY** profit?

☐ Yes ☐ No
☐ Don´t know/no answer

48. And if your profit increased by [€*A* per hectare; total €*B*], would you sell your property in order to make this investment and obtain this increase in **YEARLY** profit?

☐ Yes ☐ No
☐ Don´t know/no answer

49. What would be the minimum increase in **YEARLY** profit that you would have to get from this non-agroforestry investment in order for you to sell your property and make said investment?

☐ ________ € **YEARLY** *(go to q. 51)*
☐ None *(go to q. 50)* ☐ Don´t know/no answer (*go to q. 50*)

50. For what reason (would you not sell/do you not know if you would sell) your property if it would increase your yearly profit with respect to what you currently obtain from your property?