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Willingness to accept for rewilding farmland in environmentally sensitive areas

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ABSTRACT

Rewilding farmland represents a good policy option to restore and conserve the environment in environmentally sensitive areas. This paper is the first to analyze farmers' preferences for rewilding schemes, focusing on partial and complete passive rewilding schemes and using a novel methodological application of the contingent valuation method and an extensive Mediterranean agricultural system as a case study. The results show that farmers would only be willing to participate in rewilding schemes at very high payment levels (€833 and €1187/ha/year on average for partial and complete rewilding schemes, respectively). High heterogeneity of preferences is also evidenced, especially related to farm characteristics (yield) and management (use of environmentally friendly practices), farmer characteristics (perceived succession probability and farm income dependence), attitudes, and opinions (with regard to the scheme's objective). Significant policy implications can be drawn from the results, including the need for targeting in rewilding programs, the suitability of complementing them with rural economy diversification actions, and the usefulness of environmental awareness campaigns among farmers.

1. Introduction

Agricultural expansion has had significant environmental impacts worldwide (Liu et al., 2019; Tilman, 1999). Often, the areas most recently turned over to agricultural activities are not particularly apt for agriculture (poor, shallow soils, on steep-sloped, remote land), hence resulting in low profitability (Keenleyside and Tucker, 2010). From an economic point of view, the extent to which such an expansion has actually yielded net social gains tends to be questionable. In effect, farming activities on the agricultural fringe make economic sense only if the gains from the (not very productive) economic activity—particularly relating to farm income and employment in rural areas with few economic alternatives (Leal Filho et al., 2017), but also other possible gains (e.g., cultural values) (van der Sluis et al., 2014)—offset the negative environmental externalities produced by these farming systems (i.e., lower provision of ecosystem services, ES). This concern has recently been compounded by society's changing priorities, with a growing demand for environmental conservation (EC, 2019), especially regarding environmentally sensitive areas (e.g., mountain areas), where environmental losses are usually higher.

Under the circumstances pointed out above, there is room for government action to promote the environmental use of land, with rewilding approaches representing a good policy option to restore and conserve the environment in these sensitive areas (Perino et al., 2019; Schulte to Bühne et al., 2022). Rewilding is aimed at restoring self-sustaining and complex ecosystems, fixing interlinked ecological processes that benefit and support one another by minimizing human interventions (Lorimer et al., 2015). More formally, rewilding can be defined as "the reorganization of biota and ecosystem processes to set an identified social-ecological system on a preferred trajectory, leading to the self-sustaining provision of ES with minimal ongoing management" (Pettorelli et al., 2018; p. 1115).[1] However, it is worth pointing out that there are various kinds of rewilding, differing in two key aspects: the baseline used to decide which biodiversity components should be

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[1] There is no consensus among conservationists about the precise definition of the term rewilding. As noted by Schulte to Bühne et al., 2022, the different views very much depend on what is meant by "wild", which basically relates to two different notions, describing: "wilderness" (i.e., pristine areas with minimal human impact), or "wildness" (i.e., the autonomy of non-human actors in a system). A discussion about the definition of rewilding is beyond the scope of the present study. In any case, we use that provided by Pettorelli et al. (2018), considering their definition embraces both kinds of notions.

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restored and the type of interventions required to achieve their objectives (Fernández et al., 2017). Thus, several formulations of rewilding have been proposed (Pettorelli et al., 2018), most notably the "Pleistocene", "trophic", "ecological", and "passive" rewilding approaches.[2] These rewilding approaches can be ordered on a scale from more actively-managed initiatives to less actively-managed or passive initiatives.

Among the various rewilding approaches, the passive rewilding of former farmland is one of the most prominent in terms of potential area and relevance (Navarro and Pereira, 2012; Pettorelli et al., 2018). Passive rewilding of farmland specifically refers to cases where farmland is abandoned and minimal or no actions are carried out, allowing ecological dynamics to reestablish themselves (Fernández et al., 2017).[3] While other types of rewilding can in principle be implemented in former farmland, the use of passive approaches usually presents advantages such as lower management costs, conservation of local plant genotypes, avoidance of pests and diseases brought in on imported saplings, and greater drought resistance during establishment (Broughton et al., 2021). Examples of passive rewilding of farmland include long-term woodland restoration on low-land (Broughton et al., 2021), most of the farmland in the Chernobyl exclusion zone (Perino et al., 2019), natural recolonization of former permanent crop land (Guzmán and Navarro, 2005) and mountainous pastures (Bruno et al., 2021), and removal of livestock from moorlands (zu Ermgassen et al., 2018), among others.

As farmers generally hold the property rights attached to the land, the rewilding of farmland typically entails compensating them for the foregone income due to the change from agricultural to environmental management. As a result, economic analysis can provide useful information on the compensation needed (i.e., willingness to accept, WTA) for the rewilding of farmland. Yet, assessments of this type are lacking in the literature, in contrast to the abundant studies focusing on farmers' willingness to participate in incentive-based policy instruments such as payments for ES (PES) and, more specifically, agri-environmental schemes (AES) (Mamine et al., 2020; Villanueva et al., 2017a).

Some previous studies (e.g., Junge et al., 2011; zu Ermgassen et al., 2018) have assessed farmers' preferences for rewilding initiatives, but without using monetary valuation techniques aiming at estimating WTA as the compensation needed to encourage farmers to rewild their farmland. Precedents of assessments of farmers' WTA for rewilding schemes are only loosely similar. For example, some studies focus on farmers' WTA for setting small parts of their farm aside temporarily (Schulz et al., 2014; Villanueva et al., 2017c) or for excluding cattle (temporarily or completely) from some farmland without abandoning it (i.e., including some management) (Greiner, 2015). Other studies focus on farmers' WTA for afforestation schemes, either centering on patches of forest (Villamayor-Tomas et al., 2019) or larger areas of the farm (Aslam et al., 2017; Baker et al., 2019; Chen et al., 2009; Lienhoop and Brouwer, 2015). The examples of the first type (i.e., temporary setting aside of farmland) are broadly related to passive rewilding, as they do not entail permanently ceasing agricultural activity. However, examples focusing on afforestation schemes, which entail the permanent cessation of such activity, may arguably be aligned with other types of rewilding, especially if well designed (e.g., using autochthonous tree species, planning tree density and spatial distribution, etc.) (Brancalion et al., 2016). Yet, to the authors' knowledge, no study has specifically analyzed farmers' WTA for participating in rewilding schemes.

Against this theoretical background, this paper analyzes farmers' preferences for passive rewilding schemes. The analysis relies on a novel methodological application of the contingent valuation method (CVM) to estimate farmers' WTA for rewilding schemes for the case study of traditional mountain olive groves (MOG), an extensive agricultural system that is widespread in the Mediterranean region. Two passive rewilding schemes are considered, involving partial and complete rewilding of farmland. The results will help policy-making oriented toward conserving and restoring ES in environmentally sensitive areas, especially within the AES/PES framework (Gómez-Limón et al., 2019; Granado-Díaz et al., 2020).

2. Materials and methods

2.1. Case study

For this research, MOG has been chosen as an illustrative case study. It is one of the most prominent types of olive grove, accounting for more than 3 million hectares worldwide (IOC, 2015), most of them in the Mediterranean basin. Although there are various types of MOG across the Mediterranean basin (Stroosnijder et al., 2008), the present study focuses on traditional MOG, which represents around one-fourth of total MOG (Duarte et al., 2008). This type of MOG is characterized by rainfed olive groves in poor, shallow soils with slopes of at least 15%, managed using low-input-low-output production technology (average yields equal to or lower than 2500 kg of olives per hectare), all of which leads to low profitability (Granado-Díaz et al., 2020). Evidence suggests that the implementation of passive rewilding schemes in this agricultural system would yield significant environmental benefits, helping to redress the severe negative environmental externalities that traditional MOG may generate, especially by providing ES related to soil conservation (e.g., substantially reducing soil erosion) and biodiversity (Assandri et al., 2017; Rodrigo-Comino et al., 2018; Romero-Díaz et al., 2017; Sánchez-Fernández et al., 2020; Solomou and Sfougaris, 2014; van Hall et al., 2017). Thus, although rewilding schemes would also entail negative socioeconomic and cultural impacts (Rocamora-Montiel et al., 2014; Rodríguez-Entrena et al., 2017), traditional MOG is potentially an agricultural system where the implementation of rewilding schemes would yield net social gains (Guzmán and Navarro, 2008).

We focus the assessment on traditional MOG in Andalusia (southern Spain). MOG constitutes the last expansion of agricultural land in Andalusia, with the change in land-use from former forest land happening during the 20th century (Guzmán, 2004). Within this region, traditional MOG is highly concentrated in Sierra Morena (Cordova and Seville provinces) and the Pedroches valley (Cordova province), where said land-use change gradually intensified towards the end of the last century. For this reason, the area of study considered includes the agricultural districts of La Sierra and Pedroches (Cordova), and Sierra Norte (Seville) (see Fig. 1). The study area accounts for 27% of total traditional MOG area in the region, and is managed by 3500 olive growers, whose farms have an average of 17 ha of olive groves. Agricultural activity here is often limited to traditional MOG farms and extensive livestock systems, with little variety in terms of other economic activities. In addition, as shown in Fig. 1, much of the traditional MOG area is located in environmentally sensitive areas in or near to nature protection areas (i.e., Natura 2000 areas).

The proposed agri-environmental program is aimed at achieving Mediterranean forest reconversion by means of passive rewilding of traditional MOG. The implementation of this program would require a series of conditions to be met by all olive growers who voluntarily opted to take part in it. Within this program, two possible alternative schemes are defined: flexible and strict passive rewilding. In the first scheme, called *partial rewilding*, the implementation of herbaceous cover (also

[2] "Pleistocene" rewilding refers to the restoration of ecological interactions lost during that era; "trophic" rewilding involves introductions to reestablish top-down trophic interactions; "ecological" rewilding seeks to facilitate natural processes to reestablish dominance; and "passive" rewilding implies land abandonment, removing human interference.

[3] In this sense, using the framework proposed by Schulte to Bühne et al., 2022, it implicitly interprets "wild" as "wildness", where wild nature and people co-exist, and it can occur at any scale (including small sites surrounded by still productive farmland).

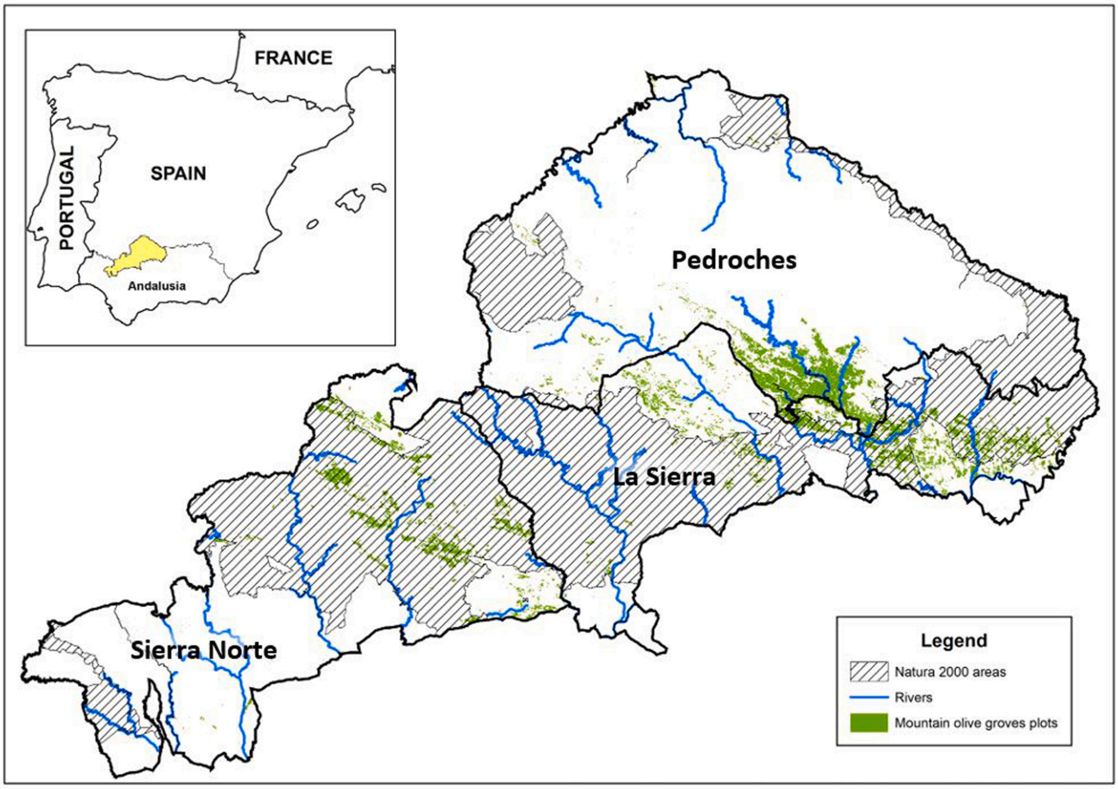

Fig. 1. Distribution of the mountain olive groves in the area of study. Source: Own elaboration from Olive Grove Geographical Information System, Foresight Department of the Agency of Agricultural and Fishing Management of Andalusia (AGAPA).

known as natural cover crops) over the total area would be required, and any type of soil tillage and the application of any type of biocide product would be prohibited, in an effort to maximize the biodiversity and minimize the risk of soil erosion. However, to reduce wildfire risk (MacDonald et al., 2000), mechanical mowing or grazing the herbaceous cover would be mandatory at the beginning of summer, and pruning would be required once every five years (normally, farmers prune once every 2–3 years). This scheme does not place any limitations on olive harvesting. The second scheme, called *complete rewilding*, is more demanding since, in addition to the abovementioned requirements, it imposes a ban on olive harvesting to increase food availability for the fauna (mainly birds), thus enhancing the contribution to biodiversity (Duarte et al., 2009).

The implementation of the proposed rewilding program would result in a loss of income for traditional MOG growers. Thus, the promotion of this rewilding would require economic compensation (agri-environmental payment) to be paid to those growers who voluntarily agreed to implement these changes on their farms. Logically, the agri-environmental payment for the scheme with stricter environmental requirements (complete rewilding) should be higher than that for the scheme with fewer requirements (partial rewilding), as the losses to be compensated would be greater.

It is proposed that the implementation of this program, which requires farmers to make a voluntary improvement in the environmental performance of their farming activity in exchange for compensation for loss of income, should mirror the AES already included in the European Union's Common Agricultural Policy (CAP). Thus, the proposed program could be implemented under the current CAP, offering interested olive growers the chance to sign a newly designed five-year agri-environmental contract, mirroring regular standards in other AES. However, given that the effects of the rewilding program proposed would be hard to reverse, these contracts could be renewed indefinitely, providing participant farmers guaranteed support in the long term.

2.2. Contingent valuation exercise

This work is based on the data gathered through a survey in which a representative sample of traditional MOG growers in the case study area were interviewed to collect information about their acceptance of the two schemes proposed according to the level of compensation offered.

To analyze the acceptance of the proposed schemes, the double-bounded dichotomous choice CVM was used (Hanemann et al., 1991). CVM including a double-bounded dichotomous choice model is a commonly-used elicitation mechanism (Durand-Morat et al., 2016; Entele, 2020; Schläpfer, 2006), and has previously been successfully used to analyze farmers' preferences for policy options (Cook and Rabotyagov, 2014; Krishna et al., 2013). As noted by Bateman et al. (2001) and Haab and McConnell (2002), the use of this type of CVM improves the precision of the estimates compared to CVM based on open-ended questions (by reducing the biases of strategic behavior) or CVM based on a simple dichotomous choice (more observations per individual are obtained).

For the implementation of the double-bounded dichotomous choice CVM, the interviewees were first given a detailed explanation of the scheme requirements corresponding to the *partial rewilding* scheme, which could be accepted by the interviewees in exchange for a compensation payment established in a first offer of €250/ha/year. Depending on whether the response was negative (the interviewee did not accept the scheme in exchange for this compensation) or positive (the interviewee did accept the scheme), a second offer of €375 or €125/ha/year, respectively, was made. Farmers were informed that this scheme would, in all cases, be compatible with the current CAP direct payments, as is the case with the rest of the AES.

Having finished the valuation exercise corresponding to the first scheme, the additional requirements included in the *complete rewilding* scheme (i.e., the ban on olive harvesting) were explained and the offer procedure implemented was similar to the previous case. The first offer was €500/ha/year, and the second offer was €250 or €750/ha/year, depending on whether the response to the first offer was affirmative (acceptance of the scheme) or negative, respectively.

Thus, according to the responses to both offers, it was possible to determine the number of interviewees who could benefit from the program in both schemes according to the three payment levels established (€125, €250, and €375/ha/year for the first scheme, and €250, €500, and €750/ha/year for the second scheme). The levels of agri-environmental payments used were established taking into account the AES currently implemented in traditional MOG with similar (although less demanding) requirements (Junta de Andalucía, 2015) and the income forgone as a result of not harvesting olives, as explained in Granado-Díaz et al. (2020).[4]

2.3. Econometric specification

The farmer's indirect utility attached to the agricultural activity is assumed to be expressed as a function of the net income obtained from the farm (I), other services (environmental, social, cultural, recreational, etc.) related to the agricultural activity (q), and a random factor (ε) which encompasses all other aspects not directly observable.

$$u = f(I, q, \varepsilon) \tag{1}$$

Note that the utility attached to those other services q would explain why farmers continue agricultural activity in low-profitability farms, even if it results in negative profitability, as is frequently the case of traditional MOG, since the utility obtained from these services would offset their low (or even negative) income (e.g., farmers who like being farmers, as pointed out by Strijker, 2005).

Participation in a rewilding scheme implies the use of practices that affect the farmer's utility function, modifying the net income obtained for the agricultural activity, as well the services related to the agricultural activity. As compensation, the farmer receives a payment (P). The farmer would therefore participate in the scheme if, and only if, the utility obtained after participation (u_s) is at least equal to the utility obtained before (u_0):

$$u_s \geq u_0 \quad \leftrightarrow \quad f(I_s + P - I_0, \quad q_s - q_0, \quad \varepsilon_s - \varepsilon_0) \geq 0 \tag{2}$$

where the sub-index 0 and s represent respectively the situations before farmer participates in the scheme and during his/her participation in the scheme, the $(I_s + P - I_0)$ term represents the variation in income due to participation in the scheme, and the $(q_s - q_0)$ term represents the variation in the other services attached to the agricultural activity. In general, variation in income will be related to characteristics of the farm (such as size, yield, production technology, etc.) and farmer (age, training level, experience, the share of income from farming activities, etc.), while the variation in the other services would be related to the farmer's attitudes and opinions regarding such services. As such, expression (2) can be expressed as a function of farm and farmer characteristics, the farmer's attitudes and opinions, and the agri-environmental payment:

$$f(x, P, \eta) \geq 0 \tag{3}$$

with x being a vector of farm and farmer characteristics (including attitudes and opinions), and $\eta = \varepsilon_s - \varepsilon_0$, a random term including the unobserved characteristics of the farm, the farmer, and the scheme.

Assuming a linear form of the indirect utility function, then expression (3) can be written as follows:

$$f(x, P, \eta) = \alpha x + \beta P + \eta \geq 0 \tag{4}$$

which can be reordered to obtain:

$$\frac{\alpha x + \eta}{\beta} \leq P \tag{5}$$

with α and β being the vector of parameters for the farm/farmer characteristics and the monetary compensation, respectively; hence the left-hand side of expression (5) represents the farmer's minimum willingness to accept (WTA) for participating in the scheme, so that s/he would only participate if the payment P offered at least equals his/her WTA. Therefore, WTA can be considered to be:

$$WTA = \frac{\alpha x + \eta}{\beta} \tag{6}$$

and, assuming η follows a standard normal distribution, then WTA follows a normal distribution with $\mu = \alpha x/\beta$ and $\sigma^2 = 1/\beta^2$ (Carson and Hanemann, 2005).

The main methodological novelty of the econometric approach used in the analysis is that it involves modeling a sequence of two double-bounded dichotomous contingent valuation questions for WTA estimation. We basically consider the correlation between the responses to the two schemes, following the suggestion made by Hanemann and Kanninen (1999). As the second scheme (i.e., complete rewilding) is built on top of the first one (i.e., partial rewilding) by going a step further and completely banning the harvesting of olives, it could be expected that farmers' responses about participating in the two schemes are correlated. Consequently, by taking this potential correlation into consideration, model fit is expected to significantly improve. An analogous approach was used by Riddel and Loomis (1998) in a different valuation context (WTP for biodiversity conservation) but, to the authors' knowledge, this is the first time it has been applied in a WTA context. We now describe the modeling specification used.

The double-bounded contingent valuation exercise used in this investigation allows for four possible results as a combination of the two payments offered: accept both payments (*yes,yes* or *y,y*), accept the first and reject the second (*yes,no* or *y,n*), reject the first and accept the second (*no,yes* or *n,y*), or reject both payments (*no,no* or *n,n*). From these possible responses, the farmer's WTA can be bounded as follows:

$$WTA_{y,y} \leq A_{low} \tag{7.1}$$

$$A_{low} < WTA_{y,n} \leq A_{ini} \tag{7.2}$$

$$A_{ini} < WTA_{n,y} \leq A_{upp} \tag{7.3}$$

$$WTA_{n,n} > A_{upp} \tag{7.4}$$

where $WTA_{y,y}$, $WTA_{y,n}$, $WTA_{n,y}$, and $WTA_{n,n}$ represent the WTA associated with each of the possible combinations of answers to both payments offered, A_{ini} is the initial payment (€250 and €500/ha/year in the first and second schemes, respectively), A_{low} is the lower payment, offered after the initial payment is accepted (€125 and €250/ha/year in the first and second schemes, respectively), and A_{upp} is the upper payment, offered after the initial payment is rejected (€375 and €750/ha/year in the first and second schemes, respectively).

In the interviews administered, as mentioned before, farmers were

[4] AES currently in effect for Andalusian MOG include a scheme targeted at integrated production using cover crops, with yearly payments of between €110 and €243/ha/year, depending on the slope, the width of the cover crop area and its management, and another focusing on organic production, with yearly payments falling within the €248–362/ha/year range. Requirements for the partial rewilding scheme would be aligned to a degree with those of the organic production scheme, although they would be noticeably more stringent. With regard to the complete rewilding scheme, compared to the management in the partial rewilding scheme, the (additional) income forgone as a result of not harvesting is estimated at €250/ha/year approximately, as suggested by Granado-Díaz et al. (2020).

asked about two consecutive contingent valuation exercises for the two schemes. In that situation, farmers' WTA for participation in both schemes would be:

$$WTA_1 = \frac{\alpha_1 x_1 + \eta_1}{\beta_1} \tag{8.1}$$

$$WTA_2 = \frac{\alpha_2 x_2 + \eta_2}{\beta_2} \tag{8.2}$$

with sub-indexes 1 and 2 representing choice situations related to schemes involving partial and complete rewilding of traditional MOG, respectively. Taking into account that most of the practices were the same in both schemes, it can be reasonably assumed that farmers' choices with regard to participating in the schemes proposed are correlated, as farmers with a high (low) WTA for the first scheme would probably also have high (low) WTA for the second. In order to model such a correlation, a joint density function for the η term of both WTA functions (WTA_1 and WTA_2) is used (Hanemann et al., 1991), following a bivariate normal distribution. As both contingent valuation exercises are double-bounded, 16 different combinations of responses are possible, ranging from accepting the four payments offered (two per scheme) to rejecting all of them. As a result, the farmer's choice probability can be expressed as a function of the payment offered, as follows:

$$Pr[a_1, a_2] = Pr[A_{l1} < WTA_1 \leq A_{u1} | A_{l2} < WTA_2 \leq A_{u2}] = \int_{A_{l1}}^{A_{u1}} \int_{A_{l2}}^{A_{u2}} \varphi(WTA_1, WTA_2, \rho) dWTA_1 dWTA_2 \tag{9}$$

where $[a_1, a_2]$ represents the possible combination of responses (*yes,yes*; *yes,no*; *no,yes*; *no,no*) to the two payments offered for schemes 1 and 2; A_{l1}, A_{u1}, A_{l2}, and A_{u2} represent the lower and upper bounds associated with each combination of responses according to the expressions (7.1–7.4); and φ is the density function of a bivariate normal distribution whose vector of means and variance matrix are obtained from the parameters of the WTA for participating in each scheme.

Further refinements to the model can be incorporated. First, since the second scheme (complete rewilding) is more restrictive than the first one (partial rewilding), it can be assumed that the farmer would not accept a lower amount for participating in the second scheme than for the first one (i.e., $WTA_2 \geq WTA_1$). Second, in some cases, the responses to the first scheme give additional information about the behavior of the farmer with regard to the second one, and vice-versa, meaning the bounds of the farmers' WTA can be adapted.[5]

Considering the model explained above, the values of α_1, β_1, α_2, and β_2 of the WTA function for participating in schemes 1 and 2, as well as the ρ parameter of the bivariate normal, are obtained maximizing the following likelihood function, using the maxLik package of the software R (Henningsen and Toomet, 2011):

$$\begin{aligned} LogLik = {} & yy_1 yy_2 \log(\Pr[y,y,y,y]) + yy_1 yn_2 \log(\Pr[y,y,y,n]) \\ & + yy_1 ny_2 \log(\Pr[y,y,n,y]) + yy_1 nn_2 \log(\Pr[y,y,n,n]) \\ & + yn_1 yy_2 \log(\Pr[y,n,y,y]) + yn_1 yn_2 \log(\Pr[y,n,y,n]) \\ & + yn_1 ny_2 \log(\Pr[y,n,n,y]) + yn_1 nn_2 \log(\Pr[y,n,n,n]) \\ & + ny_1 yn_2 \log(\Pr[n,y,y,n]) + ny_1 ny_2 \log(\Pr[n,y,n,y]) \\ & + ny_1 nn_2 \log(\Pr[n,y,n,n]) + nn_1 yn_2 \log(\Pr[n,n,y,n]) \\ & + nn_1 ny_2 \log(\Pr[n,n,n,y]) + nn_1 nn_2 \log(\Pr[n,n,n,n]) \end{aligned} \tag{10}$$

where $yy_1 \ldots nn_2$ are dichotomous variables representing the response of the farmer to the payment offered in schemes 1 and 2, and $\Pr[y,y,y,y] \ldots \Pr[n,n,n,n]$ the probabilities associated with those responses, which are shown in Appendix A.

2.4. Data collection

A two-stage sampling procedure was used to survey farmers within the case study area (districts of La Sierra and Pedroches in Cordoba, and Sierra Norte in Seville). First, the municipalities to be sampled within each agricultural district were randomly selected. Secondly, a random route procedure was used in the selected municipalities in each district, carrying out personal interviews with farmers in various public places and at various times of day. The interviews were conducted between October and December 2016, totaling 261 interviews. The sampling error was 5.85%, for a confidence level of 95% (total population, N = 3500 farmers).

The questionnaire designed for this survey was divided into five blocks of questions. One of them focused on the preferences of olive growers regarding their participation in the schemes proposed. The other four blocks collected primary information on the characteristics of the farm (location, area, age and frame of the plantation, slope, etc.), olive grove management (yield, tillage, treatments, etc.), the socioeconomic characteristics of the olive grower (age, professional experience, agricultural training, level of studies, percentage of income from agricultural activity, etc.), and her/his attitudes, opinions, and knowledge regarding the provision of ES by traditional MOG. Within the latter block of questions, the farmers were asked about the reasons behind their responses, with their answers providing useful qualitative information on their willingness to participate in rewilding schemes.

Table 1 shows the descriptive statistics of the sample for the main variables, including those finally used to model farmers' participation in the rewilding schemes proposed.

Table 1
Descriptive statistics of the sample.

Acronym	Description [units]	Mean or ratio	St. Dev.
AREA	Traditional MOG area [ha]	16.9	24.3
SLOPE	Average slope of MOG plot [%]	26.9	10.8
YIELD	Yield [kg of olives/ha/year]	1582.4	706.8
HC50	Herbaceous cover on at least 50% of the area [1 =Yes, 0 =No]	0.59	
INC20	More than 20% of the farmer income comes from the traditional MOG farm [1 =Yes, 0 =No]	0.63	
NOHARV	Level of agreement with the statement 'Setting aside low productivity olive groves is a good option for environmental reasons' [Likert 1–5][(1)]	2.80	1.63
NOOAC	Level of agreement with the statement 'A reason to continue managing my MOG farm is that there is no alternative economic activity' [Likert 1–5][(1)]	1.93	1.44
NOSUCC	Farmer's perception that there will be no farm succession [1 =Yes, 0 =No]	0.13	

[(1)] Likert scale: 1-Strongly disagree, 2-Disagree, 3-Neither, 4-Agree, 5-Strongly agree.

[5] Specifically, for farmers who respond *y,n* to the first scheme (i.e., accept the first payment but reject the second) and *y,y* to the second (i.e., accept both payments), it can be assumed that their WTA for the second scheme would be at least equal to the lower payment of the first (i.e., A_{low1}=€125/ha/year). Equally, for farmers who reject both payments (i.e., *n,n*) in the first scheme and accept the first payment in the second scheme but reject the second one (i.e., *y, n*), their WTA for the first scheme can be bounded at a maximum equal to the initial payment of the second scheme (i.e., A_{ini2}=€500/ha/year), while their WTA for the second scheme would be at least the upper payment of the first scheme (A_{upp1}=€375/ha/year). In the case of farmers who reject both payments in the first scheme (*n,n*) and accept the upper payment in the second one (*n,y*), the maximum WTA for the first scheme can be bounded to the upper payment of the second scheme (A_{upp2}=€750/ha/year). Finally, it would not be possible for farmers to respond *n,y* to the first scheme and *y,y* to the second, or *n,n* to the first scheme and *y,y* to the second, as these responses would imply that the farmer's WTA for the second scheme would be lower than for the first one. In any case, none of the farmers interviewed present any of those combination of responses.

Table 2
Results of the model.

Scheme	Variable	Coef.	Std. Error
Partial rewilding	YIELD [kg of olives/ha/year]	0.0006***	0.0001
	HC50 [1 if there is an herbaceous cover on at least 50% of the area, 0 otherwise]	-1.0221***	0.2372
	INC20 [1 if more than 20% of the farmer income comes from the traditional MOG farm, 0 otherwise]	0.4212**	0.1467
	NOSUCC [1 if farmer perceives there will be no farm succession, 0 otherwise]	-0.8328**	0.2536
	PAYM1 [payment parameter for scheme 1]	0.0018***	0.0003
	Constant 1	0.9642***	0.3495
Complete rewilding	YIELD	0.0007***	0.0001
	HC50	-0.6302**	0.2391
	NOSUCC	-0.5083*	0.2484
	NOHARV [Likert scale on the level of agreement (1-Strongly disagree to 5-Strongly agree) with the statement 'Setting aside…for environmental reasons']	-0.1372**	0.0488
	NOOAC [Likert scale on the level of agreement (1-Strongly disagree to 5-Strongly agree) with the statement 'A reason… no alternative economic activity']	-0.1233**	0.0466
	PAYM2 [payment parameter for scheme 2]	0.0022***	0.0003
	Constant 2	2.6447***	0.4365
Rho		0.7807***	0.0520
Log-Likelihood		-322.85	
Pseudo-R^2 [(1)]		0.382	

* , **, and *** denote significance at 5%, 1%, and 0.1% level, respectively. [(1)]Calculated using the adjustment proposed by Herriges (1999).

Table 3
Marginal and total WTA estimates.

Scheme	Parameter	Mean WTA (€/ha/year)	Confidence interval (95%)
Partial rewilding	YIELD	542.16***	(317.45; 810.04)
	HC50	-349.81***	(−522.59; − 206.71)
	NOSUCC	-60.49***	(−98.48; − 28.68)
	INC20	150.18**	(61.27; 246.43)
	Constant 1	550.81**	(241.96; 882.02)
	Total	832.83***	(684.77; 1035.89)
	St. Dev.	578.96***	(439.59; 778.97)
Complete rewilding	YIELD	467.23***	(295.41; 656.09)
	HC50	-172.01**	(−287.55; −64.44)
	NOSUCC	-29.44*	(−54.66; −5.36)
	NOHARV	-175.69**	(−283.64; −73.63)
	NOOAC	-108.20**	(−177.49; −41.95)
	Constant 2	1205.26***	(921.01; 1518.35)
	Total	1187.15***	(1065.89; 1338.07)
	St. Dev.	459.87***	(373.11; 571.66)

* , **, and *** denote significance at 5%, 1%, and 0.1% level, respectively. Estimations were obtained using the Krinsky and Robb method (1986) (10,000 random draws). To calculate the mean marginal WTA for each variable, mean values were used (see Table 1, which shows the descriptives of the variables considered).

3. Results

3.1. Factor influencing the acceptance of the rewilding schemes

Table 2 shows the results of the econometric model proposed accounting for olive growers' heterogeneity. As can be seen, the model is highly significant, showing very good goodness-of-fit (pseudo-R2 = 0.382). The Rho parameter of the bivariate normal distribution is significant and positive, indicating that farmers' participation choices in the two schemes considered are correlated. This lends support to the modeling approach used.

As shown in the table, several significant determinants of choice are identified, three of which affect both schemes: farm yield (YIELD), the use of an herbaceous cover on at least 50% of the area (HC50), and the absence of farm succession (NOSUCC). The first has a positive sign for both schemes, indicating that the higher the olive yield per hectare the higher the farmer's WTA for participation in both schemes. This clearly relates to the opportunity costs of participation. The other two show negative signs for both schemes, indicating lower WTA for farmers who have at least 50% of the area covered by an herbaceous cover and those who believe there will be no farm succession when they retire. In the case of HC50, the variable is related to the implementation of environmentally friendly agricultural practices, showing that farmers who already use these practices would require a lower payment. The positive use and perception of environmentally friendly practices have previously been identified as enabling factors for AES uptake (Niskanen et al., 2021; Rodríguez-Entrena et al., 2019). For the case of NOSUCC, when the farmer has no sure successor, s/he would be more willing to participate in schemes like the ones proposed. These schemes would significantly affect the farm's long-term production capacity, especially in the case of complete rewilding. Therefore, farmers who do not have a successor are likely to be less reluctant to participate in these schemes, since the implications of their participation would not be borne by anyone else. Farm succession has also been previously identified as a significant factor for AES enrollment (Ruto and Garrod, 2009; Villanueva et al., 2017c), though this is the first study that provides evidence on this issue for rewilding schemes.

In addition, for the first scheme (partial rewilding), the variable INC20, which takes the value 1 when more than 20% of the farmer's total income comes from the traditional MOG farm, turns out to be positive and significant. This indicates that farmers whose livelihood is more dependent on their farming income are less willing to participate in these schemes (i.e., they show higher WTA), which is in keeping with the results of Defrancesco et al. (2008) for non-rewilding schemes.

For the second scheme (complete rewilding), other significant determinants of participation choices relate to traditional MOG farmers' opinions. First, WTA is negatively affected by the NOHARV variable, which measures the farmers' level of agreement with setting aside low-productivity olive groves for environmental reasons. This implies that WTA is reduced when farmers are in favor of setting aside low-productivity farmland. Second, WTA is also negatively affected by the variable NOOAC, which measures the level of agreement with the statement "a reason to continue managing my MOG farm is that there is no alternative economic activity". Therefore, farmers who agreed with this statement continue the productive activity for pragmatic reasons and would be more willing to participate in a scheme that would allow them to obtain an income without maintaining the farming activity.

3.2. WTA estimates

Table 3 shows the WTA estimates. The results show that the mean WTA for participating in the partial rewilding scheme is about 70% of that for the complete rewilding scheme (€832.83/ha/year vs. €1187.15/ha/year). As expected, this difference in WTA indicates that farmers require more compensation for the latter, since the requirements are more stringent.

Table 3 also shows estimates of the average effects of the above-mentioned determinants on the total WTA for each scheme. In the partial rewilding scheme, farm and farmer characteristics represent an important part of the total WTA, while the constant term represents two-thirds of the total mean WTA. However, in the complete rewilding scheme, most of the total WTA is determined by the constant term. YIELD is the farm characteristic that most influences the total WTA in both schemes, although the effect is higher for the partial rewilding scheme. The same occurs for HC50 and NOSUCC, as the presence of these variables reduces the total WTA but has a more pronounced effect for the partial rewilding scheme. In the case of the complete rewilding scheme, the opinion variables NOHARV and NOOAC show an effect similar to HC50. Lastly, it is worth noting that the standard deviation for the partial rewilding scheme is higher than for the complete rewilding scheme, indicating greater variability in the WTA for the former than for the latter.

To analyze the impact of how different combinations of these characteristics affect the total WTA, we estimated the WTA for a selection of five farmer profiles (which account for roughly 86% of the total sample).[6] Profiles are ordered from more willing to less willing to participate in the schemes on offer. The first three profiles correspond to farms that have more than 50% of the area covered with herbaceous cover and where farm succession is assured, but which differ in the olive yields: Profile 1 corresponds to a low-yield farm (800 kg/ha/year); Profile 2 to an intermediate-yield farm (1600 kg/ha/year); and Profile 3 to a high-yield farm (2500 kg/ha/year). The other two profiles are related to farmers with high-yield farms (2500 kg/ha/year) that have less than 50% of the area covered with an herbaceous cover, but that differ in terms of farm succession: it is assured in Profile 4 but not in Profile 5.[7] The mean WTA of these five profiles is shown in Table 4.

Mean WTA for the five profiles ranges from €386.03 to €1557.52/ha/year for the partial rewilding scheme and from €867.94 to €1659.53/ha/year for the complete rewilding scheme, with Profile 1 having the lowest WTA and Profile 5 the highest WTA in both schemes. Results show a higher variability in the WTA for the first scheme. Another interesting result is that profiles with higher WTA show the lowest differences between the WTA for the two schemes. In the case of Profile 1 (i.e., YIELD=800 kg/ha/year, HC50 =1, NOSUCC=0), the WTA for the second scheme is more than double the WTA for the first one, while in Profile 5 (i.e., YIELD=2500 kg/ha/year, HC50 =0, NOSUCC=0) the WTA for the second scheme is only 6.5% higher.

3.3. Probability of acceptance of rewilding scheme participation

Fig. 2 depicts the simulation of farmers' probability of participating in the schemes on offer, on average for the whole sample of olive growers and for Profiles 1–5 described above. In this figure, the payment levels of €100, €350, and €900/ha/year are highlighted (horizontal dashed lines), with the first two corresponding (approximately) to the payments offered by the current AES open to traditional MOG farmers in the case study region, and the last one corresponding to the maximum agri-environmental payment allowed by the EU (Regulation (EU) nº 1305/2013).

The probability of acceptance may be seen as equivalent to the participation rate, so we will interpret it that way.[8] For the partial rewilding scheme, the participation rate at current levels of agri-environmental payments, €100 and €350/ha/year, is approximately 10% and 20%, respectively, for the whole sample. This rate would be slightly higher than 50% for the maximum allowed payment (i.e., €900/ha/year), hence the remainder require extremely high payments to participate. The fact that there is some probability of acceptance (8% approx.) in the absence of payment indicates that there are few farmers already complying with the practices required in this scheme. Observing the farmer profiles considered, it is easy to infer the high heterogeneity of preferences. Profiles 1 and 2 show practically linear curves and significant participation rates at moderate payment levels (e.g., almost 50% and 30% of farmers would participate at a payment level of €350/ha/year). In contrast, Profiles 3, 4, and 5 show slightly concave curves (especially Profile 5) and very low participation rates at low to moderate payments. For example, for a payment level of €350/ha/year, around 10% and 13% of Profile 3 and 4 farmers would participate, respectively, while these participation rates are only achieved for Profile 5 farmers at payments levels above €800/ha/year (especially due to the steep slope of the curve at low payment levels).

In the case of the complete rewilding scheme, participation rates are much lower compared to the figures shown for the partial rewilding scheme. For instance, a 10% rate is only achieved for payments above €600/ha/year approx. for the whole sample, while with €900/ha/year just 27% of farmers would participate. Logically, in this case, the percentage of farmers already complying with the requisites is virtually zero. For both the whole sample and the profiles, the curves are significantly concave. This implies that very low participation rates are reported for low to moderate payment levels. For example, at a €350/ha/year payment level, 3.5% of the whole sample would participate, with no profile showing rates over 5%, except Profile 1 (13%).

4. Discussion and concluding remarks

Results show a low willingness to participate in rewilding schemes, indicating a need for very high payments which go beyond the levels of agri-environmental payments currently implemented. The mean WTA estimates for participating in the proposed schemes (€833 and €1187/ha/year for partial and complete rewilding schemes, respectively) are thus much higher than those obtained in previous investigations regarding the participation of these traditional MOG farmers in conventional AES (Villanueva et al., 2017b, 2017c), which vary from €29 to €305/ha/year depending on the requirements. The differences in these farmers' WTA can be explained by the more stringent requirements for the proposed rewilding schemes compared to the conventional AES. However, it is worth pointing out that the traditional MOG system is characterized by low profitability.[9] Thus, the high level of compensation demanded by these MOG farmers to participate in the rewilding schemes cannot be totally explained by the foregone income associated with participation, which reflects previous results found by Schulz et al. (2014) for the temporary setting aside of small pieces of farmland and Ryan et al. (2018) for farm afforestation. These authors hint at farmers' emotional motivations for refusing to retire productive land, while Lienhoop and Brouwer (2015) also allude to other non-pecuniary explanations for farmers' interest in participating in afforestation schemes. Based on the qualitative information gathered in our survey, possible explanations for such high payment levels relate to negative cultural biases towards the permanent nature of the land-use change (Duesberg et al., 2013; Ingram et al., 2013; Lawrence and Dandy, 2014), the loss in the value of fixed assets (lower value of land for rewilded olive groves compared to productive olive groves) (Jongeneel et al., 2012; Riley, 2006), or not wanting to give up farming due to the loss of social prestige within the farming community associated with receiving payment for doing (almost) nothing (Burton et al., 2008). Examining the reasons underlying such high payments clearly represents an area for further research, which could include a focus on the different values that farmers place on the various ES provided by farming systems (not only environmental but also sociocultural ones) compared to the rewilding alternatives (Duesberg et al., 2013).

[6] Profiles have been selected from the combination of the three variables which were found to be significant for both schemes (i.e., YIELD, HC50, and NOSUCC), considering those combinations which account for at least 5% of farmers in the sample.

[7] For the rest of the variables, the mean values for all the farmers are considered for every profile.

[8] For large populations, as is the case here, the proportion of farmers who would participate should tend to be equal to the probability of acceptance obtained with the model.

[9] Considering a mean yield of 1600 kg/ha/year, 18–22% olive fat yield and a mean olive oil price of €2.4/kg, farmers would obtain a gross income of €691–845/ha/year, which is of the same order of magnitude as the mean WTA for the partial rewilding scheme (harvesting allowed) and lower than the mean WTA for the complete one. If production costs are taken into account, the net income would be far below the mean WTA obtained for both schemes.

Table 4
Mean WTA by farmer profile.

	Sample prevalence (%)	Characteristics			Partial rewilding scheme			Complete rewilding scheme
		YIELD (kg/ha)	HC50	NOSUCC	Mean WTA (€/ha/year)	Confidence interval (95%)	Mean WTA (€/ha/year)	Confidence interval (95%)
Profile 1	15.7%	800	1	0	386.03***	(278.06–510.94)	867.94***	(771.23–984.66)
Profile 2	19.2%	1600	1	0	660.12***	(524.68–832.58)	1104.15***	(981.99–1252.12)
Profile 3	17.6%	2500	1	0	968.48***	(727.75–1274.95)	1369.89***	(1173.45–1603.40)
Profile 4	5.0%	2500	0	1	1079.06***	(778.24–1458.97)	1426.70***	(1183.72–1703.14)
Profile 5	28.4%	2500	0	0	1557.52***	(1223.18–2015.38)	1659.53***	(1432.40–1934.15)

*** denotes significance at 0.1% level. Estimations were obtained using the Krinsky and Robb method (1986) (10,000 random draws).

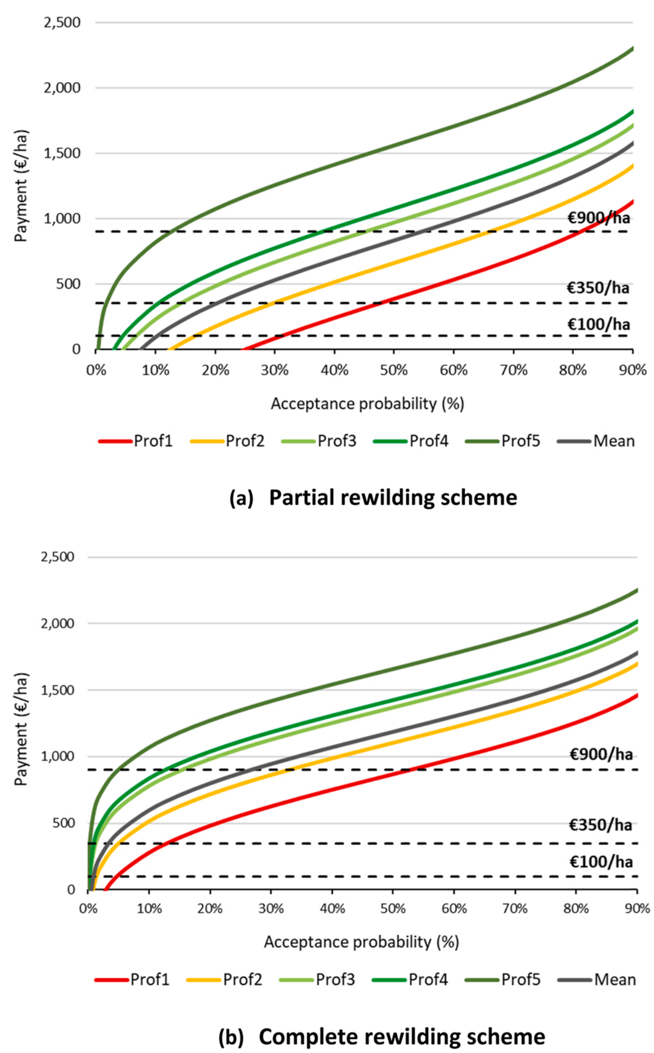

Fig. 2. Probability of acceptance for the partial and complete rewilding schemes as a function of payment level by farmer profile.

To the authors' knowledge, there are no real-world applications of rewilding schemes such as those proposed in this investigation with which to compare. The most similar would be the afforestation programs in the CAP, which finance the planting costs and the income foregone as a result of the afforestation. As an indication of the low uptake of this type of measure, only 946.53 ha of agricultural land were afforested in Andalusia in the period 2007–2013 (CEC, 2016), when the annual premium for covering income losses was up to €700/ha/year (OJ, 2005). Although theirs was a hypothetical application, it is also worth noting the assessment by Lienhoop and Brouwer (2015), who estimate that farmers require a premium of €50/ha/year per percentage of their farmland given over to afforestation, thus resulting in a total premium of €5000/ha/year for implementation in the whole farm. While this is in the same order of magnitude as our WTA estimates (i.e., both studies show three-digit figures), it could be argued that the different land-use change, production context, and costs incurred by the farmers, among others, are behind the differences with our estimates.

The high level of payment needed to assure a minimum level of area enrolled in the schemes would lead to a high cost of implementation. However, the results show the existence of a high degree of heterogeneity in farmers' WTA, with some farmers willing to participate at much lower (policy affordable) payment levels than others, depending on their characteristics, with farm yield being the strongest determinant of WTA. This opens up the possibility of reducing the cost of the proposed schemes by targeting them at those farmers with lower WTA (i.e., those with lower yield). Said high heterogeneity also implies that a flat-rate payment for all eligible payments would lead to an overcompensation of farmers with lower WTA. To prevent this from happening, an auction system could be implemented, which would also contribute to reducing the cost of the schemes (Stoneham et al., 2003). Regardless of the payment system, better environmental performance can be achieved by ensuring connectivity among areas enrolled on the rewilding schemes; hence collective and/or collaborative approaches would be highly recommended (though this would likely increase the payments needed, as shown by Villanueva et al., 2015).

In the partial rewilding scheme, farmers who have a high share of their income depending on the traditional MOG farm show higher WTA, while those who maintain their productive activity due to the lack of economic alternatives present a lower WTA for the complete rewilding scheme. These results suggest that the development of viable economic alternatives to agricultural production could foster willingness to participate in rewilding schemes. In this regard, a comprehensive program for environmentally sensitive areas that combines schemes aimed at rewilding farmland areas with rural economy diversification programs could increase the attractiveness of the scheme and improve its environmental performance, especially if the diversification activities are of a nature-based type (e.g., ecotourism). In any case, farmers' acceptance of such comprehensive programs is plainly an open research question for future studies.

In addition, the current environmental performance of traditional MOG farms (more than 50% of herbaceous cover) reduces the WTA for both schemes, while farmers agreeing to leave olive groves unharvested for environmental reasons does so for the complete rewilding scheme. Villamayor-Tomas et al. (2019) find that farmers' agreement with the scheme's objective influences WTA for participating in AES. Our results are consistent with this finding, especially regarding the complete rewilding scheme. This suggests that, prior to the implementation of the schemes, awareness campaigns targeted at farmers could be useful as they could potentially increase farmers' willingness to participate.

Finally, in the case of the complete rewilding scheme, the payment needed to achieve a minimum share of area enrolled in this scheme would have to be high, even for low-yield farms. This raises the issue of whether the increase in the ES associated with this scheme (relative to the increase for the partial rewilding one) is worth such high payments. The answer to this question would require a complementary demand-side analysis to estimate society's willingness to pay (WTP) for this improvement in the provision of ES related to this scheme. Only in cases where society's WTP was higher than farmers' WTA (i.e., the social benefits from the enhanced provision of ES exceed the costs of achieving this improvement) would this rewilding policy make sense. However, this demand-side analysis is beyond the scope of this paper and remains an interesting avenue for further research.

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Appendix A. Probabilities associated with double-bounded dichotomous choice responses

$$Pr[y,y,y,y] = Pr[WTA_1 \le A_{low1} | WTA_2 \le A_{low2}] = \int_{-\infty}^{A_{low1}} \int_{-\infty}^{A_{low2}} \varphi(WTA_1, WTA_2, \rho) dWTA_1 dWTA_2$$

$$Pr[y,y,y,n] = Pr[WTA_1 \le A_{low1} | A_{l2} < WTA_2 \le A_{ini2}] = \int_{-\infty}^{A_{low1}} \int_{A_{low2}}^{A_{ini2}} \varphi(WTA_1, WTA_2, \rho) dWTA_1 dWTA_2$$

$$Pr[y,y,n,y] = Pr\left[WTA_1 \le A_{low1} | A_{ini2} < WTA_2 \le A_{upp2}\right] = \int_{-\infty}^{A_{low1}} \int_{A_{ini2}}^{A_{upp2}} \varphi(WTA_1, WTA_2, \rho) dWTA_1 dWTA_2$$

$$Pr[y,y,n,n] = Pr\left[WTA_1 \le A_{low1} | WTA_2 > A_{upp2}\right] = \int_{-\infty}^{A_{low1}} \varphi(WTA_1, WTA_2, \rho) dWTA_1 dWTA_2$$

$$Pr[y,n,y,y] = Pr[A_{low1} < WTA_1 \le A_{ini1} | A_{low1} < WTA_2 \le A_{low2}] = \int_{A_{low1}}^{A_{iow1}} \int_{A_{low1}}^{A_{low2}} \varphi(WTA_1, WTA_2, \rho) dWTA_1 dWTA_2$$

$$Pr[y,n,y,n] = Pr[A_{low1} < WTA_1 \le A_{ini1} | A_{low2} < WTA_2 \le A_{ini2}] = \int_{A_{low1}}^{A_{ini1}} \int_{A_{low2}}^{A_{ini2}} \varphi(WTA_1, WTA_2, \rho) dWTA_1 dWTA_2$$

$$Pr[y,n,n,y] = Pr\left[A_{low1} < WTA_1 \le A_{ini1} | A_{ini2} < WTA_2 \le A_{upp2}\right] = \int_{A_{low1}}^{A_{ini1}} \int_{A_{ini2}}^{A_{ppu2}} \varphi(WTA_1, WTA_2, \rho) dWTA_1 dWTA_2$$

$$Pr[y,n,n,n] = Pr\left[A_{low1} < WTA_1 \le A_{ini1} | WTA_2 > A_{upp2}\right] = \int_{A_{low1}}^{A_{ini1}} \int_{A_{upp2}}^{+\infty} \varphi(WTA_1, WTA_2, \rho) dWTA_1 dWTA_2$$

$$Pr[n,y,y,n] = Pr\left[A_{ini1} < WTA_1 \le A_{upp1} | A_{low2} < WTA_2 \le A_{ini2}\right] = \int_{A_{iow1}}^{A_{upp1}} \int_{A_{low2}}^{A_{ini2}} \varphi(WTA_1, WTA_2, \rho) dWTA_1 dWTA_2$$

$$Pr[n,y,n,y] = Pr\left[A_{ini1} < WTA_1 \le A_{upp1} | A_{ini2} < WTA_2 \le A_{upp2}\right] = \int_{A_{ini1}}^{A_{upp1}} \int_{A_{ini2}}^{A_{upp2}} \varphi(WTA_1, WTA_2, \rho) dWTA_1 dWTA_2$$

$$Pr[n,y,n,n] = Pr\left[A_{ini1} < WTA_1 \le A_{upp1} | WTA_2 > A_{upp2}\right] = \int_{A_{ini1}}^{A_{upp1}} \int_{A_{upp2}}^{+\infty} \varphi(WTA_1, WTA_2, \rho) dWTA_1 dWTA_2$$

$$Pr[n,n,y,n] = Pr\left[A_{upp1} < WTA_1 \le A_{ini2} | A_{upp1} < WTA_2 \le A_{ini2}\right] = \int_{A_{upp1}}^{A_{ini2}} \int_{A_{upp1}}^{A_{ini2}} \varphi(WTA_1, WTA_2, \rho) dWTA_1 dWTA_2$$

$$Pr[n,n,n,y] = Pr\left[A_{upp1} < WTA_1 \le A_{upp2} | A_{ini1} < WTA_2 \le A_{upp2}\right] = \int_{A_{upp1}}^{A_{u2pp}} \int_{A_{ini1}}^{A_{upp2}} \varphi(WTA_1, WTA_2, \rho) dWTA_1 dWTA_2$$

$$Pr[n,n,n,n] = Pr\left[WTA_1 > A_{upp1} | WTA_2 > A_{upp2}\right] = \int_{A_{upp1}}^{+\infty} \int_{A_{upp2}}^{+\infty} \varphi(WTA_1, WTA_2, \rho) dWTA_1 dWTA_2$$

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