Spanish Journal of Agricultural Research
13(4), e0108, 16 pages (2015)
eISSN: 2171-9292
http://dx.doi.org/10.5424/sjar/2015134-7376
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)

RESEARCH ARTICLE

OPEN ACCESS

Assessment of greening and collective participation in the context of agri-environmental schemes: The case of Andalusian irrigated olive groves

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Abstract

Agri-environmental schemes (AES) in irrigated olive groves (IOG) in southern Spain were assessed based on farmers' preferences toward these schemes. A choice experiment was used in this ex-ante assessment, with the inclusion of some innovative elements, such as collective participation and ecological focus areas (EFA). The results showed that farmers' mean willingness to accept (WTA) participation in collective rather than individual AES was €124.5/ha. Their mean WTA for an additional 1% of EFA was €64.6/ha, while regarding the use of other agri-environmental practices, they showed a WTA of €6.3/ha and €114.7/ha for an additional 1% in the use of cover crops (CC) in olive grove areas and restrictive management of CC, respectively. These estimates were strongly influenced by farmers' expectations and socio-economic characteristics, as well as farm management. We obtained that farmers' expectations of no farm takeover reduce WTA for collective participation, whereas agricultural training and having at least a secondary-school education reduce farmers' WTA for EFA and restrictive management of the CC, respectively. Conversely, harvesting ground olives increased farmers' WTA for a high proportion of the area under CC. The analysis of the AES scenarios showed moderately high estimates of total WTA (€101-349/ha), especially when collective participation is required (€225-474/ha). The results supported the argument that there are efficient ways to encourage public goods provision, overcoming trade-offs with private goods provision by identifying the type of joint production.

Additional key words: AES; agglomeration bonus; ecological focus areas; soil conservation; public goods; choice experiment.

Abbreviations used: AES (agri-environmental schemes); ASC_{SQ} (alternative-specific constant for the *status quo* choice); CAP (Common Agricultural Policy); CC (cover crops); CE (choice experiment); EC_RPL (error component random parameter logit); EFA (ecological focus areas); EU (European Union); IOG (irrigated olive groves); PGs (public goods); RPL (random parameter logit); SQ (*status quo*); WTA (willingness to accept).

Citation: Villanueva, A. J.; Gómez-Limón, J. A.; Arriaza, M.; Rodríguez-Entrena, M. (2015). Assessment of greening and collective participation in the context of agri-environmental schemes: The case of Andalusian irrigated olive groves. Spanish Journal of Agricultural Research, Volume 13, Issue 4, e0108, 16 pages. http://dx.doi.org/10.5424/sjar/2015134-7376.

This work has one supplementary figure published online alongside the electronic version of the article.

Received: 14 Jan 2015 **Accepted**: 28 Oct 2015

Funding: This research is co-financed by the Spanish Ministry of Economics and Competitiveness (MINECO), the National Institute for Agricultural and Food Research and Technology (INIA) and the European Regional Development Fund (ERDF) through the projects MERCAGUA (AGL2013-48080-C2-1-R), MERCAOLI (RTA2013-00032-00-00 –"Programa Operativo de Crecimiento Inteligente"), and SUSTANOLEA (P10-AGR-5892). AJV and MRE acknowledge the support provided by IFAPA and ESF (European Social Fund) within the Operative Program of Andalusia 2007-2013 through postdoctoral training programs.

Competing interests: There is no competing interest.

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Introduction

The provision of public goods (PGs) is one of the most significant objectives of the current Common Agricultural Policy (CAP) of the European Union (EU) and is set to remain so in the foreseeable future (EC, 2010a). This objective is the policy response to the EU society's increasing demands for environmental and socio-cultural public goods and services produced by European agriculture (EC, 2010b). Hence, CAP includes an array of instruments aimed at promoting such production, with Agri-environmental schemes (AES) one of the most important among these. AES are multi-annual and voluntary incentive-based payments to farmers for preserving and enhancing environmental PGs. The impact of these schemes derives from both their aggregated expenditure assigned (22% of the budget of the European Rural Development Policy

2007-2013, according to ECA, 2011); and their efficiency in promoting the production of environmental PGs by agricultural systems (Hodge, 2013).

AES have been the subject of much attention by researchers (Siebert *et al.*, 2006; Uthes & Matzdorf, 2013). Earlier studies have focused mainly on the barriers to participation in such schemes (Falconer, 2000; Christensen *et al.*, 2011; Broch & Vedel, 2012), and on improving their design (Ruto & Garrod, 2009; Espinosa-Goded *et al.*, 2010; Bartolini *et al.*, 2011), yet there are still some broad issues that merit further research. Firstly, while there are studies that quantitatively assess farmers' willingness to accept (WTA) AES in herbaceous rainfed agricultural systems (good examples of such assessments include Espinosa-Goded *et al.*, 2010, and Christensen *et al.*, 2011), there is a lack of this type of study with respect to both permanent crops and irrigated agricultural systems. Among the few studies that analyze AES in permanent crops, it is worth mentioning Villanueva *et al.* (2015a), who suggested the influence of the type of olive groves (rainfed and irrigated) on AES uptake. From a policy perspective, the relevance of taking into account the different types of agricultural systems is that production of environmental PGs differs significantly according to the agricultural system in question (Cooper *et al.*, 2009), with particularly notable contrasts between arable and permanent crops or between rainfed and irrigated systems. Different agricultural systems are therefore expected to respond differently to the implementation of AES.

In addition, the design of AES is still open to further research, not only with regard to the type of agri-environmental practices to be promoted but also the type of contracts. As regard the former, the promotion of ecological focus areas (EFA) in farmland is a relevant issue but one that has received little attention in the literature about agri-environmental policy. EFA are defined in CAP regulations as areas with landscape features, terraces, buffer strips, land lying fallow, afforested and agro-forestry areas, or farmland employing reduced farming inputs. The presence of EFA generally improves biodiversity, as well as other PGs such as visual quality of landscapes, soil conservation, and so on (Stoate *et al.*, 2009; EC, 2011a). This is the main reason why the European Commission (EC, 2011b) proposed a new instrument in the CAP 2014-2020, known as *green payment*, for those farms fulfilling some basic environmental requirements, including dedicating 7% of their farmland to EFA. However, this particular requirement was relaxed as a result of the political debate about the share of EFA, and in the final regulation (OJEU, 2013; Art. 43-47) this share was set at 5% for arable land only (permanent crops are eligible for this payment without any minimum EFA requisite). In light of this, we considered it appropriate to anticipate a future implementation of a green payment for permanent crops by analyzing the inclusion of EFA as a requisite of AES (representing a more stringent commitment than the one currently enforced for arable crops through the annual green payment).

With regard to the type of AES contracts, *collective participation*, where farmers collectively sign AES contracts, is also an issue that requires further research (Uthes & Matzdorf, 2013). Collective contracts represent a promising way of reducing transaction costs (mainly public) while increasing the environmental effectiveness of policy instruments. Specifically, increasing collective participation in AES reduces the number of applications to be processed as well as monitoring costs, consequently reducing the transaction costs incurred by the government (Franks, 2011; Emery & Franks, 2012). Besides, if collective participation in AES is implemented in such a way that ensures the proximity (Sutherland *et al.*, 2012) and the correct spatial configuration (Banerjee *et al.*, 2014) of the farms that form the collective, a greater environmental effect would also be expected. As highlighted by Austin *et al.* (2014), collective management of natural resources can better match the ecological scale, thus leading to their more efficient and sustainable management. These authors also found that a high financial incentive is required to promote such collective management although did not quantify the amount. To the authors' knowledge, only Kuhfuss *et al.* (2014) and Villanueva *et al.* (2015a) provide estimates of the financial incentive needed for such a participation for the cases of wineyards in southern France and olive groves in southern Spain (with the former not distinguishing between different types of olive groves). Yet quantitative analysis of farmers' WTA is still required for the efficient design of collective contracts. Our analysis adds estimates of farmers' WTA participation in collective AES contracts for the case of an irrigated permanent crop.

In this paper, an analysis is carried out to better understand how farmers decide to participate in AES, with the inclusion of the abovementioned innovative elements: AES uptake in irrigated permanent crops, the inclusion of EFA as an environmental requirement and of collective participation in these schemes. To this end, the choice experiment (CE) method has been used to analyze farmers' preferences toward AES for the case study of the irrigated olive grove (IOG) system in the region of Andalusia (southern Spain). Special emphasis is placed on analyzing the heterogeneity of preferences by using a random parameter logit model. In addition, estimates of farmers' total WTA are provided with respect to the uptake of AES for different hypothetical scenarios. The paper is useful for policy-makers in that it is strongly policy oriented and aims to identify appropriate policy options for promoting agricultural PGs.

Material and methods

Case study

IOG in Andalusia is the irrigated permanent crop used as a case study in the present analysis. This agricultural system is widespread in southern Europe and merits analysis of its specific AES design. The analysis of AES for IOG is particularly opportune not only due to IOG's high socio-economic significance (it covers over half a million hectares in the region studied, Gómez-Limón *et al.*, 2013), but also because of the numerous environmental issues that have emerged associated with the expansion and intensification of olive growing over the past two decades (Gómez-Limón & Arriaza, 2011). These negative environmental impacts are soil erosion, biodiversity loss, overexploitation of water resources, non-point water pollution and deterioration of traditional landscapes. Indeed, a recent study of Villanueva *et al.* (2014) highlights the great scope for improving the production of environmental PGs through IOG. These authors found that soil fertility, visual quality of the landscape, biodiversity and contribution to fighting climate change are the four PGs with the greatest potential for improvement from a supply perspective. Moreover, all of these PGs are in high demand in European (EC, 2010b) and Andalusian (Rodríguez-Entrena *et al.*, 2012; 2014a; Salazar *et al.*, 2013) societies. Thus, it is reasonable to state that any AES for IOG should focus on agronomic practices aimed at increasing the provision of these PGs.

Choice experiment approach

A CE was used to analyze farmers' preferences toward AES. The CE is a stated preference valuation technique based on the Lancasterian Consumer Theory of utility maximization which postulates that consumption decisions are determined by the utility or value derived from the attributes of the good being consumed (Lancaster, 1966). The econometric basis of the approach is the Random Utility Theory (McFadden, 1974). For an extensive explanation of the CE theory and practice, see Hensher *et al.* (2005). CE is well suited to measuring the marginal value of the attributes of a good or policy (Ruto & Garrod, 2009). In the case of the latter (*i.e.*, attributes of a certain policy such as AES), the underlying assumption is that farmers' choices among subsidy schemes depend on the specific characteristics of subsidy schemes (Christensen *et al.*, 2011). The increasing use of CE in recent specialized literature (Ruto & Garrod, 2009; Espinosa-Goded *et al.*, 2010; Christensen *et al.*, 2011; Broch & Vedel, 2012; Schulz *et al.*, 2014) indicates its usefulness and validity for analyzing farmers' preferences toward policy measures, especially AES. Thus, this was the methodological approach chosen for this analysis.

Attributes and levels

As in any other application of CE, attributes and levels of the good or policy under study have to be established. The attributes of the CE were selected with respect to the provision of the four abovementioned PGs to be promoted by the implementation of AES in Andalusian olive growing. As a result, six attributes were chosen to build possible AES, three were linked to agricultural management (two relating to the use of cover crops and one to EFA), two policy design attributes and one concerning payment (see Table 1).

The two attributes related to the use of cover crops (CC) were included in the CE since this practice has been reported as possibly the most useful agricultural practice in olive growing in terms of enhancing the production of environmental PGs (Villanueva *et al.*, 2014). The level of production of these PGs stemming from the use of CC in olive groves depends on the area covered and how farmers manage the CC (Barranco *et al.*, 2008). Therefore, the two attributes related to the use of CC were *Cover crops area* (CCAR) and *Cover crops management* (CCMA). For the attribute CCAR, two levels were set: 25% and 50% of the olive grove area (CCAR-25% and CCAR-50%, respectively). In both cases, CC were supposed to be maintained for a period spanning at least from October to mid-March every year. Regarding the attribute CCMA, two levels were set: free (CCMA-Free) and restrictive management (CCMA-Restr). The latter corresponds to the type of management set out in past AES focusing specifically on olive growing (*Sub-measure 7* or SM7), and basically restricts the use of both tillage and herbicide in CC management. CCMA-Free, on the other hand, entails no restrictions other than those required for cross-compliance.

The inclusion of *Ecological focus areas* (EFA) as an attribute of the CE also met the criterion of the contribution that these areas make to fostering the production of the four abovementioned PGs. For this attribute, two levels were set: 0% and 2% of the olive grove plots containing EFA (EFA-0% and EFA-2%, respectively). The first level is equivalent to the stipulated requirement for the green payment for permanent crops. The second is substantially below the 5% of EFA eventually established for arable lands in the new CAP, and was decided on after taking into account both the current lack of this kind of area in Andalusian olive groves

Table 1. Attributes and levels used in the choice set design.

Attribute [Acronym]	Explanation	Levels
Cover crops area [CCAR]	Percentage of the olive grove area covered by cover crops	25% 50%
Cover crops mana-gement [CCMA]	Farmer's management of the cover crops	Free Restrictive management
Ecological focus areas [EFA]	Percentage of the olive grove plots covered by ecological focus areas	0% 2%
Collective partici-pation [COLLE]	Participation of a group of farmers (at least 5) with farms located in the same municipality	Individual participation Collective participation
Monitoring [MONI]	Percentage of farms monitored each year	5% 20%
Payment [PAYM]	Yearly payment per hectare for a 5-year AES contract	€100/ha €200/ha €300/ha €400/ha

Source: Compiled by authors.

and the difficulties of increasing the share of EFA in permanent crops (Gómez-Limón & Arriaza, 2011). In any case, it can be assumed that the proposed 2% EFA could effectively entail environmental improvements by creating new buffer strips, vegetation boundaries and islets or maintaining some olive trees out of production (which are the four elements included as EFA in the analysis).

The two design attributes also included in the CE were collective participation and level of monitoring. The attribute *Collective participation* (COLLE) was included due to the abovementioned expected positive effects that this type of participation can exert on the production of the environmental PGs that are the objective of the AES. The two levels of this attribute are straightforward, that is, collective and individual participation. A precise definition of the former was needed; for participation to be considered collective, a group of at least five olive growers whose farms were located in the same municipality had to sign the same AES contract. It was explained to farmers that they were free to choose whichever group members they wished. Also, it was specified that if a member of the collective was monitored and found not to comply with the scheme requirements, in addition to regular sanctions being imposed on that farmer (calculated, as usual, according to the nature and gravity of the infringement), the other farmers in the collective would then also be monitored to ensure their compliance with requirements. In order to account for the possible impact of monitoring and sanctions on farmers' decision with regard to COLLE and the other three agri-environmental attributes, we decided to include the attribute *Monitoring* (MONI). Two levels were also set for MONI: 5% and 20% (MONI-5% and MONI-20%). The lower level was set in line with the normal monitoring level of the CAP measures, while the higher was set to make the difference with respect to the lower level more visible to the farmers[1].

For the last attribute, *Payment* (PAYM), four levels were set according to current payments in SM7 (€204-286/ha·year). Two levels (€200/ha and €300/ha) were set in line with SM7 payments, while two more levels (€100/ha and €400/ha) were set as minimum and maximum payments. Farmers were reminded that AES payments are made in addition to direct payments. Finally, it is worth commenting that for every scenario proposed a five-year contract with no available exit-option was set, and the minimum area for participation was set at the area of the largest plot.

Experimental design and data collection

A fractional factorial design and optimal orthogonal in the differences proposed by Street & Burgess (2007) was used to create a more manageable number of options, reducing the possible combinations (1924) to 192

[1] In the pre-test, the upper level of MONI was set at 10%. However, we noticed that farmers did not perceive a clear difference compared to the lower level of MONI-5%. As a result, we decided to use the higher upper level of MONI-20% to more noticeably mark the difference with MONI-5%, while acknowledging that such an upper level might be less realistic. This upper level proved to be perceived differently by the farmers and consequently was used for the CE.

profiles (D-efficiency=91.3%). This design allowed the analysis of main and second-order effects, though the latter were found to be not significant. The 192 choice sets were divided into 24 blocks of 8 choice-sets each, with one farmer answering one block. In each choice set, farmers were asked to choose between two alternatives, in addition to a possible no-choice (*Status Quo,* SQ). The SQ alternative represented the "business as usual" option, *i.e.*, the alternative with no additional payment for farmers apart from the direct payments and the one which allows them to continue using their current management practices in the olive groves. Figure S1 [online supplement] shows an example of a choice set.

A multi-stage procedure was employed for sampling. In the first stage, five Andalusian agricultural districts[2] were selected from a total of 52, using a proportional random procedure according to olive grove area. This sample of districts covers 453,682 ha and accounts for 31% of the Andalusian olive groves. In the next stage of the procedure, at least 60 personal interviews were conducted per district (randomly selecting 10 towns for each district), as a result of which 330 completed questionnaires were obtained, 117 for IOG. Of these 117, 13 were considered to be protests[3], reducing the total number of valid interviews to 104 (832 choices). Interviews were carried out from October 2013 to January 2014. A cheap talk was used to ensure that farmers understood correctly before answering the questionnaire.

Description of farmers surveyed

Farm and farmer characteristics of the sample were roughly in line with previous surveys of IOG in Andalusia (*e.g.*, Gómez-Limón & Arriaza, 2011). Most of the farms surveyed were located in Jaen, with a smaller number in Cordoba and Malaga. Their average olive grove area was 24.4 ha, more than three-quarters of which was irrigated. The age of the olive groves was around 60 years old and they had 137 olive trees/ha on average, with 2.4 stems/tree. The olive groves were for the most part located on low-to-moderate slopes and 0.65% of their area was dedicated to EFA.

Most farmers surveyed use conventional olive–growing techniques (55.8%), while the vast majority of the remaining farmers use integrated techniques (42.3%). The use of CC was widespread (more than three-quarters of the farmers used CC), although with low-to-moderate coverage (on average, 21.7% of the olive groves area was devoted to CC). In fact, only 38.5% of the farmers used CC in over 25% of their olive grove plots. With regard to irrigation, farmers surveyed used 909 m^3/ha·year on average, with the vast majority using localized irrigation systems (mainly drip irrigation), and two-thirds belonging to water user associations.

The yearly average yield of farmers surveyed was 6,352 kg of olives/ha. A considerable share of the yield (23.5% on average) is harvested from the ground (olives that fall directly onto the ground). The average CAP single payment reported was €766/ha·year.

Farmers surveyed registered an average age of 48.5 years old and dedicate most of their time to farming (56.5%). They usually had a secondary school leaving certificate (53%), and had undergone agricultural professional training (64%). Only 16% of farmers took up AES in olive growing. Around 40% of farmers did not anticipate a farm takeover.

Model specification: Random parameter logit model

As the analysis of preference heterogeneity is at the core of this paper, a random parameter logit (RPL) model was used for the econometric specification to analyze the choice data. The RPL model is well suited to analyzing preference heterogeneity since it allows for random taste variation, unrestricted substitution patterns and correlation in unobserved factors (Train, 2003; Hensher *et al.*, 2005). We used this continuous mixed logit solution (RPL model) instead of the discrete one (*i.e.*, latent class model) because we did not expect farmers to be grouped into homogeneous classes that differed from one another in function of preferences toward AES, but rather farmers belonging to a homogeneous agricultural system (IOG) where there is some preference heterogeneity related to farm/farmer characteristics. A number of studies have shown the RPL model to be a very effective way of examining preference heterogeneity, especially when evaluating environmental PGs (Scarpa & Thiene, 2005; Rodríguez-Entrena *et al.*, 2012), and agri-environmental policies (Ruto & Garrod, 2009; Espinosa-Goded *et al.*,

[2] Campiña Norte and La Loma (province of Jaen), La Sierra and Campiña Alta (province of Cordoba), and Norte (province of Malaga).

[3] Those who chose the SQ-option in all the choice sets without considering the alternative AES proposed in each (*i.e.,* did not make trade-offs among alternatives but directly chose the SQ-option) were considered protesters. The most often cited reasons for always choosing the SQ-option can be classified as non-acceptance of the valuation context (*e.g.,* rejection of the idea of a complementary environmental subsidy, lack of trust in the implementing institution, etc.). This definition of protesters has also been used in previous studies (*e.g.,* Christensen *et al.*, 2011).

2010; Christensen *et al.*, 2011; Broch & Vedel, 2012). This study uses a specific version of the RPL model, the Error Component RPL (EC_RPL) model, which includes an additional random error component in the utility function to capture the error variance common to both A and B (*i.e.*, it accounts for the fact that respondents may treat the hypothetical AES-alternatives [A, B] differently to the SQ) (Scarpa *et al.*, 2007). The EC_RPL model has previously been used in this type of analysis (Espinosa-Goded *et al.*, 2010; Broch & Vedel, 2012), confirming its suitability for this purpose.

The econometric specification of the model is provided below. In the EC_RPL model, the utility function associated with each alternative is expressed as follows:

$$U_{Alt\,A} = \beta\chi + \eta_{Non\_SQ} + \varepsilon \quad [1]$$

$$U_{Alt\,B} = \beta\chi + \eta_{Non\_SQ} + \varepsilon \quad [2]$$

$$U_{SQ} = ASC_{SQ} + \beta\chi + \gamma S + \varepsilon \quad [3]$$

where χ is a vector representing the attributes, β is the vector of coefficients associated with these attributes (reflecting individual preferences and heterogeneity that can be explained by individual –farm and/or farmer– characteristics), ε is the random error terms, η_{Non_SQ} is the additional error component that captures the correlation between the non SQ alternatives, assuming normal distribution [$\eta_{Non\_SQ} \sim N(0, \sigma^2)$], γS captures heterogeneity in preferences toward choosing the SQ option explained by a set of individual characteristics, and ASC_{SQ} is the alternative-specific constant for the SQ choice. The ASC_{SQ} represents the utility not captured by the attributes and the reason for its inclusion is to account for SQ bias, as otherwise this bias would be captured by the attribute parameters (Adamowicz *et al.*, 1998). As in Horne (2006) and Espinosa-Goded *et al.* (2010), we interpret the ASC_{SQ} as likely representing farmers' attitude toward AES. β is randomly distributed in the population following a density function $f(\beta_n \mid \theta)$, where θ represents the distribution parameters. ε random error terms follow a Gumbel distribution and have been assumed constant among the different choices made by each individual. Thus, choices are modelled following a panel structure. For panel data, the integer probability involves a product of logit formulas (Train, 2003). The joint probability of respondent *n* choosing alternative *i* in each of the T choice situations is given by:

$$P[t(n)] = \\ = \int_\beta \int_\eta \Pi_{t=1}^{T} \frac{\exp(\lambda(\beta_n'\chi_{ti} + \eta_{in}))}{\sum_{j\subset A_t}(\beta_n'\chi_{ti} + \eta_{jn}))} f(\beta_n \mid \theta)\, d\beta \cdot \varphi(0,\sigma^2)\, d\eta_{jn} \quad [4]$$

where A_t = (Alt A, Alt B, SQ) is the choice set, λ is a scale parameter, and $\varphi(\cdot)$ is the normal density of the error component (η_j) which equals zero when j = SQ. This equation cannot be evaluated analytically because the choice probability does not have a closed form. Hence it is approximated using simulation methods; in this paper we used 200 Halton draws. In the EC_RPL model used here, all attributes were assumed to follow a normal distribution, except for PAYM and MONI which were assumed to be non-random.

To capture observed heterogeneity in farmers' preferences, the EC_RPL model included interactions of the attributes and the ASC_{SQ} with farm and farmer characteristics. The final model was obtained using a three-step procedure. First, following an iterative routine significant interactions were explored using EC_RPL model with a single interaction of one non-monetary attribute (except MONI as it soon proved to be non-significant) with one variable. More than 200 different single-interaction models were generated for each sub-system. Second, multiple-interaction models were explored using different combinations of the interactions that had been found to be significant in the first step. As a result, more than 150 multiple-interaction models were generated. From these, the selection was made by simultaneously observing the level of significant parameters, goodness-of-fit statistics, and model parsimony. In the third step, after having selected the multiple-interaction model, interactions with the ASC_{SQ} were added and the final model was selected using the same three criteria. As a final result of this procedure, the following four interactions with attributes and two interactions with the ASC_{SQ} were included in the final EC_RPL model:

- CCAR×Groundharv, which represents the interaction between the CCAR attribute and the share of olives harvested from the ground;
- CCMA×Educa2, which represents the interaction between the CCMA attribute and the dichotomous variable of secondary education (a score of 1 assigned if the farmer attended secondary school or higher);
- EFA×No-training, which represents the interaction between the EFA attribute and the dichotomous variable of agricultural professional training (a score of 1 assigned if the farmer has undergone professional training);
- COLLE×No-takeover, which represents the interaction between the COLLE attribute and the dichotomous variable of farmers' perception about farm takeover (a score of 1 assigned if the farmer does not anticipate a farm takeover);

- ASC_{SQ}×Oliarea20, which represents farm size (a score of 1 assigned when the olive grove area exceeds 20 ha);
- ASC_{SQ}×SinglePaym750, which represents single payment received (a score of 1 assigned when the average single payment to the farm exceeds €750/ha per year).

Farmers' welfare analysis

In CEs, marginal rates of substitution between non-monetary attributes and the monetary attribute are estimated by calculating the ratio of the coefficient of the former to the negative of the coefficient of the latter [$WTA_{NM} = -(\beta_{NM} / \beta_M)$]. These are also called the "implicit prices", representing the WTA for a 1% or 1 unit increase in the quantity of the attribute in question, if quantitative (*e.g.*, area of EFA), or for a discrete change in the attribute (*e.g.*, from free to restrictive CCMA) if qualitative. Additionally, to provide a broader picture of the required payments for different AES scenarios and to estimate adoption rates in terms of farmers and area, total WTA was estimated for different AES scenarios. Individual total WTA related to AES scenarios (V_1), which change several attribute levels simultaneously, with respect to the *status quo* (V_0) was estimated following Hanemann (1984).

The six hypothesized AES scenarios that were used for the analysis are shown in Table 2. They represented different alternatives of AES, with different combinations of the attributes. There were three minimally restrictive scenarios, namely EFA_2, which only included the EFA-2% requisite; M_25, comprising CCMA-Restr and CCAR-25% (in line with past SM7); and EFA_25, which represented AES with CCAR-25% and EFA-2%. There were two highly restrictive scenarios, AES_Max and AES_MaxC, which represented AES with all the attributes at their highest levels (CCMA-Restr, CCAR-50% and EFA-2%) but with individual and collective participation respectively. Finally, there was also an intermediate scenario, EFAM_25, with CCMA-Restr, CCAR-25%, and EFA-2%. In all scenarios, MONI remained constant at 5%, since it was not significant in the EC_RPL model. Finally, we assumed that a farmer would participate in a certain AES scenario if the level of payment was equal to or higher than the disutility (in absolute terms) experienced by the farmer (*i.e.*, total WTA) as a result of participating in such AES.

Results

Irrigated olive groves farmers' preferences toward AES

The results of the EC_RPL model are presented in Table 3. As can be observed, the model was highly significant and fitted well, as shown by the main goodness-of-fit statistics (pseudo-R^2=0.441; LL=-496.5). The data in Table 3 showed all but one of the attributes to be highly significant determinants of choice; all the coefficients showed a statistical significance level of 5% or less (with the exception of MONI) and had the expected sign (negative coefficient in all cases except PAYM, reflecting farmers' disutility –or utility in case of PAYM). MONI was the attribute that received the least attention from farmers, indicating that the level of monitoring played a minor role in their choices.

The results of the EC_RPL model showed a high heterogeneity of farmers' preferences toward AES. This statement is supported by the following results: all standard deviations of the random parameters were significant, indicating that preferences varied significantly within the population; all the interaction parameters (socio-economic variables interacted with the at-

Table 2. Scenarios of agri-environmental schemes considered for the analysis[1].

Scenario	COLLE	CCMA	EFA	MONI	CCAR
EFA_2	0	0	2	5	0
M_25	0	1	0	5	25
EFA_25	0	0	2	5	25
EFAM_25	0	1	2	5	25
AES_Max	0	1	2	5	50
AES_MaxC	1	1	2	5	50

[1] COLLE=0 and COLLE=1 represent individual and collective participation, respectively; CCMA=0 and CCMA=1 represent free and restrictive cover crops management, respectively; EFA=0 and EFA=2 represent 0% and 2% of olive grove area devoted to ecological focus areas; MONI=5 represent 5% of olive grove farms are monitored; CCAR=0, CCAR=25, and CCAR=50 represent 0%, 25%, and 50% of the olive grove area covered by cover crops, respectively. *Source:* Compiled by authors.

Table 3. Error component random parameter logit model.

Parameter[1]	Mean values		Standard deviations	
	Coef.	St. Error	Coef.	St. Error
CCAR (Cover crops area)	-0.038 *	0.017	0.097 ***	0.016
CCAR×Groundharv	-0.002 ***	0.000		
CCMA (Cover crops management)	-2.303 ***	0.531	1.956 ***	0.397
CCMA×Educa2	1.403 *	0.682		
EFA (Ecological focus areas)	-0.621 **	0.226	0.867 ***	0.156
EFA×No-training	-0.695 *	0.279		
COLLE (Collective participation)	-2.168 ***	0.413	1.706 ***	0.350
COLLE×No-takeover	1.187 *	0.584		
MONI (Level of monitoring)	-0.009	0.012		
PAYM (Payment)	0.014 ***	0.001		
ASC_{SQ}	-3.563 ***	0.917		
$\eta_{No\ SQ}$			3.519 ***	0.581
Covariates				
ASC_{SQ}×Oliarea20	-2.453 **	0.910		
ASC_{SQ}×SinglePaym750	2.163 *	0.946		
Log-likelihood=-887.7				
McFadden Pseudo-R^2 = 0.441				
Valid respondents/choices: 102/816				

[1] Groundharv: share of olives harvested from the ground; Educa2: having at least a secondary-school education; No-training: having undergone professional training; No-takeover: not anticipating a farm takeover; Oliarea20: olive grove area exceeds 20 ha; SinglePaym750: average single payment to the farm exceeds €750/ha·year; ASC_{SQ}: alternative-specific constant for the *status quo* choice. *, **, and *** reflect significance level of 5%, 1%, and 0.1% respectively. *Source:* Compiled by authors.

tributes) were significant, indicating that preferences across farmers toward each attribute varied as a function of certain farmers' socio-economic characteristics; and covariates interacting with ASC_{SQ} (*i.e.*, SinglePaym750 and Oliarea20) were also significant, reflecting the fact that general farmers' willingness to uptake AES (that is, their willingness to choose AES alternatives instead of SQ) also depended on farm characteristics.

Results of the attributes and their interactions can be better appreciated by observing Table 4, which shows mean WTA estimates for the whole sample and for specific profiles (elicited from the interactions) of the farmers identified as the most and the least willing to participate in AES. As regards the attribute CCAR, mean IOG farmers' WTA is €6.2/ha per 1% increase in the olive grove area covered by CC. However, we found that there was a significant negative interaction between CCAR and the share of ground olives over the total volume of olives harvested (Groundharv). Accordingly, farmers' WTA for CCAR fell to €2.8/ha for those farmers who did not harvest ground olives at all (see *most-willing* farmer profile in Table 4). The main reason for such an interaction is that, in general, farmers would not be willing to reach high levels of CCAR (*e.g.*, the levels used in the CE, CCAR-25% and CCAR-50%) as it would hinder the harvesting of ground olives.

With regard to CCMA, the results showed a moderately high WTA for this attribute (€115.2/ha), indicating that IOG farmers had a very negative perception of managing CC without tillage and with a very restrictive use of herbicides. Yet when farmers had at least a secondary-school education, their WTA fell (€66.5/ha), and the opposite is true for farmers who had not reached this level of education (€170.1/ha).

Regarding EFA, an average WTA of €64.6/ha was registered per 1% increase in EFA in the olive grove area. Agricultural training played a role in farmers' preferences toward EFA given that when they underwent training, their WTA fell to €45.9/ha, whereas it reached €97.1/ha when they did not.

Average IOG farmers' WTA for COLLE was €124.5/ha. We found that when farmers did not anticipate a farm takeover, they were more willing to participate in AES collectively and their WTA was reduced to €72.4/ha as a result. The opposite is also true, namely, their WTA increased to €160.1/ha if they thought there would be a farm takeover. It is worth outlining here some qualitative information about COLLE gathered from the interviews. Some of the most repeated statements about collective participation showed skepticism about its usefulness in enhancing environmental performance and concerns about the possible intrusion of other farmers into their farm man-

Table 4. Mean willingness to accept (WTA) for the attributes (€/ha per year)[1] and for extreme farmer's profiles.

Attribute	Mean[2]	St. Error	Farmer's profile[3]	
			Most-willing	Least-willing
CCAR (Cover crops area)	6.3***	1.0	2.8	17.2
CCMA (Cover crops management)	114.7***	25.3	66.5	170.1
EFA (Ecological focus areas)	64.6***	12.4	45.9	97.1
COLLE (Collective participation)	124.5***	25.0	72.4	160.1
MONI (Level of monitoring)	0.7	0.9	0.7	0.7

[1] In the case of EFA, MONI and CCAR, it is EUR per 1% of olive groves area assigned to EFA, 1% of farms monitored, and 1% of olive groves area with cover crops, respectively. [2] Estimates were calculated using the mean values of the variables included as interactions with the attributes. [3] Farmers-most-willing to participate in AES: 0% of olives harvested from the ground; have at least a secondary school education; have undergone some professional training; do not anticipate farm takeover. Farmers-least-willing profile is the opposite (*i.e.*, 100% of olives harvested from the ground, do not have at least a secondary school education, etc.). *, **, and *** reflect significance level of 5%, 1%, and 0.1% respectively. *Source:* Compiled by authors.

agement. Farmers also expressed concerns about the issue of the setting-up of groups. In this respect, most of the farmers thought that producers' cooperatives could act as a collective in the AES contract, suggesting an active role in the creation of groups. In addition, it is worth pointing out that the sanction system revealed to be crucial for farmers to accept collective participation. In the pre-test, a tougher sanction system was included, linking individual to collective compliance. Almost all farmers interviewed in the pre-test refused to participate collectively, primarily as they considered monetary punishment due to non-compliance by other farmers to be unfair.

With respect to MONI, the main finding is that farmers were barely aware of it when it came to choosing whether to participate in AES or not. The qualitative information collected during the survey pointed to two different reasons that could explain such low WTA for high-level monitoring, namely the willingness to comply with the requisites (expecting "fair" monitoring) and the adoption of strategic behavior (*i.e.*, not willing to comply but assuming that they would not be fully monitored).

It is also worth highlighting the results for ASC_{SQ}. The fact that its coefficient was significant and negative indicates, respectively, that there were also other sources of unobserved heterogeneity not taken into account in the model, and that olive growers were generally more willing to participate than not (that is, there was a negative willingness to choose SQ-option). During the interviews, two main reasons were found to explain such a positive attitude: the fact that a certain number of farmers already complied some requisites of the AES-alternatives or perceived the changes proposed not to be too drastic, and the fact that some farmers adopted a 'rent seeking' behavior, so they preferred AES-alternatives because of the related payment. The two interactions with the ASC_{SQ} provided further insight about the initial attitude of IOG farmers when deciding whether to participate in AES or not. The interaction ASC_{SQ}×Oliarea20 was significant and negative, which means that those farms with more than 20 ha of olive groves (Oliarea20=1) were less likely to choose SQ and were generally more willing to participate in AES. The interaction ASC_{SQ}×SinglePaym750, which was significant and positive, indicates that farmers with average single payments of more than €750/ha·year were less willing to participate in AES.

Farmers' total WTA related to scenarios of agri-environmental schemes

Table 5 shows estimates of farmers' total WTA regarding each scenario. Total WTA of IOG farmers ranged from €100.8/ha for the least stringent individual-AES scenario considered (*i.e.*, EFA_2) to €349.1/ha for the most stringent one (AES_Max). When collective participation was considered, €124.5/ha had to be added to each scenario (*e.g.*, this is the difference between the total WTA of AES_Max and AES_MaxC, with the latter being €473.6/ha on average).

Table 5. Mean farmers' total willingness to accept (WTA) for different scenarios of agri-environmental schemes, in €/ha.

Scenario	Mean	St. Error
EFA_2	100.8***	19.3
M_25	160.4***	21.7
EFA_25	129.5***	16.6
EFAM_25	230.3***	23.2
AES_Max	349.1***	33.8
AES_MaxC	473.6***	47.4

*** reflects significance level of 0.1%. *Source:* Compiled by authors.

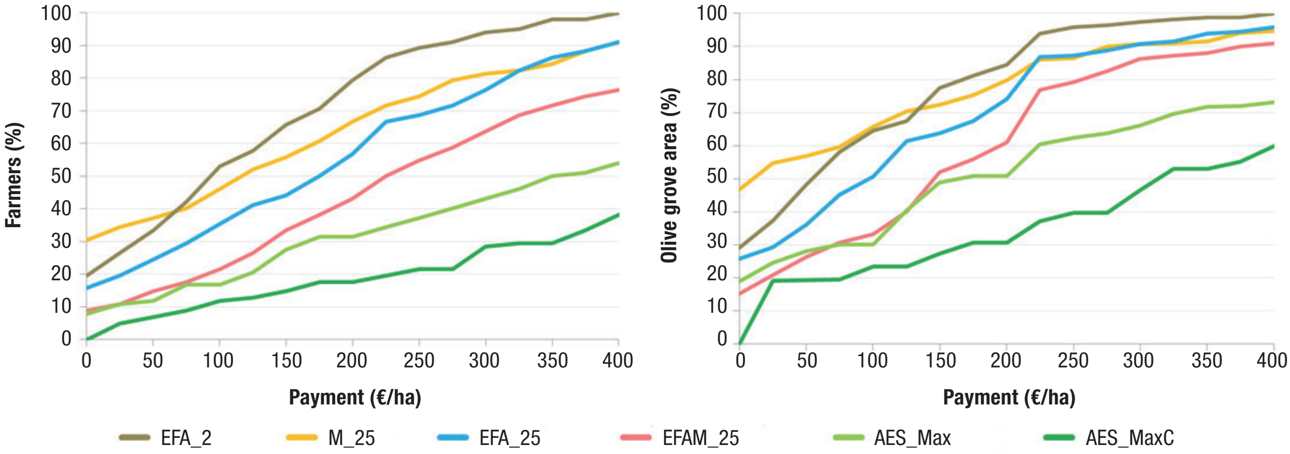

Figure 1. Participation in different scenarios of agri-environmental schemes and payments. *Source:* Compiled by authors.

Figure 1 shows the rate of participation in AES both in terms of percentage of farmers and percentage of area for the different scenarios considered and for different payments. Clearly, the participation rate (in terms of both farmers and area) changed depending on the scenario considered. For example, at the €150/ha-level of payment, 15% and 66% of the farmers would be willing to participate in AES_MaxC and EFA_2, respectively, which corresponded to the minimum and maximum rate obtained for the six scenarios. For any area-payment the participation rate was higher in terms of area than in number of farmers, reflecting the correlation found between farm size and AES uptake.

With respect to farmers' participation, it must be noted that the more stringent the AES requisites, the less sensitive farmers were to payments. While participation rates in the most stringent AES considered (AES_MaxC) for €0-400/ha of payment reaches 38% (ranging from 0% for €0/ha to 38% for €400/ha), the rest of the scenarios considered range from 46% to 80%. Furthermore, Figure 1 shows the participation rate with a payment of €0/ha, representing the percentage of farmers and area using the practices that were to be encouraged through AES (*i.e.*, percentage of farmers/area providing PGs at the level established in the AES without any incentive). Literature uses the term "deadweight" to refer to a policy measure that funds something (*e.g.*, the use of an agricultural practice) that would have existed (been implemented) in the absence of such a measure. For example, for M_25 the deadweight would be 30% of farmers (representing 47% of the area), indicating that 30% of the farmers complied with the requisites included in this AES without receiving any payment for it. In contrast, deadweight was much lower for more stringent AES (*e.g.*, for AES_Max it was 8% and 19% in terms of farmers and area, respectively).

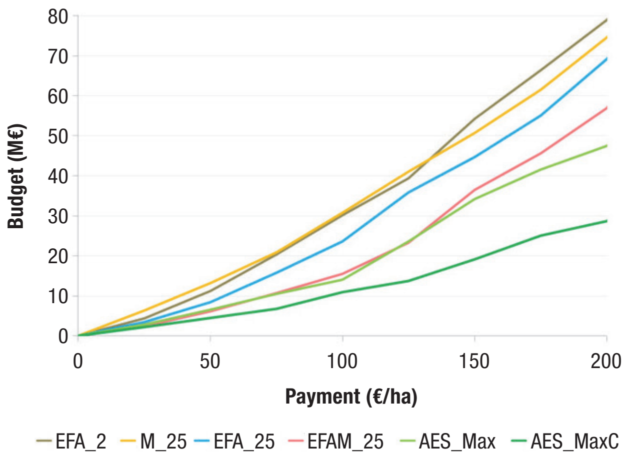

Figure 2. Budget estimates for each scenario of agri-environmental schemes and different payments. *Source:* Compiled by authors.

Figure 2 shows budget estimates for the implementation of each scenario according to the level of payment, arrived at by multiplying the latter by the enrolled area for each payment. For example, if a payment of €150/ha were set for the implementation of AES M_25, 218,194 ha of IOG would be enrolled, requiring a total budget of €50.7M. Logically, the less stringent scenarios would imply higher budgets, given that the participation rate would be higher.

Discussion

Policy-makers face a great challenge when designing AES for IOG, given the large heterogeneity of the preferences of farmers. This study proffers support to AES design by providing valuable information about AES uptake. In this way, this section addresses: a) a general discussion of the results comparing them to previous studies; b) the main policy implications drawn from the attributes analyzed; and c) the main policy implications linked to the analysis of AES scenarios.

Attributes of agri-environmental schemes: Previous evidences

The results are generally in line with previous studies. They suggest a high heterogeneity of farmers' preferences toward AES, mirroring the results obtained by Espinosa-Goded *et al.* (2010), Christensen *et al.* (2011), and Broch & Vedel (2012), and reinforcing the relationships suggested by Villanueva *et al.* (2015a) for the olive groves (considering rainfed and irrigated ones at the same time) within the same region. Actually, the interactions included in the EC_RPL model suggest that there are many factors behind the heterogeneity of preferences that determine farmers' AES uptake, particularly farm management (CCAR×Groundharv) and characteristics (ASC_{SQ}×Oliarea20 and ASC_{SQ}×SinglePaym750), and farmers' features (CCMA×Educa2 and EFA×No-training) and expectations (COLLE×No-takeover). These factors have largely been highlighted previously by the specialized literature (Falconer, 2000; Siebert *et al.*, 2006; Defrancesco *et al.*, 2008; Ruto & Garrod, 2009; Rodríguez-Entrena & Arriaza, 2013; Uthes & Matzdorf, 2013; Rodríguez-Entrena *et al.*, 2014b).

It is also worth discussing some specific results with regard to the attributes. For instance, the results (especially those related to the attribute CCMA) indicate strong farmers' preferences toward flexibility concerning agri-environmental practices, which has also been pointed out by Espinosa-Goded *et al.* (2010) and Christensen *et al.* (2011). Yet, whereas the IOG farmers' WTA is moderately high for CCMA (€115/ha on average), it is not as high as that of some types of olive growers in Villanueva *et al.* (2015a) (with 3 out of 4 olive grower-types showing average WTA higher than €190/ha), suggesting that IOG can more easily adopt this soil conservation measure than rainfed olive groves.

With regard to EFA the estimates of WTA (mean of €64.6/ha) are, as expected, notably above those obtained by Schulz *et al.* (2014) for the use of EFA by German farmers in their arable land (with WTA of €9-51/ha). Such a discrepancy in the WTA estimates can be attributed to the different types of agricultural systems analyzed: arable crops in the case of Schulz *et al.* (2014) and permanent crops in the present study. Implicit spatial restrictions related to permanent crops seem to have the effect of raising farmers' WTA (*i.e.*, it is much easier to comply with EFA in the absence of permanent elements such as trees). Moreover, comparing IOG to rainfed olive groves (see Villanueva *et al.*, 2015a), IOG shows a higher WTA than the latter likely due to higher opportunity costs.

Regarding COLLE, the estimation of farmers' WTA for collective participation is almost lacking in the literature. To the authors' knowledge, only Kuhfuss *et al.* (2014), for wine growers in southern Spain, and Villanueva *et al.* (2015a) provide WTA estimates for such participation. Kuhfuss *et al.* (2014) obtain that farmers have a WTA of €135-189/ha per year for collective participation. Since they include a "collective bonus" of €150/ha for the 5-years AES contract (*i.e.*, €30/ha per year), it could be argued that wine growers disutility associated with collective participation is around €105-159/ha per year. Although collective participation is not equally defined in both, their study and ours, and the approach taken differs (*e.g.*, they used a conditional bonus for collective participation), it is worth noting that our estimates (*i.e.*, €125/ha on average) fall within theirs. In the comparison with Villanueva *et al.* (2015a), the estimates of IOG farmers' WTA for COLLE are closer to those obtained in that study for the olive grower-types with the lowest WTA, suggesting that IOG shows a lower WTA for COLLE compared to rainfed olive groves.

With respect to MONI, the results indicating that the level of monitoring barely influenced farmers' participation in AES appears to be counterintuitive and contradicts literature on AES uptake. In fact, Broch & Vedel (2012) estimated farmers' WTA of €38/ha per 1% absolute increase in the level of monitoring in AES in Denmark. Thus, the results obtained indicate a different behavior of the IOG farmers regarding preferences toward the level of monitoring in AES. In order to clarify to what extent significant disutility to higher levels of monitoring in AES can be expected, future research could focus on the reasons behind this different behavior. Future research should confirm to what extent the two abovementioned reasons –*i.e.*, willingness to comply with the requisites and strategic behavior– are operating behind IOG farmers' preferences toward the level of monitoring in AES.

Joint production and collective participation: Policy implications

For CCAR, CCMA and EFA, trade-offs between the provision of private goods and PGs become apparent, at least through the farmers' eyes. The main challenge for the policy-maker is to overcome such trade-offs, and this requires a thorough understanding of how both kinds of goods are produced. For instance, in the case of CCAR, two different production relationships emerge. For low CCAR (*e.g.*, CCAR lower than 25%), there appears to be no trade-off, but rather a complementary relationship between production of private goods and PGs. In this regard, the study shows that three-quarters of farmers use CC with an average CCAR of 21%, since they consider CC useful, primarily for preventing soil erosion and by extension, the long-term sustainability of the farms. These figures reflect the outcome of efforts made (principally through training and awareness campaigns) by the Andalusian Regional Government and professional associations to encourage the use of CC. These efforts should now focus on the remaining one-quarter of farmers that do not use CC. However, for a higher CCAR (*e.g.*, CCAR higher than 25%) the trade-off becomes evident, since farmers consider it a handicap for ground olive harvesting. In this case, it is important to understand why farmers harvest ground olives and to seek a possible alternative solution. The harvest of ground olives is a widely-used practice due to its lower cost (at least for traditional olive groves) and workforce availability[4]. However, olive oil obtained from these olives is of a low quality and as a result, the olive oil industry usually pays less for ground-harvested olives. Therefore, an alternative solution to overcome such a trade-off might be a market incentive to encourage the olive oil industry to establish a quality premium for early harvesting directly from the tree; for instance, implementing public promotion campaigns favoring the consumption of "virgin and extra-virgin olive oil" (obtained from olives directly harvested from the tree) instead of simply "olive oil" (obtained from olives harvested from the tree or the ground). Alternatively, R&D activities focused on developing cheaper technologies for harvesting olives from the trees could be promoted. Thus, by identifying the type and causes of the joint production, policy-makers can easily identify efficient ways to encourage PGs provision, overcoming trade-offs with private goods provision.

With regard to CCMA and EFA, competitive relationships likely characterize the joint production of private goods and PGs. In the case of the CCMA, the relatively high estimated WTA points to farmers' low willingness to manage CC without tilling and/or with restrictions on the number of herbicide treatments. Two main reasons behind these results are that farmers are generally worried about the presence of resistant weed species within CC (and thus have a negative perception of the reduction of permitted options for managing CC), and that many farmers consider tillage a useful way to reduce soil water evaporation during summertime. As a result, CCMA-Restr appears very stringent to most olive growers, who consequently require moderate-to-high compensation to comply with such a requisite. Therefore, the large budget required to implement CCMA-Restr in IOG means that policy-makers should only consider this practice in special circumstances (*e.g.*, in environmentally-sensitive areas).

With respect to EFA, there is also a moderately high WTA. Yet when observing farmers' total WTA associated with EFA_2 scenario (€100.8/ha), it seems that 30% of direct payments assigned in the new CAP regulation to green payments (equivalent to €229.8/ha on average for the farms surveyed[5]) would be enough to encourage the acceptance of a green payment if EFA_2 was considered as a requirement in IOG. In fact, a payment of €229.8/ha would result in a participation rate of 85% and 95% in terms of farmers and area, respectively. So, in this scenario it seems that a vast majority of IOG farmers would be substantially rewarded for a modest additional commitment to the environment. Nevertheless, for higher shares of EFA (*e.g.*, 5-7%), it is unlikely that such a level of payments would be enough for farmers to apply for green payment. Indeed, assuming linear WTA for the interval of 0 to 7% of EFA, estimates of total WTA for the scenarios EFA_5 and EFA_7 (equivalent to the 5% set for EFA in arable crops in the CAP regulation, which may be increased to 7% in 2017) would be €300 and €427.4/ha, respectively, well above the likely green payment in IOG (€229.8/ha). However, linear WTA is a strong assumption with regard to EFA, given that IOG farmers' WTA would probably rise as the share of EFA increases. Therefore, although there is room for devoting some part of IOG land to EFA (*e.g.*, 0-3%), it would be very difficult for farmers to comply with higher shares of EFA. Finally, it is worth noting that EFA is analyzed here as a requisite of a multiannual scheme which is in addition to direct payments (and which represents a more stringent commitment than the one currently enforced in direct payments for arable crops, through the green payment). However, it would

[4] It is worth noting that this practice is mostly used in family-run farms, which make up the vast majority of IOG farms. So, the low costs of harvesting ground olives can be explained by the fact that family labor is frequently not accounted for by the farmer when deciding whether or not to harvest these olives. Coupled to this, another reason for harvesting ground olives is the fact that farmers can harvest these olives during a longer period of time than tree olives, thus allowing them to more easily adapt their (family) workforce to harvesting and other farm tasks.

[5] This figure is estimated as the 30% of the per-hectare single payment received on average by the surveyed farmers, which can be claimed to be a good approximation of the average green payment likely to be received by IOG farmers since they barely receive other direct payment but the single payment. It is worth mentioning that, as a result of the CAP reform, a decrease in the direct payments received by olive growers is expected in the coming years, although the exact decrease is unknown yet.

be interesting to analyze to what extent WTA estimates would vary if EFA were considered as part of a annual direct payment scheme, such as the green payment. Due the different time commitment, WTA estimates would presumably decrease for green payment but further research is needed to confirm this.

With regard to COLLE, there are several policy implications that can be drawn from the results. Firstly, the EU-wide up-to-30% bonus set in the CAP 2014-2020 regulations does not appear to be enough to promote collective participation in IOG. In any of the scenarios considered, adding 30% to total WTA estimates would not surpass the €124.5/ha needed for collective participation. However, our results indicate that olive growers' WTA for collective participation is sensitive to the stringency of sanction system specifically designed for this participation and to farmers' expectations about their farm takeover. With regard to the former, IOG farmers refused collective participation particularly when monetary sanctions due to other farmers defaulting were imposed. While this calls for a careful design of the sanction system in collective AES, further research is needed to inform such a design, the main challenge being to find sanction systems that encourage group self-control of moral hazard but do not totally discourage farmers' participation in collective AES. With regard to farmers' expectations of farm takeover, the 30% bonus is more likely to be enough to encourage the farmers' collective participation in AES when they anticipate a farm takeover. This information can be used in policy design; for instance, when a known successor is expected to take over farm management, not only the predecessor but also the successor should be involved in the process of signing collective contracts (informing both parties, including a specific clause addressing the issue, etc.). Also, the usefulness of collective participation in enhancing environmental performance must be disseminated to farmers to overcome their skeptical attitudes, since they represent a barrier to such participation (Emery & Franks, 2012). In addition, the link underlined by the farmers between group creation and producer cooperatives suggests the use of these organizations as facilitators to that task. As highlighted by Franks (2011), the use of facilitators is key to creating groups in collective/collaborative AES. These cooperatives normally embody a common trusted platform for the setting-up of groups, providing information to farmers (*e.g.*, about other farmers), which Banerjee *et al.* (2014) highlight as vital for engaging farmers in this type of collective scheme. Therefore, results suggest that it would be recommendable to identify these facilitators and take them into account when designing collective AES.

There are some issues of collective participation that require further research. Firstly, further research is needed to estimate gains from the collective participation in AES and find the necessary information to set the appropriate bonus. In this regard, while expected gains from the reduction of transaction costs could easily be estimated, those deriving from improved environmental performance are far more difficult to quantify as they depend not only on the requisites/practices included in the AES, but also the proximity and configuration of enrolled farmland (Sutherland *et al.*, 2012; Banerjee *et al.*, 2014). These facts are evidence that an up-to-30% bonus may be too rough an estimation to reflect society's net gains from collective participation. Moreover, it would be interesting to further analyze other forms of incentives, such as non-monetary ones (*e.g.*, giving priority to collective rather than individual applications to AES), or simply not offering individual AES but only collective contracts. Future research should also provide information about how farmers' preferences toward collective AES can be influenced by the level of collaboration and spatial restrictions when forming the collective (*e.g.*, only allowing neighboring farms to collaborate).

Scenarios of agri-environmental schemes

The analysis of the AES scenarios shows moderately high average estimates of total WTA (€101-349/ha), especially when collective participation is required (€225-474/ha). Accordingly, this requires a sizable budget when extrapolating to the whole IOG system in Andalusia. This is not surprising since IOG is characterized by semi-intensive farming, that is, it is largely oriented to the production of private goods. As a result, IOG farmers face high opportunity costs when asked to increase their production of PGs and thus high payments are usually required to outweigh these costs and incentivize AES uptake. Although these results a priori suggest that the implementation of AES in IOG is not advisable, further analysis should be carried out in order to confidently make such a recommendation. First, there are some issues that will have to be incorporated into future supply-side analysis in order to provide more accurate estimates. This analysis should be expanded by estimating the transaction costs (at least for the implementing body) associated with the implementation of AES, and by incorporating possible market effects (namely changes in commodity prices) on farmers' preferences toward AES. Moreover, it is worth underlining that here we are comparing welfare changes from the SQ situation to the hypothetical situation where AES are implemented in IOG, so we only take into account the additional production of PGs from the SQ to AES level. However, as our results underscore, there are some farmers that are currently providing PGs at (some of) the proposed AES levels. As highlighted in Vedel *et al.* (2015), it can be argued that by introducing public incentives, such as these types of schemes, there is a risk of crowding-out private incentives (*i.e.*, those incentives that have encouraged these farmers to use agri-environmental practices at the proposed AES level). Conversely, experience suggests that it is doubtful whether these 'environmentally-friendly' producers will continue providing PGs at the AES level in the absence of any public incentive. Therefore, future analyses on the supply side should shed light on these issues and provide more complete estimates of farmers' preferences toward AES.

Second, in order to provide sound advice for policy-making, any estimates from the supply side have to be compared to estimates from the demand side to decide whether or not a scheme is worth implementing from society's point of view. The 'costs' of AES implementation estimated in the present supply-side analysis should therefore be compared to the social gains obtained from such implementation, to ensure that net social welfare gains are achieved. Although this complementary analysis is beyond the scope of this paper, some approximate figures can be provided by using the estimates of social gains for Andalusian society shown by Rodríguez-Entrena *et al.* (2012) and some technical coefficients for the production of PGs provided in the specialized literature. Such an exploratory analysis from the demand side gives rise to an average total WTA ranging from €17.2/ha to €115.4/ha for implementing the least (EFA_2) and the most stringent (AES_Max) individual-AES scenario, respectively[6]. These estimates involve strong assumptions and are likely conservative as the analysis overlooks the fact that some PGs are global (and thus fails to acknowledge the value from individuals outside of Andalusia). Despite this, the estimates of social gains produced are well below the estimates of producers' total WTA in all the AES scenarios, thus indicating a limited scope for implementation of AES in IOG in Andalusia. Finally, although there may well be other agricultural systems offering higher net gains from AES, further supply- and demand-side analyses are required to confirm this.

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[6] The following figures were used: €29.7/t CO_2 sequestered; €4.2/t of soil loss prevented; and €0.6/bird·ha (Rodríguez-Entrena *et al.*, 2012). To include benefits associated with the higher visual quality of landscapes when EFA and CC are present, ratios between such functions and the other environmental functions were used according to estimates from Gómez-Limón & Arriaza (2011). See Villanueva *et al.* (2015b) for a detailed description of the calculation.

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