Extensive Mediterranean agroecosystems and their linked traditional breeds: societal demand for the conservation of the Majorcan black pig

ABSTRACT

Extensive outdoor low-intensity livestock farming systems are the principal form of management of high natural value farmland in Europe. Their marginalization and poor recognition in policies and markets, can ultimately risk the future of sustainable farming and their paired mosaic landscapes.

Traditional high-quality meat products from Mediterranean pigs are produced in extensive-type production systems using native agro-pastoral resources. This is the case of the *porc negre mallorquí*, the Majorcan Black Pig (MBP), a traditional extensive pig breed native from Mallorca island (Balearic islands, Spain), characterized by its high rusticity and adaptation to the Mediterranean climatic conditions.

In this study we assessed island dwellers' preferences for management options for MBP, its agroecosystem and related products through a choice experiment valuation survey. Our results show overall societal support for improved breed conservation status, tree crop and product diversity. Outcomes of this study call for complementary policies to support this breed and its coupled agroecosystem where breed conservation and enhancement of landscape diversity through public funding is complemented with product innovation and premium niche markets for overall agroecosystem viability.

Keywords: *choice experiment; societal preferences; extensive farming; latent-class model; random-parameter model; rural landscape*

1 Introduction

Agricultural areas in Europe are known to support biodiversity conservation and the provision of ecosystem services (Pe'er et al., 2017). However, the general decline in biodiversity linked to agroecosystems (European Environmental Agency, 2015) threatens the provision of a large segment of public goods and services stemming from farming systems (Cooper et al., 2009). Extensive outdoor low-intensity livestock farming systems are the principal form of managing high natural value farmland in Europe (Beaufoy and Cooper, 2008). However, market forces and technological innovation have propelled these systems down a route of restructuring towards either more profitable forms of land use or land abandonment (Cooper et al., 2009) that can ultimately risk the future of sustainable farming (e.g. Bauer and Johnston, 2013; Dale and Polasky, 2007; Kroeger and Casey, 2007; Swinton et al., 2007; Zhang et al., 2007).

Traditional breeds are a key element in the maintenance of extensive farming systems since they are adapted to marginal areas and due to their rusticity can thrive in low input agricultural systems. They result from the long-term selection that livestock breeders have made of their animal genetic resources (AnGRs) according to their own preferences and needs, adapted to their local conditions and over thousands of years of domestication (Anderson, 2003). AnGRs support agroecosystem resilience (Hajjar et al., 2008), maintain socio-cultural traditions, local identities and traditional knowledge (Nautiyal et al., 2008). Furthermore, they contribute to evolutionary processes, gene flow (Bellon, 2009) and conservation of cultural landscapes (Tisdell, 2003). This broad array of benefits for society as a whole are usually delivered as positive externalities (i.e. side effects of production decisions taken by the farmers for producing marketable outputs) (Madureira et al., 2013), sharing the characteristics of public goods (Fisher and Kerry Turner, 2008). In contrast, the private production dimension is linked to the products these animals provide to their owners (Zander et al., 2009), including the private benefits associated with using agrobiodiversity to minimize risks related to external shocks (Di Falco et al., 2008). The significant private use component is a distinctive feature of the conservation of traditional AnGR that gives it its impure public good characteristics (Narloch et al., 2011).

Since AnGR play a crucial role in maintaining agroecosystems that deliver a broad array of public goods, conservation policies have frequently been oriented towards direct support payments to compensate farmers for the opportunity cost of maintaining such breeds and their agroecosystems. However, the economic incentives provided by the common agricultural policy (CAP) through its second pillar have not achieved the desired environmental (Navarro and López-Bao, 2018) and rural development goals (Ragkos et al., 2017). Furthermore, the need for long-term support raises issues related to the sustainability of such approaches (Martin-Collado et al., 2014), especially in a post 2020 framework with diminishing CAP budgets.

The renewed search of consumers for products and services associated with tradition, heritage and culture represents an opportunity for these farming systems to retain locally the value generated and engage these areas in endogenous development dynamics that render economically viable these farming systems (Jenkins, 2000). Innovation in traditional products increasing their variety, can represent an opportunity to widening their market (Kühne et al., 2010), accessing niche markets and increasing the added-value of farm production, contributing to create business models that protect these areas from depopulation (Avermaete et al., 2004). Purely private goods from these extensive agroecosystems, whose benefit is appraised by the farmer/local community, can make a decisive contribution to the maintenance of the agroecosystem and hence of its linked public goods and services. Therefore, a mix of breed/farming conservation policies and product innovation may work synergistically by compensating farmers for the positive externalities they provide while simultaneously increasing farm profitability through added-value products. This mix would address environmental conservation, product quality, efficiency of resource use, and retention of value generated locally towards an endogenous development (Jenkins, 2000).

Central to the claim for an agricultural policy agenda aimed to conserving and enhancing these traditional farming models for public good provision (Navarro and López-Bao, 2018), is to provide estimates of the societal benefits (costs) of a policy intervention aimed at improving the condition of those farming systems, their provision of public goods and traditional product innovation. These estimates would the assessment of whether the costs of agro-environmental schemes or subsidies are justified from a societal welfare point of view (e.g. Campbell, 2006; Górriz-Mifsud et al., 2016) as well as identify the optimal level of policy intervention to correct the underlying market failure (Madureira et al., 2013).

The discrete choice experiment (DCE) is a questionnaire–based method extensively used to elicit the values and preferences of different societal groups, from farmers to citizens or policy makers (Huber et al., 2010) for hypothetical changes in the provision level of non-market goods or services due to policy development (Madureira et al., 2013). Individuals participating in a DCE survey are invited to select their preferred alternative from a fixed set of scenarios (choice sets) according to their own preferences and budget constraints and where each choice set represents different combinations of welfare losses and gains. The DCE has been extensively used to assess the multifunctional role of agriculture (e.g. Bernués et al., 2015; Campbell et al., 2008; Domínguez-Torreiro et al., 2013; Kallas et al., 2007; Ragkos and Theodoridis, 2016a; Rodríguez-Entrena et al., 2014) or the societal values accrued by agricultural landscapes (e.g. Domínguez-Torreiro et al., 2013; Hynes and Campbell, 2011; Grammatikopoulou et al., 2020; Kallas et al., 2007; Ragkos and Theodoridis, 2016b; Rocchi et al., 2019; van Zanten et al., 2016a).

In this study we conducted a DCE survey with the aim of assessing the societal preferences of a sample of Majorcan dwellers for the conservation and enhancement of the most relevant dimensions of the Majorcan black pig (MBP) farming system likely to be improved by policy mixes of breed conservation and product innovation. Our survey considers attributes of the MBP farming system that have impure public good features such as breed conservation status or tree polyculture enhancement, as well as product diversification that despite holding a private good character, is likely to be enhanced through public policy support (Zander et al., 2013; Bernués et al., 2014), Our study focuses on traditional breeds beyond their role as elements of rural landscapes (Hynes and Campbell, 2011; van Zanten et al., 2016b) or their in-situ/ex-situ conservation options (Pouta et al., 2014). It aligns with previous studies addressing societal preferences for traditional breeds and their related landscapes and products (Zander et al., 2013; Bernués et al., 2014; Martín-Collado et al., 2014). Differently from previous studies, we address the breed existence in probabilistic terms and consider the type of breed management. Furthermore, biodiversity in our study is not conveyed through iconic threatened species (Bernués et al., 2014) but though agrobiodiversity expressed as the variety of tree crop species. The most remarkable novelty in our work resides in that it estimates welfare changes derived from hypothetical scenarios conveyed through attributes that can be influenced by policy mixes of agroecosystem conservation and product innovation. We explore preference heterogeneity through responses to attitudinal variables as well through continuous and discrete modelling approaches in order to provide relevant inputs for policy development. Differently from previous studies, we assess whether attitudes towards available options for funding MBP agroecosystems, i.e. via taxpayer money and/or via increased (premium) prices for meat-based products, can be a source of preference heterogeneity.

This manuscript is organized as follows: The next section presents the description of the case study area and the MBP farming systems in the island of Majorca. Section 3 introduces the econometric modelling approach and the survey design details. The results section follows considering the details of the sampled population, the preference and willingness to pay estimates. Section 5 discusses the results including their policy implications and section 6 concludes the paper.

2 Case study description

Traditional high-quality meat products from Mediterranean pigs are produced in extensive-type production systems using native agro-sylvo-pastoral resources (Silva and Nunes, 2013). This is the case of the *porc negre mallorquí*, the Majorcan Black Pig (MBP), a traditional extensive pig breed native from Majorca island (Balearic islands, Spain), characterized by its high rusticity and adaptation to the Mediterranean climatic conditions (Gonzalez et al., 2013; Tibau et al., 2019) and its ability to exploit the scarce natural resources of the plains in the central part of the Island (Jaume and Alfonso, 2000). This breed is reared in a mosaic landscape of tree polycultures with a positive interplay between intermediate level of farming disturbances and land-cover complexity, endowed with a rich bio-cultural heritage able to preserve a wildlife-friendly agro-ecological matrix likely to house high biodiversity (Marull et al., 2015b).

Traditional MBP farms are mixed extensive farms with a density of 10 to 25 pigs per hectare and where pig rearing has been one the income generation activities in family farms (Gonzalez et al., 2013). Feeding regime is traditionally based on pasture, cereals (barley), legume seeds, but also on figs, almonds, acorns and several Mediterranean shrubs present in the typical MBP plots (Gonzalez et al., 2013; Tibau et al., 2019).

The island of Mallorca has followed similar pathways to other areas in the Mediterranean where land-use intensification through urban sprawl and abandonment of rain-fed arboriculture and spontaneous reforestation (Marull et al., 2015a) have taken place since 1950. The impact of tourism in the island entailed a strong socioeconomic marginalization of farming (Marull et al., 2015a) and the decline of MBP population over the last 150 years. Due to the efforts of the Majorcan Black Pig Producers Association, the herd book of the breed was initiated in 1997 with 400 reproductive sows. The latest census of MBP (August, 2016) registered 59 farms with less than 1,000 breeding sows and 54 males. Exchange of genetic material across farms is encouraged as part of the ongoing conservation program (Tibau et al., 2019). Its genetic diversity provides high flexibility to adapt to changes in the production system while maintaining its high quality traits (Muñoz et al., 2018).

The breed shows distinctively high-quality traits although with low productive efficiency (Muñoz et al., 2018). The main meat product obtained from this breed is a specialty fat-rich cured sausage Protected Geographical Indication (PGI-certified) since 1994 (Tibau et al., 2019). The reduction in generational relay and the low financial performance of these farms, call for the development of new products that can push the demand and their added-value towards new niche markets that can improve revenues to producers (Gonzalez et al., 2013; Kallas et al., 2019).

3 Data and methods

We implemented a discrete choice experiment (DCE) survey to analyse the heterogeneous preferences of citizens for the improved provision of goods and services that stem from the MBP agroecosystems that are likely to be improved by agroecosystem conservation and/or product innovation policies. Most of them have an impure public good character, such as breed conservation and management, tree and landscape diversity conservation, while the increased variety of meat-based products based on product innovation holds a more prevalent private character.

DCE is particularly well suited when the trade-offs that need to be considered relate to agricultural policy, aimed at fostering a multifunctional agricultural sector with multidimensional attributes (Hynes and Campbell, 2011), hence not involving a complete loss or gain in the provision of a particular good or service, but rather compromises across levels of provision (Bernués et al., 2015).

3.1 Attribute selection

The survey design covered the key goods and services namely with a mixed public-private good character provided by the MBP agroecosystem that are likely to be improved by conservation and product innovation policies. An initial list of relevant attributes was devised through extensive literature review on valuation of endangered domestic animal genetic resources (AnGRs), followed by in-depth discussion and exchange with colleagues having intensively worked in socioecological transitions in Mallorca and the MBP production system (breed quality traits and genetic features).

Two focus group sessions were held with island dwellers corresponding to urban and rural profiles, respectively. These sessions were organized as a world café (Schieffer et al., 2004), where attributes were grouped in three thematic conversation tables: breed conservation and management, biodiversity and landscape and, product and commercialization, respectively. During these sessions, we also checked their perception of these attributes as final output/outcome attributes (Boyd and Krupnick, 2013) and consequently we assume that the selected attributes are framed and perceived by the sampled respondents as final outcomes. Respondents were then requested to rank individually the five attributes that they considered more important to maintain the MBP breed. As a result, some of the tested attributes were dropped out of the final design such as bird species diversity. Since we hypothesized that institutional distrust may play a role in raising protesting behaviour among the sampled respondents (Kassahun et al., 2020), the final time slot was devoted to discuss with them different management options for the hypothetical funds collected, ranging from regional and local administrations to the breeders' association. Most of them were in favour of the latter option.

A group valuation session was held with 15 scholars for fine-tuning the questionnaire and its visual aids, followed by pilot testing with 20 individuals. The pilot test allowed to making final fine-tuning of the questionnaire to improve wording and fluency in some of the questions; the estimates of the pilot test also served to improve the experimental design of the attributes (see below).

The final list of attributes gathers a comprehensive combination of attributes that characterize the MBP agroecosystem. The first attribute considered the future existence of the breed. Discussion held with geneticists in the project, allowed identifying threshold levels for breed survival: i. Below 200 sows; the population is linked with a high risk of breed extinction, ii. Between 200-1000 sows' population sets risk in medium levels, while iii. Surpassing 1000 sows' sets risk levels in a low status. Accordingly, these levels were depicted to respondents conveying simultaneously risk levels and number of sows.

Traditional MBP is bred outdoors, allowing the animals develop their natural behaviour while improving the organoleptic features of the meat such as intramuscular fat (Tibau et al., 2019). Traditional extensive management systems sometimes provide a shelter to the sows in early mothering stages to reduce piglet mortality due to low temperatures. Hence, we included a level in the management attribute considering that the animals spend half of their time in sheltered spaces. Since intensification, understood as indoor breeding with external feeding inputs, is one of the pathways followed by these farming systems, we included an extra (hypothetical) level that considered indoor breeding to seize respondents' preferences for this option.

Two attributes considered the multifunctionality of the system at two levels. The tree diversity attribute considered diversity of domestic tree species (tree polycultures) that are also a key source of feed for MBP breed and confer to its products a distinctive flavour (i.e. almond, carob and fig trees); these are currently in a process of abandonment and diversity decrease (Marull et al., 2015b). The landscape attribute considered heterogeneity-homogeneity levels (conveyed as landscape "variety" to the respondents). This attribute was presented through photographs provided by landscape ecologists specialists on the MBP agroecosystem; these are a valid surrogate for assessing landscape preferences (e.g. Bateman et al., 2009; Hull and Stewart, 1992; Ode et al., 2009; van Zanten et al., 2016a).

An attribute was included concerning the product-related dimension of the MBP considering the innovation (Guerrero et al., 2009) and increase in product availability. This way we measured societal preferences for developing new products more aligned with nowadays consumers' demand (Kühne et al., 2010). The diversity of MBP meat-based products, despite having a pure private character, can be regarded as an outcome of policies supporting product innovation to make financially viable these extensive farming systems.

Finally, the monetary attribute considered six payment levels from €10 to €60. The payment vehicle was expressed as annual household payments for three years. Since the credibility of the payment vehicle is crucial for stated preference studies (Carson and Groves, 2007), we discarded an infinite payment vehicle since it would look improbable, thus reducing the incentive compatibility while one-time payment may yield higher estimates compared to annual payments (Richardson and Loomis, 2009). To make our survey incentive compatible, the payment vehicle was framed as a compulsory tax payment.

Table 1. Description of attributes and levels1

ATTRIBUTE	VARIABLE NAME	DESCRIPTION
BREED EXISTENCE	H_RISK*	HIGH risk of extinction (< 200 sows)
	M_RISK	MEDIUM risk of extinction (200–1000 sows)
	L_RISK	LOW risk of extinction (1000–2000 sows)
TYPE OF MANAGEMENT	OUTDOOR*	Most of the time outdoors
	OUT-IN DOOR	50% outdoors, 50% indoors
	INDOOR	Most of the time indoors
TREE CROPS	1 TSP*	1 tree species, low variety
	2 TSP	2 tree species, medium variety

[1] Appendix 1 shows the full list of images used to convey the attributes' levels to the participants

	3 TSP	3 tree species, high variety
TYPE OF LANDSCAPE	LOW*	Low heterogeneity
	MEDIUM	Medium heterogeneity
	HIGH	High heterogeneity
PRODUCT VARIETY	LOW*	Low product variety
	MEDIUM	Medium product variety
	HIGH	High product variety
COST (€/household)	0*, 10, 20, 30, 40, 50, 60	

* Status quo level

3.2 Sampling strategy and questionnaire

Previous studies on societal preferences for rural landscapes have addressed contrasted samples of local-rural population and urban dwellers (i.e. living closely to the rural landscapes vs. living distant from the resources) (e.g. (Bernués et al., 2014; Domínguez-Torreiro et al., 2013; Hynes and Campbell, 2011). Usually local dwellers are more concerned with specific attributes related to the production systems (Bernués et al., 2014) and are more willing to move to scenarios different from the SQ (Hynes and Campbell, 2011) while urban people have a more general view and concern (Bernués et al., 2014). In order to considering the influence of rural and urban profiles on the preferences for the MBP and its related agroecosystem, our sampling strategy attached equal weights to rural (< 20,000 inhabitants) and urban (> 20,000 inhabitants) populations. Each subsample was stratified according to population size, gender and three age groups.

The island of Majorca has 861,000 inhabitants; around 600,000 live in urban areas and with 400,000 located in Palma de Mallorca, the capital city (Ibestat, 2016). A total sample of 400 respondents was surveyed in April 2017 through face-to-face questionnaires. A quota sampling procedure was used to guarantee gender and age classes representativeness with proportional allocation to each stratum (see table 2). We sampled 211 and 189 respondents in rural and urban areas, respectively. The urban share of the survey was undertaken in four towns with more than 20, 000 inhabitants plus the capital city Palma de Mallorca, where 150 respondents were interviewed. The rural sampling was undertaken in seven municipalities ranging from 2,000 to 5,000 inhabitants in the central part of the island where the MBP farms are located. Potential adult respondents were approached in public places such as squares, markets or schools, considering age groups and gender quotas.

Table 2. Percentage gender and age representativeness of the sample

	SAMPLE	POPULATION	Chi- square
GENDER			
URBAN			
Male	49.73	48.44	P(χ^2 >0.125) =0.724
Female	50.27	51.56	
RURAL			
Male	46.44	52.2	P(χ^2 >1.19) =0.275
Female	53.56	49.8	
AGE CLASSES			
URBAN			
20-39	40.10	36.59	P(χ^2 >0.983) =0.612
40-64	41.71	44.05	
>65	18.18	19.36	
RURAL			
20-39	23.83	29.25	

40-64	45.79	44.3	P(χ^2>3.443) =0.179
>65	30.37	26.44	

The valuation questionnaire included questions on knowledge of the MBP agroecosystem and the perception of current status for the selected attributes. To minimize the incidence of protest responses, a question prior the choice cards was included so that respondents expressed their preferred institutions to manage taxpayers' money for support MPB. Then, they were asked to make their elections considering that this institution would manage their contributions towards the most preferred scenario. We adopted this approach based on the results of the world café sessions presented above where we identified that institutional distrust existed among some participants. Furthermore, respondents were presented with a short cheap talk[2] script to try to reduce hypothetical bias (Ladenburg et al., 2007; Varela et al., 2014b).

The debriefing section of the questionnaire collected standard socieconomic data and included two attitudinal questions with statements to elicit respondent's agreement in a seven-point Likert scale (1-completely disagree, 7- completely agree) with funding the improvements in the MBP agroecosystem via MBP products' price increase and via an earmarked tax increase, respectively.

True zero bidders were disentangled from protesters through a close-ended question. Protesters were these respondents choosing one of these two options: "I already pay enough taxes and the government should use that money to fund this type of initiatives" or "I would collaborate if the way of raising funds would be different". Zero bidders were these choosing one of these two options: "I do not think any of the proposed measures would have any positive effect" or "Other measures should be implemented to protect the breed".144 respondents out of 400 classified as protesters, i.e. 36% of the total and were removed from the sample for the ulterior econometric analysis. Despite the number of protesters in the sample is significant, it is within the range of similar studies (e.g. Castillo-Eguskitza et al., 2019; Valasiuk et al., 2017; Varela et al., 2014a). Significant differences were found in the protesting behaviour, where 45% of the rural subsample showed protesting behaviour while protesters in the urban subsample accounted for 25.7% of this subsample (Pearson χ^2=16.291 p= 0.000).

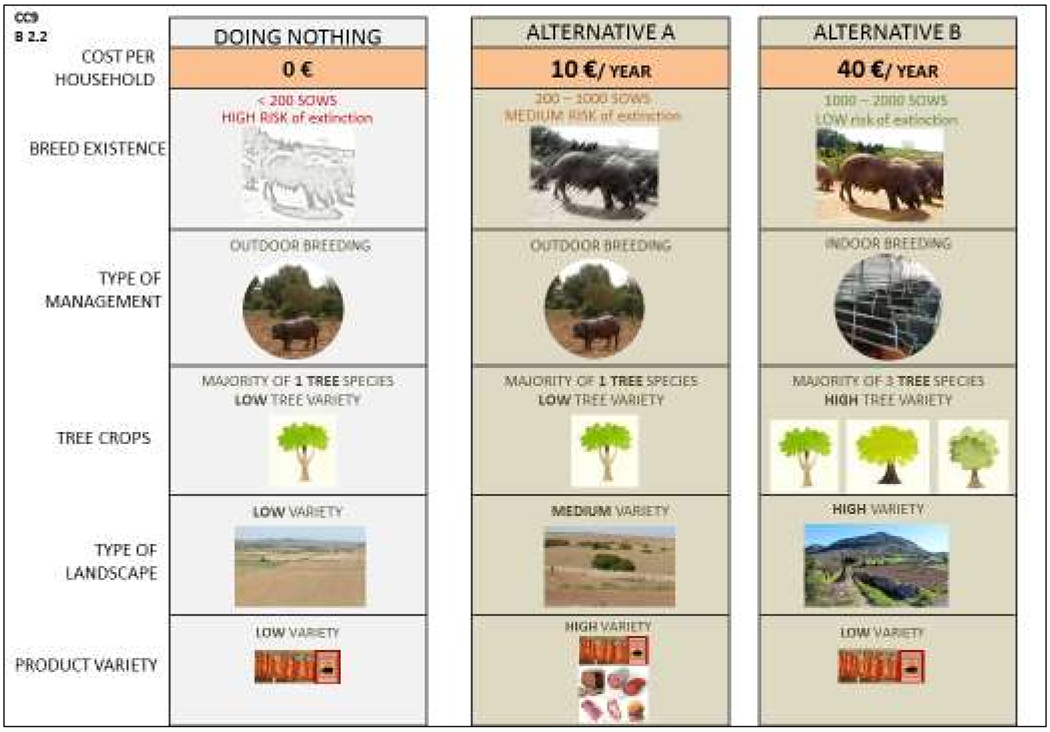
3.3 The choice experiment

Each respondent faced six choice cards where each of them displayed three alternative scenarios: the status quo scenario covered by the current level of tax payment (i.e. no extra cost) that was the same for all respondents and choice cards (see Figure 2) while alternative scenarios would entail an additional cost in terms of regional taxes. An experimental design with 24 alternatives distributed in four blocks was optimized employing Ngene (Choice Metrics 2012) for D-efficiency, retrieving a D-error of 0.064.

[2] A cheap talk is a script introduced just before the choice exercise in the questionnaire that described the hypothetical bias to respondents who are asked to revise downward their willingness to pay. The cheap talk script in our questionnaire read as follows: Before we start, I want to tell you a problem that we have found in similar surveys. When people indicate their preferred program, they sometimes tend to overestimate what they are willing to pay. Each of the programs we will show implies a cost. Therefore, we invite you to carefully consider each alternative in relation to your household income. The money spent on the program will not be available for other purchases. We ask you to consider if you are really willing to pay for it. If the cost is higher than what you are really willing to pay, then you should choose the status quo.

An efficient design aims to minimise the d-error derived from the variance-covariance matrix, which lastly results from the model estimation (Hensher et al., 2015). Constructing an efficient design requires from the use of prior information on the parameter estimates. As these and their related variance-covariance matrix are unknown when the design is set up, it is common practice to conduct a pilot study and use the estimates from it as priors for the final design. Accordingly, our experimental design followed a two-stage procedure. First, we assumed a zero value for all the coefficients of the attributes' levels and produced a D-efficient design for a multinomial logit specification for the pilot test. The parameter estimates for the attributes' levels obtained from the pilot tests were used as fixed priors to feed the modelling of the final experimental design which was optimized for a multinomial logit model (Rose et al., 2011; Rose and Bliemer, 2008).

Figure 2. Example of choice cards shown to respondents



3.4 Econometric approach

Discrete choice experiments (DCE) base their econometric analysis on the evaluation of the utility that the sampled respondents derived from the choice of the best alternative among a set of multi-attribute management scenarios. The conceptual basis of DCE is grounded in the Random Utility Theory (McFadden, 1974) and Lancaster's Theory of Value (Lancaster, 1966) that assumes individuals will gain their utility not from the whole good or service but rather from its attributes and the levels these take.

The random utility model (McFadden, 1974) suggests that individuals (i= 1,…, I) will choose the alternative (j=1,…,J) providing them with the highest utility. Accordingly, the utility that is obtained from each alternative is decomposed into a deterministic part V_j following a linear and additive function of n= 1,…, N attributes X_n, and a stochastic part not observable by the researcher, ε_j, that follows an extreme value type I distribution function, capturing the variance not explained by V_j.:

$U_{ij} = V_{ij} + \varepsilon_{ij} = \sum_n \beta * X_{inj} + \varepsilon_{ij}$ (1)

where β represents the associate parameters of attributes X_{nj} that can be estimated by simulation with maximum likelihood using the conditional logit model (Train, 2003).

It is likely that preferences vary among individuals and that this heterogeneity may be relevant to understand the distributional implications of who will be affected by a management change, which can be of interest for policy analysis and development. Preference heterogeneity can be integrated in DCE through random parameter logit model (RPL) that allows for taste variation in the deterministic component of utility. This is undertaken by specifying the attribute parameters as random, with each one being characterized by a location (mean) and a scale parameter (variance or spread). The underlying distribution of the random parameters represents preference heterogeneity that cannot be explained by the observed variables, being therefore referred to as unobserved (random) preference heterogeneity. A complementary approach consists on incorporating sources of observed preference heterogeneity by introducing an interaction between the mean estimate of the random parameter and an individual characteristic (socioeconomic or attitudinal variable, for example) [3] (Hensher et al., 2005; Train, 2003).

Accounting for these two types of heterogeneity involves including two additional terms in the utility equation. The term $\sigma_n * x_{inj}$ represents the standard deviation of the β parameter vector and accommodates the presence of unobservable preference heterogeneity (random taste among individuals); the term $\delta_n * z_i * x_{inj}$ intends to reveal the preference heterogeneity around the mean parameters estimates where z_i is a set of person-specific influences.

$$U_{ij} = \alpha j + \sum\nolimits_n [\beta * X_{inj} + \sigma_n * X_{inj} + \delta_n * z_i * X_{inj]} + \varepsilon_{ij}$$

α is an alternative specific constant (ASC) for each alternative k that captures the average of the unobserved effects not captured by the systematic component of the utility (i.e. attribute parameters) (Hensher et al., 2005). In studies like this where the status quo option is included in the set of alternatives, it can cause respondents to regard the status quo alternative in a systematically different way from these alternatives involving changes since the status quo is actually experienced (Campbell, 2006). Therefore, the utilities of the hypothetical alternatives are more correlated amongst themselves than with the status quo. In this situation, the inclusion of an ASC captures the tendency to choose either the status quo or an alternative scenario. This constant was kept fixed and coded as a dummy variable with value 1 for the status quo option and 0 otherwise. Thereby *ceteris paribus*, positive values indicate overall preference to stay in the current situation while negative estimates of the ASC indicate willingness to depart from it. Coefficients β vary across respondents and follow a distribution with density f(β), that is the multivariate probability density function of β given the continuous distributional assumptions adopted by the researcher. If we assume independence over choice-tasks made by the same individual, the joint probability of an individual making a sequence of choices is the product, in our case, of six probabilities. Each of them represents the probability of choosing an

[3] Interactions can also be considered between socioeconomic variables and the constant. For a recent example see Grammatikopoulou et al. (2020).

alternative over the choice task and it is a weighted average of the logit formula evaluated at different values of β.

$$P_{ij} = \int \frac{\exp\left(x_{ij}\beta'\right)}{\sum_{j=1}^{J} \exp\ \left(x_{ij}\beta'\right)} f(\beta) d\beta$$

Since the integral does not have an analytical solution, assumptions have to be made about the distribution of the β parameters across the population and then take a set of draws from the distribution and calculate the logit probability for each of them. The RPL model can be further specified to handle panel data in order to accurately measure interpersonal heterogeneity.

All non-monetary attributes were coded using dummy coding (Daly et al., 2016), considering the status quo as the base level, except the number of tree species which was continuously coded. All the non-monetary attributes plus the ASC were specified to follow a triangular distribution while cost parameter was modelled as constrained triangular distribution, i.e. the mean and standard deviation are assumed to be equal (Grammatikopoulou et al., 2020), to restrict it to be negative. Initially an RPL model was estimated with no interactions and gradually interactions between attributes and the socioeconomic and attitudinal variables (covariates) of interest were introduced. The covariates included in the final model consider the answers to the two statements on available funding options for the MBP agroecosystems (i.e. funding via price increase and via tax increase). These were recoded into two dummy variables respectively with value 1 for agreement and 0 otherwise. The selected RPL model is reported in Table 3. The model was estimated using NLOGIT5 and distribution simulations were based on 500 Halton draws.

While the RPL model allows to analyse unobserved heterogeneity through a continuous representation, assuming that each member in the sample has a different set of utility parameters (Train, 2003), latent class (LC) models offer an alternative view (Greene and Hensher, 2013). In LC models heterogeneity in preferences is addressed by a discrete distribution of these into a finite number of classes or segments of individuals (Hynes et al., 2008; Scarpa and Thiene, 2005). This approach is suitable when preferences can be explained in the form of clusters or discrete groups. Heterogeneity is addressed by simultaneously dividing individuals into behavioural groups or latent classes and estimating a choice model for each of these classes. LC modelling does not require making specific assumptions about the distribution of parameters across individuals (Hensher et al., 2015). Despite LC models can adopt random parameter distributions within each class, we have opted for the standard LC model approach, considering fixed parameters within the segments[4].

In the LC variant of the conditional logit model, we assume that individuals are probabilistically allocated to different classes that differ with respect to the β parameters.

[4] We found that for the data set analysed, if attribute processing is handled through discrete distributions defined in a sufficiently flexible way, the extra layer of taste heterogeneity through random parameters within a latent class did not help in successfully identifying the classes. As Hensher et al. (2015) indicate, a random parameter treatment in this setting may be confounding with attribute processing; including attribute processing in the absence of continuously distributed random parameters is preferred to including continuously distributed random parameters in the absence of attribute processing.

Thereby, the LC model can be seen as a discrete form of the mixing distribution where β with probability s_m of being in segment m, takes on the value b_m, m = 1, . . . , M and f (β) = s_m for β = b_m, and the choice probabilities can be written as (cf. Train 2009):

$$\Pr\,(kin) = \sum_{m=1}^{M} s_m \prod_{n=1}^{N} \left(\frac{\exp\,(b'_m x_{ik})}{\sum_j^J \exp\,(b'_m x_{ij})} \right)$$

s_m is the probability of membership of segment m and can be written as:

$$s_m = \frac{\exp(\lambda_s Z_i)}{\sum_{s=1}^{S} \exp(\lambda_s Z_i)}$$

Where Z_i is a vector of socioeconomic characteristics and/or attitudinal variables and λ is a vector of parameters (Boxall and Adamowicz, 2002). The number of classes in LC model has to be specified before evaluating the parameters since its identification is not part of the maximization process. We tested the model with number of classes varying between one and seven. A balance between statistical information criteria (BIC, AIC and AIC3), reasonable parameter estimates and sound standard errors and class probabilities was considered in order to select the final number of classes (Boxall and Adamowicz 2002; Scarpa and Thiene 2005).

LC models have become popular to investigate the role of various processing heuristics such as attribute non-attendance (ANA), imposing restrictions on particular parameters within the different latent classes in order to investigate attribute processing rules (e.g. Scarpa et al., 2009; Campbell et al., 2011; Nair et al., 2012). We have considered a 4-class model where three of the classes are specified as full attribute attendance (FAA), allowing beta parameters to freely distribute across and within them, while the fourth class introduces ANA for the cost parameter. This strategy allows optimal allocation of zero bidders to class 4 and improves overall fit and model outcomes[5]. Furthermore, we considered the attitudinal variables related to funding options for the MBP agroecosystems and the income level of the respondents as covariates that contribute to explain the probabilistic membership of respondents to the different latent classes. The LC model is reported in Table 4 and it was estimated using Latent Gold software.

Since the DCE method is consistent with utility maximisation and demand theory (Bateman et al., 2003), parameter estimates can be used as input for welfare estimating to calculate the monetary value that individuals allocate to certain changes from the current situation.

For the linear utility index, the marginal rate of substitution between income and the attribute in question, i.e. the marginal WTP for a change in the attribute or implicit price for attribute, can be represented as the ratio of the coefficient for any attribute to the negative of the coefficient for the price attribute with all else remaining constant (Louviere et al., 2000).

$$WTP = -\beta / \beta_{cost}$$

[5] We are grateful to one of the reviewers for suggesting this modelling option.

In the case of the LC model, the WTP has to be averaged across classes to produce a global estimate. This is undertaken by using the posterior probabilities as weights.

4 Results

4.1 Preference for the DCE attributes: RPL model

Table 3 reports the results of the RPL model. These indicate that four attributes contributed to shape the preferences of the respondents, two of them related to the breed and its management while the remaining two concerned the agroecosystem. The parameter for the ASC indicated an overall preference for the status quo option, else equal. Reducing the risk of extinction for the breed to medium and low levels contributed significantly to shape the preferences of the respondents, with the latter determining their preferences to a higher extent. The indoor breeding of the MBP retrieved negative preference estimates, indicating that this type of management reduces the utility of the respondents and that societal support existed for the base level, which is traditional outdoor extensive management. Increasing the diversity in tree polycultures also contributed to positively shaping the preferences of the respondents.

The significant and high value of the standard deviation of the ASC parameter implied that not all individuals within the sample may prefer the current scenario. The standard deviation was also found statistically significant for low risk of extinction, high landscape heterogeneity, indoor management and medium product variety. Its magnitude for the three latter attributes indicates that beyond mean negative estimates, positive preferences may also be found across the sampled respondents. These estimates presume high variation in preferences for some of the attributes and led us to explore them from a discrete perspective employing LC modelling.

Finally, the significant interaction terms between the medium and low risk of extinction levels with the funding options for the MP agroecosystems indicated relevant heterogeneity around the mean estimates of these attribute levels. More specifically, breed conservation was positively considered by the individuals willing to contribute via taxes and negatively regarded by the supporters of increases in product prices.

Table 3. Results of the random parameter logit model

	Estimate	Std. deviation[a]
ASC	2.4315***	14.9464***
Breed existence: M_RISK	0.9196***	0.0307
Breed existence: L_RISK	1.3794***	1.0768***
Type of management: OUT-IN DOOR	-0.3149	0.1838
Type of management: INDOOR	-0.5548***	1.1693***
Tree crops: number of tree species	0.3291***	0.0496
Type of landscape: MEDIUM heterog.	-0.3487*	0.0991
Type of landscape: HIGH heterog.	-0.1925	0.4149*
Product variety: MEDIUM	-0.1542	1.3697***
Product variety: HIGH	0.0885	0.3937
COST	-0.0258***	0.0258***
Non-random parameters in utility functions		
M_RISK * PAY_PRICE	-0.65027**	
L_RISK * PAY_PRICE	-0.6819*	
L_RISK* PAY_TAXES	0.9789***	
Model diagnostics		
Loglikelihood	-1224.948	
McFadden's pseudo-R2	0.5352	
AIC	2497.9	
AIC/n	1.041	
Observations	2400	
Number of draws	500	

***1% significance level. **5% significance level. *10% significance level.
[a]The standard deviation is estimated based on the spread (s) of the distribution estimates. The standard deviation equals $s/\sqrt{6}$.

4.2 Preference for the DCE attributes: LC model

A 4-class LC model with fixed parameters and where the cost attribute was modelled as equal to cero and non-significant in the forth segment was selected as the best performing model and it is displayed in table 4. This model allowed exploring heterogeneity in preferences from a discrete perspective, in contrast with the previous RPL model where preferences are modelled in a continuous fashion. The estimates of the cost parameter are significant and of the expected sign in the three classes where full attribute attendance was allowed in the modelling phase.

Class 1 comprised 47% of the respondents. The value of the constant was positive and significant, indicating an overall preference for alternative management scenarios. Significant preferences were also found for reducing the risk of extinction of MBP to medium and low levels. Respondents in this class rejected indoor breed management and showed a positive preference for increasing the tree crop species as well as the variety of MBP products to high levels. This class was best described as "agroecosystem conservationist" since different dimensions from breed to management, trees or products determined their preferences.

Class 2 comprised 14% of the sample. Preferences of respondents in this class were determined by a narrower list of attributes. While they showed positive preferences for increasing tree and product diversity, they rejected the high landscape diversity. This class was named as “breed indifferent”.

Class 3 gathered 12% of the sample. In contrast with the previous class, preferences of respondents were strongly driven by medium and low extinction levels for the MBP breed. They also showed positive and significant preferences for indoor management and rejected improvements in tree species, landscape and product diversity. Thus, we named this class as “breed conservationists”.

Class 4 comprised 27% of the sample and the estimate of the cost attribute was equated to zero prior to the model estimation in order to deterministically identify zero bidders. The non-monetary attributes in this class retrieve non-significant estimates.

Considering the effects of the covariates (attitudinal and income variables) on the individuals’ class assignment, it should be noted that Class 1 represents the reference group. Therefore, the interpretation of the significant covariate coefficients should be made considering that an individual is more (or less) likely to belong to the given class than to class 1. Respondents that agree with financing conservation policies via product price increase are more likely to be found in Class 2 (breed indifferent class). Individuals preferring financing it via tax increase are more likely to be found in class 3 (breed aware group) and less likely to be found in classes 2 and 4 (breed indifferent and zero bidders classes, respectively). The higher the income, the more likely it is to find these individuals in class3 while the opposite applies for class 4.

Table 4. Results of the latent class model

	CLASS 1	CLASS 2	CLASS 3	CLASS 4	OVERALL	
Class Size	0.47	0.14	0.12	0.27	Wald p-value	Wald (=) p-value
ASC alternative 1	4.1261***	0.4716	-4.8757	-9.8824	0.000	0.001
ASC alternative2	4.404***	0.3407	-6.1975	-8.0931		
Breed existence: M_RISK	0.5589***	-0.0212	19.206***	-1.2141	0.000	0.19
Breed existence: L_RISK	0.9347***	0.2386	19.3933***	1.0734		
Type of management: OUT-IN DOOR	-0.2793	0.477	-5.8175**	-0.8541	0.017	0.066
Type of management: INDOOR	-0.2978**	-0.4487	4.0247***	-1.652		
Tree crops: number of tree species	0.207**	0.5639**	-1.0399*	1.6251	0.037	0.11
Type of landscape: MEDIUM heterog.	-0.2834	-0.143	-4.363*	-1.2035	0.022	0.024
Type of landscape: HIGH heterog.	-0.0792	-0.9359**	1.7242	-1.6142		
Product variety: MEDIUM	0.0232	0.424	0.7692	-0.3059	0.029	0.086
Product variety: HIGH	0.2671**	0.698**	-2.6009**	2.0003		
COST	-0.0142***	-0.0284**	-0.1739***	0	0.0000	0.0000
Covariates						
Finance via prices:PAY_PRICE	ref	2.268***	-0.870	1.875		
Finance via taxes: PAY_TAXES	ref	-2.703***	1.600***	-2.582***		
Income	ref	-0.187	0.376**	-0.224**		
Log likelihood	-1009.7405					
BIC	2347.1056					
AIC	2137.481					
AIC3	2196.481					
R2	0.532					
Respondents	257					
Parameters	59					

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4.3 WTP estimation

Estimates for WTP are reported jointly for the RPL and LC model in table 5. The last column corresponds to overall estimates for the LC model considering posterior probability weights for the latent classes. The RPL model retrieved positive and significant estimates for reducing the breed risk of extinction. The low risk of extinction level obtained the highest welfare estimates, with 53.45€ per household and year. This value would be reduced in 26.42€ for these individuals willing to pay a higher price in MBP products to support conservation programs and increased in 37.93€ for those respondents willing to support the agroecosystem through tax increases. The medium risk of extinction on average increased the welfare of respondents in 35.63€ with respect to the status quo situation. This value, however, was reduced in 25.19€ on average for the respondents willing to pay higher prices for MBP products. Finally, the increase in tree species also obtained positive significant estimates with 12.75€. Indoor management on average produced a disutility in the respondents, -21.49€ per household, who should be theoretically compensated.

The WTP estimates obtained for the LC model revealed similar patterns to these shown in the preference analysis. Respondents in class 1 and 3 showed high estimates for supporting breed conservation, with the later revealing estimates beyond 110 € per household and year for both attribute levels. Differently from RPL outcomes, management levels were significant only in class3, where indoor management retrieved positive estimates. Improving the number of tree species was supported by individuals in class 1 and 2 while landscape attribute levels were either not contributing to welfare gains or resulted in negative and significant estimates in class 3 for high heterogeneity levels. The high variety of products positively contributed to the welfare of respondents in class1 and class2 (18.82€ and 24.56 €, respectively) while the opposite applied for class 3 respondents (-14.95€ per household).

Table 5. Implicit prices (€/household year) and 95% confidence intervals of WTP estimates

	RPL model	LC model				
		CLASS 1	CLASS 2	CLASS 3	CLASS 4	OVERALL
Breed existence: M_RISK	35.63***(18.36, 52.90)	39.37*** (12.32, 66.41)	-0.75 (-30.87, 29.38)	110.42*** (54.38, 166.47)	0.00	32.15
Breed existence: L_RISK	53.45*** (32.17, 74.72)	65.84***(30.70, 100,99)	8.40 (-23.61, 40.40)	111.50*** (55.76, 167.24)	0.00	44.71
Type of management: OUT-IN DOOR	-12.20 (-33.35, 8.95)	-19.68 (-58.20, 18.84)	16.78 (-14.27, 47.83)	-33.45*** (-47.81, -19.08)	0.00	-4.14
Type of management: INDOOR	-21.49** (-42.30, -0.69)	-20.97 (-52.18, 10.23)	-15.79 (-48.86, 17.28)	23.14*** (14.66, 31.62)	0.00	2.86
Tree crops: number of tree species	12.75*** (4.42, 21.09)	14.58** (-0.19, 29.36)	19.84** (0.74, 38.94)	-5.98 (-13.57, 1.61)	0.00	9.54
Type of landscape: MEDIUM heterog.	-13.51 (-30.32, 3.30)	-19.96 (-53.36, 13.44)	-5.03 (-39.55, 29.49)	-25.08*** (-40.07, -10.10)	0.00	-3.10
Type of landscape: HIGH heterog.	-7.46 (-23.42, 8.51)	-5.58 (-31.98, 20.82)	-32.93 (-76.69, 10.84)	9.91 (-8.01, 27.84)	0.00	n.s.
Product variety: MEDIUM	-5.97 (-23.37, 11.43)	1.63 (-28.07, 31.34)	14.92 (-14.26, 44.10)	4.42 (18.19, 17.03)	0.00	n.s.
Product variety: HIGH	3.43 (-6.64, 13.50)	18.82** (1.42, 36.21)	24.56** (0.86, 48.25)	-14.95*** (-23.19, -6.72)	0.00	10.32
M_RISK * PAY_PRICE	-25.19* (-51.84, 1.46)					
LOW_RISK * PAY_PRICE	-26.42* (-57-33, 4.50)					
LOW_RISK * PAY_TAXES	37.93*** (9.29, 66.57)					

5 Discussion

The MBP and its related agroecosystem represent a traditional management model hosting high biodiversity levels and providing ecosystem services to society that are however, threatened by abandonment due to its reduced profitability (Marull et al. 2015b). This study assessed through a DCE valuation survey, the social preferences for key dimensions of the MBP agroecosystem through attributes that have an impure public good character, accrue several relevant values for society and, importantly, can be influenced by policy mixes of agroecosystem conservation and product innovation.

5.1 Societal demand for MBP agroecosystems

Our results identify a majority in the sampled respondents that supports the enhancement of breed conservation status, the tree species diversity and the increase in product diversity. In contrast, the high preference heterogeneity found in some of the attributes may contribute to the larger variances of the data (Pouta et al., 2014; Sælensminde, 2006; Zander et al., 2013). In this situation, the complementary views offered by discrete (RPL) and continuous (LC) modelling approaches may provide insights into the results obtained.

Furthermore, the distinctive way that covariates enter the two models, allowed us to disentangle the role played by tax and product price increase in determining preferences for breed conservation status (RPL) while identifying the membership of the respondents agreeing with each of the funding options proposed (LC) to different preference patterns. Our results show that these respondents agreeing with tax increase to improve the MBP agroecosystem conservation are highly concerned with breed conservation status (RPL) and have a narrow preference scheme (LC- class 3), where the high concern about the breed overrides the rest of elements of the agroecosystem in their preference framing. This result reinforces the necessity to inform wide audiences about the linkages between breed and agroecosystem conservation. The preservation of the MBP breed, tightly linked to the heritage of the island, may raise high social concern and hence respondents being inclined to favour what they considered as a moral duty over their budget restrictions. This type of behaviour may be explained by either simplified heuristics or real preferences (Sælensminde et al., 2006). Both the positive and significant value of the interaction between low risk of extinction and tax increase together with the higher likelihood of finding these respondents in class 3 add evidence to the latter.

In contrast, the respondents that agree on price increases in MBP products to fund improvements in the MBP agroecosystem are less concerned about breed conservation (RPL) and are more likely to be found in class 2, where the highest WTP estimates are obtained for high product variety. These results would suggest that beyond standard considerations of extrinsic quality dimensions such as heritage and culture (Ilbery and Kneafsey, 1999), it may also be important to strive for superior sensory properties when innovating in traditional product variety (Bernués et al., 2015; Kallas et al., 2019) to expand the market of potential buyers. Indeed, the special qualities of MBP meat appeals to niche buyers and it may command a substantial price premium compared against mainstream alternative products (Balogh et al., 2016; Kallas et al., 2019).

Insensitiveness of respondents to the cost of the alternatives and exhibition of lexicographic preferences has been reported previously in studies assessing societal preferences for biodiversity conservation (Hanley et al., 1998; Sælensminde, 2006) or environmental public goods linked to farming activities (Campbell, 2006; Pouta et al., 2014; Scarpa et al., 2009; van Zanten et al., 2016b). The LC approach is particularly well suited to identify non-compensatory decision rules that are frequent when respondents express their values (Rosenberger et al., 2003) or when an attribute is considered of relatively high importance (Blamey et al., 2002; Luce et al., 2000). In our study, we set a deterministic rule in the LC model to allocate to class 4 these respondents that did not attend the cost attribute. Similarly to previous studies on societal preferences and traditional breeds (Pouta et al., 2014; Zander et al., 2013), approximately one third of the sampled respondents are identified as zero bidders while some other studies report even a higher share of respondents selecting this option (Martin-Collado et al., 2014). In the study by Pouta et al. (2014) these respondents considered that farmers held a higher responsibility than citizens on conservation programs. Similarly, in or study these respondents that preferred conservation programs to be supported via taxes are less likely to be found in this group. Lower income respondents are more likely to be in this group what somehow aligns with the lower education profiles in the study by Pouta et al. (2014) that showed this preference pattern.

The large standard deviations found on indoor management estimates in RPL are further disentangled through LC modelling, where 12% of the sample considered it positively. The average negative preference pattern identified in the RPL model for indoor breeding most likely is linked with meat quality concerns and not with outdoor breeding as a proxy for welfare (Burnier et al., 2021). This may also contribute to explain the results obtained in Class3 where respondents may presumably have little knowledge about the MBP agroecosystem.

In the case of the landscape attribute, we obtained similar results to these of Martin-Collado et al. (2014) where respondents were indifferent towards improvements on this dimension. Indeed, some of our respondents showed negative values for increases in landscape heterogeneity that would deserve further exploration. The pictures employed in the survey were selected by landscape ecologists working in the island and thoroughly tested in focus group sessions and in the pilot survey; hence, we do not consider that a lack of understanding is the reason underpinning these estimates. Rather, another potential interpretation is that given the decreasing share of heterogeneous landscapes in the central part of the island (Marull et al. 2015a), a negative perception among the participants of these landscapes may be due to a lack of identification may be present (Schaak and Musshoff, 2020). Another possible explanation as stated by some of the rural dwellers in the focus group sessions is that the less diverse landscapes are more amenable to crop cultivation presenting less burden to mechanization. This can be one of the preference drivers among the rural share of the sample.

5.2 Land use and policy implications

Rendering these breeds and their agroecosystems viable relates to multidimensional policies and mechanisms that, on the one hand reward for the provision of public goods and the opportunity costs related to maintaining and enhancing these breeds while on the other hand, support strategies aimed at increasing their profitability.

Our findings show that societal support exists for both taxpayer money to support breed conservation and price increase in premium products to stimulate innovation in meat – based products from traditional breeds. Where linked with premium quality, niche product opportunities may also be worth exploring, reinforcing their cultural dimensions (Martín-Collado et al., 2014) to attract wider audiences that are concerned about breed conservation but are unaware of its linkage with the environment.

A complementary approach would be to apply market-based incentives such as payments for environmental services (PES) for the conservation of genetic resources (Narloch et al., 2011) that can be framed as conservation contracts for supplying farm animal genetic resources (Wainwright et al., 2019) as well as agroecosystem conservation.

6 Conclusions

Traditional breeds are tightly linked to extensive agrarian systems and are related to high natural value farming areas. Their vulnerability due to present economic conditions also threatens the landscapes where they thrive since their adaptive traits render marginal lands economically viable (Gandini and Villa, 2003; Hoffmann and Scherf, 2010).

The Majorcan black pig farming system is a paragon example since evidence suggests that a great deal of the biodiversity currently existing in the island may actually be associated to the remaining agricultural and forest mosaics still worked by the local peasantry (Marull et al., 2015a). The protection of values tied to traditional breeds and cultural landscapes calls for approaches directly targeted at agricultural policy with the integration of effective support for low-intensity use (Hill et al., 2004).

Despite some categories of value are incommensurate and thus not easily amenable to trade-offs (Adamowicz et al., 1998), our results on societal preferences for the MBP breeding agroecosystem call for a policy mix where breed conservation and enhancement of landscape diversity may work synergistically with product innovation by simultaneously addressing public funding and premium niche markets for overall system viability.

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