A Latent Class Approach to Investigate Farmers' Preferences for Biodiversity Offset Contracts

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Abstract
Biodiversity offsets are activities that provide measurable ecological gains that are equivalent to the ecological losses in the impacted area of a development project (No Net Loss (NNL) of biodiversity principle). Following the Law on Biodiversity (August 2016; articles 2 and 69), developers are now liable for the measurable ecological outcomes of their BO. The regulatory framework has not yet fully incorporated these changes, and this creates a somewhat fuzzy context for BO design and implementation. In addition, BO raises social acceptance issues, especially in the agricultural sector. In this paper, we aim at defining the conditions within which farmers would accept to enrol in BO activities. Our goal is to assess whether these conditions (e.g., duration, type of ecological activities) are in accordance with BO requirements for achieving NNL, and if the monetary claims seem realistic with budgets usually earmarked for mitigation in development projects. We used a Choice Experiment (CE) to assess farmer preferences building on a Latent Class Model (LCM) to identify key features that characterize group of farmers regarding BO activities and taking into account heterogeneity of preferences. We modeled farmers' decisions to enrol in a BO contract and we calculated the farmers' Willingness To Accept (WTA) for implementing different features of BO contracts that aim at compensating ecological loss. The attributes considered in the CE (payment, management plan, contract duration, and an innovative conditional monetary bonus) have a significant effect on the likelihood of choosing a BO contract. The likelihood of choosing a BO measure decreases with increasing levels of constraints on management practices and the duration of the contract. Higher payment levels and the proposal of a bonus for increased extent of interconnectedness of contracted land improve the likelihood of farmers signing-up to implement a BO contract on behalf of a developer. In addition, we show that there is heterogeneity of preferences between farmers especially with regards to the WTA.

***JEL* classification**
Q15, Q24, Q57.

Keywords
Agricultural contract, biodiversity offset, choice experiment, latent class model.

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1 Introduction

Development projects often leads to the destruction or degradation of natural and semi-natural ecosystems, with consequent impacts on ecological processes, biodiversity and associated ecosystem services. Offsetting, the last step of the mitigation hierarchy, is supposed to compensate for residual ecological losses in order to achieve No Net Loss (NNL) of biodiversity once the project's mitigation and offsetting measures have been successfully carried out (Kiesecker et al., 2010; Bull et al., 2013). Biodiversity Offsets (BO)[4] are activities that provide measurable ecological gains that are equivalent to the ecological losses in the impacted area. In the agricultural sector at the European scale, these activities include eco-conditionality requirements under the Common Agricultural Policy (CAP), Agri-Environment Schemes (AES), or mandatory buffer zones along watercourses and lakes (pursuant to the Nitrate Directive), and cannot replace previously planned and funded programs.

The mitigation hierarchy and BO have been promoted as an innovative mechanism for sustainability and are finding their way into environmental regulations in many countries (e.g. Madsen et al., 2011; Calvet et al., 2015; Gonçalves et al., 2015). In France, BO has been very poorly implemented since the concept was introduced in the 1976 Nature Protection Act (Quétier et al., 2014). Following the evolution of the international and more specifically European environmental legislation (Convention on Biological Diversity in 1992; 85/337/CEE, 2011/92/UE and 2014/52/UE Directives between 1985 and 2014) and the Laws of August 2009 and July 2010 (L. 122-3-1 of the environmental code), the French Ministry of Environment published several guidelines for improved implementation of the mitigation hierarchy (MEDTL, 2012; MEDDE, 2013). These guidance documents were not coercive until the Law on Biodiversity was passed in August 2016 (articles 2 and 69). From now, developers are then liable for the measurable ecological outcomes of their BO. The regulatory framework has not yet fully incorporated these changes, and this creates a somewhat fuzzy context for BO design and implementation. In addition, BO raises social acceptance issues, especially in the agricultural sector. Objections by farmers relate mainly to a so-called threefold penalty (de Billy et al., 2015; Etrillard and Pech, 2015): (1) the use of arable land for development projects; (2) the use of arable land for offsetting; and, (3) the resulting pressure on arable land prices. The implementation of BO on arable land is therefore controversial. One of the reasons for the BO controversy is that BO requirements are much more restrictive for agricultural activity than well-established AES. Restrictions include longer duration of contracts, from which it is not possible to withdraw without stiff penalties. This questions the long term compatibility of BO with agriculture. For instance, contracts may seem out of step with the fact that, in some countries like France, most farmers rent their lands for short to mid-term contracts (from 9 to 25 years). Compared to AES, BO schemes are also voluntary but they rely on the implementation of a regulatory requirement by farmers on behalf of public or private developers (who remain the environmental permit holder in France). Yet some farmers see an opportunity to diversify their activities by implementing biodiversity-friendly activities on their land, on behalf of developers, without selling the land itself (Etrillard and Pech, 2015).

In this paper, we aim at defining the conditions within which farmers would accept to enrol in BO activities. Our goal is to assess whether these conditions (e.g., duration, type of ecological activities) are in accordance with BO requirements for achieving NNL, and if the monetary claims seem realistic with budgets usually earmarked for mitigation in development

[4] We use BO to refer to Biodiversity Offset(s) or Biodiversity Offsetting, indiscriminately.

projects. Our results have policy implications as the various technical and organisational solutions for achieving NNL are being actively discussed in France, and more broadly in Europe in the context of the "No Net Loss initiative" of the European Commission (Tucker et al. 2014) and in view of the next CAP reform (Pe'er et al., 2016).

We used a Choice Experiment (CE) to assess farmer preferences building on a Latent Class Model (LCM) to identify key features that characterize group of farmers regarding BO activities. CE have been increasingly used over the past few years regarding the analysis of farmers' preferences for Agri-Environment Schemes (AES), of which understanding participation for biodiversity conservation schemes (e.g., Broch and Vedel, 2012; Lienhoop and Brouwer, 2015; Greiner, 2016). In addition to contract length and the extent of the subsidy, which are frequently tested, many attributes related to the flexibility of the contracts are tested like technical choices (Espinosa-Goded et al., 2010; Christensen et al., 2011; Kuhfuss et al., 2014; Greiner, 2016), the parcels being involved in the contracts (Ruto and Garrod, 2009), or the possibilty to go back to agriculture at the end of contract (Lienhoop and Brouwer, 2015). The administrative burden is also often studied (Ruto and Garrod, 2009; Christensen et al., 2011). BO requirements include many such considerations. To our knowledge, there are only a few studies dealing with the implementation of BO on arable land that have used a CE approach to assess farmers' preferences. Rare exceptions are the works of Le Coënt et al. (2016) and Le Coënt and Calvet (2016) who respectively study framing effects on farmers' participation in agri-environmental contracts (BO *versus* a biodiversity conservation program) and the social norm issues involved in the choice by a farmer to adopt biodiversity friendly practices to offset environmental impacts.

We modeled farmers' decisions to enrol in a BO contract and we calculated the farmers' Willingness To Accept (WTA) for implementing different features of BO contracts that aim at compensating ecological loss. We conducted a CE in Hauts-de-France / Picardy, northern France. BO proposals vary with different levels of contract attributes selected with focus groups: management plan of the land restoration, contract duration, the annual payment and an additional conditional bonus.

Our contributions are therefore both policy-oriented and methodological. Firstly, we assess the boundaries of the BO contracts features that can be proposed to and get accepted by farmers. Secondly, our conditional bonus consists in a side payment offered in addition to the baseline payment and is only paid if a minimum amount of contiguous lands is enroled within a farm. Consequently, our approach complement previous studies by considering connection and/or agglomeration only within a single (individual) land holding (not coordination with neighboring land holdings) and preferences of farmers for ecological efficiency. A significant proportion of the literature on bonuses is indeed based on laboratory experiments, with few empirical studies. Moreover, proposed agglomeration bonuses are mostly applied when reaching a specific spatial coordination of enroled parcels between neighbours, as for instance the protection or restoration of contiguous patches of land (Parkhurst et al., 2002; Wätzold and Drechsler, 2013). In the context of BO policies, a smaller number of agents involved in the restoration of ecosystems reduces transaction costs of policy implementation (e.g., Levrel et al., 2015; Vaissière and Levrel, 2015). This is why we designed a new bonus proposed to individual farmers for increasing the extent or connection of land under contract. There is an ecological debate around the interest of having single large *versus* several small areas for conservation (the SLOSS debate). For instance, Verboom et al. (2001) demonstrate the stabilizing role of large patches in marshland (birds habitat) networks but other studies also underline the importance of a network of smaller patches for certain species (e.g., invertebrates in Rösch et al., 2015. In the context of agri-environmental

schemes, Gonthier et al. (2014) discuss the relative merits of local and landscape-scale approaches for conserving farmland biodiversity.

The remainder of this paper is organised as follows. In Section 2, we present the methodological options chosen in this study. In Section 3, we present the results of our empirical work through descriptive statistics and an econometric analysis through a latent class approach. In Section 4, we discuss our results and conclude on their policy implications.

2 Materials and methods

2.1 Modeling the heterogeneity of farmers to enrol in a biodiversity offset contracts and willingness to accept

Farmers' decision to enrol or not in a BO contract will result from the comparison of the utility they will derive from different alternatives. Following Lancaster's theory (1966) and the Random Utility Theory (Luce, 1959; McFadden, 1974), the farmer *i* (*i=1,…,n*) will choose alternative *j* (*j=1,…,m*) in choice card C_t *(t=1,…,T)* if the alternative is the one that procures him the highest level of utility among all *m* alternatives proposed in the choice card. The utility is defined by an observable part and a random part represented by error terms. In the Conditional Logit (CL) model, it is supposed that the error terms are Independently and Identically Distributed (IID) among the alternatives and across the population, and that Irrelevant Alternatives are Independent (IIA). This hypothesis is a strong assumption and the Latent Class Model (LCM) relaxes this assumption to capture the heterogeneity of farmers' preferences (Greene and Hensher, 2003; Birol et al., 2006; Garrod et al., 2012; Jaeck and Lifran, 2014; Kuhfuss et al., 2014). The LCM takes indeed into account preference heterogeneity in choice models and is a specific case of mixed logit models (Garrod et al., 2012). This relies on a discrete distribution of preferences in which individuals are sorted into a number of classes where preferences are homogenous in and heterogeneous between them. This allows investigating groups of stakeholders or people with particular preferences that can be useful for policymakers. LCM have been applied in various fields of study of which the agricultural sector with regards to, e.g., farmers' preferences for cropping and management practices (Jaeck and Lifran, 2014; Kuhfuss et al., 2014) or biodiversity conservation schemes (Greiner, 2015 and 2016).

In a LCM, farmers who are members of a same class s ($s \in S$; S is a partition of the population) have similar preference parameters over the attributes that explain farmers' choices on enroling in a BO contract. The conditional probability that farmers who are members of class s choose alternative *j* in choice card C_t is (equation (1)):

$$P_{jt|s} = \frac{\exp\left(X'_{jt}\beta_s\right)}{\sum_{m \in C_t} \exp\left(X'_{mt}\beta_s\right)} \quad (1)$$

Where X_{jt} are the attributes of the alternative *j* and β_s is the vector of preference parameters specific to each class *s*, representing the average importance of each attribute of the BO contract for farmers members of *s*.

Thus, the unconditional probability of choosing alternative *j* for the whole set of farmers is (equation (2)):

$$P_{jt} = \sum_{s=1}^{S} M_{is} \frac{\exp\left(X'_{jt}\beta_s\right)}{\sum_{m \in C_t} \exp\left(X'_{mt}\beta_s\right)} \quad (2)$$

With M_{is} the probability of membership of farmer *i* in class *s*.

Following the analysis of the attributes that explain farmers' choices on enroling in a BO contract, we calculate farmers' Willingness To Accept (WTA) from variations of attributes in BO contracts regarding their respective latent classes. The marginal WTA for the individual i for a variation of the attribute k can be computed per class following equation (3):

$$WTA_{ki|s} = M^*_{is} \frac{-\beta_{ks}}{\beta_{mons}} \quad (3)$$

Where s are the latent classes of the model; β_{ks} the parameter associated to attribute k for each latent class s; β_{mons} the parameter associated to the monetary attributes for each latent class s; and M^*_{is} the posterior estimate of the individual-specific class probability of membership of farmer *i* in class *s*.

2.2 Case study and survey

Our study uses agricultural lands located in Hauts-de-France / Picardy, northern France, as a case study. Agriculture is the dominant land use, covering 75.2% of Picardy (forests and urban areas cover 17% and 6.7% respectively), as shown in Figure 1 (Corine Land Cover, 2012). Most farms have a Utilised Agriculture Area (UAA) of more than 100 hectares (the mean surface is of 200 hectares) and the most represented types of farming are cereals, oilseeds and other arable crops (AGRESTE, 2010). Although modified habitats dominate, they include birds such as the corncrake (*Crex crex*) or the stone-curlew (*Burhinus oedicnemus*), and plants such as the hurtsickle (*Centaurea cyanus*), which are of conservation concern. These species are dependent on large expanses of extensive agricultural land and permanent grasslands, that have experienced a sustained decrease over the past decades.

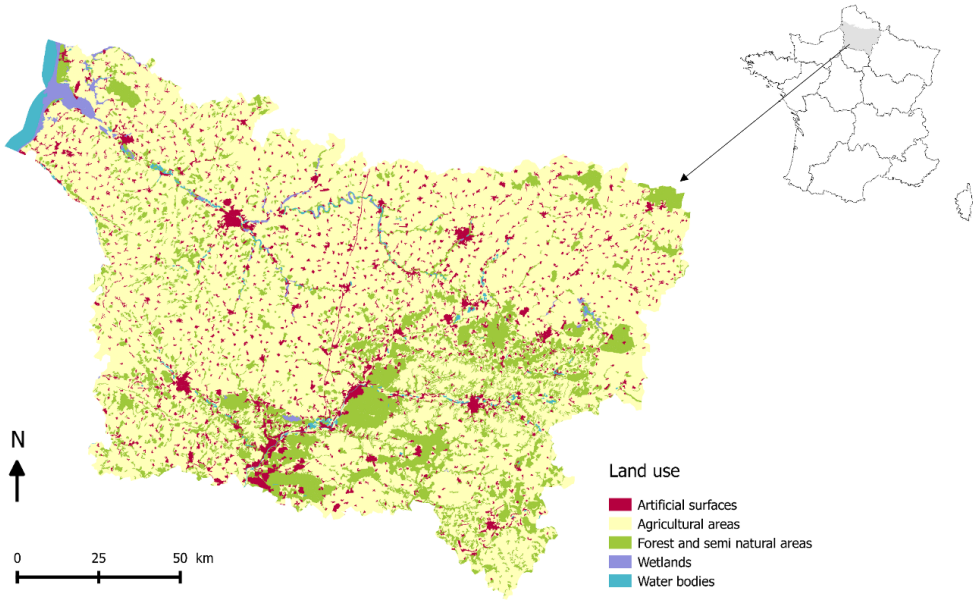

Figure 1: Land use in Picardy, northern France (Corine Land Cover, 2012)

To inform the design of our CE, we conducted three focus groups with local farmer union-run bodies (*Chambres d'Agriculture*) in Picardy from July 2015 to February 2016. Focus groups included administrative people and/or farmers who helped us determine key characteristics of BO contracts (i.e., the attributes in our CE and their levels) and to make the most realistic scenarios and follow up questions for our survey. A pilot survey was conducted during February and March 2016 with 26 farmers in Picardy to test the questionnaire and make adjustments. The final questionnaire includes three parts that are the attributes description, the choice experiment and follow-up questions. This questionnaire was proposed to farmers through an on-line survey. The time to fill the study was estimated at 15-20 minutes. The link to the survey was sent to all the available email addresses for farmers in Picardy (5100 contacts) at the beginning of May 2016 and the study stayed opened during one month, until early June 2016. This approach is well suited for our case study as farmers in this region are well connected to the Internet and this method enables us to reach out to a large sample of farmers.

The questionnaire was sent with a presentation of the current legal framework for BO in France, as farmers are not necessarily well-informed on the topic. Afterwards, we describe a fictive development project that would occur in their region and imply a destruction of meadows of ecological interest. The developer would need to carry out BO in order to compensate for this ecological loss and would propose to the farmers that they sign a BO contract (without involving a sale of their land). If the farmer accepts one of the two contracts proposed, he would implement the management plan of the BO on arable lands on his farm on behalf of the developer and would be paid for this activity. Conversely, the farmer can decline the offer and keep his current agricultural practices by choosing the status quo option. The eligibility rules and minimal terms and conditions of the contract are described as follows: the measures have to be additional with other regulatory obligations (e.g., from CAP obligations and AES contracts); farmers would be accompanied by relevant technical and administrative staff from the local farmer union-run bodies, or other specialised public agencies or Non-Governmental Organizations (NGOs); farmers must agree to give access to their land for ecological monitoring and compliance control by regulators; in addition, none of the parties of the BO contracts can give it up. Instead of using long written explanations, we created short and accessible videos and made them available online.[5]

The proposed BO contracts have four attributes leading to requirements close to the contracts a farmer would be confronted with in a 'real life' BO situation for the sorts of species and other biodiversity features that trigger offsets in northern France. The first attribute is the *management plan.* A common base is shared by four possible levels of management. The base includes technical details such as the fact that measures must be the conversion of arable cultivated land into meadows, on an area at least 10 meters wide and of more than 0.5 ha, with a mix of seeds of legumes and grasses, and subsequently mowed (not grazed). Details regarding mowing are also provided (centrifugal, forbidden at night, of a 15 cm minimum height, etc.). The four levels of the attributes are a combination of a total quantity of nitrogen (N) fertilization, a specific earliest date for mowing and the presence or not of a refuge zone (i.e., a zone of the meadow of at least 10 meters wide representing 10% of the surface of the BO that is not mowed any given year, and that can be moved from one year to the next). The second attribute is the *contract duration* with chosen durations of 9, 18, 25 or 40 years. The third attribute is the *conditional monetary bonus* regarding the respect of additional (ecologically relevant) conditions to the management plan.

[5] The videos are available on https://youtu.be/7rXahUmFpM8 for the offsetting explanations and https://youtu.be/BRLKNW-84zo for the choice modelling explanations.

The bonus is proposed in some scenarios and can be accepted or not by the farmers. The two levels for this attribute are thus “available” or “not available” in the scenarios. If the bonus is available, the farmer may decide to activate this bonus implying a €200/ha/year additional payment to the baseline payment. However, this bonus is only received under the following conditions: the farmer signs the contract for the scenario for at least 5 ha and the restored lands must be placed in one piece or following an interconnected ecological network on the farm. The fourth attribute is the actual *payment* of €800/ha/year, €1100/ha/year, €1500/ha/year or €2000/ha/year. The lower limit of these amounts was chosen based on unit AES payments to restore and manage a meadow (EU COUVER06), stop fertilization on a parcel (EU HERBE03), delay mowing (EU HERBE06), and focus the management of the meadow on a specific flora/fauna (EU COUVER07). The latter is similar to the maintenance of a refuge zone as spelled out in our scenarios.

Regarding the Choice Experiment (CE) *per se*, the different attribute levels are then combined in scenarios that describe different types of BO contracts. We decided how many scenarios to propose to interviewees, that is 16 different combinations (using the SAS %mktruns command). We gathered the scenarios in pairs, in 8 choice cards (illustrated in an example in Figure 2). We added an opt-out answer to each choice card, entitled “I prefer to keep my current agricultural practices” (the status quo) to improve the realism of the choice cards and hence that of the model estimations (Kontoleon and Yabe, 2003). If farmers have selected one of the contracts, an additional question appears: we ask them how many hectares they would be able to commit to the selected BO.

Attributes	Theoretical BO contract A	Theoretical BO contract B	None of the contracts
Management plan	**Level II** Maximum fertilization: 0 UN Delayed mowing: June 20th no refuge zone	**Level III** Maximum fertilization: 0 UN Delayed mowing: July 20th no refuge zone	I prefer to keep my current agricultural practices
Contract duration	25 years	18 years	
Conditional monetary bonus	B The contract proposes a 200€/ha/year bonus if you meet the requirements of the bonus	B The contract does not propose a bonus	
Payment	€1100/ha/year	€800/ha/year	
Your choice:	Contract A ☐	Contract B ☐	None of them ☐

Figure 2: Example of one of the choice cards of the final choice experiment survey

We selected the 8 choice cards following a two-step procedure (using the NGene software). First, the pilot study choice cards were chosen using an orthogonal efficient design with all the prior parameters set to 0, to determine the specific prior parameters of our sample. Second, the final study choice cards were chosen using a Bayesian efficient design, using the parameters revealed during the previous pilot study. We used effects coding instead of dummy coding with the bonus variable in order to avoid confounding the coefficient of the opt-out answer (Bech and Gyrd-Hansen, 2005; Hasan-Basri and Karim, 2013). The value of the attribute is 1 when the bonus is proposed in a contract and we differentiate the absence of bonus because the opt-out option has no bonus by definition (coded 0) and the absence of the bonus in a proposed BO contract (-1). As suggested by Haaijer et al (2001), we used an additional variable for the opt-out. The opt-out takes the value of 1 when the farmer is proposed to keep their current practices while the level is set to 0 for the 4 attributes. When a BO contract is proposed, the opt-out takes the value of 0. The opt-out variable thus capture the preference of the farmers for their current practices.

Table 1 sums up information on the attribute description and variable names, attribute levels and the corresponding coding for the analysis.

Table 1: Attribute description, levels and their coding to describe BO scenarios proposed to farmers

BO attributes and the opt-out	Description	Levels	Coding
Management plan	Levels of management plan required by the BO contract related to: quantity of azote fertilization (UN), date of mowing, and presence of a refuge zone	Level I: 30 UN, June 20th, no refuge zone	1
		Level II: 0 UN, June 20th, no refuge zone	2
		Level III: 0 UN, July 20th, no refuge zone	3
		Level IV: 0 UN, July 20th, refuge zone	4
		Opt-out	0
Contract duration	Total duration of the BO contract	9 years	9
		18 years	18
		25 years	25
		40 years	40
		Opt-out	0
Conditional monetary bonus	Additional payment (€200/ha/year) for ecologically relevant measures, provided that the bonus is available in the scenario	Available bonus (€200/ha/year)	+1
		No bonus in a BO contract	-1
		No bonus because this is the opt-out answer	0
Payment	Payment received each year by the farmer per enroled hectare	€800/ha/year	800
		€1100/ha/year	1100
		€1500/ha/year	1500
		€2000/ha/year	2000
		Opt-out	0
Opt-out	The farmer prefers to keep its current practices	Opt-out	1
		BO contract 1 or 2	0

The third part of the questionnaire includes follow up questions that we built with the help of the focus groups to understand BO in arable lands. Questions deal with the farmers, their socio-economical profile and details about their farms. Among these questions, we asked a specific question to those who systematically chose the opt-out answer and to those who chose the opt-out answer at least once. This is a way to identify protest responses that must be removed from the analysed sample (Barrio and Loureiro, 2013).

3 Results and discussion

3.1 Sample characteristics

162 answers by farmers were received, giving us a response rate of about 3.2%. This seems to be a common result for surveys on controversial topics and moreover based on an on-line survey. Examples of low response rates in other CE surveys are Abildtrup et al. (2013) and Torres et al. (2015) with respectively 2.2% and 1.1% of the estimated sample, for studies on forest ecosystem services valuation; and Czajkowski et al. (2017) with 5.23% of the

estimated sample with regards to household waste recycling behaviour. As a consequence of this low response rate, we may expect that farmers with strong opinions about BO have responded allowing for possible self-selection into the sample. However, as showed below, the representativeness of the sample is good, allowing us to draw broadly applicable conclusions from our results. After dropping 18 protest responses, we obtained 144 useful responses, equivalent to 3456 observations. The fact that we did not separate the 8 choice cards in blocks lead to a high number of observations per farmer. Follow-up questions for checking protest responses gave us some insights on farmers' behaviours. 19% of the 144 farmers systematically chose the opt-out option, without being protest responders, because: (1) they prefer to conserve their actual use of land and are not willing to change whatever the payment or other considerations, (2) they were not satisfied by the different BO contracts proposed, and (3) the BO contracts are technically not feasible on their lands.

Descriptive statistics of useful answers are presented in Table 2. The representativeness of the sample is good, in terms of spatial distribution of the sampled farmers and age (apart for age class over 60 years old). We observed however a slight over-representation of farmers with large farms (the mean UAA in Picardy is of 199 ha). Moreover, cereal and oil seed crops and single household unincorporated farms are also slightly over-represented. A majority (78%) of the farmers in the sample have never been contacted before by project developers for BO contract, and 31% of the farmers had never heard of BO contracts before receiving the questionnaire. However, 22% of the sampled farmers are already committed in AES schemes or other environmental contracts.

Table 2: Sample and population characteristics

		Farms and farmers in the sample	Farms and farmers in Picardy*
Gender (%)	Male	83	
	Female	9	No data
	No answer	8	
Age class (%)	[18,39]	20	18
	[40,49]	33	29
	[50-59]	35	32
	>60	6	21
	No answer	6	/
Used Agricultural Area (UAA)	Mean UAA in Picardy (ha)	199	98
	Number of exploitation (%):		
	<50 ha	5	38
	[50-100] ha	14	22
	>100 ha	72	40
	No Answer	9	/
Agricultural status (%)	Single household unincorporated farms	24	57
	Jointly run farms (*Groupement Agricole d'Exploitation en Commun (GAEC)*)	7	6
	Private limited farming company (*Entreprise Agricole à Responsabilité Limitée (EARL)*)	40	26
	Other	20	11
	No answer	9	/
Cultural types (%)	Cereals and oilseeds	43	28
	Other arable crops	21	29
	Livestock	16	21
	Livestock and crops combination	13	15
	No answer	14	/
Contracts previously signed by farmers (%)	BO contract	2	No data
	AES	17	
	Other (Natura 2000, etc.)	3	
Lease duration	18 years	67	No data
	9 years	13	
	Other	4	
	No answer	16	

*Agricultural census for 2010 (AGRESTE)

3.2 Econometric analysis

We modeled the heterogeneity of farmers' decision to participate in a BO contract with a Latent Class Model (LCM) whereby participation is modeled according to the attributes of the BO contracts as sole factors of choice. We selected the number of classes using the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC) criterion, and the predictive quality of the model (i.e., the mean likelihood that farmers belong to the class they

have been assigned to). Table 3 shows that, according to these criteria, we must select a three-classes model as this minimizes the AIC and BIC criteria while providing a high predictive quality (greater than 96%) (Pacifico and Yoo, 2013).

Table 3: Selection criteria of the latent class model

	Number of classes			
	2 classes	**3 classes**	**4 classes**	**5 classes**
Number of farmers	144	144	144	144
ll	-814.6008	-752.2537	-729.9511	-708.4854
AIC	1651.202	1538.507	1505.902	1474.971
BIC	1683.869	1588.994	1574.208	1561.095
Predictive quality (%)	97.04	96.85	92.51	92.48

Following this selection, we provided CL model estimates and LCM estimates through the three classes (Table 4). Our LCM results then identify three types of farmers with contrasted preferences for BO contracts. Class share highlights that class 1 comprises 40% of the respondents, whereas class 2 and class 3 comprises respectively 24% and 36% of them.

Our CL estimates show significant impacts regarding the attributes with increased likelihood to sign a BO contract with regards to the payment and the conditional monetary bonus, and with decreased likelihood with regards to the management plan the contract duration. If we now turn to the LCM estimates, as expected the payment increases the likelihood to sign a BO contract in the three classes. Moreover, the models show that the contract attributes have significant similar effects on farmers' choices in classes 1 and 3. In these classes, contract duration has a significant negative utility for farmers. Participation increases with the conditional bonus. The fact that the bonus improves the likelihood of signing a contract is coherent with the information that farmers generally decided to benefit from the bonus when they choose a contract including a bonus. The likelihood to participate decreases with more demanding management plans is only significant for class 3. The difference from 0 and significance of the opt-out parameter means that the farmers have a strong preference for keeping their current practices.[6] Regarding the class 2 farmers, the payment attribute is the only attribute at stake.

[6] The opt-out variable is how we interpreted the Alternative Specific Constant (ASC) variable in these models.

Table 4: Conditional logit and latent class model estimates

	Conditional logit	Latent class estimates		
		Class 1	Class 2	Class 3
Payment	0.002***	0.00301***	0.00402**	0.00257***
	(0.0001)	(0.000404)	(0.00170)	(0.000228)
Management plan	-0.270***	-0.170	-1.566	-0.303***
	(0.053)	(0.152)	(1.054)	(0.0745)
Contract duration	-0.051***	-0.235***	0.0180	-0.0253***
	(0.0047)	(0.0317)	(0.0575)	(0.00669)
Conditional monetary bonus	0.193***	0.196*	3.278	0.159**
	(0.049)	(0.116)	(2.046)	(0.0702)
Opt-out	1.960***	1.075*	9.928	1.508***
	(0.216)	(0.620)	(0)	(0.328)
Constant	-	0.0858	-0.410*	-
	-	(0.212)	(0.228)	-
Observations	3,456	3456	3456	3456
Number of groups	-	1,152	1,152	1,152
Number of farmers (*N*)	144	55	36	53
Class share (%)	-	40	24	36

Standard errors in parentheses
Significant levels: *** p<0.01, ** p<0.05, * p<0.1

In Table 5, we present the farmers' Willingness To Accept (WTA) for implementing different features of BO contracts for the CL model and the LCM per class.

Table 5: Willingness To Accept (WTA) for Biodiversity Offsetting (BO) contracts implementation for each class

	Conditional logit	Latent class model					
		Class 1		Class 2		Class 3	
Attributes	**WTA (€/ha/year)**	**WTA (€/ha/year)**	***SD***	**WTA (€/ha/year)**	***SD***	**WTA (€/ha/year)**	***SD***
Number of farmers (*N*)	144	55		36		53	
Management plan	135	-	-	-	-	112	11.42
Contract duration	25.5	76	5.32	-	-	9.6	0.95
Conditional monetary bonus[a]	-96.5	-126	8.86	-	-	-119	11.94
Opt-out	-980	-348	24.4	-	-	-566.3	56.8

[a] Effect coded variable, the WTA must be multiplied by 2 (Le Coënt et al., 2016) because we introduced a two-units variation (instead of a one-unit variation) between the two levels of this variable.

WTA analysis is focused on class 1 and class 3 following our LCM estimates because attributes' coefficients, apart from the monetary attribute, are non-significant for class 2.

When looking more precisely at the follow-up questions and answers provided by the farmers in the different class, we can precise the farmers classes profile. Farmers belonging to the class 2 are less engaged than other classes' farmers in environmental contracts (AES or other types of contracts). Farmers in this class thus seem to show a lower predisposition at accepting environmental contracts whatever the attributes composing it. Moreover, conversely to other classes, a majority (75%) felt that the proposed contracts were not realistic explaining somehow the non-significance of the attributes. On average, this class contains the older and less educated farmers. However, and surprisingly, class 2 is the class seeing the most the opportunity of BO contract for a valorization strategy.

In the case of class 3, WTA for the management plan is 112€/ha/year for a composite increase in the level of constraint imposed by our four levels management plan. This is lower than for the CL model for which the amount is 135€/ha/year for the whole set of farmers. Class 3 farmers are then less likely to participate with more demanding management plans (Table 4) but are less conservative in terms of monetary amounts and are more willing to implement changes with ecologically framed management plan compared to the whole sample. This seems to be confirmed by the fact that farmers in this class are significantly more engaged in environmental contracts than the two other classes. In addition, class 3 farmers are willing to accept 9.6€/ha/year to a one-year increase in the duration of the offset contract compared to 25.5€/ha/year in the CL model. On average, this class contains the youngest and the most educated farmers. In majority, they found the proposed contracts realistic (67%).

If we now turn to the inclusion of the monetary bonus, this is well-understood by the farmers. They are ready to waive respectively 126€/ha/year (class 1) and 119€/ha/year (class 3) of the payment to get the bonus whereas this one is worth €200/ha/year if this is included in the contract. However, this would be higher than the whole sample with 96.5€/ha/year if we compare to the CL estimate. Last, farmers are ready to waive respectively 348€/ha/year (class 1) and 566.3€/ha/year (class 3) to keep their current practices. This is far lower that the whole sample for which this is 980€/ha/year in the CL estimate. Consequently, class 3 farmers and especially class 1 farmers are ready to enrol in BO contracts at lower amounts. Nevertheless, there is heterogeneity of preferences between classes as there are trade-offs for example with the contract duration for class 1 farmers.

4 Discussion and conclusion

Biodiversity Offset (BO) is, in principle, aimed at achieving No Net Loss (NNL) of biodiversity in the context of economic development projects, plans or programs. Agricultural landscapes may have good potential for ecological gains through ecological restoration or enhancement of arable land. However, implementation of BO by farmers remains a controversial topic that has been little studied and discussed in the scientific literature. One could wonder if the implementation of long term BO contracts, satisfying restrictive conditions in terms of ecological performance, can match farmers' preferences and constraints. Our study aimed at identifying key factors that explain decisions by farmers to sign a BO contract. The attributes considered in the CE have a significant effect on the likelihood of choosing a BO contract. The likelihood of choosing a BO measure decreases with increasing levels of constraints on management practices and the duration of the contract. Higher payment levels and the proposal of a bonus for increased extent of interconnectedness of contracted land improve the likelihood of farmers signing-up to implement a BO contract on behalf of a developer. In addition, we show that there is heterogeneity of preferences between farmers especially with regards to the WTA. Some groups of farmers are less conservative than the whole sample

and are bound to enrol in BO contracts. There are however trade-offs regarding the features of the contracts, in particular whilst considering the contract duration.

Regarding the policy implications of these results, it is important to consider that BO are currently implemented in a piecemeal approach, through the purchase and *ad-hoc* contracting of a multitude of small sized parcels of land, including farmland. This is costly for developers to put in place and manage, makes it difficult for regulators to control and monitor BO performance, and decreases the likelihood of BO having a lasting ecological efficiency (Quétier et al., 2014). Our results show that a conditional monetary bonus can improve the organisational and ecological efficiency of BO, although with an increased cost for developers, per unit-area. This extra cost can be justified as developers are liable for the measurable ecological outcomes of their BO.

A structural limit to the implementation of BO on arable land is that offsets are supposed to be effective for as long as impacts occur, and this tends to be over long time periods and even theoretically into perpetuity for many public infrastructure projects. Contract duration is one of the attributes for which farmers are reluctant to sign contracts in our study. We expected this result since other studies with shorter durations made the same observation (Ruto et Garrod, 2009; Christensen et al., 2011; Greiner et al., 2014). Reasons that explain this result are: having land under a lease makes it more difficult to accept a BO contract, because if a lease is shorter than the duration of the BO contract, farmers must be ready to enter into discussions and negotiations with the owners of the land they farm, to include contract requirements in their leases (these contracts would have to be transferred to future farmers leasing the land); the introduction of perpetual conservation easements that limit forever most of, or even any, agricultural practices (Vaissière and Levrel, 2015) and this may limit the land sales; institutional and environmental uncertainty that farmers face can prevent them from signing this kind of contracts (e.g., the recent experience with temporary meadows having been preserved during five years under AES contracts and then being designated as permanent meadows; or, the future link between the CAP subsidies and the BO contracts). As a consequence, contracting farmers to enhance arable land for biodiversity may be suitable for offsetting temporary impacts on already degraded areas of natural habitat (e.g., field margins and young permanent grasslands), but may not be suitable for permanent impacts on high quality habitat (e.g., old permanent grasslands). This is because less constraining and shorter contracts will only provide minimal biodiversity gains, which are only suitable for offsetting moderate biodiversity losses (Quétier and Lavorel, 2011). In addition, land tenure patterns (e.g., whether farmers own the land they farm and their capacity to sign contracts with developers) are likely to determine the transferability of our results. In France, they appear applicable to similar intensive agricultural regions, where biodiversity offsetting is considered as particularly controversial.

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