Farmers' Preferences for Biodiversity Offset Contracts on Arable Land: A Choice Experiment Study

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Abstract

Biodiversity Offsetting (BO) is, in principle, aimed at achieving No Net Loss of biodiversity in the context of economic development projects, plans or programs. Agricultural landscapes sometimes have low levels of biodiversity, with good potential for ecological gains through ecological restoration or enhancement of arable land. However, having farmers implement BO on their land 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 aims at identifying key factors that explain decisions by farmers to sign a BO contract. We conducted a Choice Experiment study at the scale of Picardy, a French agricultural region. Four attributes, describing different scenarios of BO contracts, were selected: the actual enhancement activities (in a management plan), the contract duration, the annual payment, as well as the option of receiving a monetary bonus for the spatial extent and distribution of enhanced land. Farmers have a clear preference for not signing up a BO contract. The likelihood of signing-up decreases with increased ecological requirements of the management plan and contract duration. However, higher levels of annual payment and the addition of a monetary bonus for the spatial extent and distribution of enhanced land improves this likelihood. This means that contracting farmers to enhance arable land for biodiversity is suitable for offsetting temporary impacts on already degraded areas of natural habitat, but may not be suitable for permanent impacts on high quality habitat. The bonus makes the enroled share of cultivated lands increase and thus bring organizational and ecological improvements.

JEL classification: Q15, Q24, Q57.

Keywords: Agricultural contract, biodiversity offset, choice experiment, land management.

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1 Introduction

Development projects, including urban development or the construction of transport infrastructure, often leads to the destruction or degradation of natural and semi-natural ecosystems, with consequent impacts on ecological processes and biodiversity and associated ecosystem services. Even if developers must follow a mitigation hierarchy including measures to first avoid and then reduce their potential impacts on biodiversity, they often end up with significant residual impacts on ecosystems and species. Offsetting, the last step of the mitigation hierarchy, is supposed to compensate for these residual ecological losses in order to achieve a No Net Loss (NNL) of biodiversity once the project and its mitigation and offsetting measures have been successfully carried out (Kiesecker et al., 2010). Biodiversity Offsets (BO)[5] are activities that provide measurable ecological gains that are equivalent to the ecological losses in the impacted area. To be qualified as gains, they also have to be additional to other biodiversity conservation activities such as eco-conditionality requirements under the Common Agricultural Policy (CAP), or Agri-Environment Schemes (AES), mandatory buffer zones along watercourses and lakes (pursuant to the Nitrate Directive), and cannot replace previously planned and funded programs (cost shifting). So far, most of the technical and scientific discussion on mitigation and offsetting has focused on threatened species and habitats, and protected areas, as has actual implementation. In practice, impacts on “ordinary” biodiversity are generally not considered (CBD and UNEP-WCMC, 2012; Baker et al., 2013; Tardieu et al., 2015).

In France, BO has been very poorly implemented since its very first mention in the 1976 Nature Protection Act (Quétier et al. 2014). Over the past few years, 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. The regulatory framework has not yet fully incorporated these changes, and this creates a somewhat fuzzy context for BO design and implementation. In addition, this raises social acceptance issues, especially by farmers. Objections by farmers relate mainly to: (1) the use of arable land for development projects; (2) the use of additional arable land for offsetting; and, (3) the resulting pressure on arable land prices (de Billy et al., 2015). 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 traditional AES. Restrictive requirements deal with the contract length: as the duration of the contracts is indeed longer, it is not possible to withdraw from these contracts even if the management plans may lead to give up agricultural activities on the enroled parcels. One can thus wonder if BO is compatible with agriculture over the long term. 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 (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 by implementing biodiversity-friendly activities on their land, on behalf of developers, without selling the land itself (Etrillard and Pech, 2015).

The objective of this article is to assess farmers’ preferences for BO contracts on arable land. We aim at defining, from an empirical perspective, the conditions within which farmers would accept to enrol in BO activities (or not) and the factors that influence the enroled share of the cultivated lands. The main idea is to assess whether these conditions (e.g., duration, type of

[5] We use BO in turns whilst referring to Biodiversity Offset(s) or Biodiversity Offsetting.

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. Our results have policy implications as the various technical and organizational solutions for achieving NNL are being actively discussed in France, and in Europe in the context of the “No Net Loss initiative” of the European Commission (Tucker et al. 2014) and in designing further improvements at the next CAP reform (Pe’er et al. 2016). As the dominant land-use in many parts of Europe, agriculture has an important role to play in the compensation of development project impacts on biodiversity. However, working with farmers to implement BO contracts requires a more precise understanding of when, where and how (and at what cost) biodiversity goals are compatible with their constraints. This paper contributes to informing this discussion.

Since Lancaster’s Consumer Theory (Lancaster, 1966) and the Random Utility Theory (Luce, 1959; McFadden, 1974), the Choice Experiment (CE) approach has been increasingly used over the past few years in various research areas (transport economics, marketing, environmental economics, etc.), including for the analysis of farmers’ preferences for Agri-Environment Schemes (AES). These studies seek to understand which parameters would be considered for improving the participation in AES contracts, and to understand the stakeholder’s preferences for biodiversity conservation schemes (e.g., Broch and Vedel, 2012; Lienhoop and Brouwer, 2015; Greiner, 2016). Over the contract length and the extent of the subsidy that are usually tested, attributes related to the flexibility of the contracts may involve technical choices (Bougherara and Ducos, 2006; 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), the fact that the BO contracts, or bonuses, have a collective dimension (Chen et al., 2009; Kuhfuss et al., 2016), or the possibility to opt out of the contract before its end (Broch et al., 2013; Greiner et al., 2014). The administrative burden is also often studied (Bougherara and Ducos, 2006; Ruto and Garrod 2009; Christensen et al., 2011). Additional attributes linked to the specific case studies are discussed such as the width of pesticide free buffer zones (Christensen et al., 2011), cattle and tree density in measures for the protection of a specific forest ecosystem (Santos et al., 2015), the possibility to conduct local pesticide treatment in vineyards (Kuhfuss et al., 2016), the possibilty to go back to agriculture at the end of contract (Lienhoop and Brouwer, 2015), or contracts linked to afforestation and effect of spatial variables (Broch and Vedel, 2012).

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). Le Coënt et al. (2016) study framing effects on farmers’ participation in agri-environmental contracts for biodiversity offsets, whereas Le Coënt and Calvet (2016) discuss the social norm issues involved in the choice by a farmer to adopt biodiversity friendly practices to offset environmental impacts. We conducted a CE in Picardy, northern France, and explore a less studied feature of this now widely used methodological approach. We used a Bayesian efficient design, based on results from a pilot study, to create choice cards in which farmers are asked to choose between two different alternative BO contracts and a status quo option where farmers keep their actual practices. 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.

This 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. Bonuses for increasing the number of signed AES have been added in some studies such as Buckley et al. (2012), Banerjee et al. (2014) or Khufuss et al. (2016). These bonuses are mostly based on the number of contracting farmers reaching a predetermined threshold, within a given geographical area. Some studies are not limited to agricultural land and may also involve conservation or restoration contracts on private lands. A significant proportion of this literature on bonuses is based on laboratory experiments, with few empirical studies. Proposed agglomeration bonuses are applied when reaching a specific spatial coordination of enroled parcels, as for instance the protection or restoration of contiguous patches of land (Parkhurst et al., 2002; Dreschler et al., 2010; Parkhurst and Shogren, 2007; Wätzold and Drechsler, 2013). Khufuss et al. (2016) studied (empirically) the effect of nudging respondents in order to increase land enrolement. Our approach thus differs from 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. Regarding BO, in organizational terms, it is more interesting if a smaller number of agents are involved in the restoration of ecosystems because it reduces transaction costs linked to this environmental policy implementation (e.g., Levrel et al., 2015; Vaissière and Levrel, 2015). This is why we do not seek to investigate coordination among neighbours, within an area, but study how far an individual farmer is ready to go, on the land he or she is cultivating, to increase ecological performance. We design thus designed a new bonus proposed to individual farmers for increasing the extent or connection of land under contract. This is also interesting because from an ecological perspective, at least for wetlands, restoration on small-size parcels rarely succeed (Moreno-mateos 2012). To our knowledge, this is the first time this type of bonus is proposed in a CE.

From the collected data, we modeled the farmer's decision to enrol in a BO contract and the associated enroled acreage and we calculated the farmer's Willingness To Accept (WTA) for implementing different features of BO contracts.

The remainder of this paper is organized 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. In Section 4, we conclude discussing our results on farmers' preferences for BO contracts on arable land and their policy implications.

2 Materials and methods

2.1 Methodological options

2.1.1 Modeling the farmer's decision to enrol in a BO contract

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, the farmer *n* will choose alternative *i* in choice card C_t *(t=1,…,T)* if the alternative is the one that procures him the highest level of utility among all 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). If A_{int} is a dummy variable that takes the value of 1 if alternative *i* is chosen by farmer *n* in the choice card C_t, the probability related to this choice is:

$$P(A_{int} = 1) = \frac{\exp(X'_{int}\beta)}{\sum_{j \in C_t} \exp(X'\beta)} \quad (1)$$

With X_{int} the attributes of the contract *i* faced by farmer *n*, and *β* the vector of *k* preference parameters, representing the average importance of each attributes of the BO contract on the farmers' preferences. The hypothesis of IIA is a strong assumption. The Mixed Logit (ML) model relaxes this assumption and allows assessing the β_{kn} that are specific to each interviewee, and randomly distributed across the population, with a density function $f(\beta_k)$. It thus captures heterogeneity of farmer's preferences. Then, conditional on vector β_n the probability that farmer *n* chooses alternative *i* in choice card C_t is (Kuhfuss et al., 2016):

$$P(A_{int} = 1|\beta_n) = \frac{\exp(X'_{int}\beta_n)}{\sum_{j \in C_t} \exp(X'_{jnt}\beta_{n)}} \quad (2)$$

Thus, the probability of observing the sequence of *T* choices by individual *n* is

$$P(A_{in1} = 1, \dots, A_{inT} = 1) = \int \prod_{t=1}^{T} \left(\frac{\exp(X'_{int}\beta)}{\sum_{j \in C_t} \exp(X'_{jnt}\beta)} \right) f(\beta) d\beta \quad (3)$$

Where $f(\beta)$ can be specified to be normal or lognormal: $\beta \sim N(b, \sigma)$ or $\ln\beta \sim N(b, \sigma)$.The mean (β) and the covariance (σ) are to be estimated by simulation (Train, 2009).

Then, we calculate the individual-level parameters corresponding to each attribute using the method proposed by Revelt and Train (2000) for mixed logit models.

2.1.2 Calculating the Willingness To Accept (WTA) for implementing Biodiversity Offsets (BO) contracts

The Willingness To Accept (WTA) that farmers would be able to accept from variations of attributes *k* in BO contracts can be computed following equation (4).

$$WTA_k = -\frac{\beta_k}{\beta_{mon}} \quad (4)$$

Where β_k and β_{mon} are the parameters associated to attributes *k* and the monetary attributes respectively.

The individual WTA for the attribute *k* is calculated as follows (equation (5)).

$$WTA_{k,i} = -\frac{\beta_{k,i}}{\beta_{mon}} \quad (5)$$

Where $\beta_{k,i}$ and β_{mon} are the parameters associated to attributes *k* for the individual *i* and the monetary attributes for the full sample respectively.

2.1.3 *Modeling the farmer's decision of the acreage to enrol in a BO contract*

The aim is to explain the famers' decision to enrol a certain acreage in a BO contract. Our dependent variable y is the enroled share of each farmer's Used Agricultural Area (UAA) with $0 < y < 1$. Explanatory variables are the contracts attributes and other individual characteristics. To model this proportion, similarly to Kuhfuss et al. (2016), we used a beta regression model instead of a simple linear one. The parametrization of the beta law, indexed on the mean and a dispersion parameter, is discussed in Ferrari and Cribari-Neto (2004) and particularly advised in political science (Paolino 2001).

2.2 The Picardy case study and the inquiry including the choice experiment

Our study is based on agricultural lands located in Picardy, northern France. 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 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, several biodiversity features regularly raise concerns and lead to developers having to offset impacts on these features. They include birds such as the corncrake (*Crex crex*) or the stone-curlew (*Burhinus oedicnemus*) and plants such as the hurtsickle (*Centaurea cyanus*). All these species are dependent on large expanses of extensive agricultural land and permanent grasslands, that have experienced a sustained decrease over the past decades.

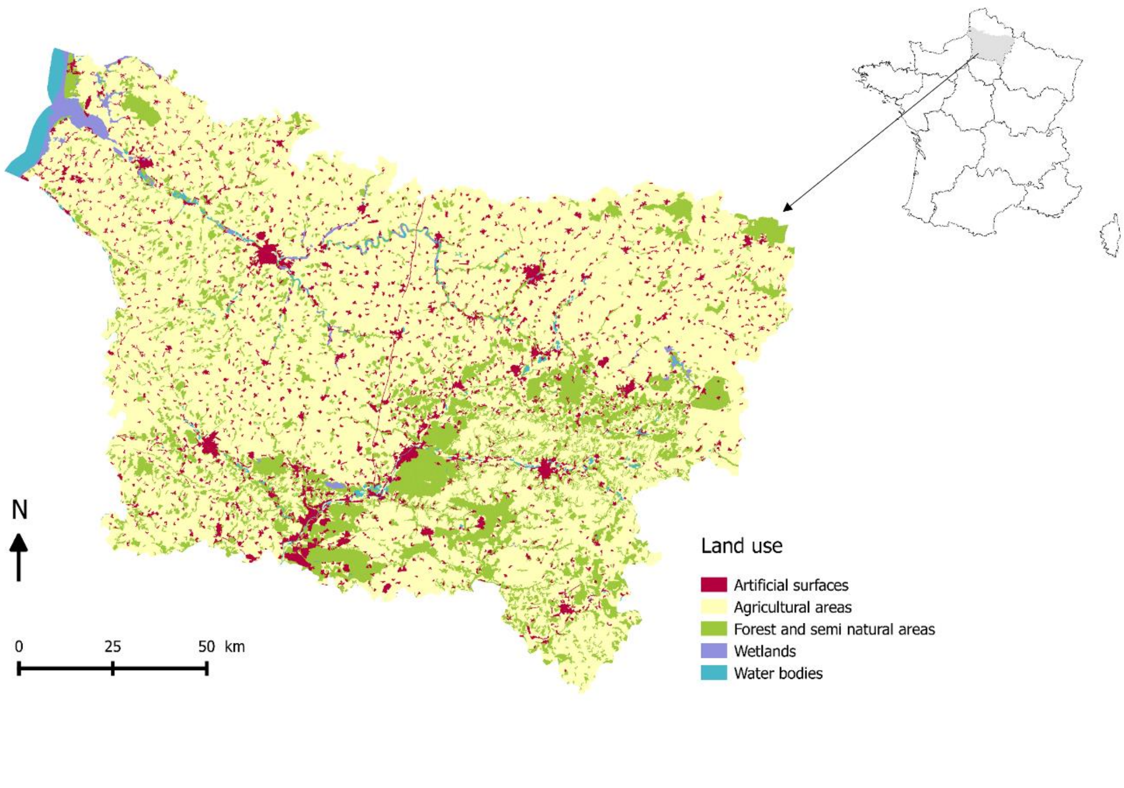

Figure 1: Land use in Picardy, northern France (Corine Land Cover 2012)

We conducted three focus groups with local farm 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 to 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. A pilot survey was finally conducted with 26 farmers of Picardy to test the questionnaire accuracy and form during February and March 2016. The questionnaire was adjusted following feedback from farmers having filled the pilot survey. We raised the payment for the contracts and the bonus, and we overall improved the questionnaire. The questionnaire was developed in three parts.

2.2.1 Introduction of the questionnaire

In the first part, we present the actual legal framework of BO in France to farmers who are not necessarily well informed. 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 farm union-run bodies, or other specialized 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 explanation texts, we created concise and playful videos made available on-line[6].

The four attributes that describe the BO contracts are presented in Table 1. The first attribute details the *management plan* required by the BO contract. The BO has a common base for the four possible levels. The base includes technical details such as the fact that measures must be the restoration of meadows on arable cultivated lands of at least 10 meters wide and 0.5 ha in area, with a mix of seeds of legumes and grasses, and its management must be mowing. Details regarding mowing are also provided (centrifugal, forbidden at night, of a 15 cm minimum height, etc.). As detailed in Table 1, 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). These BO requirements are very 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. This is also true for the second attribute related to the contract duration.

The *contract duration* is frequently mentioned as an important factor of enrolment and are likely to be important for BO contracts as well. After the focus groups consultation, chosen durations were 9, 18, 25 or 40 years (that cannot be terminated during the contract period).

The third attribute is the *conditional monetary bonus* regarding the respect of additional (ecologically relevant) conditions to the management plan. The bonus is proposed in some

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

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.

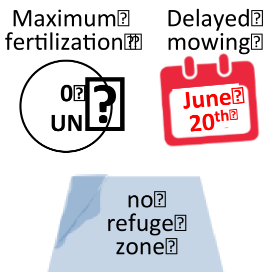
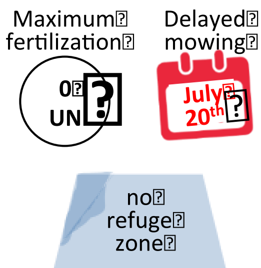
The fourth attribute is the actual *payment* of 800, 1100, 1500 or €2000/ha/year. The lower limit of these amounts was chosen based on unit AES payments to restore and manage a meadow (EU COUVER06, at €450/ha/year), stop fertilization on a parcel (EU HERBE03, at €148/ha/year), delay mowing (EU HERBE06, at €204/ha/year), and focus the management of the meadow on a specific flora/fauna (EU COUVER07, at €600/ha/year). The latter is similar to the maintenance of a refuge zone as spelled out in our scenarios. Based on a combination of the above mentioned AES payments, the values of the four management plan levels would be: €450/ha/year (Level I), €600/ha/year (Level II), €800/ha/year (Level III) and €1400/ha/year (Level IV). The range of values has then been discussed and adjusted during the focus group discussions and after the pilot study. Based on a recommendation made by Rose and Bliemer (2013), proposing a large range of payments allows us to measure the WTA of the most reluctant farmers to a change of agricultural practices.

Table 1: Attributes types, 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 Level II: 0 UN, June 20th, no refuge zone Level III: 0 UN, July 20th, no refuge zone Level IV: 0 UN, July 20th, refuge zone Opt-out	1 2 3 4 0
Contract duration	Total duration of the BO contract	9 years 18 years 25 years 40 years Opt-out	9 18 25 40 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) No bonus in a BO contract No bonus because this is the opt-out answer	+1 -1 0
Payment	Payment received each year by the farmer per enroled hectare	€800/ha/year €1100/ha/year €1500/ha/year €2000/ha/year Opt-out	800 1100 1500 2000 0
Opt-out	The farmer prefers to keep its current practices	Opt-out BO contract 1 or 2	1 0

2.2.2 *The choice experiment*

The second part of the questionnaire is the CE *per se*. To understand which of the four attributes are the most important to farmers, we must combine their different levels in scenarios that describe different types of BO. For instance, a possible scenario is to carry out the level III management plan during 40 years with no bonus for €1100/ha/year. Because we have 4 attributes with 2 to 4 levels and choice cards with 2 alternatives, the full factorial design generates 16256[7] different choice cards, that is too much for the interviewees to consider. We used the SAS software (SAS University Edition, Version workstation 6.5-7.x virtual machine) and its command %mktruns to decide how many scenarios to propose to interviewees: 16 different combinations. We gathered the scenarios in pairs, in 8 choice cards (illustrated in Figure 2). We added an opt-out answer to each choice card, entitled "I prefer to keep my current agricultural practices". The use of an opt-out answer is supposed to improve the realism of the choice cards and hence that of the model estimations (Adamowicz and Boxall, 2001; Kontoleon and Yabe, 2003). Thus, farmers must choose which BO they would agree to carry out on their farm. If they 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 contract A	Theoretical contract B	None of the contracts
Management plan	**Level II** 	**Level III** 	I prefer to keep my current agricultural practices
Contract duration	25 years	18 years	
Conditional monetary bonus	 The contract proposes a 200€/ha/year bonus if you meet the requirements of the bonus	 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

[7] The full factorial design generates (4x4x2x4) x ((4x4x2x4)-1) = 16256 choice cards.

We selected the 8 choice cards following a two steps procedure. First, the pilot study choice cards were chosen using an orthogonal efficient design with all the prior parameters set to 0 in order to determine the specific prior parameters of our sample (using the NGene software). Our D-error was worth 0.020317 that is acceptable. We analyzed the results of the pilot study with a Multinomial Logit Model (MNL) in order to get a better idea of the value of the prior parameters for each attribute, or for each level of attribute for the dummy variables, and then minimize the variance. Second, the final study choice cards were chosen using a Bayesian efficient design, using the parameters revealed during the previous pilot study (using the NGene software). Bayesian prior parameters are increasingly used as they enable random priors to be defined around the value of the prior parameters determined during the pilot study (for a review, see Chaloner and Verdinelli 1995). To minimize the approximation error when calculating the Bayesian efficiency, we use a Gaussian quadrature. Because we have 6 priors parameters, the Gaussian quadrature might need a large number of raws so we decided to include*; bdraws = gauss(3)* in our design.

As several authors did (Rambonilaza and Dachary-Bernard, 2007; Kaczan et al., 2013; Le Coënt et al., 2016), we have 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 is 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. This coding is detailed in Table 1. The opt out variable thus capture the preference of the farmer for their current practices (Vermeulen et al., 2008).

2.2.3 Follow up questions

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. These questions are aimed at better characterizing the respondents, for the use of the Mixed Logit (ML) model, and at improving our analysis of the results. Questions deals with the farmers, their socio-economical profile and details about their farms. Among these questions, we asked respondents if they focused their answers on one specific attribute or, on the contrary, if they systematically did not take into account an attribute, in order to reveal possible attribute non-attendances (see Kehlbacher et al. 2013 for a review and test). Depending on their answers during the CE, we asked a specific question to those who systematically choose the opt-out answer and to those who choose at least one time the opt-out answer. This is a way to identify protest responses that must be removed from the analyzed sample (Adamowicz et al. 1998; Barrio and Loureiro, 2013). We identified the protest responses as follows:

- All the farmers having systematically chosen the opt-out answer and having stopped to fill the questionnaire just after the last choice card;
- All the farmers having systematically chosen the opt-out answer and having answered that the main reason they did it was that (1) the fact the contract cannot be broken is unacceptable, (2) the farmer is against the biodiversity offsetting principle or (3) the farmer is against the biodiversity offsetting principle in the agricultural context.

The surveys were proposed to farmers using Lime Survey (Version 2.05+ Build 150413), an on-line survey application. The time to fill the study was estimated at 15-20 minutes (10 minutes of video explanations and 5-10 minutes of responding to questions). The link to the survey has been sent to all the available email addresses of the farmers from 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. Firstly, farmers in this French region are quite well connected to Internet and usually use this communication means. Secondly, this method enables us to reach out to the large number of farmers from Picardy. Thirdly, it is often considered that web-based enquiries limit bias linked to the presence of the interviewer.

3 Results and discussion

3.1 Descriptive statistics and representativeness of the sample

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 online participation. 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. (2015) with 5.23% of the estimated sample with regards to household waste recycling behaviour. As a consequence, with this low 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. Follow-up questions for checking protest responses gave us some insights on the behaviours of farmers. 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. The remaining 81% have chosen at least one time the opt-out answer for the same second and third reasons but the first one is that the payment of the contract was not enough. This is confirmed by the fact that 20% of the farmers claim that BO contracts are too restrictive given the payments offered.

Descriptive statistics of useful answers are presented in Table 2. 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	No data
	Female	9	
	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 Limité (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	
Leases duration	18 years	67	No data
	9 years	13	
	Other	4	
	No answer	16	

*Agricultural census for 2010 (AGRESTE)

The representativeness of the sample is good, in terms of (1) spatial distribution of the sampled farmers (see Figure 3), (2) gender, (3) age (apart for age class over 60 years old) and finally (4) types of farms. 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.

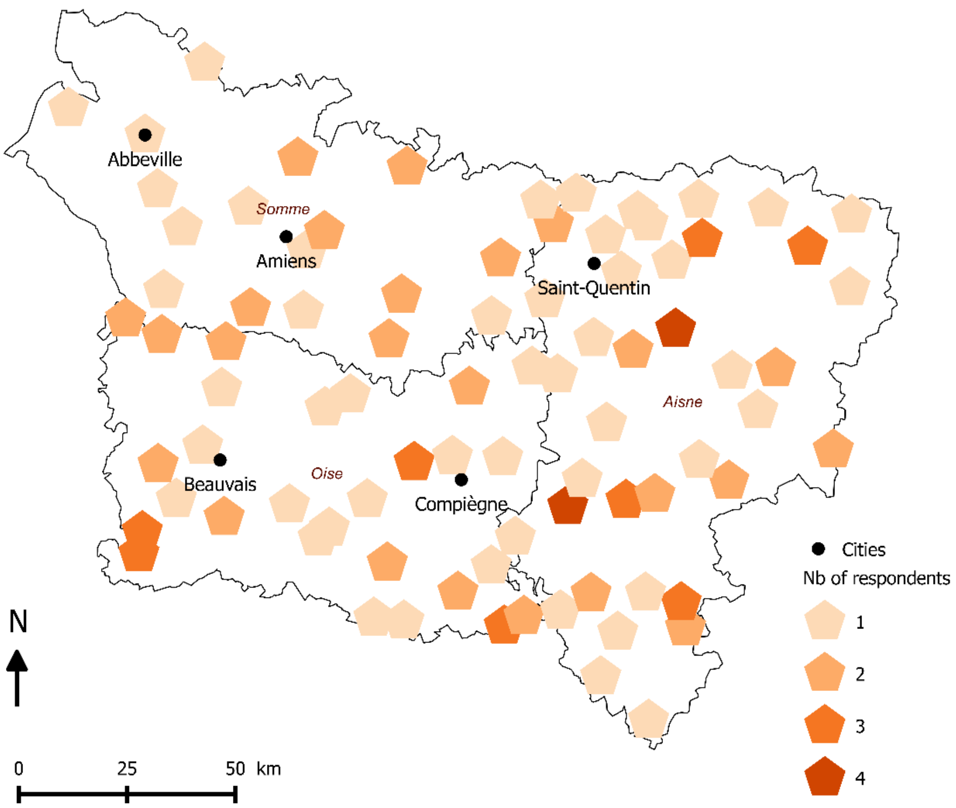


Figure 3: Distribution of sampled farmers in Picardy, northern France

Regarding the bonus, among the 312 made choices that included the conditional monetary bonus, 67% of the choices activated the bonus, 25% will not benefit from the 200€/ha/year because a lower than 5ha surface was entered,[8] only 3% refused the bonus even if a higher than 5ha surface was entered (which means that the farmer does not accept the ecological constraints of the bonus) and 5% of the choices remain without surface.[9]

3.2 Econometric analysis

3.2.1 Farmer's decision to enrol in a BO contract

We first conducted a Conditional Logit (CL) model to analyse the willingness of farmers to enrol in a BO contract. The participation is modelled according to the attributes of BO contracts as sole factors of choice. We used the log likelihood maximisation. The model seemed to be relevant as all the contract attributes have significant effects on farmers' choice (i.e., roughly all the attributes' β were significant). To test the validity of the IIA hypothesis we conducted the Hausman test by comparing estimations of the full logit model and partial logits by dropping each time one alternative. The test showed that the IIA hypothesis is rejected in our sample (with Prob>Chi^2 = 0.3101; 0.3725 and 0.4377) making the conditional logit estimations invalid.

[8] In such a case during the inquiry, an error message displayed to inform the farmer that with the proposed number of ha, he/she would not benefit from the bonus to make sure the farmer understood the principle.

[9] The answer to this question was not mandatory.

To relax this hypothesis, we modelled farmer's willingness to participate in a BO contract with a Mixed Logit (ML) model whereby participation is modelled first according to the attributes of BO contracts as sole factors of choice and later by integrating individual characteristics (MLogit1 and MLogit2 models in Table 3). As individual variables cannot be integrated alone in the model (they do not vary across one individual), they are captured through interaction variables. The payment, and the interaction variables in model MLogit2, are fixed and the other attributes are random (normally distributed). We used the log likelihood maximisation.

The two models (with and without interactions) are good as all the contract attributes have significant effects on farmers' choice. There were no attribute non-attendances. The model without interaction (Mlogit1) shows that the probability to participate decreases with more demanding management plans. Contract duration also has a significant negative utility for farmers. Willingness to participate increases with the conditional bonus and weakly increases with the payment. The fact that the bonus improves the likelihood of signing a contract is coherent with the information that, 67% of the choices of a contract including a bonus activated it (section 3.1). The different from 0 and high significance of the opt-out parameter means that the farmers have a strong preference for keeping their current practices. The introduction of individual characteristics (Mlogit2) leads to remove 408 observations (linked to 17 individuals) due to missing data but it improves the model since the AIC and BIC are lower. Compared to the Mlogit1 model, Mlogit2 leads to a stronger effect of contract duration and of the management plan (their absolute value is higher). The difference between the effects of duration and the bonus are less clear, but the general meaning is similar. In descending order, farmers prefer to keep their practices and then, they prefer contracts with limited constraints,[10] with the individual monetary bonus, of short duration and well paid. Two interactions with socio-economics characteristics have quite significant effects: the length of the contracts with the fact of being a partial landowner, and the management plan with the size of the farm (hundreds of Ha). The fact to be a partial landowner increases the likelihood to adopt contracts with a greater length; and having a farm with a larger area increases the likelihood to adopt more constraining measures.

[10] We previously included the management plan variable as three dummy variables, the level I being set as the reference. All the contract attributes had significant effects on farmers' choice and the parameters for the four levels of the management plan variable were ordered. The farmers have a preference for the level I over the level II, a preference for the level II over the level III and a preference for the level III over the level IV. In other words, they have a preference for the less restrictive management plans over the more restrictive ones. It is thus appropriate to interpret the management plan variable as a quantitative variable: it is continuous and ordered but not linear since the difference between each of the four levels is not similar (stop fertilizing from level I to II, delay the mowing of one more month from level II to III, set a refuge zone from level III to IV).

Table 3: Mixed Logit estimates

VARIABLES	Mlogit 1	Mlogit 2
Payment	0.00309***	0.00329***
	(0.000226)	(0.000259)
Management Plan	-0.325***	-0.722***
	(0.0749)	(0.160)
Contract length	-0.146***	-0.208***
	(0.0161)	(0.0272)
Bonus	0.265***	0.258***
	(0.0651)	(0.0704)
Opt-out	2.301***	1.941***
	(0.367)	(0.395)
Management plan * UAA		0.169***
		(0.0556)
Length * Partial landowner		0.0585**
		(0.0252)
SD		
Management plan	0.212**	0.374***
	(0.104)	(0.0987)
Length	0.102***	0.135***
	(0.0112)	(0.0148)
Bonus	0.184	0.145
	(0.127)	(0.136)
Opt-out	2.526***	2.264***
	(0.305)	(0.352)
ll	-754.84448	-643.98198
Chi^2	453.21231	387.28256
AIC	1527.689	1309.964
BIC	1583.0198	1376.2086
Observations	3456	3048
Number of farmers	144	127

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

The Standard Deviation (SD) coefficients reveal that preferences for all the attributes, except for the bonus, are heterogeneous among the farmers of our sample. This confirms the interest of studying the distribution of the individual parameter for each attribute that we have calculated using the log likelihood maximization[11]. Figure 4 presents Epanechnikov kernel density plots of the distribution of the individual parameter estimates (Epanechnikov 1969, Silverman 1992)[12].

[11] We used the *mixlbeta* command following the use of the *mixlogit* one (STATA 14).
[12] The *kdensity* command has been used here (STATA 14).

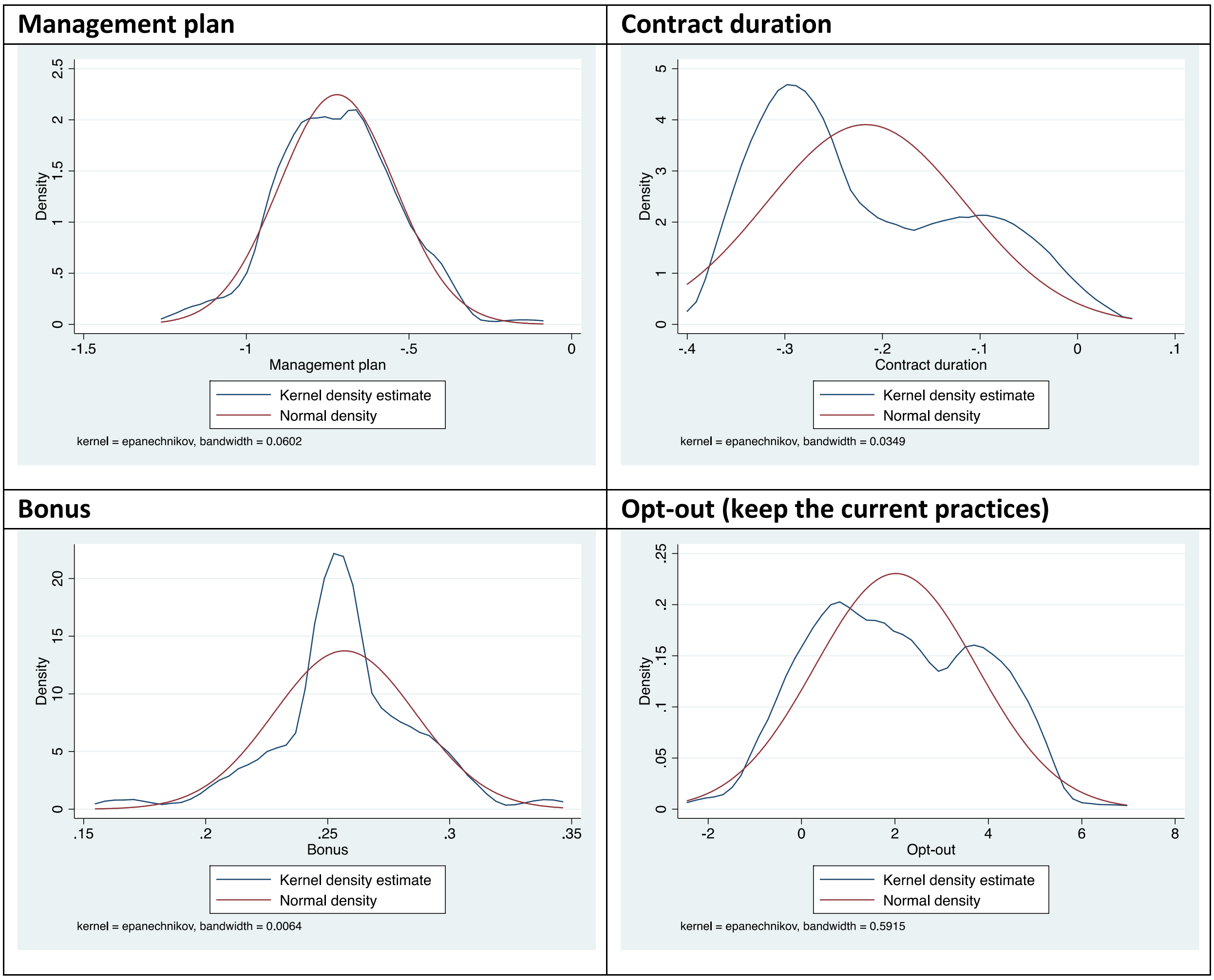


Figure 4: Distribution of the individual parameter for each attribute and the opt-out

Farmers have preferences for the bonus and the management plan that seem to be concentrated around a single value while there appears to be at least two groups of preferences for duration attribute. The two groups of the opt-out nicely illustrate the fact that there are farmers having systematically chosen to keep their practices (the spike at the right of the plot corresponding to the 19% of farmers described in section 3.1) and those who chose BO contracts (the spike at the left of the plot corresponding to the remaining 81%).

3.2.2 Willingness To Accept (WTA) for implementing Biodiversity Offsets (BO) contracts

We present the farmer's Willingness To Accept (WTA) for implementing different features of BO contracts in Table 4.

Table 4: Willingness To Accept (WTA) for Biodiversity Offsetting (BO) contracts implementation

Attributes	WTA (€/ha/year)	Mean individual WTA (€/ha/year)	SD	Min	Max
Management plan	219	219	54	45	365
Contract duration	63	66	31	-6	111
Bonus[a]	-157	-156	18	-207	-98
Opt-out	-590	-613	525	-1936	564

[a] Effect coded variable the WTA must be multiplied by 2 (Le Coënt et al. 2016)

It is difficult to interpret the value of the WTA for the management plan because we do not know the different current practices of each farmer, and because this is a mixed attribute, even if this attribute is ordered, the difference between the several levels are not of the same nature. The WTA for the management plan is €219/ha/year for a composite increase in the level of constraint imposed by our four levels management plan. Farmers are ready to accept €63/ha/year to a one year increase in the duration of the offset contract. Farmers are ready to waive €157/ha/year of the payment to get the bonus that they assess well: it is worth €200/ha/year so the farmers would still win. This means that the cost for the developer of implementing supplementary ecological constraints to the management plans is €45/ha/year. Farmers are ready to waive €590ha/year to keep their current practices, in other words they would only accept contracts that are paid more than €590ha/year.

The individual WTA for the opt-out were calculated from the individual parameters for the opt-out attribute and the parameter for the payment attribute that is unique because it has been set as fixed in the ML. Figure 5 presents Epanechnikov kernel density plots of the distribution of the individual individual WTA estimates for the opt-out.

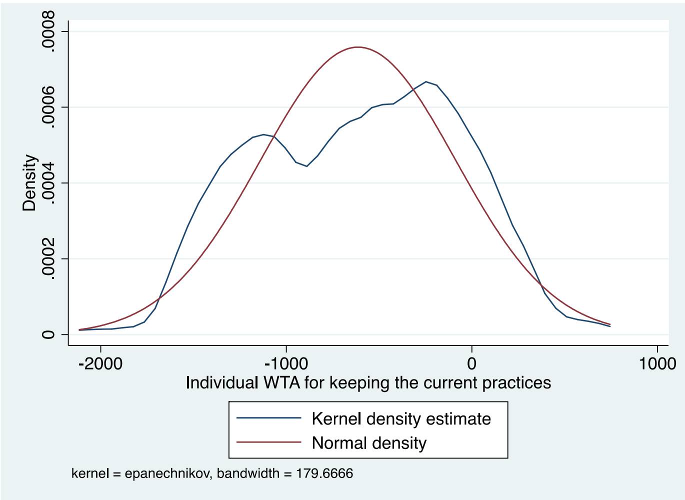


Figure 5: Distribution of the individual WTA for the opt-out

While the Mlogit2 model shows that farmers were ready to waive a mean of €590ha/year to keep their current practices, Figure 5 shows us interesting insights. The distribution of the WTA shows that the group of very reluctant farmers to BO contracts have high payment expectation around €1300/ha/year and that the second group of farmer have payment expectation around €500ha/year which is, in the end, less than the payments that we proposed.

3.2.3 Analyzing the farmer’s decision of the acreage to enrol in a BO contract

We had to remove one farmer (24 observations) from the sample because weird areas of offsets were entered. Among the choices of the 143 farmers, 530 alternatives other than keeping the current practices were chosen, 506 values of areas were completed (24 values are missing) and we can analyse 459 observations (47 values of UAA were missing so we could not calculate the enroled proportion of the UAA). These remaining observations are linked to 104 different farmers.

Farmers have enroled a mean of 13% of the UAA (from less than 1% to 100%, SD = 25)[13]. In our case, we structurally do not have cases where 0% of the farm area is enrolled (y=0) because we required the farmers who have chosen BO contract to enrol at least 0,5 ha, increased to a minimum of 5 ha if the contract includes a conditional bonus and if the farmer accepts to respect its conditions. We do not study the factors which lead farmers to enrol the totality of their UUA (y=1) because only 4 farmers did so. We finally analyse 432 observations linked to 100 farmers in this model (Table 5).

Table 5: Acreage model estimates

Dependent variable: enroled proportion of the UAA	Acreage
Proportion (0<y<1)	
Management plan	-0.00450
	(0.0211)
Contract duration	0.00690
	(0.00509)
Conditional monetary bonus	0.0520**
	(0.0240)
Payment	1.03e-05
	(9.52e-05)
UAA	-0.147**
	(0.0611)
Constant	-2.148***
	(0.339)
Ln_phi	
Constant	1.953***
	(0.423)
AIC	-1291.0413
BIC	-1262.5624
Observations	432
Number of farmers	100

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Among the attributes of the biodiversity offsets, we note that the payment has not a significant effect on the enroled acreage even if it has a significant but weak role in the

[13] We used the log likelihood maximisation though the *zoib* command (STATA 14). This command is linked to a full zero one inflated beta model but we only used its proportion part.

decision to enrol a land. Only the bonus has a significant effect on the likelihood to increase the enroled percentage of the UAA. Because the bonus implies to enrol a minimum of 5ha of the UAA, we checked if the increase of the enroled number of hectares is only linked to this constraint or if there is a true effect of the bonus among the 432 observations. The farmers enroled a mean of 14 ha ([min=0.5; max=150], *SD*=25). Table 6 shows that the number of enroled hectares is greater when there is a bonus in the proposed BO contract whether considering the observed or predicted values. Apart from testing the real effect of the bonus, these values in absolute terms are less interesting than the previously mentioned enroled share of the UAA.

Table 6: Number of enroled hectares in the BO contracts without or with bonus

	Contract without bonus (N=183)	**Contract with bonus (N=249)**
Observed individual enroled number of hectares	13 ha [min=0.5; max=140] *SD*=23	15 ha [min=0.5; max=150] *SD*=26
Predicted sample enroled number of hectares	19 ha [min=12; max=26] *SD*=3	21 ha [min=12; max=29] *SD*=3

The only individual variable having a significant effect on the enrolled percentage of the UAA is the UAA (hundreds of Ha). A 100 ha increase in the UAA leads to a 15% decrease of the enrolled percentage of the UAA. We can conclude that there is a threshold effect of the size of the mitigation measures (in absolute and not relative terms) that leads the greater farms to have a lower enroled share of their UAA.

4 Conclusion

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 sometimes have low levels of biodiversity, with 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. We conducted a CE study at the scale of northern France (Picardy). Four attributes, describing different scenarios of BO contracts, were selected: the actual enhancement activities (in a management plan), the contract duration, the annual payment, as well as the option of receiving a monetary bonus for the spatial extent and distribution of enhanced land.

We show that farmers are quite reluctant to adopt BO contracts whereby they are asked to convert arable cropland into grasslands, and manage these for biodiversity for a defined period of time. All the attributes 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. Farmers have therefore high WTA for a one year increase or a composite increase in the level of constraint imposed by the management plan. Higher payment levels and the proposal of a bonus for increased extent of interconnectedness of contracted land improve the probability of farmers signing-up to implement a BO contract on behalf of a developer. However, the payment is considered at last by farmers which means that the other attributes are more important for them to make a choice. Their mean WTA to change their practices we revealed are even lower than the range of payment we proposed. There is however a high heterogeneity of preferences where some farmers have payment expectation around the top of the range. We also show that the payment attribute does not significantly lead farmers to enrol a greater share of their UUA while the conditional bonus does. This bonus, allowing to increase the likelihood of signing up a contract and the enroled acreage, make the cost of the BO contracts increase. We also show that other reasons limit the farmers to increase their enroled share of UUA such as the total UUA but we also show that the farm with a higher UAA are likely to accept more constraining management plans.

Regarding the policy implications of these results, BO are nowadays spread out on a multitude of small size land which makes it difficult for regulators to control and monitor, and which decreases the likelihood of a lasting ecological efficacy (Quétier et al., 2014). Our works show the interest of a conditional monetary bonus to improve the organizational and ecological efficiency of the measures even if it would add a cost to BO contract for developers. Yet there are some limits to this increased enroled acreage and, unfortunately, the mean absolute number of hectares the farmers would be ready to enroll are below the threshold Moreno-Mateos et al. (2012) considers as a limit for the ecological success of a measure (at least for wetlands). Linked to the reluctance of farmers to enrol their land in complex and long term management plans, we have concerns about the relevance of the farmers' implication in the whole range of BO contracts. Contracting farmers to enhance arable land for biodiversity may be suitable for offsetting temporary impacts on already degraded areas of natural habitat, but may not be suitable for permanent impacts on high quality habitat. This is because less constraining and shorter contracts will only provide minimal biodiversity gains, which are suitable for offsetting moderate biodiversity losses. However, these results may be specific to Europe, amongst others due to the CAP subsidies the farmers receive that certainly modifies their behaviors. And in France, the results of our study are likely to only be transferable to similar intensive agricultural regions in France.

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 most reluctant to sign contracts in our study. We expected this result since other studies which shorter durations made the same observation (Ruto et Garrod 2009, Christensen 2011, Greiner et al. 2014). Moreover, European farmers are used to short term contracts with a five years duration for most of the AES. Below, we discuss the several reasons that may explain this observed reluctance to long term BO contracts.

In our study, the fact of being partially owner of the cultivated land increased the likelihood to sign a contract with a longer time which means that having a lease on an arable land is a break to enrol lands. French farmers are particularly affected since 60% of them rent their land so if their lease is shorter than the duration of the BO contracts, they must be ready to enter 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). However, other studies show that in other countries where the proportion of farmers that own the land they farm is probably higher, the contract duration is not a limitation. This is the case in Australia for pure conservation measures (Greiner 2016).

Particularly regarding BO, in the United States, many farmers use BO implementation as an alternative use for their non-profitable arable land. This includes land put into wetland mitigation banks and habitat banks that make offsets available to developers, but require perpetual conservation easements that limit forever most of, or even any, agricultural practices (Vaissière and Levrel, 2015).

Another fuzzier reason, beyond the reluctance of signing up demanding and long term contracts, may be an institutional and environmental uncertainty that famers face. In our case, we voluntarily did not give details about the possibility to go back to agriculture at the end of the contract, because mitigation measures are supposed to keep a long lasting environmental use by law, while this is an attribute in other CE examples (e.g. Lienhoop and Brouwer, 2015). French regulations, coming from the CAP ones, may add to their fear because temporary meadows having been preserved during 5 years become permanent meadows. Some of permanent meadows are even classified as sensitive meadow that cannot be ploughed to be turned back to an arable land and each French department has a specific ploughing rate only allowing a certain amount of permanent meadows to go back to an arable use at the scale of the department. It is also not clear how the CAP would remunerate for the land being used for BO and if it is compatible with the minimum land management provision the farmers who rent their lands have in their lease. Soule (2000) more generally highlighted that adopting conservation practices within the agriculture realm is also guided by the potential future agronomic value of the land, considering farmers think they would be able to go back to agriculture. All previous reasons feed the risk of a decrease on the land price if it cannot be cultivated or built anymore. In this uncertain context, the impossibility to stop the contract may be a limit for signing it up as tested by Broch et al. (2013) and Greiner et al. (2014) including this possibility as an attribute in their CE. The fear of the longevity and the fungibility of the developer who is supposed to pay for the farmer all along the contract duration may also explain the will of farmer to be able to terminate the contract before its end.

Future related work would be to analyze farmers' choices combined to environmental data such as the spatial configuration of environmental goods (e.g. occurrence and abundance of target species of fauna and flora). This will allow investigating spatial patterns of BO enrolment, spatial heterogeneity of farmers' WTA for BO contracts, as well as assessing the cost-efficiency of the measures, and more particularly regarding individual bonuses. The analysis of WTA spatial heterogeneity could be done by using a spatial regression model in a two-step approach as in Czajkowski et al. (2016). In such models farmers' estimated WTA are used as a dependent variable in a spatial lag model, while Geographical Information System (GIS) and sociodemographic data are the explanatory variables. A second option would be using a geographically weighted multinomial logit model as proposed by Budziński et al. (2016) who have shown that both approaches have advantages and disadvantages which need to be assessed.

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