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Abstract

Biodiversity offsetting (BO) claims to slow down biodiversity loss caused by development projects by generating ecological gains mainly through restoration activities conducted on land acquired to this effect. This leads to social conflicts around accessing land, especially with farmers and other land-users. The purpose of this paper is to analyze the opportunities and challenges of implementing BO by involving farmers through contracts akin to agri-environmental or stewardship schemes to produce ecological gains. We call them Agri-environmental Biodiversity Offsets Schemes (ABOS) and conduct an empirical analysis of a large ABOS program implemented for a new railway line in Southern France. We examine the effectiveness of ABOS through a survey carried out with 145 farmers and find that the main determinants of ABOS *acceptability* are: i) socio-economic factors, ii) social norms, iii) trust with contracting institutions, and iv) ease of integration in farm activities. Although ABOS allow developers to meet their legal requirements, major concerns are raised about *additionality*, especially through the manifestation of windfall effects, long-term *permanence*, and *non-compliance* with contract requirements. We conclude with policy recommendations and research perspectives to improve the implementation of ABOS for both nature and people.

Keywords

Agri-environmental schemes; Biodiversity offsets; No Net Loss policies; Behavioral Economics, Contracts theory, Survey with farmers, determinants of acceptability analysis

1. Introduction

The concept of biodiversity offsetting (henceforth BO) is being rapidly mainstreamed in government regulations and voluntary initiatives with the stated goal of achieving no net loss (NNL) of biodiversity (Bull et al. 2018; Calvet et al. 2015a). Theoretically, the concepts of BO and NNL may offer ways of thinking and improving land use planning and investment decisions while considering biodiversity. However, in practice, the implementation of BO can generate conflicts with farmers and other land users when offsets are implemented on land acquired and restored for this purpose, in particular on former farmland. This is an important challenge for offsetting in densely populated parts of European countries where agriculture occupies a large share of non-urban land and where the impact of development is getting stronger (Wende et al., 2018). This is the case in France where 51% of the total surface area is under cultivation (Pech and Etrillard, 2016). Similar challenges are raised in many countries where BO leads to restrictions on land uses and access to natural resources by local communities, who are often excluded from such decisions (e.g. Bidaud et al., 2017; Virah-Sawmy, 2009).

In this context, French farmers and farmers' organizations were initially suspicious of the development of a NNL policy and expressed concerns about BO, if not outright opposition to allowing developers to use farmland for their offsets needs. However, farmers are now increasingly involved in supplying BO through voluntary contracts with developers, under which they accept to change their farming practices or land use to provide the targeted ecological gains. We call such contracts "Agri-environmental Biodiversity Offsets Schemes" or "ABOS". These contracts allow farmers maintaining their activities but require them to adapt practices being compatible with BO objectives. By highlighting that some biodiversity offsets can be indeed compatible with farming, this approach could offer a solution to overcome land access conflicts around BO. Thus, in addition, ABOS could offer opportunities for diversifying and supplementing farmers' incomes, which is leading farmers to reconsider their initial opposition towards BO.

ABOS can be seen as similar to other contractual agreements widely used in environmental policies such as Agri-Environmental Schemes (AES) and Payments for Environmental Services (PES). AES are voluntary contracts in which farmers are offered compensation payments for reducing the negative externalities of agricultural production or for producing positive externalities. In the European Union, AES are implemented under the Common Agriculture Policy (CAP) and are considered as the main policy instrument to preserve biodiversity in agricultural landscapes (EEA, 2004). PES are voluntary conditional payments for providing environmental services (ES) that involve contracts between an ES provider and an ES beneficiary (Wunder et al. 2015), of which AES are sometimes considered a variation (Ezzine de Blas et al. 2016). Although ABOS can share similarities with those programs (for instance in their specifications or duration), it is important to note that ABOS differ from AES and PES in several ways. First, ABOS involve a destruction of biodiversity whereas AES and PES aim at providing biodiversity conservation without implying ecological losses. Moreover, in most cases, ABOS are framed under mandatory requirements for developers of impactful projects, whereas PES and AES are voluntary for both parties to the contracts.

While there is an abundant literature on PES and AES programs, to date, there has been little analysis of the use of ABOS. Yet, there are many potential ways to use these schemes in NNL policies, especially as they are rolled-out across European countries. For instance, ABOS can involve short-term contracts as is usually the case in AES (e.g. five years), but they can also be long-term agreements in accordance with developers' commitments or legal requirements tied to BO (e.g. thirty years).

In this paper, we shed light on the opportunities and limits of using ABOS in NNL policies accounting for their specific design. We conduct an empirical analysis of a large-scale BO program set up in southern France to offset the ecological impacts of a new 80 km high-speed railway line called the "Contournement Nîmes Montpellier" (CNM). We address the following main research question: what determines the effectiveness of ABOS in achieving NNL objectives?

Considering that biodiversity offsets are regulatory requirements, ABOS must achieve ecological gains that are compliant with developers' permits. As a comparison, the most frequently highlighted features of effectiveness for AES and PES potentially relevant for ABOS are the following (Karsenty et al., 2017; Engel et al., 2008; Wunder et al., 2008; Vanslembrouck et al., 2002): i) *acceptability* of farmers to participate in the program, ii) *compliance*, which means that farmers comply with the contract requirements, ii) *additionality*, whereby contracts result in a real change of land use or agricultural practices, iii) *link between land use and environmental outcomes,* meaning that land-use changes actually lead to desired biodiversity outcomes, and iv) *permanence*, which implies that changes are sustained during the BO commitment period and beyond.

We carried out a mail and internet-based survey of 145 farmers invited to participate in the implementation of the ABOS program for the CNM project. First, using an econometric model, we analyzed the determinants of farmers' intention to participate in ABOS programs. The second part of the analysis was specifically addressed to farmers who had actually signed an ABOS contract and aimed at identifying the main challenges and limits to the effectiveness of the ABOS program using simple descriptive statistics. We also tackle this issue by analyzing a database of plots used for the initial selection of farmers to be enrolled in the ABOS program.

Therefore, this study does not provide a quantitative analysis of the ecological impact of the ABOS program. Instead, it provides insights for the design of effective ABOS programs as they expand in the implementation of NNL policies.

This article is organized into five main sections. First, we present the theoretical framework we used to investigate the challenges of using ABOS in NNL policies based on the PES and AES literature. This literature review allowed us to make hypotheses on the possible effects of the five conditions mentioned above on the effectiveness of ABOS. In the next section, we present the materials and method used in the empirical analysis. The third section is dedicated to the results of the survey conducted with farmers. In the fourth section, we discuss the opportunities and limits of using ABOS compared to land acquisition, which remains the main mechanism through which BO is implemented in France. Finally, we conclude on policy recommendations for ABOS implementation and perspectives for future research.

2. Theoretical background and framework analysis for ABOS

2.1. Definition of ABOS

We define ABOS as one or a set of contract(s) between a developer and one or several farmer(s) that are implemented to meet the (regulatory or voluntary) offset needs of the developer (when these can be achieved on farmland). Farmers who voluntarily accept to participate in ABOS receive a payment that is conditional to changes in their agricultural practices or land use. These changes are expected to generate the ecological gains required to compensate for residual biodiversity losses caused by the developer's project (Figure 1). In mandatory offsets, regulatory agencies are usually involved in setting offset targets and monitoring their achievement. Intermediaries can also be involved in establishing or managing the relationship between the developer and farmers (e.g. brokers who can be agricultural institutions that hold registries of farmers or land-owners).

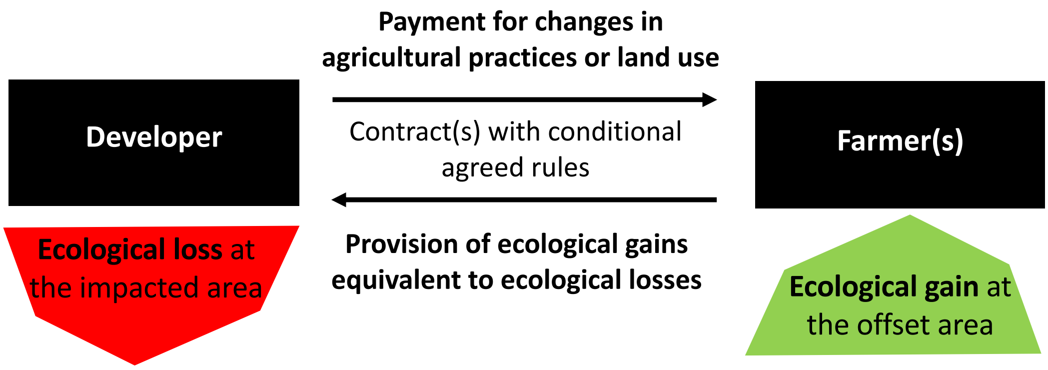

Figure 1. The Agri-Biodiversity Offset Scheme (ABOS)

2.2. Acceptability of ABOS

The acceptability of ABOS is a key challenge because developers need to find enough voluntary farmers and enough agricultural land to reach their BO objectives. In addition, considering that contracts with farmers are usually short-term (e.g. 5 years in AES), the developer must be able to extend them or roll them over to cover the legal duration of its biodiversity commitments (e.g. 25 or 30 years in public-private partnerships for large infrastructure).

An extensive literature is available on farmers' participation in AES proposed under the Common Agricultural Policy (CAP). It shows that the acceptability of agri-environmental contracts is influenced by a diversity of determinants that can be classified into four main groups: (1) farmer and farm socio-economic characteristics, (2) contract characteristics, (3) economic factors (payment level, transaction and implementation costs), and (4) behavioral factors. Acceptability of ABOS may be influenced by the same determinants but the particularities of BO may modulate their importance or even reverse their effect. The main determinants that we hypothesize may be particularly important in ABOS adoption are presented below.

Flexibility

The flexibility of contract design is a key factor that facilitates adoption. Contracts that are more likely to be adopted have a shorter duration, leave more flexibility to farmers in plot selection and in technical prescriptions. Besides, contracts for which it is easy to withdraw are preferred (Kuhfuss et al., 2014; Christensen et al., 2011; Louis and Rousset, 2010; Ruto and Garrod, 2009; Bougherara and Ducos, 2006) .

Under the CAP, contract design is generally framed by strict legislative and administrative rules limiting farmers' eligibility and leaving little flexibility for the adjustment of contract characteristics to specific contexts. In contrast, BO programs are generally operated locally and ABOS are tailor-made according to a specific development project. ABOS are signed between farmers and developers and are not bound by CAP rules. It is thus expected that ABOS could be more flexible, depending on contract requirements, which would likely have a positive influence on acceptability. This higher flexibility is clearly observed in our case study and other similar contexts (e.g. Lombard-Latune 2018). This flexibility has its pros and cons. On the one hand, it may facilitate farmers' participation and help fulfill contracting targets. On the other hand, farmers may use their influence to negotiate contracts that favor them even if they lead to lower or less reliable biodiversity outcomes. This problem has indeed already been reported in the literature, e.g. when the flexible contracts of a private offset provider effectively led to net biodiversity losses rather than NNL (Calvet et al., 2015b).

Payment / Transaction Costs

The relationship between costs and payment amounts is a key issue in the adoption of agri-environmental contracts (Barreiro-Hurlé et al., 2010) and is thus expected to also play a fundamental role for ABOS. Farmers who have the lowest compliance and opportunity costs have a higher probability to enroll into AES (Louis and Rousset, 2010; Vanslembrouck et al., 2002; Wynn et al., 2001). Compared to AES, ABOS payments could theoretically be freely set during negotiations between the developer and farmers, rather than imposed by public institutions. This can strengthen the acceptability of ABOS by farmers. It is to be noted that in our case study this difference was not observed because a fixed rate payment was used based on the preexisting AES program, at the request of local authorities concerned with avoiding competition between farmers.

Transaction costs have also been found to have a strong impact on AES adoption (Vatn, 2010; Peerlings and Polman, 2009; Ducos and Dupraz, 2007; Falconer, 2000). High private transaction costs (real or perceived) tied to AES can represent barriers for farmers' participation in agri-environmental programs (Peerlings and Polman, 2009; Rørstad et al., 2007). ABOS should generally present less administrative constraints and restrictions than AES, mainly due to simpler procedures and contract terms. This is likely to reduce transaction costs and could ease the adoption of ABOS relative to AES. The involvement of a third-party offset 'broker' or operator hired by the developer, as in our case study, can also reduce transaction costs for farmers and thus facilitate their enrollment.

Social norms

The role of social norms in the adoption of AES and pro-environmental practices is increasingly reported (Le Coent et al., 2018; Kuhfuss et al., 2016, 2015a; Chen et al., 2012, 2009; Allaire et al., 2009). This factor may also be an important determinant for the adoption of ABOS. On the one hand, the large adoption of farmers may positively influence the enrollment of other farmers through conformity and imitation effects as it is the case in our case-study (e.g Chen et al., 2009). On the other hand, BO programs are linked to development projects that may have local social and economic impacts and may be associated with farmland expropriation (for the infrastructure not its offsets). These factors may create local resistance to any actions associated with the development project and social pressure not to adopt ABOS through the effect of injunctive social norms (Le Coent et al., 2018; Cialdini et al., 1990). Thus, linked to the opposition to the project itself (or to biodiversity offsetting as a policy tool), we anticipate that social norms may influence farmers' adoption of ABOS in both directions, depending on local circumstances (e.g. bad experience tied to previous BO).

Attitude towards the environment

This factor has been shown to influence the adoption of agri-environmental programs (Mzoughi, 2011; Ducos et al., 2009; Defrancesco et al., 2008; Beedell and Rehman, 2000; Delvaux et al., 1999; Morris and Potter, 1995), although its importance is debated (Lamine, 2011). Given that ABOS aim to offset biodiversity losses generated by a development project, they may not be considered as environmental programs in the way AES or PES often are, and thus do not involve pro-environmental behaviors to the same extent. Indeed, it has been recently shown in the same CNM case study that farmers prefer contracts that state aims of creating environmental gains (AES) rather than compensating environmental losses (ABOS), and this is particularly true for farmers who are concerned about the environment (Le Coent et al., 2017). We thus anticipate that, in the case of ABOS, attitudes towards the environment may have a rather limited influence on farmers' adoption of ABOS.

Trust

Trust between contracting partners also facilitates participation in AES and reduces transaction costs both before and during the transaction (Louis and Rousset, 2010; Ducos et al., 2009; Peerlings and Polman, 2009; Ducos and Dupraz, 2007). In Europe, AES are generally struck between farmers and the State within the CAP framework. In the context of BO, developers that offer ABOS to farmers are generally private sector businesses or public agencies that are involved in building infrastructures rather than in farming. Establishing trust and good relationships between these new actors is therefore a key challenge for the success of BO programs. Perceived trustfulness by individual farmers might therefore be an important factor to predict their participation in ABOS. The involvement of recognized agricultural institutions in the program, as in our case study, can enhance farmers' confidence and participation in ABOS.

To sum up, our hypothesis is that the determinants of adoption of ABOS differ from those of AES. It is likely that ABOS are more easily adopted due to higher flexibility and limited transaction costs, while positive attitudes towards the environment may hinder participation. Social norms and trust may have an important effect on farmers' adoption of ABOS but it could be either positive or negative.

2.3. Compliance with contract requirements

In voluntary contracts between farmers and the developer, there is an information asymmetry on the actual implementation of actions to which farmers are committed. Indeed, after the contract has been negotiated, it may be rational for farmers not to respect their terms (called "moral hazard") if the developer does not invest enough in monitoring compliance or does not impose stringent sanctions (Ferraro, 2008). The implementation of a monitoring and enforcement system is, however, very costly for the developer. Unless regulators actually enforce developers' offset requirements with on-the-ground audits, developers may be tempted to minimize the burden of controlling contract execution, which could result in very limited compliance by farmers. In this regard, our assumption is that compliance is a key issue in the context of BO, especially as they are a condition for allowing projects to proceed with residual impacts on biodiversity.

2.4. Additionality

Additionality means that farmers are not only adopting land uses or agricultural practices that contribute to the targeted biodiversity outcomes, but that these would not have been adopted in the absence of ABOS (Wunder et al., 2008). If farmers adopt practices that they already implemented or would have adopted anyway, there is a “windfall effect” (Kuhfuss and Subervie, 2015; Chabé-Ferret and Subervie, 2013). In the case of NNL policies, the risk is to not achieve the expected ecological gains required to offset the ecological losses, making additionality a key requirement for BO (Maron et al. 2018; Bull et al., 2013a). If pre-contractual (baseline) assessments are not carried out carefully, then selected farmers could be paid to implement practices that they were already implementing resulting in net biodiversity losses overall.

2.5. Link between land use and environmental outcomes

Guaranteeing additionality in terms of actual changes in farming practices or land-use may not be sufficient to achieve BO targets. It is indeed necessary that those changes actually benefit the targeted biodiversity, which was impacted by the development project (in the case of ‘like for like’ offsets). Several aspects need to be considered here. First, changes in land use and practices included in ABOS requirements must lead to ecological gains, which should be adequately quantified. This requires a solid understanding of the ecology of targeted species or habitats to correctly assess the compensatory ratios. It is recommended to oversize them in order to consider uncertainties of success or poor ecological knowledge (Curran et al., 2014). Second, spatial coordination may also be required: for some species, the spatial configuration of habitats is essential and landscape-level approaches need to be included in contracts to achieve the desired ecological outcomes (Budiharta et al. 2018; Bamière et al. 2013; Bull et al., 2013b; Goldman et al., 2007). Lastly, temporal issues must also be considered in assessing biodiversity losses and gains, especially in the case of a possible time lag between impacts and the effective implementation of biodiversity offsets (Gonçalves et al; 2015), but also to include temporal dynamics of species and habitats that are not sufficiently taken into account in BO (Calvet et al., 2015c).

2.6. Permanence

According to CAP objectives, AES are supposed to help farmers to sustainably adopt pro-environmental practices. Many farmers, however, do not maintain their practices when contracts end (Kuhfuss et al., 2015). This is also a key challenge for ABOS where irreversible losses caused by development projects have to be offset by long-term ecological gains. Moreover, such gains usually require significant time to be effective. The permanence of the ecological gains provided by farmers’ practices in ABOS is thus critical. One option could be to offer long-term contracts to farmers (20 years, or more, for example), however the literature shows that contracts with long durations are generally not well accepted by famers (Vaissière et al., 2018; Christensen et al., 2011; Ruto and Garrod, 2009 Bougherara and Ducos, 2006), or would require significantly higher payments (Schöttker & Wätzold 2018; Drechsler et al. 2017b; Lennox & Armsworth 2011). For instance, only five-year contracts were accepted by farmers in the context of the CNM's BO program. This permanence issue therefore implies either that the land-use modifications required in contracts are maintained after the term (e.g. through changes in the farm's production system) or that contracts are renewed periodically as long as the ecological impact of the infrastructure remains and/or the developer is required to maintain its offsets. This is particularly important when the same land must be under contract throughout the offset period (Schöttker et al. 2016; BenDor & Woodruff 2014). In some cases, however, habitat turnover across the landscape can be acceptable for species that respond rapidly to changes in the distribution of habitat patches (Van Teeffelen et al., 2014; Bull et al. 2013b), but it is not the case for the bird species targeted by the CNM project's ABOS program.

3. Materials and methods

3.1. Presentation of the case study

In this study, we examine the use of ABOS for the implementation of biodiversity offsets required to compensate the ecological impact of building and operating an 80 km long mixed (freight and passenger) high-speed railway line between Nîmes and Montpellier, in Southern France. This project, named "Contournement Nîmes-Montpellier" (CNM), was initiated in 2000, permitted in 2013, and its construction finalized in 2017. The construction and maintenance for 25 years of the line was delegated to a private consortium (Oc'Via), including the responsibility for the project's impacts on biodiversity and the corresponding mitigation and offsetting measures.

Due to the size and location of the CNM project, there are significant ecological impacts. In particular, the railway line crosses two Natura 2000 sites designated as Special Protection Areas under the European Habitats Directive as they harbor the largest population of Little Bustard (*Tetrax tetrax* L.) in France (Devoucoux, 2014). The little bustard is a flagship species for the CNM project and its stakeholders (including regulatory agencies) due to the significance of the impacted area on its conservation status. Under French regulations, these impacts, among others, required the developer to design and implement an offsetting strategy (Quétier et al., 2014).

3.2. Description of the ABOS program

Oc'Via's ABOS program was set-up with the assistance of an *ad hoc* consortium formed by a regional nature conservancy and land trust group (*Conservatoire Régional des Espaces Naturels*), a local bird conservation group (*Centre Ornithologique du Gard*), and the Chamber of Agriculture of the Gard area (CA30), a farmers' institution at the departmental level which provides technical and administrative support to farmers. This consortium (offset consortium, henceforth) was in charge of implementing, monitoring and enforcing ABOS, under the supervision of the developer, Oc'Via.

To design and size the offsets required for the CNM project, a specific loss – gain metric was used which combines area and habitat quality to determine "compensation units" (CU), defined as a unit change in habitat-quality on one hectare. Little Bustard habitat was assessed on a scale of 0 (unfavorable habitat) to 3 (highly favorable habitat) mainly on the basis of the vegetation structure and agricultural practices. Comparisons of habitat quality before and after the impacts and before and after BO implementation (including ABOS) determine the loss and gain of CU (respectively). The full method is described in Oc'Via's permit application of 2013 and summarized in Quétier et al. (2015). This method, with its loss-gain metric and exchange rules, was considered as an innovative approach at the time, given the dominance of area-based ratios in offset practice in France, but its use is subject to debate (Billy et al., 2015; Dauguet, 2015).

The permit granted to Oc'Via requires they offset the loss of 3279 CUs, meaning that they have to generate gains of 3279 CUs relative to a pre-impact baseline and to maintain them over 25 years (until 2037). Most of the CUs concerns agricultural habitats (95%) with the objective to provide favorable habitats for the Little Bustard. This requirement represents around 1668 hectares among which 500 hectares would be acquired by Oc'Via and 1168 hectares contracted with farmers through ABOS.

In the French context, the CNM project was innovative because its offsets were piloted and implemented before the construction began. In 2010, the offset consortium offered farmers the opportunity to participate in ABOS by sending a letter to 1169 farmers. The program was opened to farmers for whom farming was their main or secondary activity, with no age restriction, and located in all the municipalities affected by the railway line. Farmers could choose the plots they volunteered to enroll in the program, and could select among a catalogue of 11 agri-environmental measures based on existing AES framed under the CAP. The involvement of the CA30, also in charge of the local AES program, is intended to avoid double counting of the same plots in both programs (AES and ABOS). Thus, farmers could be involved in both ABOS and AES programs but for different plots. In our case-study, this was the case for 18% of the ABOS signatories.

The consortium received 124 propositions to participate in the offsetting program, corresponding to 2000 hectares among which they selected 1160 hectares for implementing the ABOS. The consortium set out a selection process to select the best plots to involve in ABOS based on two main criteria: (i) the cost of the measure and (ii) an ecological rating of the plots. This ecological rating is a 1 to 4 score based on the location of plots (areas of known high densities of Little Bustards), plot size ("bigger is better") and the surrounding landscape (e.g. absence of hedges and nearby roads), as Little Bustards prefer large expanses of open habitat unbroken by visual obstacles. This rating is different from the loss-gain metrics that were subsequently developed to demonstrate "No Net Loss" when the project was finally permitted. The selection of enrolled plots resulted from discussions between the consortium members and the buyer, Oc'Via. Following this selection process, the consortium selected 59 farmers to be enrolled in ABOS at the beginning of the program. In 2016, a new campaign to sign new contracts enabled 16 new farmers to join the ABOS program. Thus, in 2016, the program had 510 plots managed by 75 farmers corresponding to 1160 ha.

The program includes measures involving a change of land use (e.g. conversion of a vineyard to a grassland favorable to the Little Bustard) or a change of management practices (e.g. delayed mowing of existing grasslands to make them more favorable to the targeted birds). Among the 11 measures, the creation and maintenance of favorable cover for Little Bustards (for reproduction or wintering) by delayed mowing or cattle grazing represents 30% of the total ABOS area, with some unmown and ungrazed set-asides in each plot. Compensation Units (CU) gains depend on the initial cover and more significant changes of land-use generate more CU per unit area: 2 CU/ha for converting cereals and intensive "improved" grassland to Little Bustard habitat and 2.5 CU/ha for converting arboriculture and vineyards. The remaining areas are divided between the other measures, the main ones being the mechanical management of herbaceous fallows (gain of 1.5 CU/ha) and the maintenance and upkeeping of grass cover between vine rows (gain of 0.5 CU/ha).

ABOS payments are based on a fixed rate, per hectare. Despite a calculation of gains based on the CU metric, the payment level is not directly linked with the amount of CU generated. The CU gain is based on changes in land-use or management practices while the payment offered to farmers is only based on the average income foregone and/or additional costs associated with the selected measures. These contracts are therefore largely means-oriented and not result-oriented. Payments range from 146 €/ha to 518 €/ha in accordance with the payment level used in the existing AES. Payments are not negotiated between the parties to the transaction but agreed with farming institutions and regulators. This was imposed by regulators to avoid price spikes due to the competing demand of biodiversity offsets from other developers and existing AES, and thus to avoid competition between both programs. The annual budget required for the payment of all ABOS is around € 1 500 000.

In our ABOS case study, contracts are for five years with annual payments. The offsets consortium set up a three-year monitoring and control plan of plots in which farmers are audited without preliminary notice, but only once in three years. Enforcement rules are also very flexible. In case of non-compliance with requirements, farmers can receive lower payments, but no other sanctions or penalties are foreseen. In case of technical problems related to the implementation of the technical specifications, farmers can renegotiate contract terms and even change measures. In the worst cases, farmers can withdraw from the contract before it terminates. When the contract ends, farmers can decide to renew it (or not), on the same plots, or to sign up other plots. Compared to classic AES contracts, ABOS contracts are therefore much more flexible in terms of eligibility criteria, monitoring and enforcement.

3.3. Data collection and data analysis

The empirical study aims both at analyzing determinants of farmers' acceptability to enroll in the BO program, and exploring the effectiveness of ABOS implemented for compensating the residual impacts of the CNM project on biodiversity. The methods used are presented below.

3.3.1. Farmers' acceptability of ABOS

- **Survey design**

The issue of the acceptability of ABOS was analyzed through a survey carried out in 2015. The survey questionnaire was designed to determine factors that may explain two variables: i) whether farmers have adopted or not an ABOS contract, and ii) their intention to adopt one in the coming years. Survey questions were chosen based on factors that are considered to have an effect on the adoption of ABOS from the literature review on AES (section 2.2). The questionnaire covered the following topics: i) farmer and farm socio-economic characteristics, ii) contract flexibility, iii) transaction costs associated with the contract, iv) level of difficulty of the adoption of ABOS prescriptions, v) contract payment and their relation with costs, vi) attitude towards the environment, vii) social norms, viii) trust in the institutions involved in the contract, and ix) attitude towards BO. In most of the questions, farmers had to express their level of agreement with a statement (going from "strongly disagree", "disagree", "agree" to "strongly agree" or "do not know"). We voluntarily avoided including a neutral point in our scales in order to prevent farmers from not expressing an opinion.

The questionnaire was adjusted following discussions with the stakeholders of the CNM project. It was also tested in face-to face interviews with 4 farmers. The questionnaire was subsequently sent by postal mail and by e-mail (if we had an e-mail address) to all 1169 farmers who were initially contacted by the CA30 in 2010 when voluntary farmers were sought. Farmers were invited to fill the questionnaire on paper and send it back by postal mail or to fill the questionnaire directly online using *Limesurvey*. We received 39 questionnaires online and 106 questionnaires via postal mail. This 12.4% return rate is considered good for this type of survey according to local practitioners. Among the 145 questionnaires, 24 had to be discarded because they were incompletely filled. Thus, 121 questionnaires could be analyzed, of which 40 were farmers who had actually adopted the

ABOS contract (hereinafter referred to as “adopters”) and 81 who had not done so (hereinafter referred to as “non-adopters”).

- **Analysis of acceptability**

In our survey, two variables can be analyzed to assess acceptability: the actual decision to adopt an ABOS and the intention to adopt one in coming years. The decision to adopt an ABOS was taken 5 years before the survey for most farmers, in 2010. The analysis of the determinants of adoption may therefore suffer from a strong endogeneity problem, i.e. it will not be possible to determine whether farmers adopted the ABOS because they were different or if they became different because they have adopted the ABOS. We therefore decided to focus our investigation on the intention of farmers to adopt an ABOS in the future, as we considered this to present less endogeneity issues and because the intention to perform a behavior is considered as one of the main predictors of that behavior (Ajzen, 1991). It was evaluated through the question “Do you intend to sign an ABOS in the coming years?” with the answer options “very unlikely” “rather unlikely” “rather likely” and “very likely”. This variable however suffers from the limitations and biases of all stated preferences methodologies (Andan et al., 1995)

In this study, intention is an ordered variable (henceforth called y) coded from 1 to 4, however the difference between the different levels may not be constant. One option would be to turn this scale into a binary variable but this would partially collapse the diversity of intentions among farmers. We therefore decided to analyze this diversity using an ordered logit model.

We define a latent variable y^*, which is unobservable and defined by:

$$y^* = X'\beta + \epsilon$$

where X is a vector of variables that are considered to explain the intention to adopt an ABOS.
The intention y takes the value j if the latent variable is comprised between two thresholds:

$$y = j \text{ if } \alpha_{j-1} < y^* \leq \alpha_j$$

The probability to choose level j can be defined by:

$$p(y = j) = p(\alpha_{j-1} < y^* \leq \alpha_j) = F(\alpha_j - X'\beta) - F(\alpha_{j-1} - X'\beta)$$

where F is the logistic cumulative distribution function. This model produces one set of coefficients with (j-1) intercepts (3 in our case). The underlying ordered logistic assumption is that the relationship between each pair of outcome groups is the same. This is called the proportional odds assumption or the parallel regression assumption. An approximate likelihood-ratio test will be performed in order to verify that this assumption is verified. The description of the explanatory variables used to predict the intention to adopt is provided in appendix 2. We controlled the absence of multicollinearity of explanatory variables with correlation tests. Considering that there were missing values, the ordered logit estimation could only be done with 98 individuals out of the 121.

- **Sample description**

Descriptive statistics of our sample are provided in table 1. Compared to farmers of the Gard administrative area (*département*), the sample presents some particularities. The sample has a higher proportion of organic farmers, of farms with more land and of more cattle and field crop farms and less horticulture and fruit growing farms. These particularities could be due to the fact that contracts have been offered only in certain areas within the Gard, especially those affected by the CNM project, which could present these kinds of peculiarities. Another possibility is that farmers who had more interest in ABOS were more inclined to respond to the survey. This self-selection may partially bias responses. A way to manage this would have been to first estimate the probability to be part of the sample (Vella, 1998), but we do not have access to individual data of farmers of the area.

Variable	Modality	N	% of the 121 respondents	Gard Area Reference (%)	Variable	Modality	N.	% of the 121 respondents	Gard Area Reference (%)
Gender	Male	99	81.8	73.8	**Main farm activity**	Field crops	16	13.6	4.5
	Female	22	18.2	26.2		Horticulture	10	8.6	10.9
Age	Less than 40	22	18.2	16.9		Vine growing	61	52.1	53.8
	From 40 to 49	24	19.8	25.0		Orchard	4	3.4	13.2
	From 50 to 59	45	37.2	30.6		Livestock	17	14.6	6.6
	60 or more	30	24.8	27.6		Other	9	7.7	11.0
Farm size	Less than 20 ha	38	31.4	67.5	**Education**	Primary	17	14.2	21.5
	From 20 to 50 ha	43	35.5	21.6		Secondary short	27	22.5	33.9
	From 50 to 100 ha	17	14.1	7.0		Secondary long	40	33.3	21.2
	From 100 to 200 ha	17	14.1	2.6		Superior	36	30.0	23.3
	200 ha or more	6	5.0	0.6					
Importance of farming activity	Principal	100	84.8		**Organic agriculture**	Yes	26	21.5	12
	Secondary	17	14.4			No	95	78.5	88
	Retired	1	0.9						

Table 1. Descriptive statistics of the survey sample compared to the Gard Reference (Source: General Agriculture Census Agreste 2010)

3.3.2. Other effectiveness criteria for assessing ABOS

Four other effectiveness criteria for ABOS were analyzed (compliance, additionality, link between land use and environmental outcomes, and permanence) using the survey data from the 40 farmers enrolled in the program in 2015, who represented, at that time, 68% of the total number of enlisted farmers. These criteria were addressed through a specific section in the farmers' questionnaire for the farmers enrolled in ABOS program. Questions mainly dealt with i) the level of modification of agricultural practices following contract adoption, ii) the criteria used by farmers to select the enrolled plots, and iii) farmers' intentions after the end of contract regarding a new enrollment and maintenance of agriculture practices. In our sample, data analysis of the enrolled farmers' response is mainly based on descriptive statistics, in order to report their diversity of views.

Links between land use and environmental outcomes were mainly addressed during interviews with implementing partners and through the analysis of a database provided by the consortium that contains characteristics of plots that farmers volunteered to enroll and of plots that were finally selected. Information available on these plots is the following: previous crop, ecological rating (see section 3.2), land area offered by the farmer, measure that the farmer proposed to adopt and associated payment and CUs generated. The plot database contains 908 plots that were submitted by farmers for enrollment. Among these, we have information for 829 plots. The remaining plots were rejected before field assessments were conducted.

4. Results

4.1. Determinants of farmers' acceptability of ABOS

The intention to adopt an ABOS is characterized by a normal-shaped distribution that is well suited to the use of an ordered logit model (Figure 2).

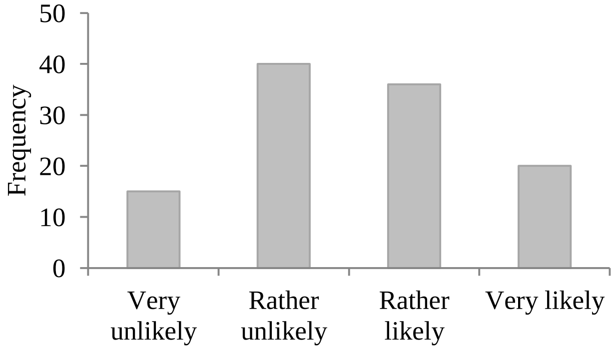

Figure 2. Frequency of farmers according to their intention to adopt an ABOS in the future (Obs: 111)

The results of the ordered logit model presented below highlight the determinants that play a crucial role in the intention of farmers to adopt ABOS contracts (table 2).

Ordered logit model on intention	Coeff.
AGE	-0.13
EDUC	1.05**
SURF	-0.24
PROFIT	-0.89*
NEWACTIVITY	1.08**
ACTIVITYRED	1.98***
FLEX	-0.19
TC	-0.07
EASE	0.55***
PAYMENT	0.96*
ENV	0.32
NATURE	0.50
RESP	0.24
INSTOPINON	0.96*
NORMDESC	1.05**
TRUST	0.70**
ATTITBO	0.80*
EFFIC	-1.43**
Cut 1	0.15
Cut 2	3.43
Cut 3	5.59
Nb. of observations	98
Pseudo R2	0.26
Log Likelihood	-95.03
LR Chi2 (5)	65.79***
Proportionality of odds likelihood ratio test	NS

***, ** and * refers to levels of significance respectively of 1%, 5% and 10%.

Table 2. Logit estimation of the intention to adopt an ABOS in the coming years
The description of the variables used in the model is provided in appendix 1 and descriptive statistics of the variables included in the analysis are presented in appendix 2.

As expected, farmers with **higher education** (EDUC) have a stronger intention to adopt an ABOS as highlighted, for instance, by Chabbé-Ferret and Subervie (2013) or Wilson (1997) for agri-environmental schemes. Farmers who perceived that it is **easy** for them to follow ABOS requirements (variable EASE) are also more likely to have a high intention to adopt an ABOS. The reasons are that the required practices fit well into their farming system, or because it is an opportunity to them to exploit an unused piece of land. It could also be that they have already adopted this practice, independently of the ABOS contract. In the same line, private benefit is an effective incentive to change agricultural practices (Pannell, 2008) and high intenders were more likely to perceive that the **payment level** proposed in contracts is interesting (PAYMENT). Similarly, farmers who suffer from a **low profitability** (PROFIT) of their farming activity considered contract payment as an opportunity to have more regular income sources and are therefore more likely to adopt an ABOS. Considering that most ABOS measures require an extensification of agriculture activities, it is not surprising to also see that farmers in a phase of **activity reduction** (ACTIVITYRED), e.g. reducing the size of their farms or planning to retire, generally have a stronger intention to adopt an ABOS compared to farmers who have not introduced significant changes in the last 5 years (Drake et al. 1999). Finally, farmers who are in a **new development project** (NEWACTIVITY), such as a new type of crop or product, or converting to organic farming, are more susceptible to adopt an ABOS to support their activity.

This study does not consider only the influence of socio-economic factors but also investigates the potential impact of behavioral factors. In accordance with our hypotheses, **social norms** may intervene in farmers' adoption. Farmers who considered the enrollment of other farmers as important (NORMDESC) (as in Chen et al, 2009) and farmers who think that agricultural institutions have a positive opinion on ABOS (INSTOPINION) (as in Le Coent et al, 2018 on the role of injunctive norms) are more likely to participate.

In the same way, ABOS involve new types of agri-environmental contracts, with new parties such as the developer, and stakeholders such as permitting authorities compared to AES. Thus, we expected that **trust** among the parties and institutions involved in the program (TRUST) would play a crucial role in the adoption of ABOS, which our results have confirmed. The involvement of the CA, the local farming organization, in the consortium has played a crucial role in this confidence of farmers who have the intention to sign an ABOS contract.

New players, and the specific context of a developer's BO program could, however, have led to opposition from farmers, particularly due to the development project and its other social and environmental impacts. Indeed, this large project has led to the expropriation of farmers and the acquisition of a large area of farmland in addition to the ABOS program itself. Due to its size and impact on the local agriculture economy, the BO program has also led to conflicts with some agricultural cooperatives and their advisors. This may have had a negative influence on the **personal attitude** of some farmers towards the program (ATTITBO) and probably on their intention to adopt ABOS. Our analysis confirms that the general opinion on BO is a driver of the adoption of ABOS. Farmers who have a negative (respectively positive) opinion on BOs are indeed less (respectively more) likely to adopt an ABOS.

In contrast to conclusions from the literature on AES, some advantages of ABOS such as higher **flexibility** (FLEX) and lower transaction costs (TC) do not come out as significant determinants of the intention to adopt ABOS contracts. This lack of influence may be due to many reasons: 1) flexibility not being fundamental in farmers' decision to enroll, or 2) farmers not being well informed of the advantages of ABOS contracts in terms of flexibility as compared to AES in a context where references to well-known AES were used to reassure farmers and incentivize adoption, and 3) there is a heterogeneity of influence of these variables in the population that could mask the effect.

The role of **attitudes towards the environment** (ENV), the feeling of **responsibility** by farmers for the protection of threatened bird species (RESP) and being a member of an **environmental group** or carrying out nature-based activities, such as hiking, hunting or fishing (NATURE) do not come out as significant determinants of the intention to adopt ABOS. Although attitude towards the environment is considered a determinant of adoption for AES it may not be as important for ABOS. In contrast to the findings of the literature review presented in section 2.2, adopting an ABOS may indeed be strictly considered as a service transaction by farmers who, therefore, do not call upon their environmental preferences. This relatively low influence of environment susceptibility indicators could also be due to the fact that farmers predominantly responded positively to environmental sensitivity questions: 89% agreed that protecting threatened bird species is a priority for the area and 86% that it is their responsibility to protect them (see appendix 2). A more discriminating indicator of environmental susceptibility may have been necessary to detect the influence of preferences for the environment on AES adoption.

Finally, farmers who perceive that the program will lead to an effective protection of threatened bird species are less likely to have a strong intention to adopt. This result is the only effect that goes against expectations. Perhaps, farmers who have the most positive opinion on the results of the program may consider their future participation superfluous.

To conclude, this analysis of the determinants of the intention to participate in ABOS highlights the role of socio-economic factors known from studies of AES: high intenders tend to have a low profitability, to be more educated, to positively judge payments, to consider the implementation of ABOS requirements easy on their farm or to have already adopted a similar contract. Factors that differentiate ABOS and AES such as the perception of the flexibility of the contracts and transaction costs do not have the expected influence. Behavioral factors such as the perception of social norms, trust with implementing institutions and the personal attitude towards BO, however, are key factors in the adoption of ABOS. Finally, the susceptibility to environmental issues does not seem to be a key factor in farmers' adoption of ABOS.

4.2. Additionality and compliance issues

To deal with these issues, we analyze questions that bring information on the magnitude of the change undertaken by farmers following their adoption of the contract. This aims to answer the question “How would you qualify the magnitude of the change of agricultural practice that you’ve had to undertake following your enrollment in the ABOS?” (Table 3).

Intensity of practice change following ABOS adoption	**% of respondents**
No change	19%
Low change	39%
Medium change	36%
High change	6%

Table 3. Intensity of practice change following ABOS adoption (N=36)

Results in Table 3 show that 58% of the enrolled farmers have declared not having made changes (19%) or low modifications (39%) to their practices following the adoption of the ABOS contracts. In light of these results, the real additional effect of these ABOS on biodiversity is questionable. It is likely that the contracts did not produce the desired gains in habitat quality for the Little Bustard. This low level of change in management practices, for a large proportion of enrolled farmers, could be explained by the selection process which initially prioritized farmers who lowest compliance and opportunity costs, as mentioned in the literature (Louis and Rousset, 2010; Vanslembrouck et al., 2002; Wynn et al., 2001), who actually were already implementing favorable management practices (an additionality issue), or because farmers did not follow the requirements of their contract (a compliance issue). These results are consistent with those of the monitoring process conducted by the offset consortium in 2013 that indicated 25% of non-compliance with the requirements on the monitored plots, which represented one third of the total ABOS (see section 3.2.). This rate includes 10% for technical reasons and 15% for deliberate non-compliance (CEN-LR, 2016).

These results are confirmed by the responses to the question “how did you select the plot that you submitted for enrollment?” (Table 4).

Farmers’ plot selection criteria	**% of answers**
Plots that seemed ecologically relevant	61%
Plots on which it seemed easy to implement the requires practices	61%
Plots on which I was already implementing the practices	78%
Plots with low productivity	2%
Plots far away from the farm	5%

Table 4. Criteria quoted by farmers for farmers for the selection of plots they offered

These results confirm that a high proportion of farmers did not implement much change in their plots. Indeed, 78% of the adopting farmers indicated that they were already implementing the required practices on the plots before they enrolled them. Although declarative, these results confirm that additionality and compliance issues that we theoretically emphasized in section 2.3 are indeed challenges for the use of ABOS to achieve BO objectives. For developers to deliver the ecological gains required to achieve the NNL objectives set by regulators, it is crucial that these challenges be addressed in future ABOS programs.

This interpretation is consistent with farmers being more likely to adopt ABOS contracts if they consider their implementation easy on their farm or had already adopted a similar contract (see previous section).

4.3. Link between land use change and the provision of ecological gains

We addressed this link by analyzing the plot selection database (n=829 plots), which reveals a loose relationship between the ecological rating and the CU provided by plots (Table 5).

Initial Ecological rating	Number of plots (out of 829 plots)	Average CU/ha once ABOS are effective
1	37	1.53
2	243	1.20
3	503	1.27
4	46	1.64

Table 5. Average CU/ha benefits for the different level of ecological rating

This analysis reveals that plots with the lowest ecological rating did not lead to the highest CU amounts, i.e. the highest improvement in habitat quality for the Little Bustard. These results show the difficulty inherent in assessing ecological gains, which depend on assumptions on e.g. species' requirements and methods used to assess these. Ecological rating used in the plot selection considers landscape features such as distance to roads or urban areas, presence or absence of Little Bustards before plot enrollment, distance to other plots with favorable practices, presence or absence of hedges, plot area etc. The CU metric, instead, is focused on the potential gains that could be provided by land-use changes at the plot level. This is mainly tied to changes in land cover and vegetation structure, rather than landscape level determinants of habitat favorability. Both methods are largely based on expert judgments, and as highlighted earlier, any assessment of the overall performance of the CNM project in relation to the Little Bustard remains tentative at best. In this context, it seems necessary to have complementary approaches to assess the expected ecological gains from the BO program and consider as many parameters as possible (favorability of plots, loss-gains provided by land use changes, landscape features, etc.).

4.4. Permanence

Considering that contracts are signed for a period of 5 years and that the BO program is legally supposed to ensure ecological benefits for a period of 25 years, permanence is a key issue. Two main dimensions of permanence are analyzed here: 1) whether farmers plan to sign a new contract at the end of their current contract (Table 6), and 2) what they plan to do in case their current contract ends and is not renewed (Table 7).

Farmers' intentions after their current contract ends regarding the signature of a new contract	**% of respondents**
Stop ABOS	6%
Sign again for the same area	56%
Sign again for a smaller area	12%
Sign again for a larger area	26%

Table 6. Farmers' intentions after their current contract ends regarding the signature of a new ABOS contract (N=34)

Farmers' intentions regarding their agricultural practices in the absence of ABOS	**% of respondents**
Abandon the practices	36%
Maintain the practices	36%
Adopt other favorable practices	24%

Table 7. Farmers' intentions regarding their agricultural practices in the absence of ABOS (N=33)

Farmers generally seem to be satisfied with the contracts and 92% of the farmers plan to maintain or increase the land area under contract after their current contract ends. Thus, maintaining farmers under contract, during the period in which the developer needs to ensure offsets are effective is critical but seems achievable. However, only 36% of farmers would maintain the practices included in the requirement of their contract in the absence of ABOS, highlighting the fragile nature of the offset gains. Although the developer is only committed for 25 years, this represents at least 5 successive contracts, and leaves unaddressed the impacts from the railway line when Oc'Via's concession ends (the line won't be dismantled). Circumstances are likely to change considerably by then.

In addition, this result is somewhat surprising considering the large number of farmers who indicate that they have made no or little change to their practices upon signing ABOS contracts. This discrepancy may be explained by the fact that farmers who are paid to implement pro-environmental practices may abandon them when payments are stopped, even if they already implemented them in the past. This phenomenon – the crowding-out effect- has been documented in the behavioral economics literature (Bénabou and Tirole, 2006) and for PES programs (Pattanayak et al., 2010), and it is another threat to the long-term effectiveness of ABOS.

These results highlight the importance of considering these effectiveness criteria in the ABOS evaluation, in particular with regard to additionality, compliance and permanence, which did not show satisfactory results in this study. A comparison thus seems useful between ABOS and land acquisition, through these different criteria in order to identify their strengths and weaknesses with regard to NNL policies.

5. Comparing ABOS and land acquisition in NNL policies

Our case study did not allow us to make a direct comparison of contract-based offsetting (ABOS) with more widespread direct purchase of land by developers. However, the CNM project does provide useful insights into the pros and cons of both approaches. This can contribute to the growing body of work comparing land acquisition with paying farmers for conservation (e.g., Schöttker and Wätzold 2018; Schöttker et al. 2016; Curran et al. 2016).

On the basis of the CNM experience, it appears that the **strengths** of ABOS lie in being more acceptable to farmers (and their sectorial representatives) than land acquisition. ABOS are perceived to reduce pressure on land markets and represents an opportunity for diversification of income streams, to the benefit of important and sometimes vocal stakeholders. This is particularly true in productive agricultural areas. In addition, ABOS can help sustain alternative farming models that are economically fragile, which may in turn have broader landscape-scale effects on biodiversity in areas that are subject to widespread abandonment (and e.g. spontaneous afforestation and loss of open habitats) and/or intensification (and e.g. loss of food resources for wildlife). Given the above, ABOS may be particularly adapted for offsetting impacts on biodiversity tied to agricultural activities (Cimon-Morin et al., 2013; Ribaudo et al., 2010). Across Europe, this includes steppe birds such as the Little Bustard (Donald et al., 2001), for which Bamière et al. (2013; 2011) modeled the cost-effectiveness of various agri-environmental contracts.

From the developer's perspective, ABOS reduce upfront costs, especially where the price of land acquisition is high. These limited costs could facilitate the effective implementation of offsetting requirements and increase the economic efficiency of the system. In practice, if the cost of offsets is too low, however, this could jeopardize the full implementation of the mitigation hierarchy and the effectiveness of the overall NNL policy by making BO more attractive than the previous steps in the hierarchy (Maron et al., 2018; Gordon et al., 2015).

ABOS allow greater flexibility and better adaptability of the offsetting system in case of environmental (climate) or institutional (agricultural policies and markets) changes. Indeed, due to climate change, it is expected that the spatial distribution of species may change over time (Devictor et al., 2012) which may require a relocation of land under BO (e.g. Bull et al., 2013b). In addition, legal and administrative obligations attached to BO have evolved considerably in the last few years and may continue to do so. Using ABOS may allow stakeholders to adjust rapidly to changes in this fast-moving environment.

Compared to land acquisition, ABOS also present a number of **weaknesses** for the achievement of NNL of biodiversity over time. First, the use of short-term agri-environmental contracts carries risks for the *permanence* of ecological gains over time. ABOS do not provide the same level of control and security as full ownership. Applicable easements and covenant did not exist when the BO program for the CNM project was set-up: they were introduced into French law only in 2016 (Wende et al., 2018).

Second, regulators must enforce compliance with permits, and thus control the compliance of farmers with contract requirements, and the *additionnality* of land use changes required under those contracts (relative to an adequate reference scenario, given policy objectives). Information asymmetries, however, represent strong challenges to meeting these two conditions.

Third, another consequence of this information asymmetry is that ABOS can lead to leakage effects. Contracts typically focus on a given plots of land, rather than the whole farm. Farmers can therefore implement the required changes on the enrolled plots but compensate them by reversing favorable practices on other plots. Thus, at the farm scale, this induces no change despite the compliance of farmers with contract requirements. Such leakage effects have already been observed in the implementation of a number of PES programs (Wunder et al., 2008).

To conclude, restoration projects conducted on land acquired for this purpose offer stronger guarantees of permamence and additionality of offset gains. This can be critical to achieving no net loss in circumstances where impacts are permitted on threatened species or ecosystems that are particularly sensitive to habitat turnover (van Teeffelen et al., 2014).

Table 8 provides a broader comparative synthesis of ABOS and land acquisition for BO in relation to the main effectiveness criteria for achieving NNL (Gonçalves et al., 2015; Bull et al., 2013a).

	Comparison criteria	Land acquisition and management in BO policies		Agri-environmental Biodiversity Offsets Schemes (ABOS)
System features	Offsetting schemes	Bespoke offsetting or habitat banking		To date, only bespoke offsetting
	Production of ecological gains	Acquisition of land, restoration actions and/or management		Changes in land use or agricultural practices
	Type of rights transferred in the transaction	Property and use rights		Use rights
Effectiveness criteria	Additionality	Land ownership provides full control which enables ecological actions that produce ecological gains; enforcement is also facilitated.	**>**	The potential for ecological gains will depend on farmers' willingness to change land-use and management, and their compliance with contract requirements. Multiple parties involved generate time and costs to enforce commitments.
	Anticipation of gains and temporal lag between losses and gains of biodiversity	Anticipation is possible, but land acquisition comes with higher up-front costs. Full management control, however, means that restoration activities can be initiated early.	**≥**	Up-front costs can be lower as no land purchase is involved, but transaction costs can be high to achieve buy-in from land-owners and secure their commitment. Coordination with multiple parties can slow down implementation of restoration activities, and contract duration is a key constraint.
	Spatial proximity between losses and gains of biodiversity	Depends on the location of the offsetting site.	**≤**	The same but considering the multitude of offsetting sites in ABOS, there are more options for locating offsets near the impact site.
	Ecological equivalence	Full management control means that more drastic land use changes can be implemented, increasing opportunities for important biodiversity gains per unit area.	**>**	Restoration and management actions must remain compatible with farming activities and are typically not implemented only for ecological purposes. Typically, management changes bring lowers biodiversity gains per unit area than conversion from one land-use type to another.
	Permanence of ecological gains over the commitment period	Guaranteed due to management control, although subsequent land sales can jeopardize commitments (some form of "easement" is necessary). Enforcement by regulators is easier on a single land-holding.	**>**	Risks are higher because long term performance depends on contract duration, and thus on farmers accepting to renew short contracts, or other farmers accepting to take up contracts.
	Permanence of ecological gains beyond the commitment period	Depends on the legal and financial arrangement, e.g. establishment of conservation easements, legal designation of the site, handover to a conservation organization, endowment of a trust fund, etc. These arrangements are easier to implement as a land-owner.	**≥**	Depends on the willingness of farmers and land-owners to sign-up to equivalent commitments, which is difficult to anticipate.

Table 8. Comparison between land acquisition and ABOS along the main effectiveness criteria to achieve the NNL of biodiversity

6. Conclusion

Policies aimed at achieving No Net Loss or Net Gains of biodiversity through biodiversity offsets are being mainstreamed worldwide. In this context, we analyze the opportunities and challenges of using agri-environmental biodiversity offsets schemes, which we call ABOS, whereby farmers are contracted by developers to deliver biodiversity offset gains by changing their farming practices or land uses. Our empirical analysis focuses on the ABOS program implemented to offset impacts from the construction of a new railway line in Southern France: the CNM project. Based on a survey of 145 farmers we explored the effectiveness of ABOS through: (1) the determinants of farmers' participation in ABOS programs, and (2) specific issues related to NNL policies, which are additionality, compliance, delivery of ecological gains, and permanence.

Our results suggest that the main determinants of ABOS acceptability are: i) socio-economic factors, ii) social norms, iii) trust with contracting institutions, and iv) ease of integration in farm activities. Although our study illustrates that ABOS allow developers to meet their legal requirements, major concerns are raised about additionality, especially through the manifestation of windfall effects and on-farm leakage, long-term permanence, and non-compliance with contract requirements. These concerns, mainly due to information asymmetries, are not specific to ABOS but are inherent to other types of agri-environmental contracts (Kuhfuss and Subervie, 2015; Chabé-Ferret and Subervie, 2013; Ferraro, 2008). Their impact, however, are more acute for ABOS given the legal requirement of NNL of biodiversity.

The literature on agri-environmental schemes allows us to propose some recommendations to limit these ABOS-related concerns. First, on the additionality issue, Ferraro (2008) proposes three solutions: (1) acquiring information on the environmental benefits that farmers can potentially offer, and selecting them on this basis; (2) offering farmers a menu of screening contracts; and (3) allocating contracts through agri-environmental auctions (e.g. Latacz-Lohmann and Van der Hamsvoort, 1997). In the case where there is more supply (of plots by farmers) than demand from the developer, as in the CNM project, auction mechanisms with differentiated payments according to the provision of ecological gains, could improve the cost-effectiveness of ABOS programs (Bamière et al., 2013). This could allow the implementation of programs that generate greater benefits at the same level of costs as current programs and reduce concerns about additionality.

Second, dealing with the issue of non-compliance would require a modification of the monitoring and enforcement system. In the CNM case study, high levels of non-compliance suggest that penalties are too low and monitoring insufficient. Expanding third party auditing could strengthen enforcement and ensure compliance. This would be a necessary step towards making payments conditional to measurable ecological outcomes, which is frequently proposed in the literature (McDonald et al., 2018; Drechsler, 2017a). This approach has been implemented for the protection of bird species (Burton and Schwarz, 2013) or grassland flora (Fleury et al., 2015), among others. However, its downsides include shifting the risks of failure from the developer to farmers, which is generally not well accepted by farmers and may hinder their participation in the program (Burton and Schwarz, 2013).

Relationships between developers and regulators are just as important as those between farmers and developers. Regulators must ensure that monitoring and enforcement systems (sanctions) for developers provide the right incentives to encourage developers to enforce compliance of contracts by farmers. These issues could benefit from further research on the design and enforcement of ABOS programs for NNL policies, including the transfer of responsibilities between the parties to the transaction.

Lastly, for permanence issues, our results show that although farmers may be ready to renew their ABOS contracts, very few would maintain their biodiversity-friendly practices in the absence of financial support. Thus, after developers' mandatory requirements (e.g. 25 years in the CNM case study), there is no guarantee from any party that the ecological gains provided will be sustained, whereas the loss of biodiversity caused by the infrastructure will persist over time. Whilst it may be hardly conceivable to expect developers to finance ecological gains *ad infinitum*, such arrangements place a considerable burden on public finances. The long-term financing of offsets, in France as in many other jurisdictions, remains to be fully addressed (Wende et al., 2018). Setting up endowment funds would offer a solution to this financing challenge, as in US mitigation banking, by providing autonomous funds to finance long-term management actions (Vaissière et al., 2015). Another way forward is to focus ABOS programs on covering investment costs for transitioning farming business to deliver biodiversity gains sustainably once payments stop (as 'Investment PES'), rather than only covering direct implementation costs (Karsenty et al. 2017). The resulting biodiversity-friendly practices are then self-financed as part of the farm's new business model.

In relation to this last recommendation, when ABOS is well implemented and suitable for achieving the NNL goal targeted, framing BO as an opportunity for farming rather than an external imposition on farmers could help improve rural opinions and effectiveness of ABOS. These opportunities include the diversification of revenue and covering the cost of investing in sustainable biodiversity-friendly practices in the long term. This is necessary for the agro-ecological transition that is required to make agricultural and food systems sustainable and compatible with climate and biodiversity objectives (Poux and Aubert, 2018).

Territorial (landscape-scale) approaches are necessary for such shifts to happen including an adaptation of agricultural sectors and supply chains to ensure the sustainability over the long term of new agricultural business models. Using ABOS to help fund the adaptation of the farming sector to its growing economic and environmental challenges can make BO more appealing to farmers, and more effective in delivering long-term biodiversity outcomes. Besides, going beyond individual plots or farms towards territorial approaches may allow taking into account broader ecological considerations (e.g. threshold effects and the need for spatial coordination).

The re-framing of ABOS is a condition to their potential success and could be achieved by more thorough engagement of the agricultural sector. Growing concerns around the loss of farmland to development ("artificialization") have led the French government to lay out the goal of "no net land take" in its 2018 Biodiversity Plan. This goal puts biodiversity and farmland under the same banner and provides opportunities to connect both NNL goals (of biodiversity and farmland). ABOS may play a role in this agenda which open crucial research avenues in that direction.

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References

Ajzen, I., 1991. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50, 179–211.

Allaire, G., Cahuzac, E., Simioni, M., 2009. Contractualisation etdiffusionspatiale des mesures agro-environnementales herbagères. Rev. d'Etudes en Agric. Environ. 90, 23–50.

Andan, O., Faivre D'Arcier, B., Hiron, B., 1995. La mesure du consentement à payer pour l'environnement. Analyse bibliographique sur les méthodes d'enquête. 131p.

Bamière, L., David, M., & Vermont, B., 2013. Agri-environmental policies for biodiversity when the spatial pattern of the reserve matters. Ecological Economics, 85, 97-104.

Bamière, L., Havlík, P., Jacquet, F., Lherm, M., Millet, G., & Bretagnolle, V., 2011. Farming system modelling for agri-environmental policy design: the case of a spatially non-aggregated allocation of conservation measures. Ecological Economics, 70(5), 891-899.

Barreiro-Hurlé, J., Espinosa-Goded, M., Dupraz, P., 2010. Does intensity of change matter? Factors affecting adoption of agri-environmental schemes in Spain. J. Environ. Plan. Manag. 53, 891–905.

Beedell, J., Rehman, T., 2000. Using social-psychology models to understand farmers' conservation behaviour. J. Rural Stud. 16, 117–127.

Bénabou, R., Tirole, J., 2006. Incentives and prosocial behavior. Am. Econ. Rev. 96, 1652–1678.

BenDor, T. K., & Woodruff, S., 2014. Moving targets and biodiversity offsets for endangered species habitat: is lesser prairie chicken habitat a stock or flow?. Sustainability, 6(3), 1250-1259.

Bidaud, C., Schreckenberg, K., Rabeharison, M., Ranjatson, P., Gibbons, J., Jones, J.P., 2017. The Sweet and the Bitter: Intertwined Positive and Negative Social Impacts of a Biodiversity Offset. Conserv. Soc. 15, 1.

Billy, V. De, Tournebize, J., Barnaud, G., Benoît, M., Birgand, F., Garnier, J., Lesaffre, B., Lévêque, C., Marsily, G. De, Muller, S., Musy, A., Zimmer, D., 2015. Compenser la destruction de zones humides. Retours d'expérience sur les méthodes et réflexions inspirées par le projet d'aéroport de Notre-Dame-des-Landes (France). Natures Sci. Sociétés 23, 27–41.

Bougherara, D., Ducos, G., 2006. Farmers' preferences over compensation contract flexibility and duration: an estimation of the effect of transaction costs using choice experiment, in: Days of the European School on New-Institutional Economics. Université de Paris-Sud XI. 26 p.

Budiharta, S., Meijaard, E., Gaveau, D. L., Struebig, M. J., Wilting, A., Kramer-Schadt, S., et al., 2018. Restoration to offset the impacts of developments at a landscape scale reveals opportunities, challenges and tough choices. Global environmental change, 52, 152-161.

Bull, J. W., & Strange, N. 2018. The global extent of biodiversity offset implementation under no net loss policies. Nature Sustainability, 1(12), 790.

Bull, J.W., Suttle, K.B., Gordon, A., Singh, N.J., Milner-Gulland, E.J., 2013a. Biodiversity offsets in theory and practice. Oryx 47, 369–380.

Bull, J.W., Suttle, K.B., Singh, N.J., Milner-Gulland, E.J., 2013b. Conservation when nothing stands still: Moving targets and biodiversity offsets. Front. Ecol. Environ. 11, 203–210.

Burton, R.J.F., Schwarz, G., 2013. Result-oriented agri-environmental schemes in Europe and their potential for promoting behavioural change. Land use policy 30, 628–641.

Calvet, C., Ollivier, G., Napoléone, C., 2015a. Tracking the origins and development of biodiversity offsetting in academic research and its implications for conservation: A review. Biol. Conserv. 192, 492–503.

Calvet, C., Levrel, H., Napoléone, C., Dutoit, T., 2015b. La Réserve d'Actifs Naturels : une nouvelle forme d'organisation pour la préservation de la biodiversité en France ? Editions Quae, Collection Synthèses, Versailles, Chapitre 12, pp. 139–156.

Calvet, C., Napoléone, C., Salles, J.-M., 2015c. The Biodiversity Offsetting Dilemma: Between Economic Rationales and Ecological Dynamics. Sustainability, 7, 7357–7378.

CEN-LR, 2016. Comité de suivi du projet de CNM, Nîmes.

Chabé-Ferret, S., Subervie, J., 2013. How much green for the buck? Estimating additional and windfall effects of French agro-environmental schemes by DID-matching. J. Environ. Econ. Manage. 65, 13–27.

Chen, X., Lupi, F., An, L., Sheely, R., Viña, A., Liu, J., 2012. Agent-based modeling of the effects of social norms on enrollment in payments for ecosystem services. Ecol. Modell. 229, 16–24.

Chen, X., Lupi, F., He, G., Liu, J., 2009. Linking social norms to efficient conservation investment in payments for ecosystem services. Proc. Natl. Acad. Sci. U. S. A. 106, 11812–7.

Christensen, T., Pedersen, A.B., Nielsen, H.O., Mørkbak, M.R., Hasler, B., Denver, S., 2011. Determinants of farmers' willingness to participate in subsidy schemes for pesticide-free buffer zones--A choice experiment study. Ecol. Econ. 70, 1558–1564.

Cialdini, R.B., Reno, R.R., Kallgren, C.A., 1990. A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places. J. Pers. Soc. Psychol. 58, 1015–1026.

Cimon-Morin, J., Darveau, M., Poulin, M., 2013. Fostering synergies between ecosystem services and biodiversity in conservation planning: A review. Biol. Conserv. 166, 144–154.

Curran, M., Kiteme, B., Wünscher, T., Koellner, T., & Hellweg, S., 2016. Pay the farmer, or buy the land? Cost-effectiveness of payments for ecosystem services versus land purchases or easements in Central Kenya. Ecological Economics, 127, 59-67.

Curran, M, Hellweg, S, and Beck, J. 2014. Is there any empirical support for biodiversity offset policy? Ecological Applications, Vol. 24, No. 4, pp. 617-632.

Dauguet, B., 2015. Biodiversity offsetting as a commodification process: A French case study as a concrete example. Biol. Conserv. 192, 533-540

Defrancesco, E., Gatto, P., Runge, F., Trestini, S., 2008. Factors affecting farmers'participation in agri-environmental measures: A northern Italian perspective. J. Agric. Econ. 59, 114–131.

Delvaux, L., Henry de Frahan, B., Dupraz, P., Vermersch, D., 1999. Adoption d'une MAE et consentement à recevoir des agriculteurs en région wallone. Économie Rural. 249, 71–81.

Devictor, V., van Swaay, C., Brereton, T., Brotons, L., Chamberlain, D., Heliölä, J., Herrando, S., Julliard, R., Kuussaari, M., Lindström, Å., Reif, J., Roy, D.B., Schweiger, O., Settele, J., Stefanescu, C. Van Strien, A., Van Turnhout, C., Vermouzek, Z., WallisDeVries, M., Wynhoff, I., Jiguet, F., 2012. Uncertainty in thermal tolerances and climatic debt. Nat. Clim. Chang. 2, 638–639.

Devoucoux, P., 2014. Conséquences et impacts prévisibles d'une perte d'habitat majeure sur une espèce menacée aux exigences écologiques complexes: Effets de la mise en place du Contournement ferroviaire à grande vitesse Nîmes-Montpellier sur la dynamique de la population d'Outardes. Université de Poitiers. PhD Thesis. 216 p.

Donald, P.F., Green, R.E., Heath, M.F., 2001. Agricultural intensification and the collapse of Europe's farmland bird populations. Proc. R. Soc. B Biol. Sci. 268, 25–29.

Drake, L., Bergström, P., Svedsäter, H., 1999. Farmers' attitudes and uptake, in: Van Huylenbroeck, G., Whitby, M. (Eds.), Countryside Stewardship: Farmers, Policies and Markets. Oxford: Elsevier Science Ltd. ELSEVIER SCI LTD, pp. 89–111.

Drechsler, M., 2017a. Performance of input-and output-based payments for the conservation of mobile species. Ecological Economics, 134, 49-56.

Drechsler, M., Johst, K., & Wätzold, F., 2017b. The cost-effective length of contracts for payments to compensate land owners for biodiversity conservation measures. Biological conservation, 207, 72-79.

Ducos, G., Dupraz, P., Bonnieux, F., 2009. Agri-environment contract adoption under fixed and variable compliance costs. J. Environ. Plan. Manag. 52, 669–687.

Ducos, G., Dupraz, P., 2007. The asset specificity issue in the private provision of environmental services: Evidence from agri-environmental contracts. Working Paper 07-02. INRA-Rennes. Unité d'Economie et Sociologie Rurales

EEA, 2004. High Nature Value Farmland – Characteristics, Trends and Policy Challenges. Copenhagen, Denmark. 31 p.

Engel, S., Pagiola, S., Wunder, S., 2008. Designing payments for environmental services in theory and practice: An overview of the issues. Ecol. Econ. 65, 822–833.

Ezzine-de-Blas, D., Wunder, S., Ruiz-Pérez, M., & del Pilar Moreno-Sanchez, R. (2016). Global patterns in the implementation of payments for environmental services. PloS one, 11(3).

Falconer, K., 2000. Farm-level constraints on agri-environmental scheme participation: a transactional perspective. J. Rural Stud. 16, 379–394.

Ferraro, P.J., 2008. Asymmetric information and contract design for payments for environmental services. Ecol. Econ. 65, 810–821.

Fleury, P., Seres, C., Dobremez, L., Nettier, B., Pauthenet, Y., 2015. Flowering Meadows, a result-oriented agri-environmental measure: Technical and value changes in favor of biodiversity. Land use policy 46, 103–114.

Goldman, R.L., Thompson, B.H., Daily, G.C., 2007. Institutional incentives for managing the landscape: Inducing cooperation for the production of ecosystem services. Ecol. Econ. 64, 333–343.

Gonçalves, B., Marques, A., Soares, A.M.V.D.M., Pereira, H.M., 2015. Biodiversity offsets: from current challenges to harmonized metrics. Curr. Opin. Environ. Sustain. 14, 61–67.

Gordon, A., Bull, J.W., Wilcox, C., Maron, M., 2015. Perverse incentives risk undermining biodiversity offset policies. J. Appl. Ecol. 52, 532-537.

Karsenty, A., Aubert, S., Brimont, L., Dutilly, C., Desbureaux, S., Ezzine de Blas, D., Le Velly, G., 2017. The Economic and Legal Sides of Additionality in Payments for Environmental Services. Environ. Policy Gov. 27, 422–435.

Kuhfuss, L., Préget, R., Thoyer, S., Hanley, N., Le Coent, P., Désolé, M., 2016. Nudges, social norms and permanence in agri-environmental schemes. Land Economics. 92, 641–655.

Kuhfuss, L., Subervie, J., 2015. Do agri-environmental schemes help reduce herbicide use ? Evidence from a natural experiment in France (No. DR n°2015-02).

Kuhfuss, L., Preget, R., Thoyer, S., 2014. Préférences individuelles et incitations collectives : quels contrats agroenvironnementaux pour la réduction des herbicides par les viticulteurs ? Rev. d'Études en Agric. Environ. 95, 111–143.

Lamine, C., 2011. Anticiper ou temporiser : injonctions environnementales et recompositions des identités professionnelles en céréaliculture. Sociol. Trav. 53, 75–92.

Latacz-Lohmann, U., Van der Hamsvoort, C., 1997. Auctioning Conservation Contracts: A Theoretical Analysis and an Application. Am. J. Agric. Econ. 79, 407–418.

Le Coent, P., Préget, R., Thoyer, S., 2018. Do farmers follow the herd? The influence of social norms in the participation to agri-environmental schemes (No. WP 2018-02), CEE-M Working Papers. Montpellier (France).

Le Coent, P., Préget, R., Thoyer, S., 2017. Compensating Environmental Losses Versus Creating Environmental Gains : Implications for Biodiversity Offsets. Ecol. Econ. 142, 120–129.

Lennox, G. D., & Armsworth, P. R., 2011. Suitability of short or long conservation contracts under ecological and socio-economic uncertainty. Ecological modelling, 222(15), 2856-2866.

Lombard-Latune, J., 2018. La compensation écologique : du principe de non perte nette de biodiversité à son opérationnalisation – analyse de l'action collective. Thèse de doctorat, AgroParisTech.

Louis, M., Rousset, S., 2010. Coûts de transaction et adoption des contrats agroenvironnementaux Le cas des MAE territorialisées à enjeu DCE en Poitou-Charentes, in: Colloque SFER Cemagref. p27.

Maron, M., Brownlie, S., Bull, J.W., Evans, M.C., von Hase, A., Quétier, F., Watson, J.E.M., Gordon, A., 2018. The many meanings of no net loss in environmental policy. Nat. Sustain. 1, 19–27.

McDonald, J. A., Helmstedt, K. J., Bode, M., Coutts, S., McDonald-Madden, E., & Possingham, H. P., 2018. Improving private land conservation with outcome-based biodiversity payments. Journal of Applied Ecology, 55(3), 1476-1485.

Morris, C., Potter, C., 1995. Recruiting the new conservationists: Farmers' adoption of agri-environmental schemes in the U.K. J. Rural Stud. 11, 51–63.

Mzoughi, N., 2011. Farmers adoption of integrated crop protection and organic farming: Do moral and social concerns matter? Ecol. Econ. 70, 1536–1545.

Pannell, D.J., 2008. Public benefits, private benefits, and policy intervention for land-use change for

environmental benefits, Land Economics 84(2): 225-240.
Pattanayak, S.K., Wunder, S., Ferraro, P.J., 2010. Show me the money: Do payments supply environmental services in developing countries? Rev. Environ. Econ. Policy 4, 254–274.
Pech, M., Étrillard, C. 2016. Le foncier agricole, variable d'ajustement ou déterminant de la compensation écologique ? Sciences Eaux & Territoires, (2), 60-63.
Peerlings, J., Polman, N., 2009. Farm choice between agri-environmental contracts in the European Union. J. Environ. Plan. Manag. 52, 593–612.
Poux, X., Aubert, P.-M., 2018. Une Europe agroécologique en 2050 : une agriculture multifonctionnelle pour une alimentation saine. Enseignements d'une modélisation du système alimentaire européen, Iddri-AScA, Study N°09/18, Paris, France, 78 p.
Quétier, F., Moura, C., Menut, T., Boulnois, R., Rufray, X., 2015. La compensation écologique fonctionnelle : innover pour mieux traiter les impacts résiduels des projets d'aménagements sur la biodiversité. Sci. Eaux Territ. 17, 24–28.
Quétier, F., Regnery, B., Levrel, H., 2014. No net loss of biodiversity or paper offsets? A critical review of the French no net loss policy. Environ. Sci. Policy 38, 120–131.
Ribaudo, M., Greene, C., Hansen, L., Hellerstein, D., 2010. Ecosystem services from agriculture: Steps for expanding markets. Ecol. Econ. 69, 2085–2092.
Rørstad, P.K., Vatn, A., Kvakkestad, V., 2007. Why do transaction costs of agricultural policies vary? Agric. Econ. 36, 1–11.
Ruto, E., Garrod, G., 2009. Investigating farmers' preferences for the design of agri-environment schemes: a choice experiment approach. J. Environ. Plan. Manag. 52, 631–647.
Schöttker, O., & Wätzold, F., 2018. Buy or lease land? Cost-effective conservation of an oligotrophic lake in a Natura 2000 area. Biodiversity and Conservation, 27(6), 1327-1345.
Schöttker, O., Johst, K., Drechsler, M., & Wätzold, F., 2016. Land for biodiversity conservation—To buy or borrow?. Ecological Economics, 129, 94-103.
Vaissière, A.-C., Tardieu, L., Quétier, F., Roussel, S., 2018. Preferences for biodiversity offset contracts on arable land: a choice experiment study with farmers. Eur. Rev. Agric. Econ.
Vaissière A.C., Levrel H., 2015. Biodiversity offset markets : what are they really ? An empirical approach to wetlands mitigation banking. Ecological Economics 110, 81–88.
Van Teeffelen, A. J., Opdam, P., Wätzold, F., Hartig, F., Johst, K., Drechsler, M., Vos, C.C., Wissel, S. & Quétier, F., 2014. Ecological and economic conditions and associated institutional challenges for conservation banking in dynamic landscapes. Landscape and Urban Planning, 130, 64-72.
Vanslembrouck, I., Van Huylenbroeck, G., Verbeke, W., 2002. Determinants of the Willingness of Belgian Farmers to Participate in Agri-environmental Measures. J. Agric. Econ. 53, 489–511.
Vatn, A., 2010. An institutional analysis of payments for environmental services. Ecol. Econ. 69, 1245–1252.
Vella, F., 1998. Estimating Models with Sample Selection Bias: A Survey. J. Hum. Resour. 33, 127–169.
Virah-Sawmy, M., 2009. Ecosystem management in Madagascar during global change. Conserv. Lett. 2, 163–170.
Wende, W., Albrecht, J., Darbi, M., Herbert, M., May, A., Schumacher, J., & Szaramowizc., 2018. Germany. In: W. Wende, G.-M. Tucker, F. Quétier, R. Matt, & M. Darbi (edit.), Biodiversity Offsets - European Perspectives on No Net Loss of Biodiversity and Ecosystem Services: Springer.
Wilson, G.A., 1997. Factors Influencing Farmer Participation in the Environmentally Sensitive Areas Scheme. J. Environ. Manage. 50, 67–93.
Wunder, S. 2015. Revisiting the concept of payments for environmental services. Ecological Economics, 117, 234-243.
Wunder, S., Engel, S., Pagiola, S., 2008. Taking stock: A comparative analysis of payments for environmental services programs in developed and developing countries. Ecol. Econ. 65, 834–852.
Wynn, G., Crabtree, B., Potts, J., 2001. Modelling farmer entry into the environmentally sensitive area schemes in Scotland. Journal of Agricultural Economics, 52 (1) (2001), pp. 65-82.

Appendix

Appendix 1: Description of the variables used in the econometric model

Variable	Description	Unit
Farmers and farm socio-economic characteristics		
AGE	Age of the farmer	Years
EDUC	Education	1=Superior or Secondary long 0= Primary or secondary short
SURF	Size of the farm as compared to other farmers with the same type of production	1 (resp. 0)=farm size superior (resp. inferior) to the average farm with the same type of production;
PROFIT	How do you judge the profitability of your activity?	1=Rather or very profitable 0=Not profitable or low profitability
ACTIVITY	Have you had important change in your farm in the last 5 years?: No modification Development of a new activity or size increase Activity decrease or retirement close	 NEWACTIVITY=1 (0 otherwise) ACTIVITYRED=1 (0 otherwise)
Contract flexibility		
FLEX	Flexibility perception index: sum of replies to:	Continuous: sum of variables below
	The diversity of measures is an advantage	1=Agree; 0=Disagree or no opinion
	There are a lot of control	1=Disagree; 0=Agree or no opinion
	Sanctions are reasonable	1=Agree; 0=Disagree or no opinion
	It is possible to renegotiate the contract	1=Agree; 0=Disagree or no opinion
	It is easy to disengage	1=Agree; 0=Disagree or no opinion
Transaction costs		
TC	Transaction costs perception index	Continuous: sum of variables below
	There is a need to invest in equipment	1=Agree; 0=Disagree or no opinion
	Requires a large amount of time for administrative procedures	1=Agree; 0=Disagree or no opinion
	Rules and requirements are easy to understand	1=Disagree; 0=Agree or no opinion
	There is a need of a third person for implementation	1=Agree; 0=Disagree or no opinion
Intensity of change		
EASE	Ease to change perception index. The proposed measures are:	Continuous: sum of variables below
	easy to implement on my farm	1=Agree; 0=Disagree or no opinion
	fit well in my farming system	1=Agree; 0=Disagree or no opinion
	an opportunity to exploit unused fields	1=Agree; 0=Disagree or no opinion
	...an opportunity to be supported for practices I had already adopted or planned to adopt	1=Agree; 0=Disagree or no opinion

Contract payment

PAYMENT	The proposed payment level is interesting	1=Agree; 0=Disagree or no opinion

Attitude towards the environment

ENV	The protection of threatened bird species is a priority for our area	1=Agree; 0=Disagree or no opinion
NATURE	Do you practice nature activity or are you member of a nature association?	1=Yes; 0=No
RESP	It is my responsibility, as a farmer, to act for the protection of threatened bird species	1=Agree; 0=Disagree or no opinion

Social Norms

INSTOPINON	What is the opinion of the Chambre d'Agriculture on ABOS, according to you?	1=Positive; 0=Negative or no opinion
NORMDESC	The fact that other farmers adopt ABOS is important to me.	1=Agree; 0=Disagree or no opinion

Trust in institutions

TRUST	Trust perception index.	
	I trust the institutions involved in the monitoring and implementation of ABOC	1=Agree; 0=Disagree or no opinion
	I trust that the developers that fund ABOS will respect their engagement	1=Agree; 0=Disagree or no opinion
TRUSTDEV	I trust that the developers that fund ABOS will respect their engagement	1=Agree; 0=Disagree or no opinion

Attitude towards biodiversity offsets (BO)

ATTITBO	What is your opinion on BO through agriculture?	1=Positive; 0=Negative or no opinion
Other		
EFFIC	ABOS will lead to the protection of threatened bird species	1=Agree; 0=Disagree or no opinion

Appendix 2: Descriptive statistics of the variables included in the ordered logit estimation

Variable	N	Mean	SD	Min	Max
PROFIT	120	0.33	0.47	0	1
NEWACTIVITY	121	0.38	0.49	0	1
ACTIVITYRED	121	0.15	0.36	0	1
FLEX	119	1.40	1.30	0	5
TC	120	1.81	1.34	0	4
EASE	119	2.13	1.55	0	4
PAYMENT	121	0.36	0.48	0	1
ENV	120	0.89	0.31	0	1
NATURE	121	0.34	0.48	0	1
RESP	121	0.86	0.35	0	1
INSTOPINON	115	0.62	0.49	0	1
NORMDESC	121	0.42	0.50	0	1
TRUST	121	1.21	0.81	0	2
ATTITBO	117	0.42	0.50	0	1
EFFIC	121	0.76	0.43	0	1