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Modelling the effects of alternative CAP policies for the Spanish high-nature value cereal-steppe farming systems

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Abstract

The latest reform of the European Common Agricultural Policy (CAP) raised concerns regarding the future of low-productivity farming systems, which are often those most worthy of environmental conservation. In Spain, the conservation of the cereal-steppe avifauna, a community of European importance, relies on the continuity of low-intensity cereal systems and traditional cultivation patterns. In this interdisciplinary study we compare the effects of alternative support mechanisms on the economic output of representative farm types in one of the most remarkable cereal-steppe systems in Spain. Our results show a significant reduction of gross profit margins under the new CAP mechanisms in comparison to the previous support system and a derived risk of activity cessation. Consequent foreseeable changes in the activity patterns, such as farming abandonment or concentration of land by remaining farmers and intensification, would imply a deterioration of the current habitat structure for birds. We then consider the economic effects of implementing an agri-environmental scheme specifically designed for conserving the local cereal-steppe avifauna. Our results show that the application of this scheme could significantly contribute to prevent activity cessation and hence related undesired changes, enhancing at the same time the quality for birds of the farmed habitat in the area.

Keywords: Cereal systems; CAP reform; Steppe birds; Agri-environmental schemes; Spain

1. Introduction

Cereal cultivation systems occupy around 38% of the utilised agricultural area (UAA) in the *mesetas* (plateaus with an average altitude of 600 m) of central Spain and in the Ebro and Guadalquivir river basins (MAPYA, 2005). The flat or slightly undulating topography, open spaces, fields of dry (i.e. non-irrigated) crops and sparse vegetation of these landscapes recall the true steppes of Russia and central Asia, with which they share some biogeographic features. However, their different species composition and soil type, combined with their Mediterranean continental climate (with annual rainfall averaging less than 600–700 mm), clearly set the Spanish cereal-steppes apart (Suárez et al., 1992).

Traditional land use has produced a dynamic agricultural mosaic comprising non-irrigated arable crops and fallow land. Typical rotations have a three-year cycle, with barley, wheat or sunflowers in the first year, followed by fallow in the second, and legumes (lucerne or vetch) in the third year. Stubble from previous crops is left through the autumn and then incorporated into the soil together with dung (chiefly from sheep) to enhance its organic content (Caballero, 2001). Fallow is a short-term non-crop situation traditionally employed to cope with the low productivity of the system. Average cereal yield is 2500 kg/ha compared with 6000 kg/ha in the European Union (EU) as a whole (Tió, 1991). The duration of fallow periods varies according to rainfall and soil fertility, averaging 1–3 years, during which fallow plots

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are ploughed-up in late autumn for weed minimisation and soil aeration. Its total extent is, in any event, very significant, comprising almost 7.5% of national UAA (MAPYA, 2005).

The system has been characterised as low-intensity (Bignal and McCracken, 1996), in the sense that it uses low fertilisers and agrochemicals inputs per hectare and maintains scattered non-cropped areas: fallows of different age, field borders and permanently abandoned plots. The variable duration of fallows in different plots and the resulting variety in density and species composition of colonising weeds, results in both spatial and temporal landscape diversity. This heterogeneity in habitat structure is positively linked to diversity and abundance of birds, which make use of the different agricultural substrata (including cereal and legume crops) during the breeding and winter seasons (Suárez et al., 1997). In fact, these farming systems are considered to be of high-nature value (EEA, 2004), mainly due to the presence of important populations of bird species, adapted to the dynamic agricultural mosaic, that are declining throughout Europe (Suárez et al., 1997). Up to 15 bird Special Protection Areas (SPAs) have been designated under the European Union's Birds Directive to protect these assets (MMA, 2004).

Cereal-steppes have been affected by the same dual processes of intensification (in areas of higher potential productivity) and abandonment (in the least productive and marginal land), which have characterised Spanish agriculture during recent decades (Barceló et al., 1995). Both, intensification (Díaz et al., 1993) and abandonment (Díaz and Tellería, 1994) of farming practices, imply a deterioration in the optimum habitat structure and quality for cereal-steppe birds, which show a continued decline in recent decades (Santos and Suárez, 2005). Since 1993, agri-environmental schemes have been implemented in Spain (Oñate et al., 1998), but design deficiencies and insufficient uptake have prevented clear effects on cereal-steppe birds (Primdahl et al., 2003; Llusia and Oñate, 2005; Kleijn et al., 2006).

The latest 2003 CAP reform has introduced additional uncertainty regarding the future of these systems. In the past, the more farmers produced the more subsidy payments they received. Under the new system farmers still receive direct income payments, but severing the link between subsidies and production, which is usually termed 'decoupling'. Furthermore, payments have been reduced by some 5%, which is termed 'modulation'. Although from an environmental point of view the reform is intended to dissuade agricultural intensification, activity cessation has been raised by different countries as a parallel and undesired risk (FAPRI, 2003; Ministerio de Agricultura, 2003), faced particularly by smaller farms, where gross profit margins are already almost outstripped by production costs. Cessation of activity is more than a possibility in Spain (MAPYA, 2002; Arnalte and Ortiz, 2003), forcing either land abandonment or the release of land to be used up, by the way of renting, by professional and well equipped farmers with expansive strategies of specialisation and intensification. In either case – abandonment or intensification – further degradation of the current habitat structure for cereal-steppe birds could be expected. Trying to prevent these impacts, a 'partial decoupling' option has been adopted in Spain to apply from 2006, by maintaining 25% of arable crop payments coupled to production. Nevertheless, concern for the conservation of the valuable communities of cereal-steppe birds remains (Oñate, 2005), mainly due to the lack of specifications involving crop rotations among the range of 'good agricultural and environmental conditions' to which payments are now subjected (i.e. cross-compliance; annexes III and IV to EC, 2003; BOE, 2004).

In this study we compare the effects of the previous and new support mechanisms in terms of the economic results of representative farm types in the cereal-steppe system at Tierra de Campos (Castilla y León, central Spain). In view of the likely future impact of the new mechanisms on traditional cultivation patterns in the area, we propose an agri-environmental scheme with measures specifically designed for the conservation of cereal-steppe birds in the area, which economic output for the different farm-types is simulated. Finally, the interest of this scheme is discussed in relation to the environmental goal of maintaining the traditional low-intensity system.

2. Study area

Tierra de Campos is located in the clay-rich countryside of Castilla y León region (central Spain) and extends across the districts (division equivalent to NUTS 4-level) of Tierra de Campos (Valladolid province), Campos (Palencia), Campos-Pan (Zamora) and Esla-Campos and Sahagún (León) (Fig. 1). This is an EU less-favoured area covering nearly 1 million ha, which constitutes a prime example of the Spanish cereal-steppe systems. According to the 2002 CAP subsidy applications database (maintained by the Regional Ministry of Agriculture), dry arable crops are present in 92% of the 16,844 holdings within the study area, covering 81% of the UAA (including 22% of fallow). Minority are irrigated land, horticulture, vineyards and other permanent crops. Average farm size is just of 53.2 ha, and the mosaic landscape is reflected in the small average area of plots, which is 2.15 ha. Sheep are reared on 13% of the farms.

The Cereal Steppes Agri-environmental Programme (hereafter CSAP) was set up during the 1993–1999 rural development programming period. In 2000, the final year for signing-up to the scheme, 2,614 farmers were involved, affecting near 13% of the study area at a total cost of 21.4 million € (Paniagua, 2001). The CSAP was not included in the 2000–2006 national programme (MAPYA, 2000), partly because it did not fit with the horizontal approach of the new programme (based on a large menu of measures available across the whole country), and partly because it included an specific payment per hectare of legu-

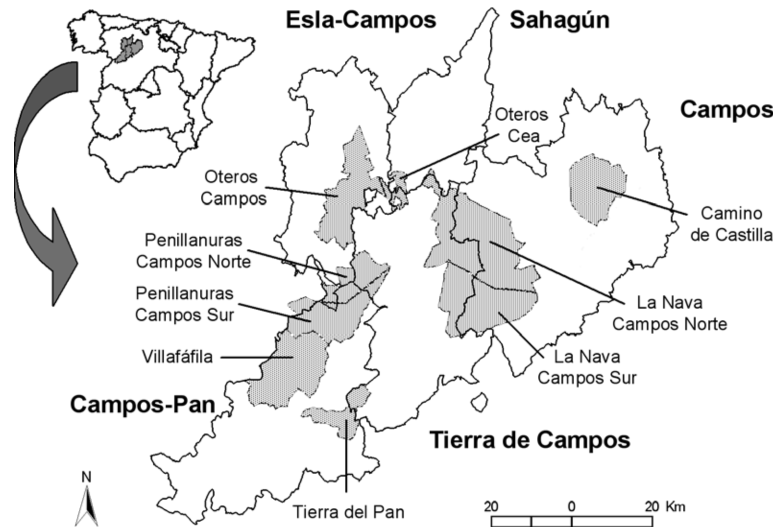

Fig. 1. Location of the study area in the Castilla y León province, comprising five districts (bold) and nine bird Special Protection Areas (dotted).

minous crops, which was perceived as a production incentive during the programme evaluation at the European Commission level. Measures taken by this scheme were all oriented towards the enhancement of the local habitat of the Great Bustard (*Otis tarda*; Oñate and Álvarez, 1997), a species classified as *vulnerable* (i.e. considered to be facing a high risk of extinction) at a global level by the IUCN (Baillie et al., 2004). This is an especially noteworthy species, with 46% of the Spanish population of 23,000 birds (which is 60% of the global population) inhabiting Castilla y León (Alonso et al., 2003). But equally *vulnerable* at a global level is the Lesser Kestrel (*Falco naumanni*), a species which is highly sensitive to changes in farming practices (Tella and Forero, 2000). Further, two species are classed as *vulnerable* at a European level (Burfield and van Bommel, 2004): the Little Bustard (*Tetrax tetrax*), for which the area is a European stronghold (De Juana and Martínez, 1996), and the Eurasian Thick-knee (*Burhinus oedicnemus*), which has a small local population (Jubete, 1997). Other local species with *declining* European status and *vulnerable* in Spain are the Black-bellied Sandgrouse (*Pterocles orientalis*), the Pin-tailed Sandgrouse (*Pterocles alchata*), the Calandra Lark (*Melanocorypha calandra*) and the Short-toed Lark (*Calandrella brachydactyla*) (Madroño et al., 2004). The importance of this bird community is further reflected in the nine SPAs declared in the area (Fig. 1), covering almost 20% of the surface (MMA, 2004).

3. Methods

The effects of three alternative support mechanisms (scenarios) on the economic output of representative farm types in Tierra de Campos have been compared by means of mathematical programming models. This requires the definition of farm-types and scenarios, the specification of the model and the simulation of consequences.

3.1. Definition of farm-types

Three groups of representative farm types were established by means of the 2002 CAP subsidy applications database (hereafter CAP database) and on the basis of their land use: dry land, dry land plus irrigated land and dry land with sheep rearing. Jointly, these three types represent 75.8% of all farms in the study area, 88.8% of dry land surface and 89.6% of farms still engaged in the CSAP. Each type was further subdivided according to farm size, resulting finally in 25 farm types (Table 1).

3.2. Scenarios

Considered support mechanisms correspond respectively to the ‘previous support system’ for producers of certain arable crops (EC, 1999), the system of ‘total decoupling’ of subsidies from production (EC, 2003), and the current ‘partial decoupling’ system adopted for arable crops in Spain (BOE, 2005). In addition, a newly designed agri-environmental scheme specifically targeting bird’s conservation in the study area has been considered.

Under the previous support system, dry arable crops attracted aid per hectare of 63 €/ton × district yield, which was established in Spain according to district reference yields and fallow indexes (Table 1). Farms still engaged in the four-year contracts of the CSAP are granted with a yearly general premium of 24.45 × district yield + 11.06 €/ha, plus a premium of 163.9 €/ha for lucerne, legumes, fodder crops or clover. Payments under the CSAP have been used to validate the initial specifications of the model (see Section 3.3.2).

Single farm payments under the total decoupling system have been estimated from the CAP database. Starting from the aggregated data of farm types, we have calculated the part of each single payment allocated to crops, the part allocated to set-aside land and the specific

Table 1
Characteristics of the 25 farm types considered in the study

District and province (yield; FI)[a]	Code	Orientation[b]	Representative farm size threshold (ha)	Average dry land area (ha)	Representation			Current crops in rotation (% farm dry land area)				
					N[c]	% C[d]	% A[e]	Cereals[f]	Sunflower	Vetch	Lucerne	Set-aside[g]
Tierra de Campos Valladolid (2.5; 10)	V.1.1	D	<90	45	1394	21.50	5.19	70.75	10.10	3.67	3.02	12.45
	V.1.2	D	90–170	130	276	22.10	5.33	66.10	11.57	5.19	3.34	13.79
	V.1.3	D	>170	240	137	22.02	5.32	64.87	11.37	5.75	3.96	14.06
	V.2	D & I	Single	110	214	7.50	1.81	67.40	8.12	5.24	2.47	16.78
	V.3	D & S	Single	75	291	7.68	1.85	54.59	3.93	7.90	25.67	7.91
Campos Palencia (2.5; 0)	P.1.1	D	<100	50	1411	17.05	5.54	81.44	4.44	3.80	1.25	9.07
	P.1.2	D	100-210	145	227	15.28	4.97	77.69	4.55	4.34	0.94	12.48
	P.1.3	D	>210	350	256	25.29	8.22	73.67	5.21	7.27	1.76	12.08
	P.2.1	D & I	<115	45	919	12.02	3.91	77.36	3.07	4.24	1.65	13.68
	P.2.2	D & I	>115	130	210	12.69	4.12	78.13	2.54	3.42	1.17	14.74
	P.3	D & S	Single	70	210	3.57	1.16	62.96	2.12	12.88	13.17	8.87
Campos-Pan Zamora (2.2; 40)	Z.1.1	D	<50	30	1794	22.38	5.34	76.84	7.14	1.83	1.91	12.27
	Z.1.2	D	50–110	75	506	23.94	5.72	71.62	7.55	1.75	0.50	18.58
	Z.1.3	D	>110	160	210	22.01	5.25	67.84	9.70	2.94	2.13	17.40
	Z.2.1	D & I	<55	20	389	3.48	0.83	66.46	9.69	2.90	0.59	20.35
	Z.2.2	D & I	>55	80	86	4.09	0.98	65.63	5.93	3.98	1.73	22.74
	Z.3	D & S	Single	55	340	6.48	1.55	53.77	1.88	8.86	26.40	9.10
Esla-Campos León (2.2; 30)	E.1.1	D	<120	65	504	24.12	2.61	61.71	1.52	12.31	1.72	22.73
	E.1.2	D	>120	190	89	23.84	2.58	65.43	3.60	7.55	2.48	20.93
	E.2.1	D & I	<65	20	613	9.81	1.06	53.27	2.01	13.49	1.47	29.76
	E.2.2	D & I	>65	100	105	12.40	1.34	50.42	3.74	12.51	2.02	31.31
	E.3	D & S	Single	50	100	6.55	0.71	50.98	2.21	18.07	14.70	14.04
Sahagún León (2.2; 30)	S.1.1	D	<90	50	450	25.34	2.19	68.60	0.08	12.87	0.38	18.08
	S.1.2	D	>90	145	102	25.54	2.21	72.53	0.05	8.07	0.86	18.49
	S.2	D & I	Single	65	154	11.27	0.98	58.92	0.00	16.38	0.58	24.12

[a] Reference yields (ton/ha) and fallow indexes (FI: % left in fallow) for the districts in the study area, according to the Regionalisation Plan.
[b] D: dry land; D & I: dry land plus irrigated land; D & S: dry land plus sheep rearing.
[c] Number of farms.
[d] Percentage of district dry land area.
[e] Percentage of dry land in the study area.
[f] Includes all grain-cereals.
[g] Includes all non-crop situations (compulsory and voluntary set-aside and traditional fallow).

payment to protein-rich crops. These amounts have been applied to the corresponding surface areas of the farm types. The three payments have been subject to modulation, subtracting an allowance of 5000 € from their total value and withholding 5% of the remainder, as stipulated for 2007 by EC (2003).

Under the partial decoupling system, payments for set-aside and protein-rich crops are the same as under the total decoupling system. The 25% of the payment per hectare of 63 €/ton × district yield has been applied to the area of arable crops (including voluntary set-aside) in each district, the remaining 75% figuring in the decoupled payment. Modulation applies as above.

In comparison to the previous CSAP and following the recommendations of Llusia and Oñate (2005), the main aim of the proposed agri-environmental scheme for biodiversity conservation is to increase habitat heterogeneity with a concentration of effort in the most valuable areas (i.e., the SPAs), but without neglecting the wider habitat mosaic of which they form part. In addition, its adoption could constitute an interesting complement to farm-income, helping to prevent activity cessation. The proposed scheme is structured in two tiers or complementary levels (Table 2). The first or 'Entry tier', with less demanding commitments by farmers and attracting lesser compensatory payments, applies throughout the study area. The second or 'Advanced tier', with additional and more-demanding commitments and attracting further payments, applies solely within the SPAs. Such a structure could be the most effective in terms of biodiversity conservation (Barret and Barret, 1996; Benton et al., 2003) and the most efficient regarding the use of the economic resources invested (Policy Commission, 2002).

Table 2
Commitments by farmers under the Entry and Advanced tiers of the proposed agri-environmental scheme

Entry tier	
(a)	Devoting at least 40% of farm area to fallow (traditional fallow and compulsory or voluntary set-aside) and leguminous crops (at least 5% each of fodder and grain legumes)
(b)	Retention of existing field boundaries, increasing their width to 1.5 m
(c)	Maintaining stubbles preceding fallows until the following Jan 31st
(d)	Neither pesticides nor herbicides to be applied to fallows
(e)	Nocturnal harvesting or sowing are prohibited
Advanced tier[a]	
(a)	Devoting 30% of farm area to fallow (traditional fallow and compulsory or voluntary set-aside). Half the fallow area to be retained unploughed for two seasons
(b)	Fodder and grain leguminous crops each to comprise 10% of farm area
(c)	10% of farm area to be devoted to oats
(d)	A minimum of 1 ha to a maximum of 5% of farm area to be set-aside from production for five years
(e)	Cereal straw to be shredded and left to cover at least 50% of stubbles
(f)	Only untreated seed to be used (AAA or AAB permitted)
(g)	Cereals not to be cropped before July 10th
(h)	Protective perimeters 25 m wide to be established around the maximum extents reached by existing wetlands and groundwater discharge sites. These to be separated from the surrounding land by ridges 1 m wide and 0.5 m high. The area within these ridges will be withdrawn from cultivation and will not be treated with agrochemicals
(i)	Protective perimeters 15 m wide to be established along the maximum extents reached by existing watercourses. These to be separated from the surrounding land by ridges 1 m wide and 0.5 m high. The area within these ridges will be withdrawn from cultivation and will not be treated with agrochemicals

[a] Also includes the Entry tier commitments, except (a).

3.3. Specifications of the model

Our approach is based on the method of Positive Mathematical Programming (PMP). PMP uses the farmer's crop allocation in the base year to generate self-calibrating models of agricultural production and resource use, in an optimisation approach that maximises an objective value of a total gross margin function. The central hypothesis of PMP is that resource allocations that are not constrained by resources or empirical constraints, result from first-order conditions of profit maximising behaviour. The most important contribution of PMP is that these types of models calibrate precisely to observed activity levels, but are free to respond to changes in competitive equilibrium induced by (among others) policy changes (Gohin and Chantreuil, 1999).

We have followed the PMP procedure devised by Howitt (1995) and employing declining marginal yield functions. Although different extensions of the PMP method have been recently developed (see Henry de Frahan, 2005; for a review and Röhm and Dabbert, 2003; for an specific extension in the field of agri-environmental programmes), limitations of available data lead us to use the standard version (as recently discussed by Howitt, 2005). In particular, we could not consider interactions between different farms (i.e. exchanging land; see Buysse and Van Huylenbroeck, 2005), since it would have required detailed data on production costs for every each farm in the area. Only information regarding the exact alternative of crops in each farm was available from the CAP database, which were complemented with data on average costs and technical coefficients for each farm type obtained by means of interviews with local farmers and technicians (see Appendix A). Therefore, and despite the possible implications regarding the results (which will be discussed later on) we decided to follow the standard PMP approach.

3.3.1. The model

The model starts from a linear sub-model where the objective function, farm's gross margin, is maximised:

$$\max \ \mathrm{GM} = \sum (p_c \times y_c - \mathrm{vc}_c + \mathrm{dp}_c) \times S_c \tag{1}$$

where p_c, y_c, vc_c, dp_c and S_c represent the price, yield, variable costs, direct payments per hectare and surface area allocated to each crop respectively. The objective function is subject to

$$S_C \leqslant H_{cc} \times S_C$$
$$\sum_C a_c^i \leqslant b^i \qquad (2)$$
$$r_0 \times \sum_{C^*} S_{C^*} \leqslant S_R \leqslant r_v \times \sum_{C^*} S_{C^*}$$

where H_{cc} is a $c \times c$ matrix of coefficients of crop succession, a_c^i represents the requirements of each crop c in terms of manpower per hectare, whilst b^i represents their availability (for $i = 1$, then b^1 = total crop area; for $i = 2, 3, 4$, then $b^{2,3,4}$ = available manpower during the most restrictive periods, which are autumn, spring and June), S_R is the area destined for set-aside, r_0 and r_v are the coefficients corresponding to compulsory and voluntary set-aside, and C^* the crops subjected to set-aside requirements (see Appendix A).

The objective function is also subject to an upper calibration constraint (Howitt, 1995):

$$S_c \leqslant \mathrm{Sup}_c \times 1.001 \qquad (3)$$

where Sup_c is the area devoted to each crop c in 2002 (see Section 3.3.2 for validation).

The linear sub-model feeds the PMP model, which objective function is

$$\max\ \mathrm{GM} = \sum [p_c \times (\beta_c - \delta_c \times \mathrm{NSL}_c) - \mathrm{vc}_c + \mathrm{dp}_c] \times \mathrm{NSL}_c \qquad (4)$$

where NSL_c is the new surface area destined for each crop, and β_c and δ_c are the coefficients of marginal yield function of each crop (Howitt, 1995). The model is subject to the same constraints as the linear one, except for the upper calibration constraint.

To simulate the proposed agri-environmental scheme, the objective function is transformed to include the corresponding payments, AP:

$$\max\ \mathrm{GM} = \mathrm{AP} \times b^1 + \sum [p_c \times (\beta_c - \delta_c \times \mathrm{NSL}_c) - \mathrm{vc}_c + \mathrm{dp}_c] \times \mathrm{NSL} \qquad (5)$$

Some scheme commitments introduce changes in technical coefficients (Entry tier, commitments (c) and (d); Advanced tier, commitments (d) to (f); see Appendix A, Table A1) as well as new restrictions. Incorporated restrictions for the Entry tier, are

$$\sum \mathrm{NSL}_c \leqslant 0.99 \times b^1 \ \text{(commitment b)} \qquad (6a)$$
$$\mathrm{NSL_F} + \mathrm{NSL_P} + \mathrm{NSL_A} \geqslant 0.40 \times \sum \mathrm{NSL}_c \ \text{(commitment a)} \qquad (6b)$$
$$\mathrm{NSL_A} \geqslant 0.05 \times \sum \mathrm{NSL}_c \ \text{(commitment a)} \qquad (6c)$$
$$\mathrm{NSL_P} \geqslant 0.05 \times \sum \mathrm{NSL}_c \ \text{(commitment a)} \qquad (6d)$$

where $\mathrm{NSL_F}$, $\mathrm{NSL_P}$ and $\mathrm{NSL_A}$, correspond respectively to the areas assigned to fallow, grain legumes and lucerne respectively. Incorporated restrictions for the Advanced tier are

$$\mathrm{NSL_F} \geqslant 0.3 \times \sum \mathrm{NSL}_c \ \text{(commitment a)} \qquad (7a)$$
$$\mathrm{NSL_A} \geqslant 0.1 \times \sum \mathrm{NSL}_c \ \text{(commitment b)} \qquad (7b)$$
$$\mathrm{SNL_P} \geqslant 0.1 \times \sum \mathrm{SNL}_c \ \text{(commitment b)} \qquad (7c)$$
$$\mathrm{NSL_O} \geqslant 0.1 \times \sum \mathrm{NSL}_c \ \text{(commitment c)} \qquad (7d)$$

where $\mathrm{NSL_O}$ corresponds to the area assigned to oats.

Commitments (e) in the Entry tier and (g), (h) and (i) in the Advanced tier (see Table 2) have not been incorporated in the model, partly because they do not match the average circumstances of the farm types, partly because they involve temporal limitation in farm practices whose cost-repercussions are difficult to estimate, partly because they affect a limited number of plots of each farm type. Nevertheless, they are considered in the model by the introduction of an increase in the payments necessary for adopting the scheme obtained in the simulations.

3.3.2. Model validation

The CAP database was used to validate the model. Introducing the observed crops in the database under the upper calibration constraint of the linear sub-model (Eq. (3) above) the PMP model was run, providing exactly the same solution to that observed in the database. In addition, the existence of the CSAP permitted us a second check, given that including the restrictions associated with this scheme the model generates an alternative cultivation regime which should coincide with that declared in the applications of the farms participating in the CSAP. In other words, the model is validated by comparing the differences between actual and simulated alternatives, both for farms participating and not participating in the CSAP. To undertake this second check, commitments from the CSAP were introduced as restrictions in the PMP model (Eqs. (6) above), while the CSAP payments were included in the objective function (Eq. (5) above). The results from this simulation were then compared with the observed crops in the CAP database for farms participating in the CSAP. This comparison provided a good test of the model performance when simulating the CSAP, which, from the modelling point of view, is equivalent to our proposed scheme. Considering the sum of the differences between the observed area for each crop and the modelled solution in the 25 farm types, the resulting mean error was weighted at 3.4% for the entire study area. This was considered an acceptable margin of error comparing with usual statistical standards ($p < 0.05$) and therefore the model was thought to be valid to simulate the alternative scenarios.

3.4. Simulation of responses

The objective is to obtain the economic outcome corresponding to land use in the different farm types under the considered scenarios and compare them with the outcome considering the application of the proposed agri-environmental scheme. Regarding the latter, it is first necessary to calculate the minimum payments required to encourage its adoption by farmers. This is done in two stages.

First, the model is applied under the conditions of each scenario, generating two types of result of interest: On the one hand, the gross profit margin for each farm type obtained under each scenario without involving the proposed scheme; On the other hand, the gross profit margins obtained under each scenario but considering the scheme's commitments. A comparison of both results allows a calculation of the minimum payments which farmers should receive to compensate for implementing the measures required under the proposed scheme if they are to obtain the same gross profit margins as non-participants.

In a second stage, the established minimum compensatory payments are included in the model, allowing a recalculation of the results for each scenario and farm type. We assume that the amount of the minimum payments will determine the uptake rate to the proposed scheme; i.e., each farmer will enter the scheme if by doing so he/she obtains higher gross profit margins than from non-participation. We also assume that all existing farms of a given type in a given district will follow the same behaviour (scheme uptake and cropping practices) as the type represented in the model. Therefore, a district-wide extrapolation of uptake rate and crop changes can then be made, on the basis of which results are obtained related to the costs of implementing the scheme and to the foreseeable changes in crop distribution.

Table 3
Gross profit margins (€/ha) for each farm type under the considered scenarios, without scheme

Farm type[a]	Previous support system	Partial decoupling		Total decoupling	
		Total[b]	Production[c]	Total[b]	Production[c]
V.1.1	198.7	198.3	89.35	198.5	49.09
V.1.2	196.3	193.2	84.74	191.8	47.33
V.1.3	198.0	192.8	85.47	193.2	50.09
V.2	188.6	184.9	74.69	185.0	38.14
V.3	195.1	191.3	110.66	195.4	85.73
P.1.1	148.4	148.7	46.50	150.4	15.80
P.1.2	147.5	142.9	43.30	143.5	21.40
P.1.3	147.2	142.1	44.00	142.8	12.20
P.2.1	146.6	146.2	43.30	146.9	11.60
P.2.2	146.5	142.4	43.00	143.0	11.20
P.3	139.7	148.0	45.80	149.8	15.20
Z.1.1	141.8	142.9	53.40	143.6	24.30
Z.1.2	138.3	135.9	46.70	136.1	18.30
Z.1.3	139.5	136.0	49.70	136.5	22.00
Z.2.1	138.6	139.3	49.20	139.5	19.70
Z.2.2	137.8	135.9	47.60	136.3	19.70
Z.3	139.0	148.8	59.30	154.1	34.80
E.1.1	132.8	124.6	45.80	123.2	19.40
E.1.2	132.4	127.9	46.20	128.4	19.90
E.2.1	130.2	127.8	42.30	129.6	15.70
E.2.2	129.2	125.0	41.60	127.9	17.50
E.3	144.3	145.2	70.60	149.1	49.60
S.1.1	145.6	145.5	63.95	147.3	32.94
S.1.2	146.5	143.1	66.51	145.5	34.79
S.2	139.7	141.3	58.92	146.7	26.57

[a] Codes as in Table 1.
[b] Total gross profit margin.
[c] Gross profit margin dependent on production (resulting from sale of commodities).

4. Results

4.1. Economic output under scenarios, without the proposed scheme

Our results illustrate the likely limitations imposed by decoupling (whether total or partial) on production-dependent gross profit margins (i.e. that resulting from sale of commodities; Table 3). It is significant to note the closeness between the mean and minimum gross margins in all farm types and for all three scenarios (Fig. 2).

Although no negative results are obtained, the likely reduction in gross profit margins under the total decoupling scenario raises doubts about the potential of this support system for maintenance of agricultural activity in all farm types, excepting the more productive ones at the district of Tierra de Campos (farm types V.1.1 to V.3). Considering that production costs in Spain may reach 109 €/ha (MAPYA, 2005), the risk of activity cessation seems

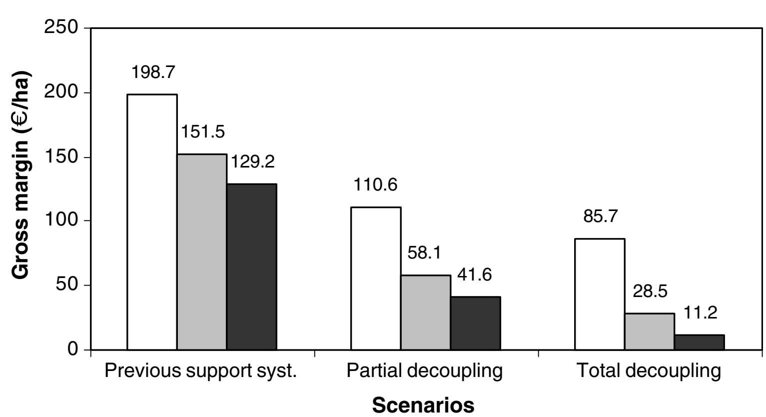

Fig. 2. Maximum (white columns), average (grey) and minimum (black) production-dependent gross profit margins (€/ha) for all farm types under each scenario.

clear for those farms with production margins below 50 €/ha. Production under the partial decoupling scenario gives better economic returns, especially in this same district. Under this support system the highest risks of activity cessation would arise in the districts of Campos (farm types P.1.1 to P.3), Esla-Campos (E.1.1 to E.2.2) and Campos-Pan (Z.1.2 to Z.2.2).

4.2. Calculation of minimum payments

As stated above, the differences between the gross profit margins obtained by each farm type under the considered scenarios (Table 3) and those which would be obtained if the commitments of the proposed scheme were adopted, indicate the minimum payments needed in each case to compensate for the costs of up-taking the scheme (Table 4). These amounts are smaller under any decoupling scenario than under the previous support system for both tiers of the scheme, although the differences are less pronounced under the Advanced tier.

As might be expected, there are slight differences among farm types as to the required compensatory payment. These seem to result from how similar the crop rotations existing in each farm type are to those required by the scheme, and from yield differences among districts (see Table 1). In particular, farms with sheep (types V.3, P.3, Z.3 and E.3), which already plant more lucerne, attract smaller minimum payments than other farm types, especially under the Entry tier of the proposed scheme. Faced with the possibility of establishing different compensatory payments for different districts or farm types, an option that would greatly complicate the administration of the scheme (transaction costs), we have preferred to adopt a single payment for each tier of the scheme, even if this results in a small degree of over-compensation for some farm types.

Obtained payments have been incremented in 20 €/ha, both to cover the costs of those commitments not included in the model (see Section 3.3.1) and to provide an incentive to encourage adoption of the scheme.

Final payments selected for the Entry tier are 60 €/ha under the previous support system scenario and 40 €/ha under both decoupling scenarios. In either case, these payments are lower than those offered by the CSAP, which ranged between 65 and 72.5 €/ha. Final payments selected for the Advanced tier are 60 €/ha in addition to the Entry tier payments, for all three scenarios.

4.3. Economic output under scenarios, with the proposed scheme

4.3.1. Economic results

Total gross profit margins are higher for all farm types adopting the proposed scheme than those for non-adopters, irrespective of scenario (Table 5). As expected, the results for mixed farms with sheep (V.3, P.3, Z.3 and E.3) are slightly better than for remaining farm types, reflecting certain over-compensation. Apart from these cases,

Table 4
Minimum compensatory payments (€/ha) under each scenario required to offset the costs of adopting the proposed agri-environmental scheme

Farm type	Entry tier			Advanced tier[a]		
	Previous support system	Partial decoupling	Total decoupling	Previous support system	Partial decoupling	Total decoupling
V.1.1	41.5	26.8	22.5	58.7	50.6	51.2
V.1.2	38.0	22.5	18.1	59.1	51.8	53.4
V.1.3	36.8	21.1	17.4	53.5	50.0	51.4
V.2	38.4	22.4	15.3	64.9	58.8	64.4
V.3	19.5	7.6	6.1	35.1	45.3	45.1
P.1.1	19.8	19.1	8.8	45.3	39.0	40.8
P.1.2	25.2	23.0	21.4	42.4	55.2	48.3
P.1.3	21.7	19.7	8.9	45.2	47.3	19.0
P.2.1	21.6	17.1	19.0	47.1	41.0	40.7
P.2.2	23.7	21.9	20.7	55.1	52.6	44.3
P.3	14.2	10.4	8.9	28.0	25.0	19.0
Z.1.1	28.4	24.5	17.1	39.0	47.9	50.7
Z.1.2	30.5	22.4	17.0	40.3	37.4	37.2
Z.1.3	23.8	20.0	13.2	46.5	41.5	43.5
Z.2.1	31.4	26.4	18.2	31.1	54.8	60.1
Z.2.2	23.1	18.6	12.9	36.4	38.6	42.6
Z.3	10.1	7.0	1.7	18.5	14.5	5.6
E.1.1	16.0	12.6	10.5	56.9	51.3	47.5
E.1.2	16.3	13.6	10.5	51.1	46.0	43.1
E.2.1	19.5	15.7	11.8	68.9	74.8	57.1
E.2.2	21.7	17.7	12.6	78.4	73.0	73.9
E.3	9.5	7.9	7.0	37.8	35.2	34.2
S.1.1	29.0	23.4	21.4	16.7	10.4	10.2
S.1.2	19.5	14.2	14.1	25.8	21.1	20.2
S.2	18.8	13.6	16.2	22.8	16.6	14.8

[a] Advanced tier payments are additional to those of the Entry tier.

Table 5
Gross profit margins (€/ha) for each farm type under the considered scenarios, without scheme

Farm type	Previous support system			Partial decoupling			Total decoupling		
	Without[a]	ET[b]	AT[c]	Without[a]	ET[b]	AT[c]	Without[a]	ET[b]	AT[c]
V.1.1	198.7	225.8	221.3	198.3	208.3	212.7	198.5	209.8	216.5
V.1.2	196.3	227.3	227.7	193.2	207.7	214.0	191.8	207.5	215.4
V.1.3	198.0	230.3	234.5	192.8	208.5	217.4	193.2	210.4	220.1
V.2	188.6	219.3	211.5	184.9	194.9	198.3	185.0	200.8	201.8
V.3	195.1	227.7	249.3	191.3	220.3	225.5	195.4	225.9	237.3
P.1.1	148.4	188.0	199.7	148.7	169.2	217.6	150.4	172.2	221.4
P.1.2	147.5	181.7	216.2	142.9	159.5	182.9	143.5	161.7	208.5
P.1.3	147.2	184.7	188.3	142.1	162.0	201.9	142.8	163.8	211.2
P.2.1	146.6	184.4	329.1	146.2	165.7	273.5	146.9	167.5	216.0
P.2.2	146.5	182.2	220.0	142.4	160.1	193.3	143.0	161.9	208.8
P.3	139.7	177.1	188.1	148.0	177.0	211.8	149.8	185.4	239.1
Z.1.1	141.8	174.3	175.7	142.9	165.3	169.8	143.6	171.4	173.9
Z.1.2	138.3	170.9	172.3	135.9	142.4	167.9	136.1	139.3	164.4
Z.1.3	139.5	169.5	179.7	136.0	160.9	166.6	136.5	157.4	169.4
Z.2.1	138.6	154.1	163.3	139.3	157.6	167.1	139.5	154.5	163.7
Z.2.2	137.8	164.1	174.0	135.9	162.1	171.9	136.3	173.4	183.8
Z.3	139.0	173.6	184.0	148.8	172.1	182.4	154.1	188.4	199.7
E.1.1	132.8	176.8	179.9	124.6	151.9	160.7	123.2	151.5	152.2
E.1.2	132.4	176.1	185.0	127.9	153.7	168.3	128.4	155.1	171.2
E.2.1	130.2	170.6	161.7	127.8	152.1	152.6	129.6	155.2.	158.7
E.2.2	129.2	147.5	149.1	125.0	147.3	148.8	127.9	148.8	150.3
E.3	144.3	194.5	216.8	145.2	177.3	202.1	149.1	182.0	207.7
S.1.1	145.6	153.0	219.9	145.5	152.2	211.8	147.3	165.8	215.7
S.1.2	146.5	176.3	221.2	143.1	168.9	207.9	145.5	170.7	238.1
S.2	139.7	167.2	206.5	141.3	167.8	211.1	146.7	176.2	242.0

[a] Non-participants in the proposed scheme, as in Table 3.
[b] Adopting the Entry tier of the proposed scheme.
[c] Adopting the Advanced tier of the proposed scheme.

selected payments seem to adjust to our initial purpose of compensating farmers for incurred costs (both included and not included in the model) of adopting the scheme, offering at the same time a modest incentive. Higher payments would clearly be an over-compensation, while lower ones would result in lower uptake. Therefore, and independent of other factors that could affect willingness to participate in the scheme (see Wilson and Hart, 2000 for a discussion), selected payments would be the minimum ones to secure its maximum uptake.

On the basis of this assumption, the cost of applying the scheme, both in its Entry and Advanced tiers, may be calculated (Table 6). Annual cost of the Entry tier under the previous support system scenario would reach nearly 31 million €, involving 520,100 ha (80.8% of the total dry land surface in the study area). Under either decoupling scenario (both with the same simulated payments), cost would fall to little more than 20.8 million €, with the same area involved. This cost would be also somewhat less than that of the CSAS (21.4 million € in 2000), despite involving a much larger area (520,100 ha vs. 215,000 ha; Paniagua, 2001). Annual cost of the Advanced tier, which applies exclusively within the existing SPAs, would slightly exceed 16 million €, involving 251,283 ha (75.5% of the total dry land area in the SPAs).

The total annual cost for both tiers of the proposed scheme combined would rise to 47.3 million € under the previous support system scenario and to 36.8 million €

Table 6
Maximum annual cost of the Entry tier (Districts) and Advanced tier (Bird Special Protection Areas, SPAs) of the proposed agri-environmental scheme in the study area

	Dry land surface (ha)[a]	Uptake rate (%)[b]	Cost (thousand €)	
			Previous support system[c]	Decoupling[d]
Districts. Entry tier				
Tierra de Campos	155,403	80.8	7533.9	5022.6
Campos	209,265	85.9	10,785.5	7190.3
Campos-Pan	153,707	82.4	7599.3	5065.9
Esla-Campos	69,727	76.7	3208.8	2139.8
Sahagún	55,705	62.2	2078.9	1384.8
Total Entry tier	643,807	80.8	31,206.4	20,803.4
SPAs. Advanced tier				
Otero-Campos	46,279	81.1	2251.9	2251.9
Otero-Cea	14,706	59.1	521.8	521.8
La Nava-Campos Norte	88,355	58.7	3113.5	3113.5
La Nava-Campos Sur	49,507	86.2	2560.2	2560.2
Penillanuras-Campos N	22,735	73.9	1008.9	1008.9
Penillanuras Campos S	34,661	77.2	1605.0	1605.0
Villafáfila	30,390	85.4	1557.2	1557.2
Camino de Santiago	23,083	89.2	1234.8	1234.8
Tierra del Pan	23,111	88.0	1219.7	1219.7
Total Advanced tier	332,826	75.5	16,073.0	16,073.0

[a] Total extent of dry crops across all farm types in each district or SPA.
[b] Representation of the defined farm types within each district or SPA.
[c] Differential cost only for the Entry tier.
[d] The cost is the same under all scenarios, given that the simulated payment does not change.

under either decoupling scenario. Although these are larger sums than those incurred by the CSAP in 2000, the proposed scheme would also provide clearly higher social and environmental benefits for Tierra de Campos. Reducing the risks of agricultural activity cessation would provide not only social benefits, helping to retain rural population, but also environmental ones, helping to maintain and even enhance the mosaic habitat of land uses and crop types on which cereal-steppe avifauna is dependant.

4.3.2. Changes in crop distribution

Expected crop changes resulting from adoption of the Entry tier, assuming maximum uptake (i.e. 520,100 ha), have a similar pattern under all three scenarios (Fig. 3). The likely decline in extent of cereals is noteworthy: to 245,591 ha under the partial decoupling scenario (15.17% less than if the scheme were not adopted) and to 243,927 ha under total decoupling (13.05% less). There would also be important increases in lucerne, which would occupy 81,344 ha (9.64% more) and 82,852 ha (10.44% more) under the same scenarios respectively, and also in vetch, which would increase to 44,572 ha (4.92% more) and 43,844 ha (5.66% more) respectively. Regarding set-aside, its extent would increase to 106,204 ha under the partial decoupling scenario (1.78% more), but would decrease to 107,140 ha under total decoupling (4.04% less).

Crop changes resulting from the adoption of the Advanced tier within the SPAs, assuming maximum uptake (i.e. 251,283 ha), are generally more marked (Fig. 4). Cereal cover would be 66,891 ha under the partial decoupling scenario (30.0% less than if the scheme were not adopted) and 63,424 ha under total decoupling (33.27% less). There would also be important increases in set-aside, to 87,095 ha (12.56% more) and 87,220 ha (13.02% more) under the same scenarios respectively, and in lucerne, which would increase to 35,682 ha (8.43% more) and 41,135 ha (10.07% more) respectively. Although less important, there would also be increases in vetch, to 24,048 ha (4.22% more) under the partial decoupling scenario and 22,942 ha (3.80% more) under total decoupling, and in oats, to 27,742 ha (5.06% more) and 24,651 ha (3.78% more) respectively. The extent of sunflowers would slightly decline to 9976 ha under the partial decoupling scenario

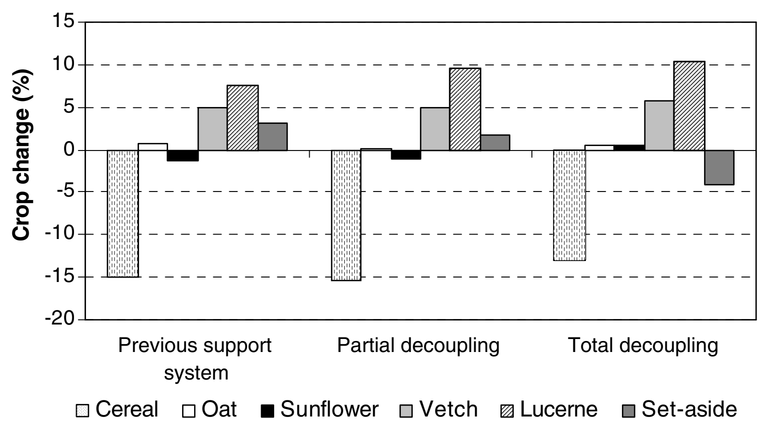

Fig. 3. Expected changes in crop distribution (as % of total dry land area) under the three scenarios, with the adoption of the Entry tier of the proposed scheme (set-aside comprises compulsory set-aside, fallow and abandoned land).

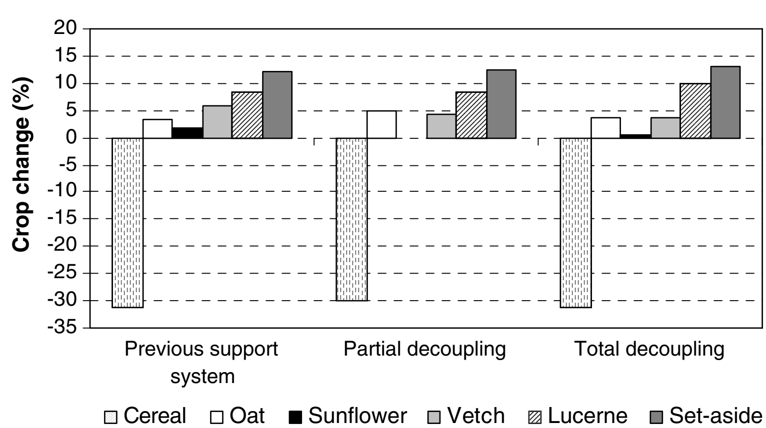

Fig. 4. Expected changes in crop distribution (as % of total dry land area) under the three scenarios, with the adoption of the Advanced tier of the proposed scheme (set-aside comprises compulsory set-aside, fallow and abandoned land).

(0.21% less) but would increase to 11,835 ha under total decoupling (0.58% more).

All these changes are in line with the record of farmers' commitments under both entries of the proposed scheme (see Table 2). The objective was to maintain the traditional mosaic of land uses and crop types, re-balancing in its case the weight of leguminous crops (vetch and lucerne) and short-term non-cropped surfaces (fallow and set-aside) at the expense of cereals and sunflower, while at the same time maintaining farm-income. Expected crop changes satisfy this objective, achieving a more equitable balance between crop types, which is further reinforced in the Advanced tier case, with greater increases in oats.

5. Conclusions

The prognosis of the environmental effects of decoupling by environmental NGOs has been far from clear. Optimistic views value the 'de-intensification' trend that the reform would trigger (e.g. BirdLife, 2003), but concerns about biological impoverishment linked to the foreseeable decline in agricultural activity in some areas have also been raised (e.g. EFNCP, 2004). In this study we have dealt with the likely changes in agricultural activity patterns that decoupling may drive, impacting low-intensity cereal systems and their natural values.

Under either alternative to the previous support system considered, total or partial decoupling, our results suggest a significant reduction in profit margins derived from agricultural activity for most farm types in Tierra de Campos. Faced with this situation, the most rational response by farmers would be to adopt a strategy of cost-minimisation, which could lead to a total activity cessation or perhaps a drastic expansion of fallows at the expense of arable crops. Another feasible possibility would be the release of land to be used up, by the way of renting, by professional and well equipped farmers with expansive strategies of specialisation. Given their dependence on the traditional mosaic of varied crops and short-term non-cropped surfaces, the cereal-steppe birds would be adversely affected, yet due to generalised decrease of arable crops following abandonment, yet due to agricultural intensification following land concentration.

As far as land transfers have not been not simulated in the model, our results must be cautiously interpreted as the maximum possible effects under either decoupling scenario. The possibility that land from farms ceasing their activities could be taken over by those farmers remaining in the area, reducing the risk of land abandonment, should not be discarded. However, it could be argued that the existence of very small differences in gross margins among modelled representative farms, related to the homogeneity of the area, would probably reduce the level of land transfers in an interactive model.

The current framework for cross-compliance in Spain is mainly limited to matters concerned with avoiding soil erosion and conserving soil structure and organic matter content. Since practices involving crop rotations have not been included among the requirements, it seems dubious that cross-compliance alone could prevent the deterioration of cereal-steppe habitats (Oñate, 2005). Under these circumstances, and given the requirements for habitat- and species-conservation imposed by European Directives, the implementation of agri-environmental schemes seems essential.

The scheme we propose would permit the future maintenance of low-intensity farming, ensuring financial returns similar to those obtained under the previous support system, without affecting the relative profitability of the various enterprises. At the same time, it would maximise environmental benefits of agriculture, thanks to the targeted and scientifically-sound design of the farmers' commitments, guaranteeing a basic level of environmental protection across the whole study area and a higher level for the most sensitive zones, such as the SPAs. Without considering transaction costs and assuming maximum uptake, our proposal would cost a total of 36.8 million € under either decoupling scenario.

It is the case that our proposal would cost less per hectare than the preceding CSAS. This added efficiency derives from the lower costs to farmers adopting the scheme under the decoupling scenarios. As we have seen, especially under the total decoupling scenario (and given the current "soft" cross-compliance conditions) activity cessation could be the most logical option for farmers, given that they can claim the decoupled payment even without farming. Adoption of the proposed scheme would not involve any loss of income (low opportunity cost). Hence, receiving the agri-environmental payment in addition to the decoupled payment comprises an attractive proposition, even if the former were reduced to only compensate for actual costs incurred.

Compared to the preceding CSAP, the proposed scheme could have greater chance to be successfully implemented. On the one hand, it avoids coupled payments for any specific crop, contrary to the CSAP with its specific payment per hectare of legumes. On the other hand, although the proposed scheme entails expenses increasing by 72% in comparison to the CSAP, the area involved increases by some 142%, resulting in enhanced efficiency. Moreover, it should be borne in mind that the available budget for such schemes could benefit in the next rural development programming period (2007–2013) from deductions resulting from modulation and from specific actions for the Natura 2000 network, which includes the SPAs.

Three aspects deserve further research efforts. Firstly, it would be interesting to model the effects of additional cross-compliance requirements specifically linked to the protection of cereal-steppe habitats for birds. Apart from largely preventing land abandonment, widening the baseline for cross-compliance would leave more money available for positive payments. However, higher administrative burden derived from the controls may be expected with this option, since disallowance risks to farmers would probably be higher. Secondly, additional data should be compiled in order to extend the model and simulate land transfers between farms under the specific implementation details of EC (2003) in Spain, recently known. Finally, it would also be equally interesting to consider the inclusion of agri-environmental commitments specifically involving herd animals, given that our study has shown that farms raising sheep have a high potential for developing optimal crop rotations.

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Appendix A. Technical coefficients used in the model

See Tables A1–A4.

Table A2
Labour availability (b^i: h) data adopted for different groups of farm types

Farm type	b^i		
	Autumn	Spring	June
V.1.3, P.1.3, Z.1.3, E.1.2	720	340	240
V.1.2, V.2, P.1.2, P.2, Z.1.2, Z.2.2, E.2.2, S.1.2	360	170	120
V.1.1, V.3, P.1.1, P.2.1, P.3, Z.1.1, Z.2.2, Z.3, E.1.1 E.2.1, E.3, S.1.1, S.2	180	85	60

Table A3
Rotation matrix (H_{cc}) between different crop types (rows and columns)

	Cereal	Sunflower	Vetch	Lucerne	Fallow
Cereal	1	1	1	1	1
Sunflower	1	0	0	0	1
Vetch	1	0	0	0	1
Lucerne	1	0	0	0	1
Fallow	1	1	1	1	1

Order in the rotation is not relevant.
1: Rotation feasible.
0: Rotation not feasible.

Table A1
Yield (y_c), price (p_c), variable costs (vc$_c$; vc$_{c*}$: under the proposed scheme) and labour time (a_c^i) data adopted for different groups of farm types

Farm type	Crop	y_c (ton/ha)	p_c (euro/ha)	vc$_c$ (euro/ha)	vc$_{c*}$ (euro/ha)	a_c^i (h/ha)		
						Autumn	Spring	June
V.1.3	Cereal	2.50	129.21	178.86	196.44	1.63	0.15	0.92
P.1.3	Sunflower	0.85	210.35	115.05	129.16	–	0.94	0.59
	Vetch	0.75	210.35	117.00	132.92	–	0.62	0.59
	Lucerne	3.82	108.18	92.99	100.43	0.92	–	2.70
	Fallow	–	–	15.83	17.09	0.47	0.47	–
V.1.2	Cereal	2.50	129.21	186.31	204.63	1.81	0.165	1.02
V.2	Sunflower	0.85	210.35	119.84	134.54	–	1.04	0.65
P.1.2	Vetch	0.75	210.35	121.88	138.46	–	0.69	0.65
P.2	Lucerne	3.82	108.18	96.86	104.61	1.02	–	3.00
	Fallow	–	–	16.49	17.80	0.52	0.52	–
V.1.1	Cereal	2.50	129.21	193.76	212.82	1.99	0.18	1.12
V.3	Sunflower	0.85	210.35	124.63	139.92	–	1.14	0.72
P.1.1	Vetch	0.75	210.35	126.76	144.00	–	0.76	0.72
P.2.1	Lucerne	3.82	108.18	100.73	108.79	1.12	–	3.30
P.3	Fallow	–	–	17.15	18.51	0.57	0.57	–
Z.1.3	Cereal	2.20	129.21	167.68	184.17	1.52	0.14	0.86
E.1.2	Sunflower	0.75	210.35	107.86	121.09	–	0.87	0.55
	Vetch	0.66	210.35	109.69	124.61	–	0.58	0.55
	Lucerne	3.36	108.18	87.17	94.15	0.86	–	2.52
	Fallow	–	–	14.84	16.02	0.44	0.44	–
Z.1.2	Cereal	2.20	129.21	175.13	192.35	1.70	0.16	0.96
Z.2.2	Sunflower	0.75	210.35	112.65	126.47	–	0.98	0.61
E.2.2	Vetch	0.66	210.35	114.57	130.15	–	0.65	0.61
S.1.2	Lucerne	3.36	108.18	91.05	98.33	0.96	–	2.82
	Fallow	–	–	15.50	16.73	0.49	0.49	–
Z.1.1	Cereal	2.20	129.21	182.58	200.54	1.88	0.17	1.06
Z.2.2	Sunflower	0.75	210.35	117.44	131.85	–	1.08	0.68
Z.3, E.1.1	Vetch	0.66	210.35	119.44	135.69	–	0.72	0.68
E.2.1, E.3	Lucerne	3.36	108.18	94.92	102.52	1.06	–	3.12
S.1.1, S.2	Fallow	–	–	16.16	17.44	0.54	0.54	–

Table A4
Set-aside coefficients

Compulsory set-aside (r_0)	0.10
Voluntary set-aside (r_v)	0.30
Crops subjected to set-aside requirements (C^{*})	Cereal and sunflower

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