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The effect of decoupling on marginal agricultural systems: implications for farm incomes, land use and upland ecology

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Abstract

In many parts of Europe, decades of production subsidies led to the steady intensification of agriculture in marginal areas, but the recent decoupling of subsidies from production decisions means that the future of farming in these areas is uncertain. For example, in the uplands of the United Kingdom, an area important both for biodiversity conservation and ecosystem service provision, hill farmers steadily increased stocking densities in response to headage payments but must now reconfigure farm businesses to account for the shift to the Single Farm Payment scheme. We examined hill farming in the Peak District National Park as a case study into the future of marginal agriculture after decoupling. We surveyed 44 farm businesses and from this identified six representative farm types based on enterprise mix and land holdings. We developed linear programming models of production decisions for each farm type to examine the impacts of policy changes, comparing the effects of decoupling with and without agri-environment and hill farm support, and evaluating the effects of removal of the Single Farm Payment. The main effects of decoupling are to reduce stocking rates, and to change the mix of livestock activities. Agri-environmental schemes mediate the income losses from decoupling, and farmers are predicted to maximise take up of new Environmental Stewardship programmes, which have both positive and negative feedback effects on livestock numbers. Finally, removal of the Single Farm Payment would lead to negative net farm incomes, and some land abandonment. These changes have important implications for ongoing debates about how ecological service flows can be maintained from upland areas, and how marginal upland farming communities can be sustained.

KEYWORDS: CAP reform, de-coupling, ecological-economic modelling, upland farming.

JEL codes: Q12, Q57.

1. **Introduction**

In many parts of Europe, decades of production subsidies led to the steady intensification of agriculture in marginal areas. However, the recent decoupling of subsidies from production decisions means that the future of farming in these areas is uncertain. European uplands are nationally and internationally important for biodiversity as well as being of significant landscape, archaeological, recreational and heritage value (Hanley et al, 2007). The UK uplands play a key role in supporting habitats and species of conservation concern (Ratcliffe & Thompson, 1988; Rodwell, 1991). However, large areas of upland habitat deteriorated throughout the last century (Anderson & Yalden, 1981; NCC, 1987; Tudor & Mackey, 1995), due in part to the steady intensification of hill farming (Anderson & Yalden, 1981). English Nature recently found that two thirds of the most valuable moorland areas in England are now in an unfavourable condition with historical and current overgrazing by sheep presenting the most common threat (English Nature, 2005).

Upland farming communities are also seen as being important to maintaining social capital, and for many years governments have offered additional supports to upland farmers in an attempt to sustain incomes, rural services and populations in these areas. The impacts of policy change on the uplands is thus of interest for both environmental and social reasons.

The Common Agricultural Policy (CAP) has been the most important land use policy within the EU. Production-based direct (headage) payments under the CAP provided an incentive for farmers to stock at high densities, which in some cases led to damage to natural and semi-natural vegetation through overgrazing. Problems of surplus accumulation and trade interventions were also important factors for reform of the CAP (HM Treasury & Defra, 2005). The CAP has since undergone a series of significant reforms, most recently those of Agenda 2000 (1999) and the Mid Term Review (June 2003 and April 2004). These reforms are phasing out production-linked support and protection ("de-couling"), and re-targeting support on environmental and rural development outcomes. In 2005, the Single Farm Payment scheme (SFP) was introduced, replacing most existing crop and livestock payments. The SFP is planned to be progressively reduced and phased out (HM Treasury & Defra, 2005), being currently only guaranteed until 2013.

Hill-farmers have come to depend on subsidy programmes additional to those received by farmers outside the uplands, such as the Hill Farm Allowance (HFA), and on payments from agri-enviroment schemes (AES). These programs are also in flux. The Environmentally Sensitive Areas (ESA) program and Countryside Stewardship Scheme (CSS) are in the process of being replaced with the Environmental Stewardship Entry Level (ELS) and Higher Level (HLS) schemes. The current version of the HFA program was due to end in 2007, although it has been extended to 2009. What form any new scheme will take is subject to an ongoing policy debate in the context of the new Rural Development Regulation which covers the period 2007-2013 (Defra, 2006). Reforms to the HFA will have to be in line with the current re-directing of CAP support away from production and towards Second and Third Pillar measures (Latacz-Lohman and Hodge, 2003); it thus seems likely that the HFA will become an agri-environmental scheme targeted at landscape and biodiversity concerns in upland areas.

Changes in core support to upland farmers through the SFP and the HFA, and in agri-environment provisions, could be expected to have significant impacts on how farms are managed, on hill-farm income, and on the ecological impacts of hill-farming (for example, through changes in stocking rates). This paper quantifies these policy reform effects for a range of farm types in the English uplands, for a range of policy scenarios. We use hill farms in the Peak District National Park (PDNP) as a case study. The challenges faced in what is Britain's oldest National Park epitomise those faced throughout the UK uplands. The area is rich in biodiversity, a major carbon store, and provides a major recreational resource for one-third of the UK population that lives within an hour's drive. However, local hill farmers constitute one of the most deprived farming communities in the UK (PDRDF, 2004), with contemporary data indicating that Less Favoured Area (LFA) farms make an average loss (Farm Business Income basis) of £16,000 per farm, from crop and livestock production, offset only by SFP, HFA, AES and diversification revenue to generate a headline Farm Business Income of £10,800; Net Farm Income averaged approximately £6000 per farm (Franks et al 2008). These data clearly demonstrate the link between support payments and farming activity in the uplands of the UK

Given the explicit link between agricultural and environmental activity in the uplands, the analysis of the link between public support and agricultural and environmental activity has received research attention. Several studies have analysed decoupling at the EU level using partial equilibrium models (e.g Witzke and Zintl, 2005; Banse *et al*., 2005; Binfield *et al*., 2005; Chantreuil *et al*., 2008; Britz, 2004) and general equilibrium models (Gohin, 2006; Hertel, 1997), as well as regional and sector models (Shrestha *et al*., 2007; Schmid and Sinabell, 2007) and agent based simulation models (Happe *et al*., 2005). Some studies have investigated the effects on farm outputs and incomes at the farm level (Matthews *et al*., 2006); others have utilised multi-period LP models (Breen *et al*., 2005) in their analysis. However, only Revell and Oglethorpe (2003) have analysed the effects of CAP on the uplands. In contrast to these existing studies, our paper examines the impacts of the decoupling across a range of farm types in a marginal upland setting, in the context of reforms to agri-environmental schemes for an upland area where farming and biodiversity are closely inter-linked. The key outcomes presented here are in terms of changes in farm incomes, land use and ecological pressures, and are related to current biodiversity levels on case study farms. We also cast light on the likely problems due to the partial abandonment of upland livestock enterprises which would appear to follow both from decoupling and from the complete removal of core income support for upland farmers.

2. Methodology

Several techniques can be used to analyse the relationship between agricultural policy and land use decisions at the farm level, including normative and econometric approaches. Mathematical models, such as Linear Programming (LP) and agent-based models, have frequently been used for policy analyses for previous CAP reforms (Donaldson *et al*., 1995; Bos, 2002; Pacini *et al*. 2004; Veysset *et al*. 2005). For present purposes, a mathematical programming approach would seem to be preferable, since we are interested in micro-level predictions of long-run behaviour by rational agents across a range of enterprise types. Econometric models would not allow such a precise spatial or small-scale focus, and are more data-demanding. Agent-based models emphasise the interaction between the agents, however this is not the main focus of this study. Whilst the limitations of LP-type models are well-known[1], the technique has proved to be a robust approach to policy analysis in issues of land use in marginal areas (Hanley *et al.*, 1998) and in the examination of agricultural and environmental trade-offs (Gibbons *et al.,* 2005). In this paper, we therefore construct LP models for a series of representative farm types.

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[1] For example, the exogeneity of prices for outputs and inputs.

Socio-economic farm survey

The initial step in the research was a farm survey to investigate how land is managed on hill farms in the Peak District, and to provide inputs to the LP models. The survey was designed and carried out with the help of experienced farm business researchers through the winter months of 2006/2007. It comprised 44 farm visits. Farms were chosen on the basis of their location and their access to moorland grazing (defined as livestock farms within two km of the moorland line). The survey included questions on land area, land types and use, production activities and subsidy payments received during the reference period of 2006.

Main farm types identified are shown in Figure 1, whilst the types of subsidies that farmers in the survey receive are shown in Figure 2. Sheep, dairy and beef cattle production were found to be the dominant activities in the uplands of the Peak District. Two types of land can be distinguished: moorland and inbye land. “Moorland” is defined as unimproved, semi natural rough grazing, situated at higher altitude, providing the poorest grazing. The “inbye” land is agriculturally improved, more productive land situated at lower altitude. Based on the survey results, six types of typical upland farms can be distinguished depending whether a part of the farm has moorland coverage or not[2]: Moorland Sheep & Beef (MSB), Moorland Sheep & Dairy (MSD), Moorland Sheep (MS), Inbye Sheep & Beef (ISB), Inbye Sheep & Dairy (ISD) and Inbye Beef (IB). In terms of subsidy payments, the SFP and HFA are received by most farmers. However, in addition, many farmers participate in different agri-environmental schemes.

[2] This distinction was important for ecological measurement and modelling purposes.

2.2 Farm modelling

2.2.1 General approach

The general structure of the mathematical models is shown in Table 1 and has the form of the standard linear programming model (Hazell & Norton, 1986):

Maximise $\{Z = c'x\}$

Subject to $Ax \leq b$

and $x \geq 0$

where:

Z =gross margin at farm level

x = vector of activities

c = vector of gross margins or costs per unit of activity

A = matrix of technical coefficients

b = vector of resource endowments and technical constraints

The group of activities, based on typical upland farming practices, are shown at the top of the Table 1 under 14 headings: activities for different land types, production activities representing several fodder crops and animal production systems, seasonal labour, purchase of fertilizer and feed, and activities for sold animal products and subsidy payments. The rows of the matrix indicate the type and form of the constraints included: land availability, supply and demand of fixed and seasonal labour, feeding and housing requirements for livestock, fertilizing requirements per land type, constraints on organic manure use in Nitrate Vulnerable Zone, constraints on subsidies for headage and Single Farm Payment based on production and land type, respectively; and restrictions for payments from Hill Farm Allowance and different agri-environment schemes. The objective function of the LP model is to maximise the gross margin, i.e. total returns from animal production and subsidy payments minus variable costs, including variable operations, fertilizer and seasonal labour. The output of the model includes the corresponding production plan with optimal land use, labour use and fertilizer application. To obtain the optimal solution for the LP models, the CONOPT solver was used in GAMS (General Algebraic Modelling System).

2.2.2 Production elements

The central element in the LP models is animal production, comprising sheep, beef and dairy. The production and the feeding requirements for each of these types are described below.

The sheep production model is based on an upland crossbreed ewe with finished and store lamb production with lambing in March-April. The feeding requirements for ewe and lambs are taken from The Farm Management Handbook 2006/07 (Beaton, 2007). The feeding requirement consists of grass grazing, silage, hay and ewe concentrate. We assumed that 1.5 lambs are born per average ewe with a 4% mortality rate. Due to voluntary and involuntary disposal of ewes, we assume that each year 25% of the ewes are replaced by gimmers raised on the farm. The ram requirement is also included, 2.5 per 100 ewes. Housing sheep is very unusual in the study area, and thus no housing requirement for sheep was specified. The returns from ewe production come from finished and store lambs, cull ewes and wool sales. The costs per ewe include those of health care, feed additives, shearing, and other costs (commission, levies, haulage and tags).

The beef cattle production model is based on a suckler cow calving in February-April and sold either young (6-12 months) or fat (12-24 months)). This includes 10% calf mortality and 1% cow mortality. The bull ratio is 1 to 35 cows. The suckler cow replacement is 7 years, which comes from purchased heifers. In winter the suckler cows are kept inside. The feeding requirement of cows and calves in winter consists of silage, straw, cow concentrates, cow cobs and some grazing. In summer the cows with calves are kept outside and fed by silage and grazing. The returns from beef production come from calf sales, minus the cost of replacements. The cost per suckler cow include those of concentrate and cow cobs, health care, straw bedding and other costs (commission, haulage and tags).

The dairy cattle production model is based on a 650kg Friesian Holstein dairy cow with a calving interval of 390 days and 6500 litre average milk production per year is used. The calves are sold either young (1 month) or fat (15-20 months). Calf mortality is 10% and the cow mortality is 1%. A 25% replacement rate is assumed with purchased heifers entering the dairy herd. Cull cows are sold for £300/head. The cows are kept inside in winter for 180 days and fed with silage and concentrates. In summer they are grazed outside and get additional forages and concentrates. The returns from dairy production come from milk production and calf sales. The costs per cow include those of concentrate, AI, vet and medicines, and other livestock expenses.

The output prices and input costs used for sheep, beef and dairy production are based on averages from the survey results across all the farm types and on The Farm Management Handbook (SAC 2006).

Feed production and purchase

The land on the farm can be used for growing grass for grazing and fodder production purposes. On inbye land, grass can be grown for grazing or fed in the form of silage or hay to sheep and to cattle. On moorland and rough grazing, only sheep can be kept for grazing, which fulfils part of their feeding requirement. Silage can be fed in winter and in summer. In addition to home-grown feed, concentrates can be purchased. Dry matter production of grass, silage and hay makes the link between the feeding requirements of sheep and cattle and supply by each land type. The dry matter production of grassland per year depends mainly on the amount of water and nutrients as well as on growing conditions. The effect of nutrients in the model is distinguished through different levels of nitrogen (N) use. The most commonly used combination of nitrogen use and cutting frequencies (1-3 cuts for silage and 1 cut for hay) were represented with separate activities ranging from 0 to 375kg N/ha (Beaton, 2007). The following main types of land use were distinguished: grass used only for grazing (N: 75, 125, 175, 250 or 375 kg/ha), grass used for silage with aftermath grazing (1, 2 or 3 cuts; N: 0, 125, 220, 250, 275, 300 or 375 kg/ha) and grass used for hay with aftermath grazing (1 cut; N: 0, 70, 125, 200). The costs of grassland include costs of renewal and sprays. On moorland no cutting or fertiliser use is specified.

Labour

Sheep and beef cattle require labour inputs. Throughout the year a particular amount is necessary for each period. Therefore the year is divided into months. Based on the survey, the amount of available unpaid family labour is assumed to be 0.8-1.7 full-time labour units (1 labour unit = 2600 hours/year) depending on the farm type. Apart from family labour there is the option of hiring seasonal labour. Labour can be hired at any time of the year at a cost of £5, £6.25, £7.5 and £6 per hour for sheep, beef, dairy and grass production, respectively. Information about the labour requirement per head (ewe or cattle) and per hectare (hay, silage making) is derived from the Farm Management Pocketbook (Nix, 2007).

Fixed costs

Fixed costs are calculated separately from the LP-model based on the socio-economic survey and data for Peak District hill farms from the Farm Business Survey given input factors such as the main production activity, the farm size, basic machinery and buildings, land rent and rental value and other miscellaneous costs (i.e. electricity, insurances, professional fees, farm maintenance).

2.2.3 Agri-environment and income support schemes for upland farmers.

Farmers in the uplands can take part in many different schemes. Payments under the CAP (in terms of the former headage payment and the Single Payment Scheme) are taken into account, along with other important schemes for the uplands such as the Hill Farm Allowance and the new agri-environmental schemes (Environmental Stewardship Schemes). The old agri-environmental schemes were not taken into account, since they are gradually being replaced with the new schemes, and most of them will be phased out by 2012. Headage payments have long been used to support sheep and cattle farming in the uplands. These historic direct subsidy schemes for sheep, beef and dairy production can be seen in Table 2. Most have now been phased out as part of the de-coupling process, but underlie the calculation of the Single Farm Payment in terms of historic payment rates.

The Single Farm Payment scheme replaced most crop and livestock payments from 2005, including those mentioned in Table 2. To comply with this scheme, farmers need to keep their land in good agricultural and environmental condition and comply with specified legal requirements relating to the environment, public and plant health and animal health and welfare ("cross-compliance"). In England, the payment consists of two elements: historical and flat-rate regional average payments. The historical payment is additional to the flat-rate payment, the amount of which is based on producers' historical claims during the 2000-2002 reference period. During the period of 2005-2012 the scheme will move from low percentage flat-rate and high percentage based on historical payments to a simple flat rate across all eligible land in England. The proportion of these payments can be seen in Table 3. The flat rate payments per land type for 2005 and the estimated flat rate payment in 2012, when it will account for 100% of payments, can be seen in Table 4. For the model, estimated payments for 2012 were included after deductions due to modulation. To receive SFP, a unit of land is required regardless of any activity on the farm. Thus, the payment is connected to the eligible land types and quantity on the farm. The payment also incurs costs of compliance, which was estimated based on the costs per hectare required to maintain grassland in "good agricultural condition". This amounted to approximately £13 per hectare for natural regeneration (SAC, 2006). In the model this was represented by the constraint that all land must be used for at least some agricultural activity, including maintenance of the land without using it for production. The constraint was set separately for the inbye land types (rough grazing and grassland). For moorland no restriction was made.

The Hill Farm Allowance is a compensatory allowance for cattle and sheep farmers in the English Less Favoured Areas (LFAs) in recognition of the difficulties they face and the vital role they play in maintaining the landscape and rural communities of the uplands. In our analyses we included the current form of the HFA payment. However, the HFA scheme will itself be revised. Currently HFA is based on area payments, which are made at different rates for different types of land and size of holding (Table 5). These payments are included in the model attached to the corresponding land types. For compliance with this allowance a minimum (0.15 LU/ha) and a maximum (1.4 LU/ha) constraint is set for the stocking density in order to avoid under- and overgrazing.

Agri-environment payments are intended to compensate or provide an incentive for farmers to undertake measures which go beyond Good Farming Practice. The Entry Level (ELS) and Higher Level Stewardships (HLS) were added to the model as payment for achieving the "Target point", which can be collected by certain management activities ("options") on the farm. The most frequently used options of ELS and HLS in the upland area of PDNP were selected and added to the model (Table 6). The ELS payments are £8/ha for LFA and £30/ha for non-LFA land types. The payments for selected HLS options can be seen in Table 6. These options can be taken up, with restrictions on fertiliser use and livestock density, as part of the maximisation of gross margin. Finally, most of the farms in the uplands in this region are situated within a Nitrate Vulnerable Zone, which imposes a limit on organic manure applications. The maximum is at 250kg/ha of total nitrogen each year averaged over the area of grass on the farm. This limit is also included in the model as a constraint.

2.3 Calibration of the farm models

The models incorporate all livestock and grass production activities carried out on the upland farms and can thus be calibrated to represent any particular farm situation in terms of basic resource endowments. Based on our survey the six typical farm types for the uplands are represented by the averages of these farm types. The six different models included calibration on the main production category (sheep, beef, dairy), on different land types, housing capacity for livestock and household labour availability (Table 7). We assumed no switching between the farm types, but allow for switching between livestock production activities within the same farm type. In order to ensure that the models provided an accurate simulation of current farming activity for representative farm types, each model calibration was completed and the output from the model (by using the same livestock numbers as in the survey averages), in terms of returns to enterprises and input costs, was compared with the survey data. Since the model is to be used to assess impacts upon the relative balance of different enterprises and associated changes in resource use, the key parameters of interest in this validation process are i) the proportion of revenue from livestock (% of total revenue from sheep, beef, dairy), ii) the proportion of variable costs (feed, seed, fertiliser, hired labour) of total costs and iii) the total net farm income (NFI). Table 8 provides a summary for these items for each farm type, for both the model and the observed survey data of 2006. Although there are inherent weaknesses in LP modelling due to factors such as assumed maximising behaviour and the explicitly linear technology (constant input-output coefficients), the models provide a reasonably accurate simulation of both farm revenue, production and cost structures.

2.4 Policy scenarios

The aim of this paper is to investigate the impacts of agricultural policy reform in marginal upland areas, in the context of on-going reforms to agri-environmental policy. The main impacts to be considered are those on farm incomes, land use and ecological pressures. The policy scenarios therefore chosen were: “Headage Payment”(HP), “Single Farm Payment”(SFP) and “No Payment” (NP) scenarios. This choice was based on focusing on three different points in time: the situation before de-coupling (HP scenario), after de-coupling (SFP scenario) and when the SFP disappears (NP scenario). These core agricultural policy scenarios are considered in interaction with additional upland supports: the HFA as currently implemented, since its reformed status is unsure at present – although as explained above this will probably become a new agri-environment scheme just for the uplands - and Environmental Stewardship options as the main agri-environmental schemes (AES). This generates three additional scenarios: (HP & AES/HFA, SFP & AES/HFA, NP & AES/HFA), giving a total of 6 policy scenarios in all[3]. The model was set to 2006 output price and input cost levels for all farming activities; whilst recent price movements in both agricultural output and input price markets have occurred, the modelling approach centres upon gross margin analysis and it is argued that the 2006 gross margin levels are an appropriate base-level for the analysis. Sensitivity analysis was then undertaken for key output and input prices.

In the "Headage Payment" scenario we model the policy situation as it existed before the introduction of the SFP. For the "Single Farm Payment" scenario we use a situation where the flat rate payment will account for 100% of payments (as planned for 2012: Table 4)[4]. In the "No Payment" scenario we assumed the loss of the SFP but also the relaxation of cross-compliance constraints which go along with this.

3. Results

Optimal production plans

From the perspective of upland biodiversity, the most important impacts of policy reform are those on land use, livestock density and fertiliser use: this section thus focuses solely on these variables. The changes in predicted land use for each farm type across the six policy scenarios can be seen in Table 9. The land that is used for livestock production or maintenance - under SFP and AES - is taken as a proportion of the total land availability per farm type. "Unused land" is land that is left as fallow.

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[3] For brevity, the "AES/HFA" treatment is henceforth referred to simply as "AES".

[4] The historical payments differ considerably between the farms and farm types and this is the year when all farm payments will be completely detached from historical production and based only on their current eligible land types. These estimated payments for all three land categories, after deductions from modulation, were used for this scenario analysis, including the compliance constraints discussed above.

Under the HP scenario all land is used for livestock production. Under the SFP scenario, all inbye land continues to be used for production or maintenance, since the payment is based on the land used for agricultural purposes. On moorland farms, however, not all moorland is used. In the case of the NP scenario even more land is left fallow, including both moorland and inbye land types. The difference between the land area used in SFP and NP scenarios comes from the compliance obligation on farmers to obtain the SFP. The optimal solution balances the marginal cost and revenue coming from production and that coming from the cross-compliance obligation and payments from the SFP. The three scenarios with AES payments show similar results to those without AES: however, with new restrictions resulting from AES contracts, in general more land is used. This is due to the adoption of more extensive production and more options for farmers to maintain their land and receive a payment for it. The ELS and HLS schemes that are taken up for each AES scenario and farm type can be seen in Appendix 1. In summary, the predicted uptake of AES schemes and the preferred options differ markedly among farm types and within farm types depending on the nature of core subsidy support (HP, SFP or NP). The loss of the SFP results in many more farms leaving their land fallow, since the constraints on maintaining land in Good Agricultural Condition are no longer binding. The largest fallowing of land occurs in the MSD farm type, where only 53% and 13% of the land is used with and without AES, respectively, after loss of the SFP. The ISD and IB farm types also have more than half of the land fallow without AES. This means that not only the SFP but also the AES are important for keeping the land in production, or for maintaining it in "good condition".

The optimal livestock production for the six policy scenarios and the six typical farm types can be seen in Table 10. The results show that under the historic HP scenario, beef and dairy is preferred to sheep production. This means that in the case of all farm types the maximum amount of beef and dairy production occurs, given the cattle housing capacity constraints of the farm, with the remainder of the land being used for intensive sheep production. By switching from the HP to the SFP and NP scenarios, livestock numbers decrease, as do grazing livestock units (LU) (Figure 3). In general, livestock densities on the moorland farms are quite low, between 0.2 and 0.8 LU/ha for all the scenarios. This figure is higher for inbye farm types, at between 0.4 and 1.5 LU/ha. Besides extensification, decoupling leads to structural change within farm types. There is a large predicted fall in beef cattle numbers under the SFP and NP scenarios for some farm types: this dramatic cut is not prevented by the availability of AES. In general, beef production is declining, and in certain farm types it disappears entirely. This is due to the lower profitability from beef production after decoupling compared to that of sheep. A structural change can also be seen in sheep and dairy farms, where dairy activity is preferred to sheep from an economic point of view. This means on the MSD farm type sheep numbers are declining, while on the ISD farm type sheep production completely disappears.

The higher livestock units on farms under the HP scenario requires more fodder which leads to more intensive grass production for grazing, silage and hay. This is supplied by higher amounts of fertiliser use per hectare on grassland. For all farm types fertiliser use declines considerably after decoupling, except for the dairy farm types MSD and ISD (see Table 12 for details).

Financial results

Prior to the inclusion of AES/HFA payments, the results show positive gross margins in the case of all scenarios for all farm types (Figure 3). However, the net farm income (NFI) is negative for five out of six farm types, with the exception of the ISD farm type (Figure 5a), which is the most profitable in the Peak District as milk production generates the highest income in the uplands. In switching from HP to SFP or NP, the greatest losses are in beef farming. However, all farm types lose income after the switch from HP to either SFP or NP. The IB farm type shows the most negative net farm income due to relatively high fixed costs, which comes from the high rental costs for land and the large amount of machinery kept on the farm. Figure 5b shows equivalent results for net farm income once the option to receive AES/HFA payments is included. The major impact is to moderate income losses in the move away from HP to either SFP or NP.

Farmers in the uplands also get income from other sources, such as from diversification and off-farm sources. Actual levels of NFI under the policy scenarios considered will thus likely be higher (Franks *et al*,. 2008). Results not reported in detail here showed that once estimates of these income streams are included, all the farm types will have positive NFI under all scenarios, except the MSB and MS farm types under the NP scenario. This result shows that many farmers depend not only on AES schemes but also on the other income sources coming from off-farm and diversification for their long-term financial sustainability (Figure 5c).

Sensitivity Analysis

We investigated the implications for key outcomes (farm income, stocking rates and land abandonment) of increases in certain output and input prices above the base case of the most common sheep and beef farm types. 25% rise in lamb, calf and concentrate prices were modelled. This showed that, in the case of MSB farm type, higher input prices would lead to lower NFI with lower stocking density and more land abandonment of 28% and 26% for the SFP&AES and NP&AES scenarios, respectively. Higher output prices would lead to 95% and 100% land use and higher stocking density for the latter scenarios. In the case of HP&AES

there is no change on the production structure only on the income of the farmer. Similar results can be drawn for ISB farm type concerning the NFI and stocking density, however all the land area would be used for production in all these cases.

4. Discussion

The key results that emerge from the analysis described above is that the effects of policy reform vary substantially across farm type, but some general trends can be discerned. Our discussion of these findings is organised according to (i) the effects of de-coupling itself, (ii) the mediating effects of agri-environment scheme payments (including the HFA), (iii) the effects of loss of the Single Farm Payment, and (iv) ecological implications. For all cases, the base level is the HP scenario (Table 12). Absolute levels for income are shown in Table 11.

4.1 What are the impacts of decoupling?

The most relevant comparison here is the (HP&AES) scenario with the (SFP&AES) scenario.

i) Effects on net farm income are slight. Two farm types see a small decrease in net farm income, and one a small increase. The magnitude of the change in overall NFI is typically less than the magnitude of the change in subsidy, because it is modified by behavioural changes.

ii) Decoupling has mixed effects on the amount of land being used for agricultural production, ranging from 18% coming out of production for one farm type to 11% more going into production for another. On the whole, though, the amount of land used or maintained changes little.

iii) The major effect of decoupling is reductions in stocking densities (Figure 3), but these vary by a factor of three across farm types as a percentage rate (from -27% to -79%).

iv) The aggregate pattern regarding stocking densities masks a lot of what is going on. Suckler cow numbers are greatly reduced and abandoned altogether on moorland sheep and beef farms. The effect on sheep varies from minimal on some farm types to abandonment of sheep production on others. Decoupling has no effect on dairy production, which is operated at a capacity dictated by animal housing constraints.

v) Decoupling also results in less fertiliser application, but again how this plays out depends on farm type, with no change on some and 80-100% reductions on others. However, in general fertiliser use is relatively low in these upland areas for all farm types.

4.2 What are the moderating effects of agri-environmental policies on decoupling?

Agri-environmental schemes offer income earning opportunities for farmers, but also constrain their operations. The relevant comparison here is (HP&AES to SFP&AES) compared with (HP to SFP).

i) AES schemes play a major role in changing the overall economic impact of decoupling (Figure 5a, Figure 5b, Table 11). Instead of facing large losses, the various farm types face either much smaller losses or in some instances actually stand to gain from decoupling. This is because the two policy instruments are now pulling in the same direction rather than pulling against one another. However, we have to note that the models predict the maximum uptake of the most commonly used AES schemes for the given land types. This means that the uptake can differ based on farm specific circumstances, where a broader range of these schemes are available, and for some schemes (HLS) competition does not always lead to success in getting the desired payment, which can result in a slightly different economic outcome.

ii) Moderation of the effect of decoupling by AES has mixed implications for the amount of fallowing. Some farm types fallow more than they would otherwise have done and some less.

iii) AES leads to a greater losses of suckler cow production than would otherwise have resulted, which may lead to unfavourable ecological outcomes (for example, with regard to some bird populations such as lapwing). For sheep, decoupling and AES are sometimes pulling in the same direction resulting in greater losses than under decoupling alone (due to extensification requirements of AES) and sometimes in opposing directions meaning smaller reductions in sheep numbers because of AES payments.

iv) AES schemes have little effect on the outcome of decoupling for fertiliser application rates.

4.3 What would be the effect of loss of the Single Farm Payment?

Here the relevant comparisons are of (SFP & AES) with NP; and of (SFP & AES) with (NP & AES). The former shows the effects of removing all subsidy; the latter shows the more realistic outcome of the removal of direct income support with the retention of agri-environmental payment schemes.

Taking the extreme case first (removal of all subsidy), we see that this results in considerable land abandonment (Table 9) on three farm types, including two inbye farm types. The loss of all subsidy support would also result in five out of six farm types having a negative net farm income, and thus being financially unsustainable. Four would have a negative income even when including revenue from off-farm sources and diversification activities. The fifth farm type, ISB, that becomes financially sustainable when including these sources changes livestock production to sheep only, and intensifies land use. Relatively little change happens to moorland sheep production, except on the MSD farm type where sheep production ceases entirely.

Turning to the more realistic case where AES (and, one presumes, the replacement for HFA) carries on after the loss of the SFP, we can see that the loss of SFP alone causes a number of important changes. First, net farm income falls considerably on all farm types, and becomes negative in 5 out of 6 cases, if we ignore income from off-farm sources and diversification. For moorland sheep and moorland sheep and beef, income becomes negative even with these other sources. The main conclusion is that loss of SFP will have a serious effect on the long-term viability of hill farms in the Peaks. The intensity of livestock production also falls in most cases, whilst land abandonment increases, especially on mixed moorland farms.

4.4 Comparison to other studies

Our results show that it is likely that there will be a move away from beef production towards sheep, although for both categories of livestock, total numbers are likely to fall. This extensification, lower fertiliser use and shift from beef to sheep production in the uplands has been noted by others for the UK (Revell and Oglethorpe, 2003; Oglethorpe, 2005; Matthews *et al*., 2006) and in the EU-15 as a whole (Balkhausen *et al*., 2008). Moss *et al.* (2005) predicted a reduction of 16.7% in beef animal numbers and a 9.5% reduction in sheep. Our results show no decline is expected in the dairy enterprise in the uplands, given current price levels. However, some EU studies have forecast that the prices will fall after CAP reform which will reduce gross margins of the dairy enterprise due to the reduction in the price of milk. Fewer but larger dairy herds were also predicted after this change in the uplands (Shrestha *et al*., 2007).

Land abandonment after decoupling is limited in our results by the requirement to keep the land in good agricultural and environmental condition under SFP. Similar results were found in other studies (Defra, 2004; Oglethorpe, 2005; IEEP, 2007; Revell and Oglethorpe, 2003). However, in marginal areas like moorland, abandonment might take place sooner due to the lower productivity of the land (Primdahl *et al.,* 2003; Defra, 2004). With regard to predicted changes in income, Oglethorpe (2005) found that decoupling would lead to net farm income becoming negative, other than for dairy. This result is also supported by the findings of this study for all the farm types except for inbye sheep & dairy, which currently is the most profitable enterprise in the uplands.

4. 5 Ecological implications

The land use changes predicted under these different policy scenarios will have important implications for upland ecosystems. To illustrate, we focus on the implications for biodiversity using the number of different bird species as an indicator. The bird community was surveyed on the same farms from which farm management data had been collected for the LP models in the following breeding season (2007; Dallimer *et al. ms*). The average number of different species ("species richness") for each farm type categorised into moorland and inbye land when appropriate are shown in Table 13, column 2. We also identified two subgroups of species of particular conservation interest. First, we identified the subset of species with an upland breeding distribution in the UK. These species include particularly emblematic examples of upland wildlife, such as the curlew (*Numenius arquata*) and ring ouzel (*Turdus torquata*), and could form local conservation priorities for these habitats: these numbers are shown in column 3. Then, we identified a second subset of species that are of national or international conservation concern, including red and amber listed species, UK Biodiversity Action Plan species and species listed in the European Community's designation of part of our study area as a Special Protection Area for wild bird conservation. These are shown in column 4.

Inbye habitats contained more species overall and more of national conservation concern, however, moorland habitats held a greater richness of upland specialist species. Farms that were composed of both moorland and inbye, had higher species richness in their inbye areas than the more intensive inbye-only operations. As such the prediction that farming will generally become less intensive under CAP reform on these inbye-only operations (with the one exception being ISB in the extreme case of no subsidies) may help biodiversity. MSB farms are richest in overall species and in upland specialists on either habitat type. As such, the loss of suckler cows and conversion of these operations just to sheep production (MS), along with the worsening economic circumstances of this sector, could pose particular problems for upland ecosystems. Such a prediction is supported by more detailed ecological analyses, where species richness was higher on farms where cattle were grazing (Dallimer *et al., ms;* Evans *et al.,* 2006). Land abandonment has been shown, historically, to lead on average to a loss of biodiversity in upland grazed systems (Hanley *et al*, 2008), so that any policy changes which increases abandonment will likely have adverse consequences for biodiversity.

5. Conclusions

In this study the aim was to investigate how policy changes under CAP reform affect farmers' income and land use in marginal upland farming systems, and to relate these to likely ecological impacts. Different policy scenarios were analysed and compared using linear programming models developed for six representative farm types in the Peak District. Results show that the change from headage-based payments to the Single Farm Payment motivates farmers to operate more extensively with part of the moorland left unused, although there is little real risk of land abandonment due to the contract requirements of the SFP. Removal of the SFP results in still lower livestock numbers, negative net farm incomes in most cases, and a rise in land abandonment. Agri-environment schemes moderate the impacts of decoupling, and play a vital role in supporting hill farm incomes. Indeed, an interesting side-effect of decoupling is predicted to be a rise in desired uptake of agri-environmental schemes, and thus an increase in competition for limited-fund schemes such as Higher Level Environmental Stewardship. This should promote increased cost-effectiveness in the delivery of public environmental goods on upland farms so long as the contract rationing scheme rewards both supply price and expected environmental delivery.

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Table 1. The general structure of the linear programming farm models for sheep, beef and dairy production

Activities	Moorland	Inbye land	Fodder production for own use	Sheep production	Beef production	Dairy production	Seasonal labour	Purchase of fertilizer	Purchase of feed	Animal production for sale	Headage payment	Single Farm Payment	Hill Farm Allowance	Agri-Environ-ment Payments	Resource endowments and technical constraints
Constraints															
Land requirements	1	1													≤ available hectares
Land types for fodder production	-1	-1	1												≤ 0
Animal production for sale				-aij	-aij	-aij				+aij					≤ 0
Labour requirements			+aij	+aij	+aij	+aij	-1								≤ available fixed labour in hours
Housing requirements					+aij	+aij									≤ avaible cattle places
Feeding requirements			-aij	+aij	+aij	+aij			-aij						≤ 0
Fertilizing requirements			+aij		-aij	-aij		-aij							≤ 0
Nitrate Vulnerable Zone		+aij		-aij	-aij	-aij									≤ max. manure application
Headage Payment				+aij	+aij	+aij					-aij				≤ 0
Single Farm Payment	+aij	+aij										-aij			≤ 0
Hill Farm Allowance	+aij	+aij											-aij		≤ 0
Agri-Environment Schemes	+aij	+aij												-aij	≤ 0
Livestock constraints for HFA & AES				+aij	+aij	+aij									≤ max. and ≥ min. livestock unit
Objective function	Costs (£/ha)	Costs (£/ha)	Costs (£/ha)	Gross margin (£/head)	Gross margin (£/head)	Gross margin (£/head)	Costs (£/hour)	Costs (£/kg)	Costs (£/unit)	Revenue (£/head)	Revenue (£/head)	Revenue (£/ha)	Revenue (£/ha)	Revenue (£/ha)	

aij - the technical coefficient that relates activity i to the constraint j

Table 2. Headage payments for sheep, beef and dairy cattle production in 2004 (Nix 2007)

Headage payment	£/head
Suckler Cow Premium	161.50
Beef Special Premium (steer)	102.00
Beef Special Premium (bulls)	142.80
Sheep Annual Premium	14.82
Sheep Annual Premium Suplement (LFA)	4.76
Dairy (2006) £/liter	0.0248

Table 3. Percentage of historical and flat-rate payment over the years (Nix 2007)

Year	2005	2006	2007	2008	2009	2010	2011	2012
Historical (%)	90	85	70	55	40	25	10	0
Flat-rate (%)	10	15	30	45	60	75	90	100

Table 4. Flat rate payments for 2005 and estimated for 2012 for Single Farm Payment

Year	2005	2012	
		before deduction	after deduction*
Moorland SDA	2.29	24	18
Non-Moorland SDA	16.09	175	131
Non SDA	19.23	215	161

* estimated 25% deduction after EU and National modulation
Source: SAC 2006/07, Nix 2007.

Table 5. Hill Farm Allowance payments per land type in 2006

Land type	0-350 ha	351-700 ha
Moorland & common land	11.66	5.83
SDA Non-Moorland	30.82	15.41
DA	16.66	8.33

Source: Nix 2007

Table 6. Management options for Entry Level and Higher Lever Stewardship schemes

	Code	Points	Unit	Fertiliser	LU/ha
ELS options					
Stone wall protection and maintenance	EB11	15	100 m	-	-
Manage permanent in-bye grassland with low inputs	EL2	35	ha	< 50kg N/ha	< 1.0
Manage in-bye pasture and meadows with very low input	EL3	60	ha	< 12.5 t/ha FYM	< 1.0
Enclosed rough grazing (<15ha parcel)	EL5	35	ha	none	< 0.75
Moorland and rough grazing (≥15 ha parcel)	EL6	5	ha	none	< 0.4
Genaral constraints for ELS at farm level					0.15 - 1.4
HLS options					
Maintenance of species-rich, semi-natural grassland	HK6	£200	ha	none	< 0.4
Suplement for hay making	HK18	£75	ha	none	none
Maintenance of rough grazing for birds	HL7	£80	ha	none	< 0.7

Source: DEFRA 2005a, DEFRA 2005b

Table 7. LP model predictions in base case for six farm types

	Units	Moorland Sheep & Beef	Moorland Sheep & Dairy	Moorland Sheep	Inbye Sheep & Beef	Inbye Sheep & Dairy	Inbye Beef
Moorland	%	86	64	85	-	-	-
In-bye	%	14	36	15	100	100	100
rough grazing	%	5	3	3	20	11	6
grassland	%	9	33	12	80	89	94
LFA	%	98	78	93	92	83	62
DA	%	1	0	1	29	45	16
SDA moorland	%	86	48	82	0	0	0
SDA in-bye	%	11	31	9	63	39	46
Non LFA	%	2	22	7	8	17	38
Nitrate Vulnerable Zone	%	53	56	18	52	44	76
Stone wall length	m	1092	1214	814	0	254	0
Housing capacity for cattle	head	151	94	-	83	100	164
Household labour availability	labour unit*	1.7	1.6	1.5	1.3	1.6	0.8

* labour unit = 2600 hours/year

Table 8. Economic comparison of the model and the observed survey data for each farm type

	Moorland Sheep & Beef		Moorland Sheep & Dairy		Moorland Sheep	
	Model	Observed	Model	Observed	Model	Observed
Revenue from sheep (%)	59	55	19	17	100	100
Revenue from beef (%)	41	45	0	0	0	0
Revenue from dairy (%)	0	0	81	83	0	0
Variable costs (% of total costs)	38	37	47	50	16	20
Net Farm Income (£/ha)	-85	-90	-86	-142	-111	-119

	Inbye Sheep & Beef		Inbye Sheep & Dairy		Inbye Beef	
	Model	Observed	Model	Observed	Model	Observed
Revenue from sheep (%)	46	53	10	10	0	0
Revenue from beef (%)	54	47	0	0	100	100
Revenue from dairy (%)	0	0	90	90	0	0
Variable costs (% of total costs)	46	52	60	57	39	44
Net Farm Income (£/ha)	-178	-252	62	90	-371	-437

Table 9. Land used for production and maintenance in different policy scenarios per farm type in % of farm area

Farm types	HP	SFP	NP	HP&AES	SFP&AES	NP&AES
Moor Sheep & Beef	100	87	89	100	82	77
Moor Sheep & Dairy	99	52	13	99	86	53
Moor Sheep	99	100	93	99	96	99
Inbye Sheep & Beef	100	100	100	100	100	100
Inbye Sheep & Dairy	100	100	42	100	100	100
Inbye Beef	93	100	43	100	100	92

Note: "AES" includes both AES and HFA schemes.

Table 10. Livestock numbers for different policy scenarios per farm type

Farm types	HP	SFP	NP	HP&AES	SFP&AES	NP&AES
Moor Sheep & Beef						
sheep	1741	1727	1727	1712	1617	1319
beef	151	0	0	151	0	0
Moor Sheep & Dairy						
sheep	995	32	0	975	272	108
dairy	94	94	94	94	94	94
Moor Sheep						
sheep	1529	1427	1155	1519	1123	1123
Inbye Sheep & Beef						
sheep	492	428	815	482	186	173
beef	83	44	5	83	38	28
Inbye Sheep & Dairy						
sheep	410	0	0	332	0	0
dairy	100	100	100	100	100	100
Inbye Beef						
beef	164	56	56	164	35	35

Note: "AES" includes both AES and HFA schemes.

Table 11. Economic results for different scenarios and farm types (£/ha).

	HP	SFP	NP	HP&AES	SFP&AES	NP&AES
Moor Sheep & Beef						
Revenue	156	89	89	154	84	68
Subsidy	65	36	0	98	73	44
Variable costs	154	71	70	157	71	59
Gross margin	67	55	19	96	86	53
Fixed costs	98	98	98	98	98	98
NFI	-31	-43	-79	-2	-12	-45
Other income	22	22	22	22	22	22
NFI with other income	-9	-21	-57	20	9	-23
Moor Sheep & Dairy						
Revenue	543	377	371	540	418	390
Subsidy	114	96	0	170	186	90
Variable costs	403	232	222	406	300	271
Gross margin	254	241	150	303	305	209
Fixed costs	235	235	235	235	235	235
NFI	19	6	-85	69	70	-26
Other income	64	64	64	64	64	64
NFI with other income	83	70	-21	133	134	38
Moor Sheep						
Revenue	126	118	95	125	93	93
Subsidy	47	44	0	80	84	42
Variable costs	103	93	70	104	73	74
Gross margin	70	68	25	101	103	61
Fixed costs	126	126	126	126	126	126
NFI	-55	-58	-101	-25	-22	-65
Other income	41	41	41	41	41	41
NFI with other income	-15	-17	-60	16	18	-24
Inbye Sheep & Beef						
Revenue	520	350	377	515	222	180
Subsidy	226	162	0	337	330	197
Variable costs	468	277	296	485	200	161
Gross margin	279	235	81	368	353	216
Fixed costs	242	242	242	242	242	242
NFI	37	-7	-161	126	111	-26
Other income	199	199	199	199	199	199
NFI with other income	236	192	38	325	310	173
Inbye Sheep & Dairy						
Revenue	1331	1128	1128	1292	1128	1128
Subsidy	227	185	0	327	357	171
Variable costs	906	692	692	873	738	737
Gross margin	652	622	437	746	747	562
Fixed costs	377	377	377	377	377	377
NFI	275	245	60	369	370	186
Other income	59	59	59	59	59	59
NFI with other income	334	305	119	429	430	245
Inbye Beef						
Revenue	783	268	268	783	167	167
Subsidy	375	175	0	469	332	156
Variable costs	917	254	247	922	155	154
Gross margin	241	189	21	330	344	169
Fixed costs	392	392	392	392	392	392
NFI	-151	-203	-371	-62	-48	-223
Other income	261	261	261	261	261	261
NFI with other income	110	59	-109	199	213	39

Table 12. Changes in production, resource use and income compared to the HP scenario.

% Change	HP	SFP	NP	HP&AES	SFP&AES	NP&AES
Moor Sheep & Beef	base					
Sheep nos.	100	-1	-1	-2	-7	-24
Beef nos.	100	-100	-100	0	-100	-100
LU	100	-31	-31	-1	-35	-47
Fertiliser use	100	-100	-100	0	-100	-100
Land used	100	-13	-11	0	-18	-23
Gross margin	100	-18	-72	43	28	-21
Subsidy	100	-44	-100	51	12	-33
Net Farm Income	100	-39	-156	94	61	-46
Moor Sheep & Dairy						
Sheep nos.	100	-97	-100	-2	-73	-89
Dairy nos.	100	0	0	0	0	0
LU	100	-59	-61	-1	-45	-55
Fertiliser use	100	1	1	0	1	1
Land used	100	-47	-87	0	-14	-47
Gross margin	100	-5	-41	20	20	-18
Subsidy	100	-15	-100	49	64	-21
Net Farm Income	100	-66	-547	260	268	-236
Moor Sheep						
Sheep nos.	100	-7	-24	-1	-27	-27
LU	100	-7	-24	-1	-27	-27
Fertiliser use	100	-100	-100	-1	-100	-100
Land used	100	1	-6	0	-3	0
Gross margin	100	-3	-64	43	47	-13
Subsidy	100	-7	-100	70	79	-10
Net Farm Income	100	-4	-82	55	60	-17
Inbye Sheep & Beef						
Sheep nos.	100	-13	65	-2	-62	-65
Beef nos.	100	-47	-93	0	-54	-66
LU	100	-28	-7	-1	-58	-65
Fertiliser use	100	-47	-5	0	-54	-66
Land used	100	0	0	0	0	0
Gross margin	100	-16	-71	32	27	-23
Subsidy	100	-28	-100	49	46	-13
Net Farm Income	100	-119	-535	241	200	-170
Inbye Sheep & Dairy						
Sheep nos.	100	-100	-100	-19	-100	-100
Dairy nos.	100	0	0	0	0	0
LU	100	-38	-38	-7	-38	-38
Fertiliser use	100	0	0	0	1	1
Land used	100	0	-58	0	0	0
Gross margin	100	123	57	168	168	102
Subsidy	100	-18	-100	44	57	-24
Net Farm Income	100	-11	-78	34	35	-32
Inbye Beef						
Beef nos.	100	-66	-66	0	-79	-79
LU	100	-66	-66	0	-79	-79
Fertiliser use	100	-66	-66	0	-79	-79
Land used	100	8	-53	8	8	-1
Gross margin	100	-21	-91	37	43	-30
Subsidy	100	-53	-100	25	-12	-58
Net Farm Income	100	-34	-145	59	68	-47

Table 13. Average number of bird species encountered on each farm type. I indicates inbye areas, and M moorland areas.

Farm type	Total species		Upland species		Conservation concern	
Moorland Sheep & Beef	I: 33.0	M: 12.2	I: 5.9	M: 6.1	I: 13.7	M: 7.7
Moorland Sheep & Dairy	I: 31.2	M: 14.2	I: 3.2	M: 5.0	I: 10.0	M: 9.2
Moorland Sheep	I: 30.3	M: 13.8	I: 3.8	M: 5.8	I: 11.3	M: 8.2
Inbye Sheep & Beef	I: 31.3		I: 3.3		I: 12.1	
Inbye Sheep & Dairy	I: 28.2		I: 2.6		I: 11.6	
Inbye Beef	I: 25.4		I: 2.2		I: 10.2	

Figures

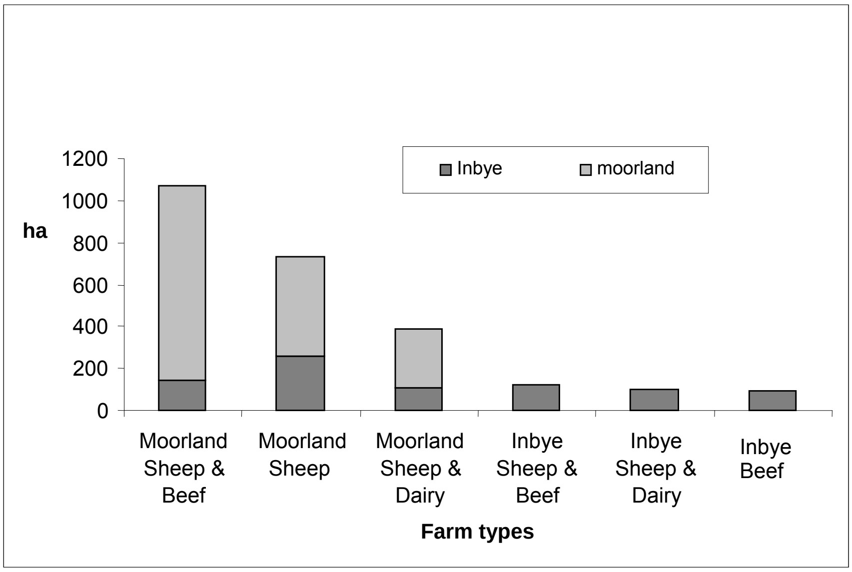


Figure 1. Average farm size of different farm types

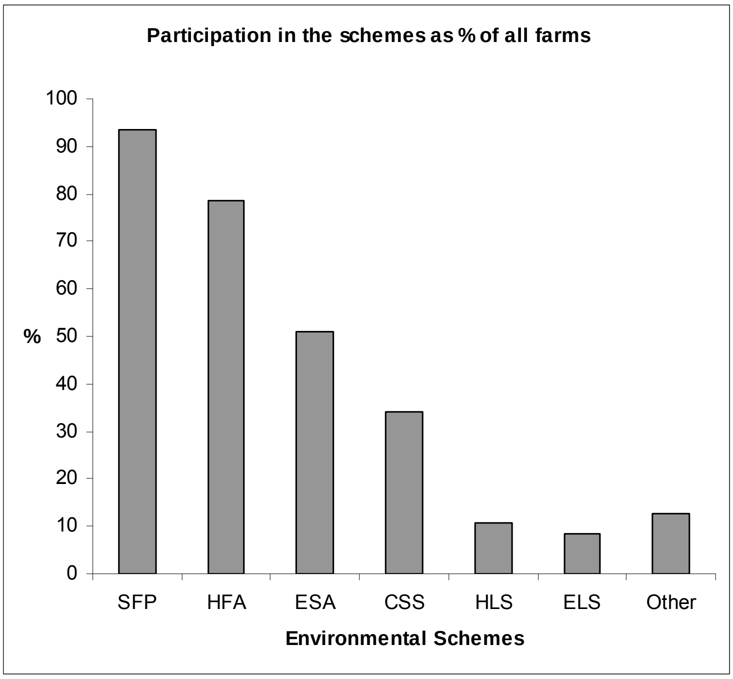
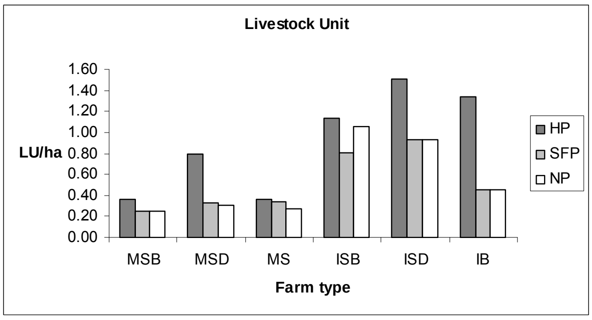


Figure 2. Participation in different schemes as a % of all farms in the survey



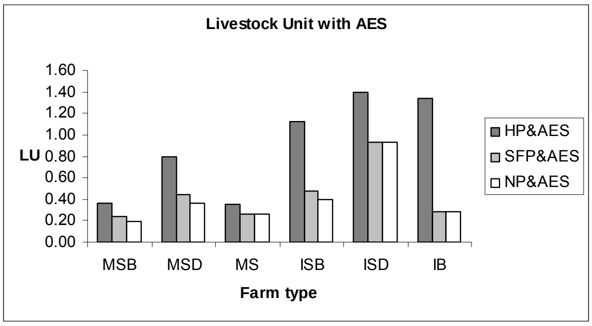


Figure 3. Livestock unit per farm type for different policy scenarios

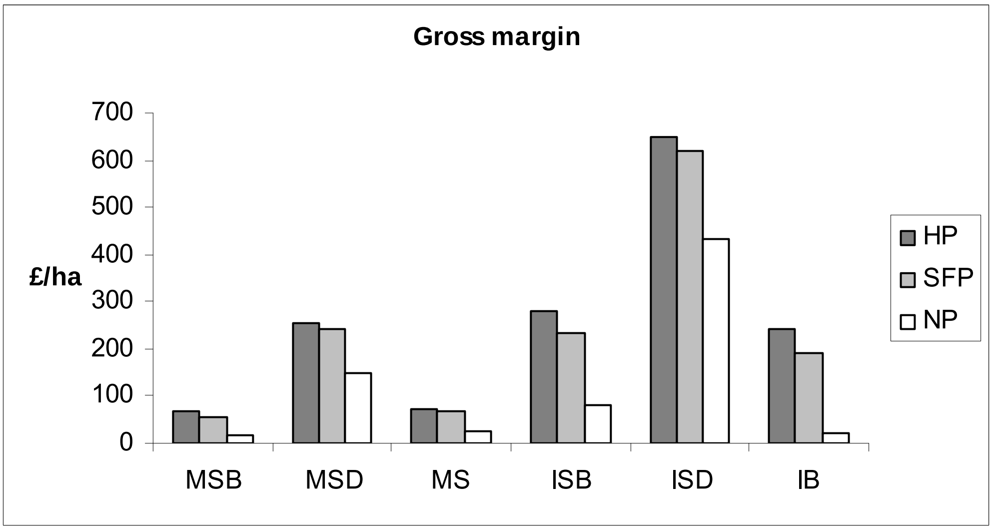


Figure 4.Gross margin per farm type for different policy scenarios.

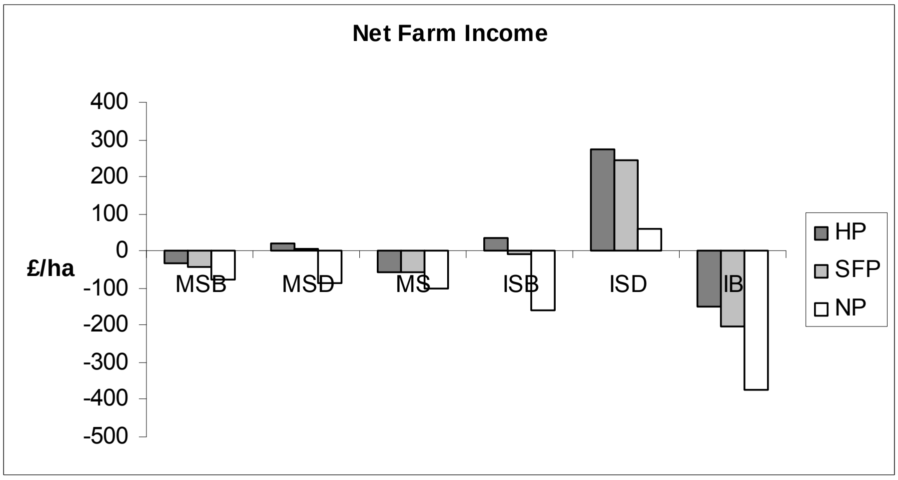


Figure 5a. Net farm income for different policy scenarios per farm type

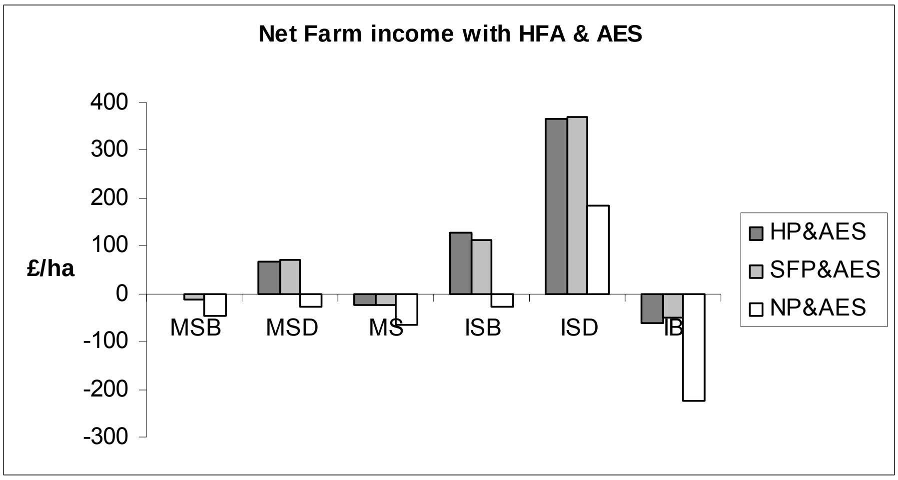


Figure 5b. Net farm income with HFA and AES payments for different policy scenarios per farm type

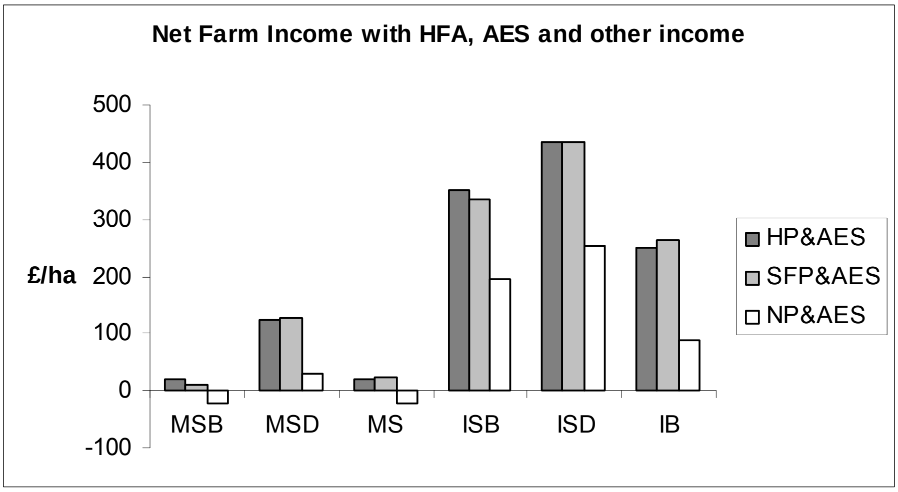
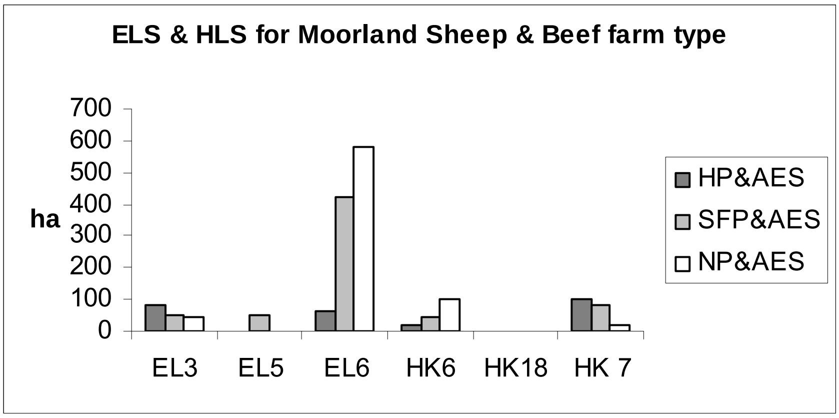
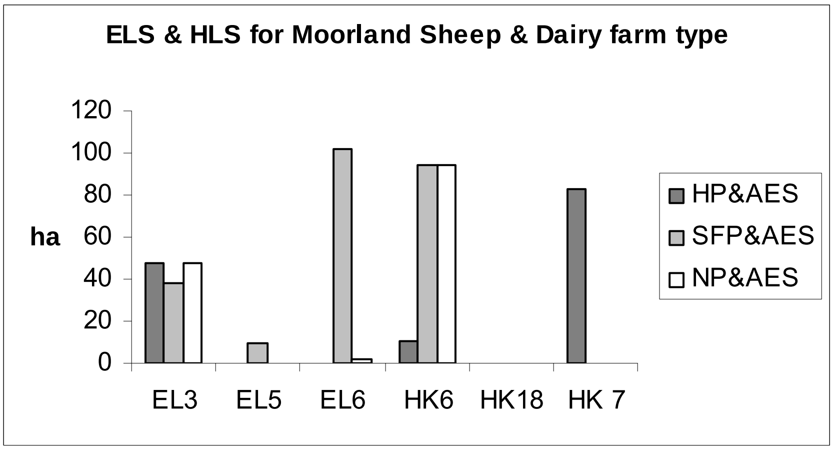


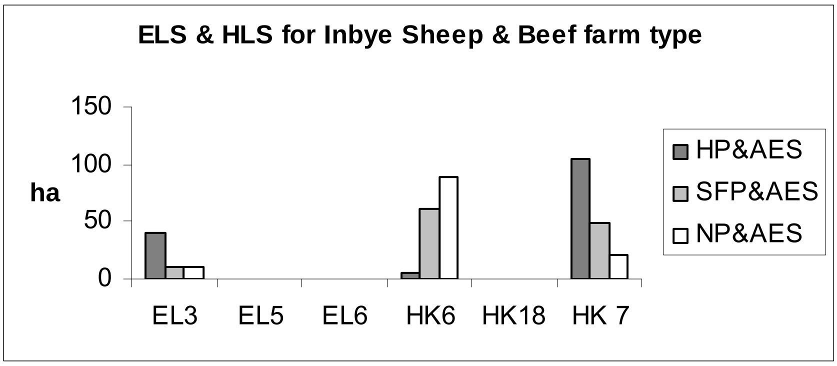
Figure 5b. Net farm income with HFA, AES payments and other income (diversification, off-farm) for different policy scenarios per farm type

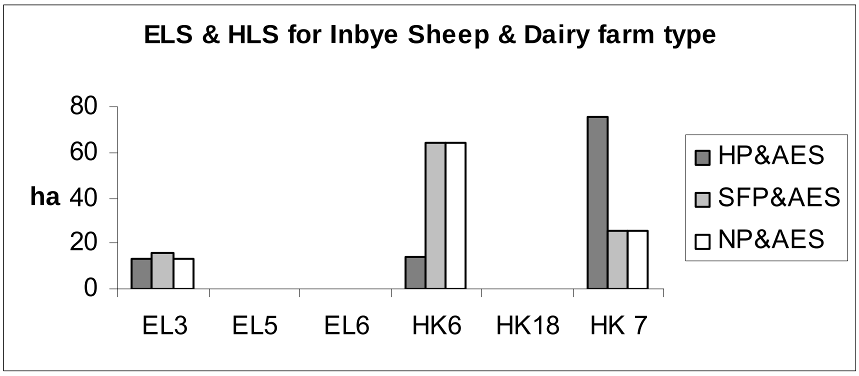
Appendix 1.

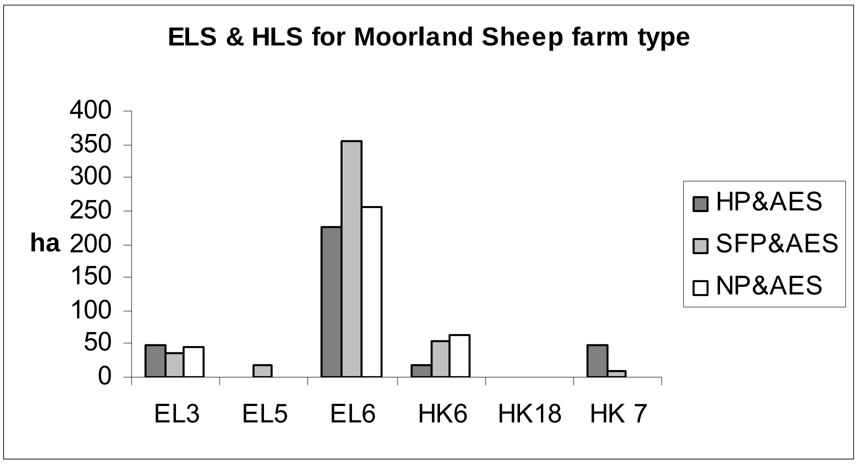
Optimal Entry Level and Higher Level Stewardships options for different scenarios for each farm type

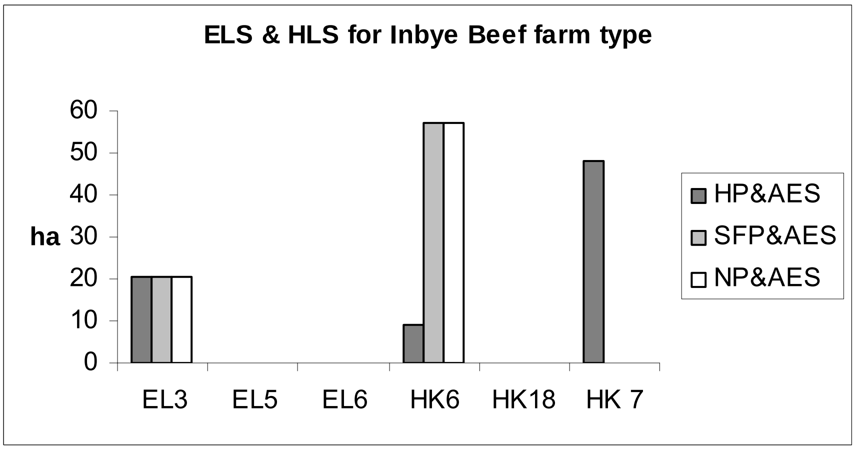







ELS & HLS for Inbye Sheep & Dairy farm type
80
60
ha 40
20
0
EL3
EL5
EL6
HK6
HK18
HK 7
HP&AES
SFP&AES
NP&AES


ELS & HLS for Moorland Sheep farm type
400
350
300
250
ha 200
150
100
50
0
EL3
EL5
EL6
HK6
HK18
HK 7
HP&AES
SFP&AES
NP&AES


ELS & HLS for Inbye Beef farm type
60
50
40
ha 30
20
10
0
EL3
EL5
EL6
HK6
HK18
HK 7
HP&AES
SFP&AES
NP&AES