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# Predicted effects of CAP reform on management of Great Britain's extensive sheep farms


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**Summary or abstract of the paper (no more than 200 words)**

**A bio-economic linear program based on data from 20 commercial extensive sheep farms was used to predict the effects on aspects of farm management of response to CAP reform in Great Britain. The objective function of the LP was to maximise gross margin while meeting ewe energy requirements from farm grown or purchased feeds on a monthly basis throughout the farming year. Three farms were constrained by availability of home-grown grass and thus contracted under a subsidy free scenario. Just one farm justified expansion using extra labour purchased at £5/hour. The other farms remained at current flock sizes using existing unpaid labour. However, all farms adjusted their grazing regime according to the balance of land types available. These adjustments varied from month to month, reflecting the complex and dynamic pattern of interactions between resource demand and supply throughout the farming year. The implied shifts in land use have implications for the environment and for animal welfare.**



**Keywords and JEL codes (if available)**

## Introduction

Since reform of the CAP in 2005 and de-coupling of subsidy from production, animals need only be retained on commercial farms where adequate profit can be made without direct subsidy and/or their presence is deemed necessary to maintain the land in good agricultural and environmental condition. In the less favoured areas where hill sheep farms predominate the first condition is very unlikely to apply and the latter may be met with much fewer animals than formerly. This has led to a mass exodus of sheep from the hills particularly in some regions (SAC, 2008a). The objective of this paper is to predict the related changes in certain aspects of farm management with reference to current practice and alternative sheep farming options as predicted by a linear program (LP). Such predictions shed light on possible change in spill over effects for example on the environment or on animal welfare.

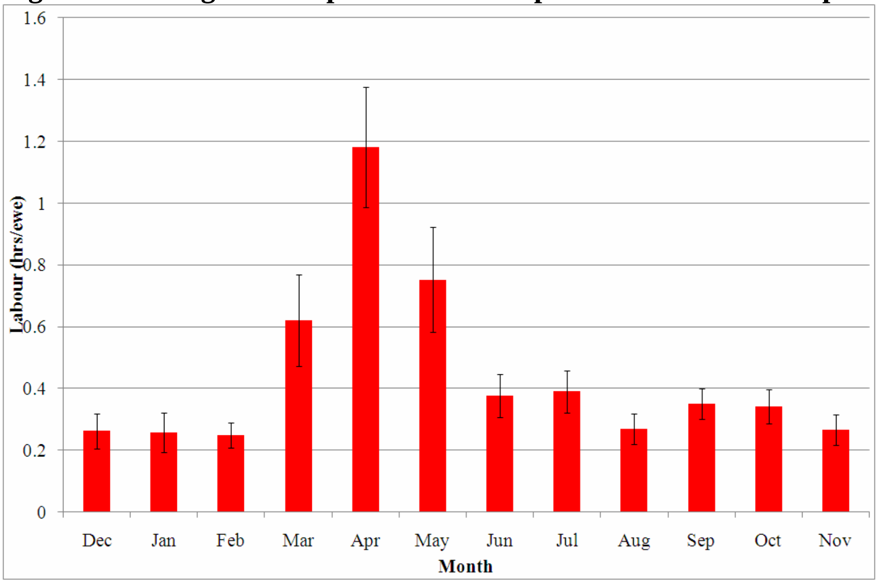
Several previous studies have assessed the impacts of decoupling on marginal agricultural systems using a combination of case studies and modelling. For example, Acs et al. (2010) used LP and a sample of 44 case farms in the Peak District of northern England. They highlighted the variability in response but indicated that extensification was likely and agri-environmental schemes important for mitigation of losses in farm income. Matthews at al. (2006) came to similar conclusions using a whole farm systems model and a case study farm based in Wales. This paper describes a model that combines elements of both these approaches i.e. an LP and simulation modelling to look in more detail at possible changes in management practice on extensive sheep farms in the absence of subsidy and hence under greater pressure to maximise gross margin.

## Methods

*Data Source*

A detailed inventory of resources, resource deployment and technical performances were collected from 20 commercial extensive sheep farms in Great Britain (equal numbers from the Scottish Highlands, Cumbria, Peak District and Mid-Wales). Farms were drawn from focus groups in this region contributing to Defra project AW1024 (SAC, 2009a, Stott et al., 2009). Average flock size on these farms was 850±128 ewes. Average farm size was 1290±368 Ha. This was made up of an average of 1175±367 Ha of open hill plus a further 509±279 Ha of pasture land. A monthly labour profile was developed for each of the 20 farms. The average labour profile is shown in Figure 1.

**Figure 1: Average labour profile for a sample of 20 extensive sheep farms in GB**



Detailed output data were collected from each farm. These included lambs born per ewe in flock and their average value added as shown in Table 1.

**Table 1: Lambs born per ewe and lamb value added for each farm in the sample (Farm number: 1-5 Cumbria; 6-10 Scotland; 11-15 Mid-Wales and 16-20 Peak District)**

| Farm No. | lambs/ewe | Lamb Value (£) |
|---|---|---|
| 1 | 1.00 | 28.42 |
| 2 | 0.88 | 28.39 |
| 3 | 1.01 | 28.16 |
| 4 | 1.07 | 28.30 |
| 5 | 1.02 | 28.62 |
| 6 | 1.27 | 26.96 |
| 7 | 0.71 | 26.96 |
| 8 | 0.81 | 26.96 |
| 9 | 1.13 | 26.96 |
| 10 | 1.08 | 27.59 |
| 11 | 1.21 | 28.42 |
| 12 | 1.58 | 28.39 |
| 13 | 0.97 | 28.16 |
| 14 | 0.86 | 28.30 |
| 15 | 1.26 | 28.62 |
| 16 | 0.98 | 29.02 |
| 17 | 0.90 | 28.92 |
| 18 | 1.26 | 29.37 |
| 19 | 1.19 | 27.99 |
| 20 | 0.72 | 27.61 |

All of the sampled farms finished at least some of the lambs surplus to requirements as replacements, selling the remainder as stores. A set sale value of £27/lamb was assumed across all farms for store lambs plus an extra £2.61 as the added margin obtained from lambs retained for finishing (based on SAC, 2008b). The variation in lamb values given in Table 1 therefore reflects differences between farms in the proportion of lambs sold store and fat. These values plus the output generated from the sold draft ewes at a sale price of £25/head were incorporated into gross outputs. Any extra resources required for lamb finishing were not otherwise accounted for. Variable costs per ewe excluding feed costs were assumed fixed at £10.58.

*Linear Program*

Stott et al. (2005) describe a method to evaluate the relative contribution to welfare of alternative sheep husbandry actions. These authors combined such welfare assessment with LP to assess the overall economic performance of sets of husbandry actions. This revealed the trade-off between animal welfare and profit allowing least-cost welfare improvement plans to be designed for the individual farm. However, the 'production functions' applied within this LP were simplified estimates derived primarily from the collective experience of farmers participating in the research. They were also confined to the husbandry actions that made up the welfare assessment. In the current LP, production functions were based on established relationships between feed energy intake and animal production (AFRC, 1993).

Grass feed energy supply was based on the model of Armstrong et al. (1997), calculated separately for hill and in-bye land. This model allows for adjustment to reflect the grass growing conditions applicable to each farm, including height above sea level for hill and in-bye land, region (Scotland or England/Wales), stocking rate, nitrogen application rate on in-bye land (150kg/Ha at £0.47/kg), proportion of improved pasture and heather cover on the hill. For the results reported here, heather was assumed to offer no nutritional value to the sheep. Variable costs of land were £0/Ha, £64/Ha and £83/Ha for hill, pasture and conservation land respectively including fertiliser costs (SAC, 2008b). Conservation land was assumed to be available for grazing from July to September inclusive. Other land was available for grazing year round. Total grass growth on conservation land prior to July was assumed available for consumption thereafter as hay or silage and any surplus transferred from month to month for the rest of the year. Any hay or silage remaining at year end was assumed to be wasted. Home grown grass and forage could be supplemented at any time by purchase of hay at £70/tonne and/or concentrates at £250/tonne (SAC, 2008b). Concentrates were constrained to a maximum of 0.15 of dietary energy supply.

Metabolisable energy (ME) demand per ewe for each month of a typical sheep farming year was calculated for an average ewe conceiving on December 1$^{st}$ and lambing on 26$^{th}$ April and weaned on 24$^{th}$ August. Barren ewes were assumed to form 0.1 of the flock and twin bearing ewes also 0.1. Mature ewe body weight was assumed to be 51kg in all cases. Further nutritional details are available from the corresponding author.

The LP estimated the maximum total gross margin (TGM) that can be achieved for a given hill sheep farming scenario. It allocated grazing, forages and bought in feeds to meet daily energy demand of ewes on a monthly basis throughout the farming year. Initial parameters for the LP were based on Conington et al. (2004) to represent ‘extensive’ hill sheep farming systems typical in Great Britain. These were modified to reflect in turn, each of the 20 commercial farms in our sample. Labour requirements per ewe per month were based on the labour supplied as indicated in the labour profile for each farm. Depending on the scenario (see below), additional casual labour was available each month to relieve the labour constraint and hence allow for expansion of flock size subject to constraints implied by on-farm grass production. For further details of the LP and its validation see Vosough Ahmadi (2010) and the final report and annex of project AW1024 (available from the corresponding author on request).

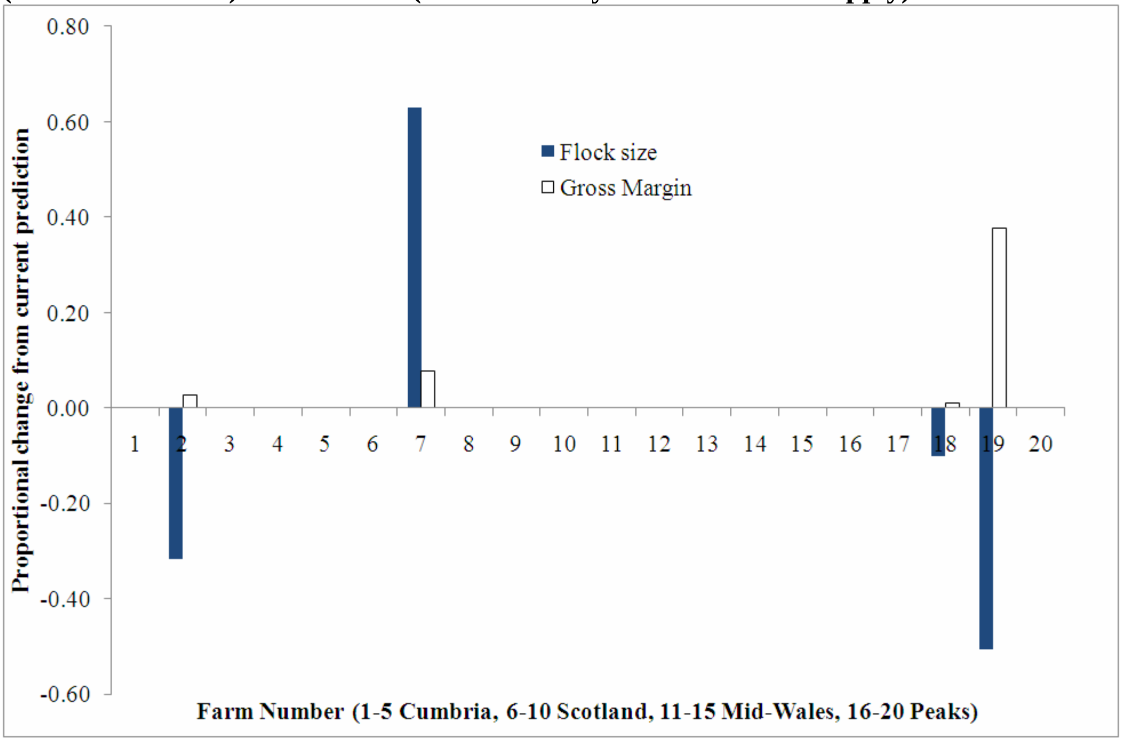
*Scenarios*

In scenario 1, flock size in the LP was constrained to be equal to current flock size. Additional casual labour was available at £5/hour but this was unnecessary as labour demand and supply each month was matched to current flock size based on the labour profile for each farm. Scenario 1 therefore served as a baseline. Scenario 2 was identical to scenario 1 except for the flock size constraint, which was removed from the LP. This allowed flock size to expand or contract with corresponding adjustments to land use each month throughout the farming year. If flock size was expanded extra labour would be required at £5/hour and if the capacity of the farm to feed the ewes was exceeded then additional feed inputs were available. The third and final scenario was identical to scenario 2 except that the cost of extra labour was set at £0/hour. This scenario was therefore only constrained by the capacity of the farm to feed the ewes or sufficient performance from the ewes to justify purchase of additional feed inputs.

## Results

The average gross margin under scenario 1 (current performance) was £8.44±0.6/ewe and £6357±762 per farm. The change from this baseline in response to Scenario 2 (no flock size constraint) is shown in Figure 2:

**Figure 2: Proportional change in flock size and gross margin from scenario 1 (current flock size) to scenario 2 (constrained by labour and feed supply)**

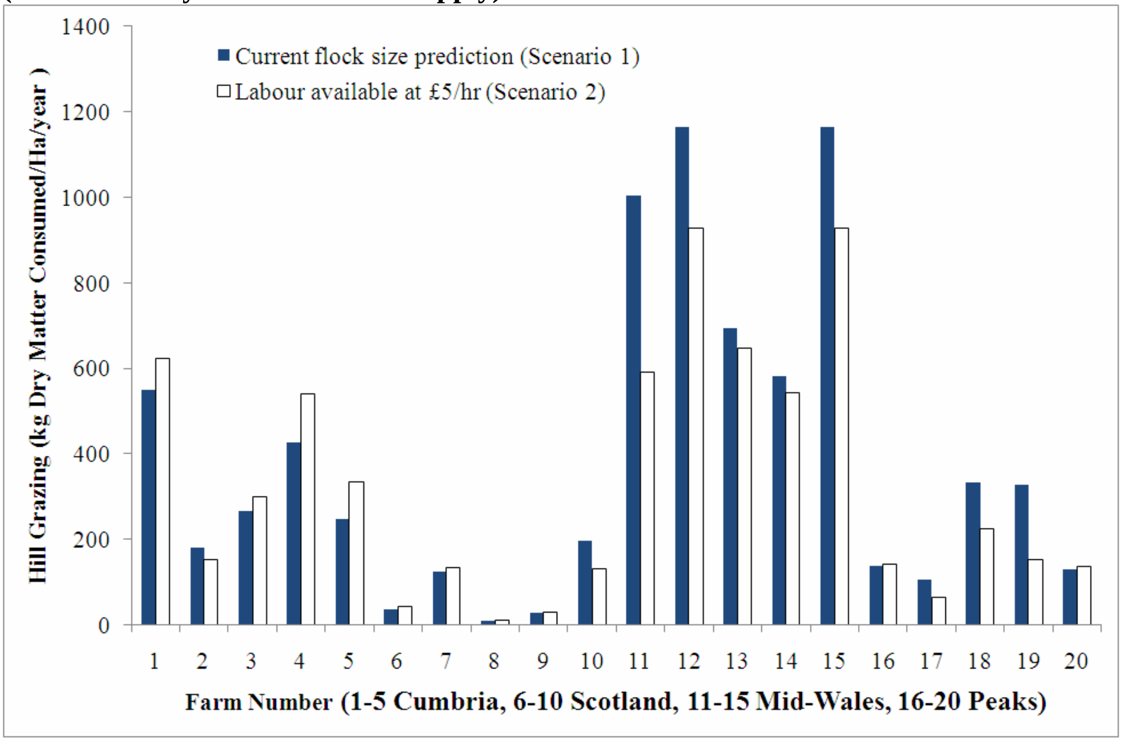



Only 4 farms gave a direct response to relaxation of the farm size constraint. Of these, 3 contracted as on-farm feed supply was inadequate to sustain current flock size. Only farm 7 expanded from 271 ewes and a gross margin of £3053 to 441 ewes and a gross margin of £3287. Expansion on farm 7 resulted in an increase in hill grazing from April to June but a decrease from July to September. However, in all months hill grass consumption was much less than production in the summer months. Total dry matter consumed on the hill rose from 72 tonnes off 576 Ha under scenario 1 to 76 tonnes in scenario 2. Consumption of hill grass dry matter per ewe was much lower in scenario 2 (173 kg/year) than in scenario 1 (267 kg/year).

The average shadow price of labour under Scenario 2 across months where it exceeded zero was £3.12±0.35/hour. For farms that did not contract under scenario 2, shadow prices other than for farm 7 ranged from £1.85/hour to £4.46/hour.

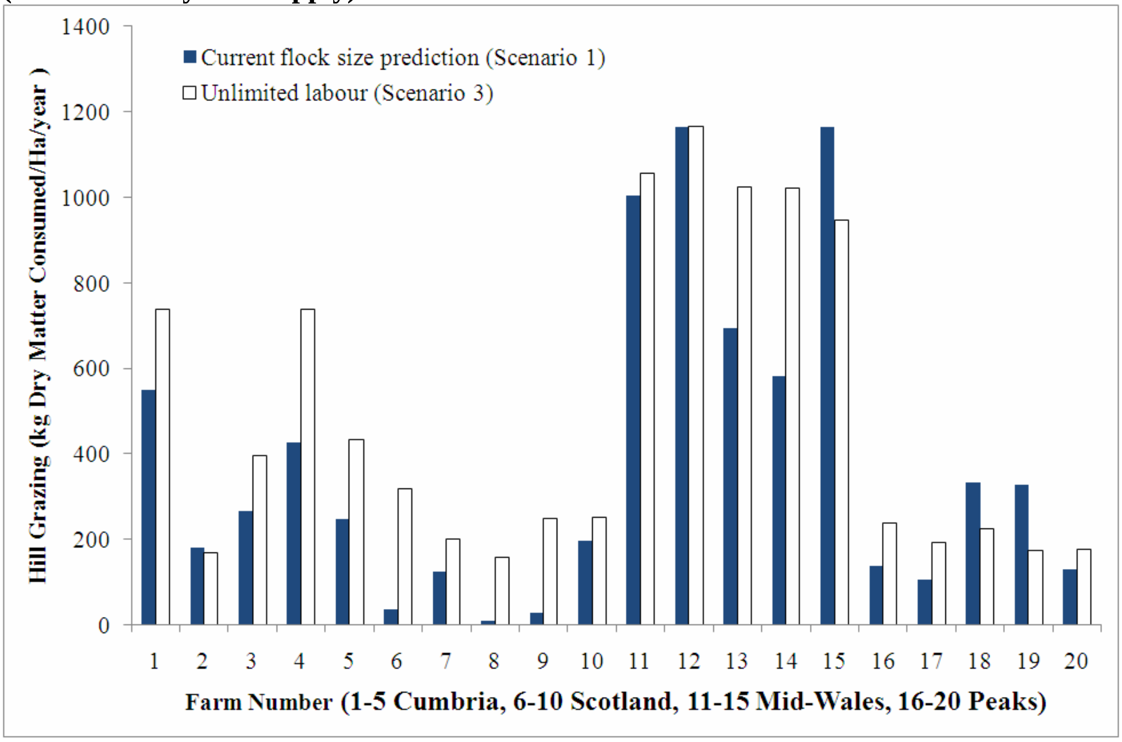
Despite the lack of response in flock size to scenario 2, all farms showed an adjustment in grazing management in response to the relaxation of the flock size constraint as shown in Figure 3. With one exception, farms in Cumbria placed more emphasis on hill grazing, while those in Wales did the opposite. Figure 3 also shows the contrast between the large extensively grazed hills in Scotland and the small more intensively grazed hills of Wales.

**Figure 3: Change in hill grazing from scenario 1 (current flock size) to scenario 2 (constrained by labour and feed supply)**




In contrast to Scenario 2, all farms that did not contract in response to scenario 2 (2, 18, 19 see Figure 2) expanded in response to Scenario 3. Average gross margin per farm rose to £13904±2218 and flock size to 2990±546. Gross margin per ewe fell to £5.43±0.41.

**Figure 4: Change in hill grazing from scenario 1 (current flock size) to scenario 3 (constrained by feed supply)**



Scenario 3 put increased grazing pressure on hill land for all expanding farms with the exception of farm 15 (Figure 4). However, this farm had a small hill area (18 Ha).

**Discussion and Conclusions**

Low returns and heavy dependence on subsidy are well known aspects of hill farming systems in Great Britain (Acs et al., 2010). The range of gross margins reported here are in line with those reported by SAC (2009b) for hill ewes producing store lambs with limited in-bye land (the closest parallel with this sample). When combined with typical fixed costs of about £50/ewe for specialist sheep farms in less favoured areas in Scotland (SAC, 2009b) the average gross margin in this sample fails even to partially cover fixed costs and hence justify continued production in the short run without subsidy. If these fixed costs per ewe applied to current flock size and expansion took place under Scenario 3 with no further increase in fixed costs then just 3 farms in the sample would return a positive net farm income.

At current flock size, all but three farms in the sample had some slack land. The variable costs on this slack land are saved in the LP, representing a baseline opportunity cost. In practice it may be possible to put such land to better use than this and hence offset some of the apparent losses referred to in the previous paragraph. However, on all but one farm this opportunity where it exists fails to generate sufficient income to cover the extra labour costs required by additional sheep (Scenario 2). The average shadow prices of labour demonstrate the range in potential returns to labour on these farms. Of the three farms constrained by land rather than labour, two had access to off-farm grassland not included in the LP. The other farm was given the second lowest score for provision of adequate nutrition by a panel of 12 experts assessing each farm in this sample for animal welfare (project AW1024 final report to Defra).

Given the restrictive influence of additional labour costs under scenario 2, it was surprising that adjustments to the feeding regime were implemented by the LP. This demonstrated the importance of the interaction between grazing management and labour management even when no direct link is specified in the LP. The relative scarcity of hill grazing seemed to determine whether this interaction was positive or negative for hill grazing. In our application labour requirements were specified only via the ewe activity and were not associated directly with land. Given the data, this deficiency could be rectified. Even then it is likely that labour requirements per ewe would alter according to grazing regime. For example, greater use of hill grazing may increase labour requirements per ewe because of the difficulty of inspecting ewes in remote locations.

If labour is not a constraint on expansion (Scenario 3) then in most cases greater use will be made of cheaper hill grazing and hence greater pressure may be put on their fragile ecosystems with potential deterioration in public goods which flow from these ecosystems. Reed et al. (2009) suggest that reduced grazing by hill sheep decreases greenhouse gas emissions both directly through the removal of the animals but also indirectly through effects on soil carbon budgets. However, they also state that the environmental implications of complete withdrawal (re-wilding) is currently unclear there being both positive and negative implications for bio-diversity. These authors conclude that the evidence base for assessing the trade-offs between public and private goods and services in the uplands remains poorly developed. Bio-economic modelling approaches such as the one described here could make a contribution to this evidence base by improving understanding of the complex interactions between farm resource management decisions as they alter throughout the farming year in response to the very specific needs of the farm and the farming family.

## References


Acs, S., Hanley, N., Dallimer, M., Gaston, K. J., Robertson, P., Wilson, P., and Armsworth, P. R. (2010). The effect of decoupling on marginal agricultural systems: Implications for farm incomes, land use and upland ecology. Land Use Policy 27, 550-563.

AFRC 1993. Energy and Protein requirements of Ruminants. An advisory manual prepared by the AFRC Technical Committee on Responses to Nutrients. CAB International, Wallingford, UK.

Armstrong, H. M., Gordon, I. J., Grant, S. A., Hutchings, N. J., Milne, J. A., and Sibbald, A. R. (1997). A model of the grazing of hill vegetation by sheep in the UK .1. The prediction of vegetation biomass. Journal of Applied Ecology 34, 166-185.

Conington, J., Bishop, S. C., Waterhouse, A., and Simm, G. (2004). A bioeconomic approach to derive economic values for pasture-based sheep genetic improvement programs. Journal of Animal Science 82, 1290-1304.

Matthews, K., Wright , I., Buchan , K., Davies, D., and Schwarz, G. (2006). Assessing the options for upland livestock systems under CAP reform: Developing and applying a livestock systems model within whole-farm systems analysis. Agricultural Systems 90, 32-61.

Reed, M. S., Bonn, A., Slee, W., Beharry-Borg, N., Birch, J., Brown, I., Burte, T. P., Chapman, D., Chapman, P. J., Clay, G. D., Cornelli, S. J., Fraser, E. D. G., Glass, J. H., Holden, J., Hodgson, J. A., Hubacek, K., Irvine, B., Jing, N., Kirkby, M. J., Kunini, W. E., Moore, O., Moseley, D., Prell, C., Price, M. F., Quinn, C. H., Redpath, S., Reid, C., Staglo, S., Stringerd, L. C., Termansend, M., Thorpp, S., Towers, W., and Worrall, F. (2009). The future of the uplands. Land Use Policy 26S1, S204-S216.

SAC (2008a) Rural Policy Centre. Farming's Retreat from the Hills. SAC, Edinburgh,UK.p.56. http://www.sac.ac.uk/ruralpolicycentre/publs/researchreports/retreatfromthehills/

SAC (2008b) The Farm Management Handbook, 29th Edition. SAC, Edinburgh.

SAC (2009a) Economics and Welfare of Extensive Sheep (EWES) project website. www.sac.ac.uk/sheepwelfare.

SAC (2009b) The Farm Management Handbook, 30th Edition. SAC, Edinburgh.

Stott, A. W., Milne, C. E., Goddard, P. J., and Waterhouse, A. (2005). Projected effect of alternative management strategies on profit and animal welfare in extensive sheep production systems in Great Britain. Livestock Production Science 91, 161-171.

Stott, A.W., Vosough Ahmadi, B., Morgan-Davies, C., Dwyer, C., Goddard, P. Phillips, K., Milne, C.E., Kupiec, B., Ringrose, S. and Waterhouse, A. (2009) Evaluating extensive sheep farming systems. Aspects of Applied Biology 93, 161-166. Proceedings of the Integrated Agricultural Systems: Methodologies, Modelling and Measurement Conference, Edinburgh, June 2nd-4th.

Vosough Ahmadi, B. , Dwyer, C.M., Erhard, H.W., Morgan-Davies, C., Waterhouse, A., Milne, C.E., Kupiec-Tehan, B., Ringrose, S., Goddard, P , Phillips, K. , Stott, A.W. (2010) Impacts of labour on interactions between economics and animal welfare in extensive sheep farms. Proc. 84th Annual Conference of the Agricultural Economics Society, Edinburgh. 29th-31st March.