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EVALUATING EXTENSIVE SHEEP FARMING SYSTEMS

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ABSTRACT

Data from each of 5 commercial, extensive sheep farms in Cumbria, UK were used as parameters in a linear program (LP) representing labour and grazing management in such farming systems. The LP maximised ewe enterprise gross margin subject to constraints dictated by the labour availability and land types on each farm. Under the assumptions used, labour availability and price restricted ewe numbers well below those observed in practice on 2 farms i.e. land resources were adequate for the farming system practiced. On two other farms stocking levels and hence returns were limited by the availability of forage and hence feed input prices relative to output. On one farm, greater grassland productivity was the key determinant of system performance. It was concluded that a holistic systems approach was needed to properly evaluate these farming systems in terms of their potential contribution to animal welfare, land use, profit and hence their sustainability.

KEY WORDS: Extensive, Sheep, Economics, LP

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INTRODUCTION

Concern is growing for the future of extensive sheep farming systems in Great Britain (SAC, 2008a). Without subsidy, such systems have long been uneconomic. Now that subsidies have been de-coupled from production, there is less incentive to maintain sheep stocking rates. This has implications for the environment, for rural communities, for farming families and for the animals themselves as changes to farming systems in these challenging regions may have significant implications for animal welfare.

Work by SAC, ADAS and MLURI for Defra under project AW1024 (A further study to assess the interaction between economics, husbandry and animal welfare in large, extensively managed sheep flocks) aims to examine, in the light of CAP reform, the interaction between economics and management decisions with respect to animal welfare. Further details of the project are available on its website at www.sac.ac.uk/sheepwelfare. The work is interdisciplinary, drawing together animal scientists, economists and the farmers themselves to explore the options for strategic decision making and the implications these will have on the viability of extensive sheep farms and on the welfare of the sheep.

At the core of project AW1024 is a model of the management of extensive sheep farms throughout the farming year. This model uses linear programming (LP) (Barnard and Nix, 1979) to establish the profit maximising farm management strategy for a given farm situation subject to constraints that reflect the main resource limitations, local environmental and climatic situations, strategic goals of farmers and the welfare needs of the sheep. By changing LP assumptions, interactions between economics, husbandry and animal welfare can be explored leading to a better understanding of alternative responses to change and their implications.

This paper uses the AW1024 LP to illustrate some of the issues arising from the evaluation of extensive sheep farming systems. The implications for development of integrated methodologies and associated projects in related agricultural systems research are discussed.

MATERIALS AND METHODS

Data collection

In project AW1024 the basis of data collection is a network of 4 farmer focus groups based in Scotland, Cumbria, the Peak District and mid-Wales. This has allowed the project team to involve the farm decision makers themselves, learn about their farming systems and management goals and how they respond to the distinct policy and marketing environment that applies in each region. The focus group data have been supplemented by a detailed inventory of 20 commercial farms (5 in each region) and in-depth interviews with the farmers concerned. These data are subject to expert evaluation to establish the animal welfare implications of the various attributes of each farm as well as the basis for the LP modelling work. By using the expert evaluation and the LP together, trade-offs between profit and welfare under alternative policy and farm management responses can be explored. In this paper we have used the inventory data for 5 farms from one of the regions, Cumbria, to illustrate our approach to evaluating extensive sheep systems. A summary of the data used appears in Table 1 and Table 2.

Table 1. Input data used in the LP.

	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5
Farm technical data					
Number of ewes	720	2000	850	1600	900
Number of lambs weaned	800	1950	950	1900	1020
Number retained female lambs	200	975	180	500	248
Number retained male lambs	20	40	0	0	6
Number of finished lambs sold	405	935	400	950	600
Number of store lambs sold	0	0	250	0	80
Number of breeding lambs sold	175	0	100	450	78
Number of draft ewes sold	160	850	131*	300	300
Gross output (£/ewe)	27.22	25.81	23.27	27.35	29.89
Land					
Hill area (ha)[1]	168	1400	470	627	550
Pasture area (ha)[2]	68	70	197	135	44
Hay land area (ha)[3]	2.8	8.0	3.4	6.4	3.6

[1] Consists of open hill and intake (hill park) area
[2] Consists of true inbye (i.e. improved land near farm buildings) minus estimated hay land area
[3] Assumed 0.004 ha/ewe (SAC, 2008b)
Sale price of draft ewes (£/head): 25
Variable costs ex-feed from SAC (2008b) of £10.58/ewe, page 171 Hill Breeding ewes-store lamb production-limited inbye
[*] Identified as missing in the original inventory data file; value was estimated by the authors based on an annual mortality rate of 4% and keeping the ewes for 6 years.

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 are now based on established relationships between feed energy intake and animal production (AFRC, 1993). Grass feed energy supply is based on the model of Armstrong et al. (1997). The LP estimates the maximum total gross margin (TGM) that can be achieved for a given hill sheep farming scenario. It allocates 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 the 5 commercial farms from Cumbria. The LP models the ewe flock only, yet all of the inventory farms finished at least some of the lambs surplus to requirements as replacements (Table 1). 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, 2008). These values plus the output generated from the sold draft ewes at sale price of £25/head were incorporated in the gross outputs shown in Table 1. Any extra resources required for lamb finishing were not otherwise accounted for.

Table 2. Monthly labour profile data of the studied farms and the average values of the mean and premium sheep labour requirements reported by Nix (2007).

	Labour (hours/ewe)					
Month	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Nix (2007)
Dec	0.2952	0.2480	0.2449	0.1744	0.3095	0.1750
Jan	0.2030	0.2480	0.0729	0.1744	0.1476	0.2500
Feb	0.2889	0.2240	0.1365	0.1225	0.1889	0.2500
Mar	0.3998	0.2790	0.1511	0.1550	0.2153	0.8500
Apr	0.7500	0.3000	0.5798	0.1688	0.5595	0.3250
May	0.7750	0.3410	0.3803	0.1938	0.4798	0.2500
Jun	0.1429	0.3600	0.2571	0.2063	0.1429	0.3500
Jul	0.2952	0.3720	0.2657	0.2131	0.3137	0.1750
Aug	0.2214	0.3720	0.1719	0.2131	0.2276	0.1750
Sep	0.2857	0.3600	0.1664	0.2063	0.3452	0.2000
Oct	0.2952	0.3100	0.1719	0.1938	0.3198	0.2000
Nov	0.2857	0.2700	0.2723	0.1688	0.3095	0.1750

Earlier work (Stott et al. 2005) showed that labour was critical for sustainable sheep farming systems as there was a particularly strong trade off between welfare and profitability associated with labour supply. We therefore explored the relationship between labour supply, profitability and other aspects of farm management. In line with earlier work and pending more information about labour requirements for animal welfare we used published figures (Nix, 2007) (Table 2). These requirements were aligned in the LP with the monthly supply of labour estimated for each farm in the farm inventory (Table 2). To explore the impact of these labour constraints on the farm plan we introduced extra labour supply activities for each month so that the constraints could be relaxed by the LP if farm gross margin was thereby increased. We first set the cost of extra labour to £0/hour to relax the labour constraint completely and so test the carrying capacity of the farm against current stocking levels. The LP was then re-optimised for each farm with extra labour set at approximate minimum market rates (£5/hour, SAC, 2008) and without extra labour. This tested the impact of labour on farm plans and farm financial performance giving clues as to the likely interactions between labour, profit and welfare on these farms.

RESULTS

Data presented in Figure 1 show the whole enterprise gross margins projected by the LP for each of the 5 inventory farms investigated while data in Figure 2 show the corresponding ewe numbers compared to the ewe numbers observed on each farm. Farms 2 and 3 were unresponsive to extra labour suggesting other constraining factors. These factors are evident from Table 3, which shows the dry matter intakes for each nutrient source projected for each farm by the LP with labour none limiting. For example, with Farm 2 and Farm 3 the LP fails to use all of the available pasture grazing. If the assumed variable costs of these grazings are reduced then the LP will utilise them, increasing the number of ewes on the farm but not up to the levels observed in practice.

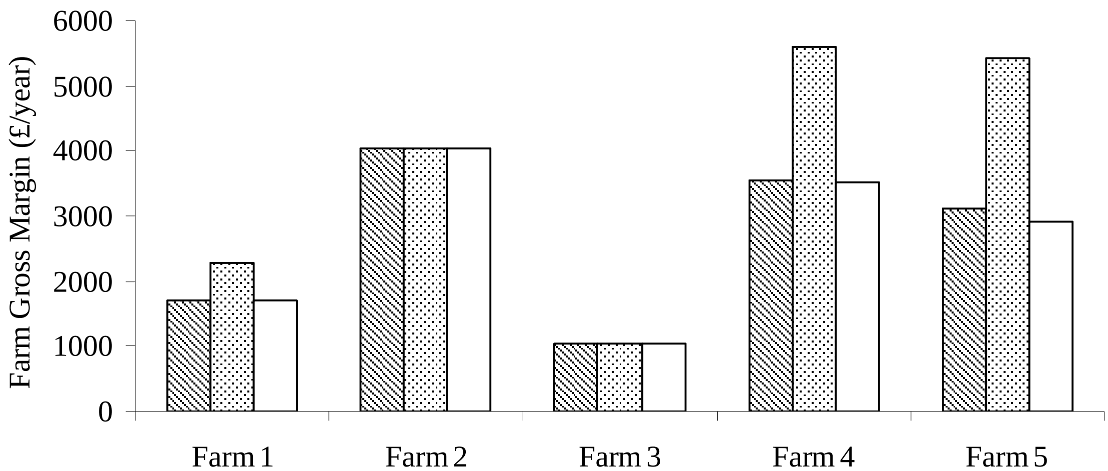

Figure 1: *Ewe enterprise gross margins projected by the LP for each inventory farm with extra labour available at £5/hour (lined bar), £0/hour (dotted bar) or with labour limited to actual labour supplied (plain bar).*

By reducing concentrate (i.e. a balanced feeding compound) prices, the observed stocking rates are achieved. Data from the inventory confirms that these farms are indeed using more concentrates than projected by the LP but more selectively than is allowed for in the current LP. For example, Farm 2 determines pregnancy status by ultrasound scanning and feeds concentrates accordingly.

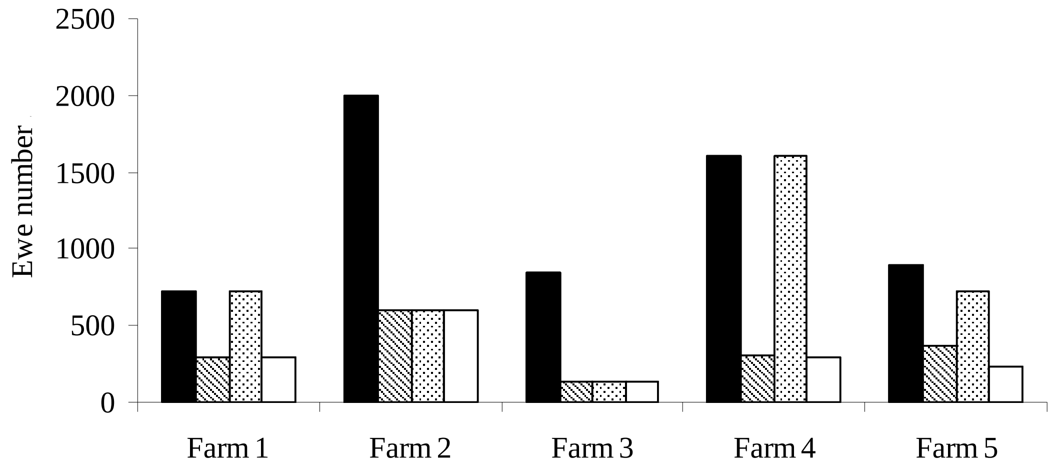

Figure 2: *Ewe numbers for each inventory farm (solid bar) compared with ewe numbers projected by the LP with extra labour available at £5/hour (lined bar), £0/hour (dotted bar) or with labour limited to actual labour supplied (plain bar).*

Table 3. Dry matter intakes projected by the LP (kg/ewe/year) with no labour constraint.

	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5
Source of nutrients					
Hill grazing[1]	99.9	319.3	335.3	104.6	126.2
Pasture grazing[1]	180.8	0.0	0.0	185.2	147.1
Aftermath grazing[1]	2.3	3.1	15.3	2.3	2.9
Own hay[2]	5.8	19.3	38.2	5.8	7.3
Bought hay[3]	112.4	95.7	39.7	112.0	124.5
Concentrates[4]	0.0	0.0	0.0	0.0	0.0

[1] *Quality of grazing varied throughout the year based on ARC (1976)*
[2] *ME 8MJ/kg, DM 850 g/kg*
[3] *ME 9MJ/kg, DM 850 g/kg, £70/t fresh*
[4] *ME 12 MJ/kg, DM 850 g/kg, £250/t fresh*

Farm 5 is at an intermediate stage where LP results respond to the price of extra labour but not to the degree where observed stocking rates are achieved when extra labour is free. In this situation the observed stocking rate of 900 ewes (Table 1) can be obtained by increasing the level of nitrogen application to the pasture from the default setting (50kg/ha) up to 120kg/ha. In contrast to Farms 2 and 3, lowering the cost of pasture alters the grazing pattern but does not increase ewe numbers.

DISCUSSION AND CONCLUSIONS

This preliminary analysis illustrates some of the interactions between labour, profit and land use in extensive sheep farming systems. It also highlights some of the difficulties involved in this type of systems modelling work. For example, the current LP meets the nutritional needs of the average ewe on the farm made up of those with twins, singles or barren. In practice these types of ewes have different needs, for example demands for concentrate feeding and hence for labour. Another difficulty was establishing the labour requirements of the ewe. The published figures used here show a labour profile that clearly differs from the observed pattern (Table 2). An important goal of AW1024 is to address this problem. With requirements based on animal welfare needs, models developed from this one will provide a means to adapt farm management plans and hence land use to better meet these needs while maintaining sustainable farm businesses. These adaptations might include so called ‘easy care’ breeds of sheep that require less attention at key times such as lambing. However, a recent study by Kirwan et al. (2009) suggests that on extensive sheep farms, dealing directly with sheep forms a very small proportion of total labour time at lambing. The major tasks at this time are travelling (26%) and inspection (22%). This suggests that a greater focus on the labour demands of the whole farming system rather than just on interactions with the animal are the key to better labour utilisation and hence improved profitability and animal welfare. Systems approaches as illustrated here provide a means to deal with these wider concerns alongside the animal oriented demands on labour.

Despite the difficulties, the analysis clearly illustrated the importance of individual farm variability when evaluating extensive sheep farming systems. In some cases projected sheep gross margin (Figure 1), stocking policies (Figure 2) and therefore grazing/land use were very sensitive to extra labour supply and its cost. However, on other farms these issues were irrelevant as existing labour supply was projected to be more than adequate to meet the limited stock carrying capacity of the farms at assumed feed input prices. If these change, the relationships between land use, labour, gross margin and hence animal welfare may also change. Observed farm practices illustrated the strategies adopted to meet the current cost-price squeeze in this sector, which can be reflected in the LP model as interests dictate. However, it will be impractical to model details of individual farm circumstances and/or obtain the necessary information from individual farms. Work is therefore underway to develop typologies that represent particular classes of extensive sheep farming systems in terms for example of their structure or management strategy (Morgan-Davies et al., 2009). These will be represented in the LP model described here to arrive at more general conclusions about the profit-land use-welfare relationship and hence provide guidance towards sustainability.

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