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Impacts of farmers' management styles on income and labour under alternative extensive land use scenarios

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Abstract

High Nature Value farming systems cover a large proportion of the agricultural land in marginal and mountain areas of Europe. These large areas face environmental, economic and social challenges and formulating policies that support all these aspects is difficult. Although farmers play an important role in maintaining the ecological diversity of these areas, their differing management styles are often not recognised when land use policies are formulated. This paper examines these issues using an optimisation model based on an extensive livestock farm in Western Scotland, where four farmers' management styles are combined with a series of six alternative future land use scenarios, to provide a more realistic and robust insight of policy impacts on land use and habitat, labour and farm income. The management styles derived from a typology that was based on a composite of both available resources and attitudinal components. The six alternative scenarios encompassed competitive land use diversification options (woodland and wild deer shooting), abandonment of native pasture for agriculture, no support, high market prices for livestock products, and increased animal efficiency. Although diversification via forestry was found to be potentially central to increasing farming incomes, farmers' reticence to adopt forestry or any diversification was a major constraint. This case study also reinforced that managing livestock on these HNV farming systems was not economical unless support subsidies were in place. The only scenario which could enhance the HNV biodiversity value on farms was one with high market prices, resulting in the most varied land use (sheep, cattle and forestry). All others scenarios meant an increase in afforestation (which displaced livestock), an increase in livestock grazing or abandonment of the land, none of which would maintain biodiversity in these areas. Very few scenarios were able to increase on-farm labour demand and although greater flexibility in farm labour was found to be essential, labour scarcity in these marginal mountain areas remained a problem. In conclusion, this case study reinforced that farmers' management style and motivation do play a major role on how they respond to policies, and unless this role is acknowledged by policy-makers, these European HNV areas may not be targeted properly for the most desired outcomes and sustainability.

Keywords: High Nature Value farming, farmers' styles, policy, optimization model

Highlights:

- HNV farmers' management styles dictate how they react to the policy-making process
- Public support is crucial to economic survival of the farmers
- Public support must acknowledge disparities in farmers' motivations
- High market prices could ensure a land use mix favourable to HNV biodiversity on farm
- Labour flexibility is a barrier to diversification and higher efficiency in HNV farming systems

1. Introduction:

In Europe, 57% of the agricultural land is classed as Less Favoured Areas (LFA) under European legislation (LFA - Article 2 of EU Council Directive No. 75/268/EEC). This territorial designation reflects the natural handicaps, such as poor climate, short growing seasons, mountainous or hilly topography, tendency towards depopulation, all of which constrain productivity and economic prosperity. As a result, farming in these marginal lands has often been challenging (MacDonald et al., 2000), as the main production systems are often livestock-based in extensive settings, with little opportunity for adaptation or adjustment. Any change in land use policies can have important repercussions and create uncertainty (Acs et al., 2010; Baldock et al., 1996; Cocca et al., 2012).

Moreover, the High Nature Value (HNV) farming system concept recognises that many European habitats and landscapes considered to be of high nature conservation value are intimately associated with the continuation of specific low-intensity farming systems (Bignal and McCracken, 2000). Although some HNV farming systems occur in association with traditional cropping systems in southern Europe, in general the majority of Europe's remaining HNV farming systems are now largely associated with livestock grazing systems on semi-natural habitats in the mountains and other remote areas of Europe (Bignal and McCracken, 2009). Ensuring the maintenance of the farmland biodiversity value associated with such areas therefore depends on ensuring the continuation of appropriate farming systems in those areas. This requires an understanding not only of how the different elements of HNV farming systems interact to maintain the high nature conservation habitats and species of interest, but also of how HNV farming systems and practices are influenced by changes in agricultural support policies. Formulating policies for these HNV farming systems and areas becomes challenging and can lead to conflicts (Morgan-Davies et al., 2006; 2010).

Land use policies are also a key driver of change in such marginal areas, and following the announcement of the latest agricultural reforms, studies have been conducted in Europe to determine how these could affect farming (e.g. Acs et al., 2010; Matthews et al., 2013; Oñate et al., 2007; Veysset et al., 2014). Most of these studies used simulation models to investigate the likely outcomes under a series of scenarios (e.g. Hanley et al., 2012). Whole-farm computer models can certainly help assess implications of any change to the farming systems studied (Pannell, 1996). Whilst simulation models can be valuable and have been widely used (e.g. Villalba et al., 2006; 2010, on mountain beef systems; Moore et al., 1997, on Australian grazing enterprises; Milne and Sibbald, 1998, for grazing systems; Villalba et al., 2015, for sheep systems), optimisation models can offer an insightful alternative viewpoint. One of the advantages of using an optimisation farm model is that many activities can be considered simultaneously and the effects of changing parameters can be easily assessed (Janssen and van Ittersum, 2007). An optimisation model can also use a combination of existing models outputs to inform and predict likely outcomes.

As well as being fragile in the broadest sense, these European HNV mountain farming systems are also diverse, and the concept of rural diversity is now increasingly recognised (e.g. van Eupen et al., 2012) and accepted. This diversity is apparent not only among and within the HNV farming systems, but is also evident within the farmers themselves. For instance, as shown by O'Rourke et al. (2012) in Southwest Ireland and by Morgan-Davies et al. (2012) in Western Scotland, extensive farmers are not a homogenous group, neither in their farming practices nor in their views and their management styles. Janssen and van Ittersum (2007) demonstrated the usefulness of "so-called" farming styles to distinguish groups of farms with different strategies. Farmers' views, attitudes and goals play a very important role in the day to day management of their business (Brodt et al., 2006; Fairweather and Keating, 1994; Girard et al., 2008), and incorporating their motivations into economic models would be useful (Howley et al., 2015). Morgan-Davies et al. (2012) underlined the importance of mountain farmers' motivations and constraints in their responses to policy reforms, as well as the effectiveness of a typology approach based on farmers' opinions and motivations, rather than government census farm types. Likewise, Morgan-Davies et al. (2014) suggested that mountain beef farmers appear to not only adapt their production systems according to their current bio-physical and financial circumstances, but also from personal experience.

However, policy-makers do not often take into account these differing farmers' motivations when introducing new policies, leading potentially to unexpected outcomes (Dumont et al., 2014). There is perhaps in policy-making circles a narrow vision of farmers' potential behaviour and reactions, which does not necessarily acknowledge farmers' wider motivations. However, the need to acknowledge the attitude and behaviour differences amongst farmers when devising land use policies has been stressed (Viaggi et al., 2011; Wilson et al., 2013). Past studies (Battershill and Gilg, 1997; Harrison et al., 1998) showed that farmers' attitudinal dispositions and personal values are often more important than any financial motivations in their farm decision-making.

Scotland is an example of a country in Europe with a large proportion of marginal land and HNV farming systems. Rural areas occupy 94% of the land mass (Scottish Government, 2012), agriculture dominates land use (72% of the land cover) and 86% of agricultural land is classified as LFA. Despite the preponderance of these marginal lands in Scotland, relatively few recent studies on the impacts of land use policy reforms on farms in these areas are available in the published literature and even fewer studies (e.g. Matthews et al., 2013; Osgathorpe et al., 2011) have used models to investigate their likely futures. No research has been done on how these impacts were influenced by farmers' management styles. In this context, it would be unique to model at farm level the likely effects of alternative land use policy scenarios on Scotland's marginal areas, superimposed on the different styles of farmers' management.

The aim of this paper is therefore to investigate whether modelling alternative future scenarios coupled with different farmers' management styles and motivations provides a more realistic and robust insight of policy impacts on land use, farm income and labour employment.

2. Methods

2.1. Overview

This paper investigated the effects of different farmers' management styles on land use, labour employment and farm income in a series of alternative land use scenarios, using an optimisation model. The model (described in further detail by Morgan-Davies, 2014) is based on linear programming that uses information from an existing computer program (Armstrong et al., 1997a, b) to estimate vegetation energy production, nutrition equations (AFRC, 1993) to predict animal energy requirements and then creates an optimisation model based on a Scottish extensive livestock farm case study to link these energy estimates, as well as labour requirements and financial information, in a series of competing productive outputs.

The general structure of the linear programming model was:

$$\text{Maximize } Z = c_1x_1 + c_2x_2 + \ldots + c_nx_n$$

$$\text{Subject to} \quad b_1 \geq a_{11}x_1 + a_{12}x_2 + \ldots a_{1n}x_n$$

$$b_m \geq a_{m1}x_1 + a_{m2}x_2 + \ldots a_{mn}x_n$$

$$\text{and } x_1 \geq 0,\ x_2 \geq 0,\ \ldots x_n \geq 0,$$

where Z was the margin at farm level; x_j was the level of the j^{th} activity; c_j was the margin or costs per unit of activities, a_{ij} was the matrix of technical coefficient; b_i was the supply of the i^{th} resource or constraint (Pannell, 1997).

A procedure was used to provide input parameters and adjust outcome values associated with the optimisation model. In this instance, energy requirements by livestock at different times of the year were used as the primary connections between animal enterprises and land use. Established computer programs were employed to estimate the energy production of different areas of vegetation (Armstrong et al., 1997a, b) and to calculate animal energy requirements throughout the year (AFRC, 1993). Local values of parameters relating to animal performance, labour requirements, fertiliser application as well as market values of animal sales and input costs were estimated (SAC, 2010). Adjustments needed to be made to the resulting overall objective function to take into account those costs and benefits which do not exhibit linear relationships with the scale of activity. Consequently, to calculate the impact on the farm's overall estimated trading margins, items such as the farm's fixed costs, Single Farm Payment (SFP) and Less Favoured Area Support Scheme (LFASS) receipts were included subsequent to running the LP model.

The model had been created around a single parameterised extensive livestock HNV farming system, so that constraints and parameters could be accurately defined, since vegetation data, animal production data, and labour and economic data were easily available. The farm in the model had an area of 2200 ha and was divided into three different simple types of land, as are most extensive mountain farms in Scotland; improved pasture (232 ha), fertilised annually, with potential for silage and hay making; hillpark land (486 ha), non-fertilised fenced-off permanent pasture of lower energetic quality than the improved pasture; hill land (1482 ha), unfenced semi-natural pasture of poorer quality vegetation, with an altitude ranging between 300-1000 m. The activities in the model, based on extensive farm practices and possible land use diversification, have been simplified and limited to: forage and feeds, livestock production (sheep and cattle), wild deer for shooting and forestry planting. Animal numbers were limited to a maximum of 2700 ewes, 70 cattle and 50 wild deer, to account for the vegetation utilisation rate on the native pasture (Holland et al. 2008). Forestry plantation was limited to 214 ha (equivalent to a maximum grant of £750,000 – Scottish Government, 2011a).

The model has been parameterised using historical (1987-88) physical data from the model farm, when it carried 2689 breeding ewes and 66 cows. The SFP and the LFASS payments have been calculated using these levels of livestock and a total grazing area of 2200 ha (Morgan-Davies, 2014). Once the model had been parameterised, it was run without the fixed livestock numbers. Instead, the upper limits on ewe and cow numbers have been added (respectively 2700 and 70). The resulting farm business income, labour and outputs were compared against published results from farm survey data (Quality Meat Scotland, 2012) and Scottish Government Farm Account Data Network Survey results (Scottish Government, 2011b), to check the reliability of the parameterisation. They corresponded with data for average to large LFA sheep and cattle farms in Scotland, which was representative of extensive HNV farms in the mountain areas (Morgan-Davies, 2014).

Although the objective function is considered in financial terms, the model was adjusted to accommodate farmers' views.

As such, four management styles have been modelled in this study: Three of them were created using results from a farmers' typology previously described by Morgan-Davies et al. (2012), who looked at Scottish extensive farmers' motivations following policy reforms. The three main types of farmers that were identified via this approach were 'adaptive', 'focused on farming' and 'resource-constrained' farmers. Although these farmers were not necessarily representative of the whole of Scotland, they were typical of their areas and illustrated the disparities in farmers' views and motivations. The last management style was modelled as 'unconstrained' farmers, to represent a style of management not encumbered by motivations or values – the type of management policy makers might assume when planning policies.

Six alternative scenarios have been devised, using current literature (Dumont et al., 2014; Godfray et al, 2010; Morgan-Davies and Waterhouse, 2010; Slee et al., 2014): Free choice, Abandonment of the hill, No support, Woodland grant only, High market prices, Increased efficiency.

The optimisation model has then been run under the conditions of each scenario and each management style. In total, 24 runs of the model have been carried out (Table 1).

<Table 1. The 24 model runs (6 scenarios x 4 management styles) >

2.2. Farmers' management styles (Table 1)

2.2.1. Management style for the Adaptive Farmer (AF)

This farmers' type comprised farmers who agreed on diversifying their income, including planting forestry. Most of them said they could use their resources differently and would be prepared to start ventures other than farming. They were also the most educated and the oldest. To reflect these views, their corresponding management style has been defined in the model so that all land resources competing activities were available to them.

However, these farmers being older, the labour coefficients relating to all activities were increased by 10% to reflect this age effect.

2.2.2. Management style for the Focused Farmer (FF)

The Focused Farmer type strongly believed that there was a future in mountain farming and had strong positive views on farming without subsidies. Farming came first in terms of their income and they had mixed views on diversification. Most of their spouses had a job outside farming. To emulate these ideas in a management style, the model was adapted so that the activities relating to wild deer shooting and forestry planting were not available.

2.2.3. Management style for the Constrained Farmer (CF)

This farmers' type was essentially constrained by its resources. Their livestock numbers were limited by the labour availability on their very extensive farms, with, for example, an average of 4.5 people needed to gather sheep (compared to only 3 and 1.6 for the adaptive and focused farmers, respectively). This farmers' type also acknowledged that distances were an issue on their farm. Although they strongly agreed on the value of diversification, labour and infrastructure were their main constraints. To reflect this in the model, all land use competing activities were available but the land and labour resources were reduced by 20%. This reduction was based on Quality Meat Scotland (2012) farm survey results, which showed a difference of ~20% in the amount of unpaid labour between hill (constrained farms) and upland (less constrained) sheep farms. The improved pasture land was reduced to 185 ha, the hillpark to 389 ha, and the hill to 1186 ha, leading to a total farm area of 1760 ha, instead of 2200 ha. Limits on casual and permanent labour in the model were also reduced, as were those on livestock numbers (set at 2160 ewes and 56 cows).

2.2.4. Management style for the Unconstrained Farmer (UF)

The unconstrained management style was created to represent an ideal management, not limited by any personal values, attitudes or motivations. All activities in the model were available under that management style, with no other limits on animal numbers, land or labour than those described in the initial model (2200 ha, 2700 ewes, 70 cows, 50 deer).

2.3. Description of the scenarios (Table 1)

2.3.1. Free choice (FC).

This scenario was created to represent a baseline or a starting point. In that scenario, the model was allowed to use all land resources competing activities; i.e. forage and feeds for the livestock, opportunities to shoot up to 50 wild deer on the hill; opportunities to plant native or conifer woodland on improved, semi-improved or semi-natural pasture land, up to a maximum of 214 ha.

2.3.2. Land Abandonment

In this scenario, all activities in the model linked to the unfenced semi-natural vegetation areas (hill) were disabled. The total area of the farm was reduced to 718 ha (improved and semi-improved pastures only). Woodland plantation on the hill was not possible and no wild deer shooting was available. All other activities remained. This scenario was created to investigate the impact of agricultural reforms (SAC Rural Policy Centre, 2008; 2011) on land abandonment.

2.3.3. No support

For this scenario, all agricultural subsidies and woodland grants were disabled in the model. The aim of this scenario was to model the effects of a free market, with no support for farming or forestry, to reflect recent debates within the EU and at a higher international level (Bartolini and Viaggi, 2013; Foresight, The Future of Food and Farming, 2011).

2.3.4. Woodland support only

There is a drive in Scotland for afforestation and woodland expansion (Scottish Government, 2009); at the same time, farming and forestry have been long in conflict and seen as mutually exclusive (Morgan-Davies et al., 2015; Slee et al., 2014) This scenario was devised to both represent this expansion drive and investigate its impacts on a mountain farm, when no livestock-subsidies based were available. In the model, no agriculturally-based subsidies were available, but the woodland plantation was supported through a woodland grant (up to a maximum of £750,000).

2.2.5 HMP – High market prices for the livestock outputs

This scenario was created to reflect the possibility that the market for animal products may change after a policy shock such as changes in agricultural subsidies and support. To investigate this concept, output prices in the model were increased by 68% for sheep products and 70% for cattle products. These increases were based, as an example, on real prices fluctuations between 2004 and 2010, not adjusted for inflation (after the major change in subsidies regime post 2003 CAP reform).

2.2.6. Increased animal efficiency

This scenario explored the effect of increasing the efficiency of the livestock system. To reflect this scenario, performance of ewes and cows in the model were increased by 5%, and the longevity of the flock/herd was increased by 1 year. A 5% difference was recorded between the average and top/bottom third of recorded upland flocks and herds in Scotland (Quality Meat Scotland, 2016), supporting the use of value differential.

3. Results

3.1. Management styles

The comparative summary of the four management styles, for each of the scenarios (Table 2 and Figure 1) focuses on income and activities.

In terms of Farm Business Income, the Unconstrained Farmer (UF) outperformed consistently the other management styles, although only marginally so when compared to the Adaptive Farmer (AF) management style (Figure 1). Since the main difference between UF and AF was the labour demand (higher in AF), this produced similar trends of results.

<Figure 1. Farm Business Income across the alternative scenarios and the management styles>

The Focused Farmer (FF) management style performed poorest practically across all scenarios. It could only compensate for its lack of forestry grants income by maximising cow numbers (Table 2) when output prices were high (High Market Prices). The Constrained Farmer (CF) management style showed better results than FF, despite its limitations in land area and labour availability.

<Table 2. Some final outputs (livestock numbers, labour hours, variable costs, subsidies and areas of planted woodlands on improved, semi-improved and native pastures)>

The forestry planting pattern varied between the management styles (Table 2), UF and AF only planted on the improved pasture (higher incomes), except in the High market prices scenario, where the planting occurred both on improved and semi-natural pastures. However, CF management style had different patterns because of its reduced improved pasture area, resulting in planting always occurring on improved, semi-improved or semi-natural pastures. When the opportunity arose to maximise cow numbers (e.g. High market prices scenario), the semi-improved pasture was not planted (and kept for animal feed) and the semi-natural pasture was used instead, despite its lesser planting income value. A trade-off between feed costs and forestry grants incomes was observed.

The Focused Farmer (FF) management styles generated most often the largest throughputs in the local economy, shown by the variable costs, mostly due to the number of animals, especially cows that it sustained (Table 2). When the animal efficiency increased (Higher efficiency scenario), or when prices for outputs were higher, its throughputs decreased compared to those of the AF and UF management styles, as feed costs were higher for these two latter styles (less improved pasture land available due to forestry).

The woodland option provided an important income against which animals (especially the cows) could not compete. There were also some trade-offs observed between animal costs (feed), land use for energy (feed) and land use for forestry, when the improved pasture area was restricted.

Management styles clearly made a difference to Farm Business Income, with the FF with no woodland diversification having the lowest incomes across most scenarios (Figure 1, Table 2). The only scenarios when the FF outperformed both the CF and AF were those with no forestry grants available (No support scenario).

3.2. Impact on land use and labour

3.2.1. Land Use

Figure 2 shows the percentage of the farm area that would be used by sheep, cattle, wild deer and for forestry, under each of the scenarios, for all management styles.

The highest percentages of land used by sheep appeared when there was no support available as sheep became the least costly land use option. The Woodland support only and Higher efficiency scenarios showed similar levels of sheep, wild deer and forestry percentages to the Free choice scenario. However, only the High market prices scenario resulted in the most varied land use (mix of sheep, cattle and forestry).

<Figure 2. Land Use under the different scenarios for the four management styles (Unconstrained Farmer UF, Adaptive Farmer AF, Focused Farmer FF, Constrained Farmer, CF). Note that the scale varies as the incomes increase or decrease dramatically between the scenarios.>

Although the land abandonment scenario was not financially disastrous for individual land managers, as it still provided positive incomes, it would release 67% of the land from use by farming and would result in abandonment of this area. This 67% restriction was imposed by the model; however, the remaining mix of land use between forestry and animals was derived from the model.

With the exception of the No support, the forestry share of land use stayed similar (at a maximum of 7%, due to the grant limit) across the scenarios. However, there were disparities across the management styles, with FF never having any forestry and thus incurring lower incomes under most scenarios. Conversely, this management style returned the highest proportion of land use for cattle.

Given the variations amongst the management styles, to obtain the 25% target of the Scottish Forestry Commission by only relying on plantation on LFA sheep and cattle farms land, such as in this example mountain farm, this would mean that more than 25% of LFA areas would have to be forested. To reach this target, the forestry scheme would have to increase substantially, an option that might not be feasible at government level.

3.2.2. Labour use

The use of labour also varied greatly under the different scenarios (Figure 3). The scenarios with high market prices or with higher animal efficiency would be the only ones to provide enough labour during the year to justify the employment of one permanent labourer (1900 hours/year).

Across management styles, the FF required most often the highest number of farm labour hours as animal numbers (especially cows) were maximised, with no forestry. Conversely, farm business incomes were generally lower than with the other management styles. AF needed the least amount of labour, except when market prices were higher. Trade-offs between output market prices and labour costs were well illustrated in that instance.

<Figure3. Labour use (in hours) and Farm Business Income (£) between all the scenarios, for the four management styles (Unconstrained Farmer UF, Adaptive Farmer AF, Focused Farmer FF, Constrained Farmer, CF) Note that the scale varies as the incomes increase or decrease dramatically between the scenarios)>

The 2015 Scottish agricultural census specified that the 14,327 holdings in the LFA sheep and cattle farms type represented the equivalent of 19,218 Standard Labour Requirements (SLR) (Scottish Government, 2015). On average, this equates to 1.3 SLR per holding, or 2460 hours of labour per year.

Comparing this number with those from different scenarios under the different management styles (Figure 4), the impact of alternative futures on Scottish LFA sheep and cattle farm actual labour could be illustrated.

Only the scenarios with higher prices and higher efficiency showed an increase in actual farm labour. There were disparities between management styles; the Focused Farmer and Unconstrained Farmer types would potentially provide the highest positive farm labour changes for these two scenarios.

<Figure 4. Average percentage change in LFA sheep and cattle farm labour for the four management styles (Unconstrained Farmer UF, Adaptive Farmer AF, Focused Farmer FF, Constrained Farmer, CF) under the different scenarios>

4. Discussion

Using differing farmers' management styles in the model helped to mirror the diversity of mountain farmers and the differences in farming styles. This notion has been highlighted by Hanley et al. (2012), who found differences between farm types in their study of ecological and economic impacts of agricultural changes in the uplands. In the Austrian LFA, a strong influence of different farming styles on biodiversity maintenance was also found (Schmitzberger et al., 2005). Defra (2008), in England, also stressed the importance of recognising the diversity within farmer's attitudes when developing policies. Likewise in the USA, Perry-Hill and Prokopy (2014) highlighted the differences between types of rural landowners and their land management decisions.

The Unconstrained Farmer and Adaptive Farmer management styles fared the best in terms of farm business income. Conversely, the Constrained Farmer management style, which experienced labour resource constraints, did not generate such levels of income. García-Martínez et al. (2011) argued that *"labour productivity is crucial"* for mountain beef cattle farm systems. In an EU wide study, labour availability and labour management was also found to be essential to on-farm investment and development when subsidies are decoupled (Viaggi et al., 2011). The Adaptive Farmers were best for income, and demanded far less labour than the other profiles because the model was able to assign activities that were less demanding of farm labour (i.e. forestry/diversification). Conversely, the Focused Farmers, who were committed to maximise livestock numbers, had to accept the need for committing labour. So we argue that flexibility in labour (i.e. labour that could be diverted to a more lucrative farm activity) is key to success. The Constrained Farmers did not have this flexibility (less labour available) and less diversification opportunities (less land), so fared less in terms of income. Consequently both availability and flexibility of labour was crucial.

The Focused Farmer management style was also most often worse off in terms of farm business income. Although this management style had more livestock, this did not compensate for the absence of forestry income. When forestry was not an option, as in the No support scenario, then the Focused Farmer was slightly better off. Although these results suggested that forestry grants can be financially attractive to farmers, this reticence to adapt to forestry is a well-known fact. Crabtree et al. (2001) highlighted some of the potential reasons, such as loss of flexibility of land use and a lack of experience in tree planting. Urquhart et al. (2010) also found that woodlands need to be profitable or at least break-even before farmers would consider planting. Additionally, Warren (2009) inferred that although farm forestry could become an attractive option for struggling mountain farmers, it was not an option for many remote farms, or many tenant farmers.

In the case of the Focused Farmer management style, the reluctance to plant trees was also extended to farm diversification in general as these farmers clearly indicated that farming came first in their motivation (Morgan-Davies et al., 2012). Although this study showed that diversification in general does bring financial benefits, some farmers have a strong feeling of identity, of 'what farmers should do', regardless of financial reasons. For example, Brandth and Haugen (2011) reported that French farmers refuse to diversify as they see it as a "*betrayal of the agricultural profession*". They also argued that in the UK, farmers are still "*dominated by productivist self-concepts despite post-productivist undertakings".* Warren (2009) mentioned this mentality as well, and further explained that farmers are "*uncomfortable with the multifunctional roles being expected of them*". In a study in South West England, Lobley and Butler (2010) found that only a minority of farmers will take on the opportunities offered by decoupling. However, if the local rural environment encourages the expansion of strictly farming activities, such as collaborations between farmers and meat processors, or the development of branded meat products, these farmers might respond favourably (Morgan et al., 2010). López-i-Gelats et al. (2011), in the mountain areas of the Pyrenees, equally found that farmers will accept different degrees of farm diversification, with more than a quarter still having a farm adjustment strategy focusing on either no diversification, or on purely agricultural diversification (e.g. new farming products such as calf fattening).

Although not included in this study, as all management styles were allowed in the model to consider any activity, tenancy and ownership status would also have an effect on diversification activities and on their type (Maye et al., 2009). Indeed in Scotland, 24% of the land and 29% of farms are rented (Edwards and Kenyon, 2014), a figure lower than other parts of Europe. For instance, Dramstad and Sang (2010) reported higher levels of rented land in Norway (44%) and parts of Spain (Navarra, 41%). Nonetheless, tenant farms tend to have higher overheads, lower value of assets and higher debt ratio (Scottish Government, 2016), and are restricted in their diversification activities as they need agreement from the landlord before they can consider them.

The results of this study also confirmed the matter of continuity of farming and the problem of succession. Whilst the Adaptive Farmer management style was the best-off financially, it was made up of older farmers. What will happen in a decade or two, when these farmers retire? Bernúes et al. (2011) identified this issue as one of the main critical points of viability for livestock-based farming systems. Gaskell et al. (2010), in the English uplands, also argued that attachment to a farming 'way of life' was not enough for the younger generation to contemplate farming in these areas. In France, Madelrieux and Dedieu (2008) also reported changes in farming work perceptions and expectations. Lobley et al. (2010) appealed to governments, educational institutions and farming institutions for measures to encourage young people into farming. They also argued that proper succession plans are needed for that purpose. Moreover, this issue of continuity of farming may not be the same across the scenarios, and, for instance, the No support scenario would potentially exacerbate the problem. Latruffe et al. (2013) found in their French study that, if the subsidies (such as the CAP) were removed, it would induce a substantial share of farmers to exit farming, particularly in the LFA.

Moreover, farming in the mountain and remote parts of Europe is challenging, and the costs of keeping and managing livestock on HNV farming systems are not offset by the financial returns possible from the sale of meat products from those systems. As a result, most HNV farming systems are financially uneconomic and it is largely only the receipt of support payments that keeps farmers on the land, maintains a diversity of land uses and thereby maintains the nature conservation value associated with the farming practices (Bignal and McCracken, 2009). In this case study, only the 'High market prices' scenario resulted in the most varied land use (mix of sheep, cattle and forestry) which would be likely to help maintain and enhance the HNV biodiversity value on the farm. All others either resulted in a marked increase in afforestation, or the abandonment of livestock grazing altogether or a marked increase in livestock grazing, none of which would maintain the range of semi-natural habitats grazed relatively extensively which would ensure the maintenance of biodiversity associated with such open habitats. Therefore the outcome suggests that a support which mirrors the High market prices is arguably one that would have the broader benefits. Whether or not such a support should be based on commodity subsidies or on other form of incentives for maintaining activities in the mountain areas is another issue and still open for debate.

Additionally, although afforestation showed to be a financially attractive option, there are still conflicting views about it amongst local stakeholders, who tend to dislike forestry as a land use option for the mountain areas (Morgan-Davies and Waterhouse, 2010). Farmers' attitudes towards forestry, as illustrated by the FF, would also have to be changed which, at present, is not an easy task (Warren, 2009), not least because schemes are perceived to be costly, time-consuming or too restrictive *(*Lawrence and Dandy, 2014; Urquhart et al., 2010). Perhaps if forestry and woodland creation were seen as integrated and complementary with other land-use objectives (Morgan-Davies et al., 2015) then conflicts could be reduced and mentalities changed. These mountain areas are also not always appropriate for economic forestry activity, and the environmental limitations of such sites should not be underestimated (Morgan-Davies et al., 2008). The type of forestry planted is also an issue. Monoculture conifer plantations provide feedstock for the wood processing and biomass energy industries, whilst native woodlands, that incorporate open areas, have a higher value for biodiversity (Skerratt et al., 2016).

Very few of the modelled scenarios, however financially attractive, created demand for farm labour. Converting HNV farming systems to forestry cannot be an answer to the local farm labour problem, even if arguably, farm labour could be used for forestry tasks, with retraining as an option. However, at present, most of the labour force within the forestry industry is employed at the national contractual level and is therefore highly transient. At the local level, it offers very few job opportunities (Robinson, 2011). The other issue is the cost of farm labour compared to the value of the farm output. Over the past twenty years, farm wages have increased faster than lamb and cattle prices. At present, to cover the wages of a permanent shepherd (around £25,000), 520 store lambs need to be sold, whereas in 1988/89, 260 lambs were sufficient (SAC, 1988; 2010). This issue over farm wages is also illustrated in Figure 3 where farm incomes stay similar between some scenarios (e.g. Free choice, Land abandonment and Higher efficiency), whilst labour hours greatly increase (e.g. labour required for High efficiency scenario). Such a disparity may be a barrier to uptake by farmers, despite scenarios being potentially financially rewarding. Nonetheless, labour change is central in these alternative scenarios, and its impacts can also have wide-ranging implications to the rest of the rural structure and social fabric linked to such HNV farming systems. Manos et al. (2013) in their modelling study in Southern Europe, equally stressed the impacts of the reduction of labour (particularly family and casual labour), induced by changes in land use policy support, on social cohesion and social inclusion.

Finally, indications to policy makers as to the uptake of policies within the extensive livestock farming population could also be obtained through scaling up. For example, this study showed that farmers belonging to the Focused Farmer management style were quite immune to policy changes, implying that a proportion of the mountain farmers, potentially, would likely demonstrate a degree of inertia faced with policy incentives. This has implications for policy makers who, in England and Wales for instance, are increasingly aware of the diversity of farmers' motivations and beliefs (Ingram et al., 2013). One scheme does not fit all and policy changes will not affect the intended recipients in a homogeneous or expected way. It is nevertheless important for policy makers to recognise that some proportion of the agricultural community is likely to a) react in a different way to what might be expected, and b) be disadvantaged by the policy implementation. The intention is not to try to elaborate a perfect policy for all but rather to bring to the attention of policy makers, as an *"a-priori"* tool, the need to investigate consequences of any rural policy. This approach could be similar for any marginal areas in Europe, where the agricultural community is diverse, both in their resources and in their attitudes (e.g. Ripoll-Bosh et al., 2014) and thus where any rural policy implementation is potentially challenging or conflictual.

There were some limitations to this study that merit to be discussed. This work was based on an optimisation model, where the linearity aspect is essential (Pannell, 1996). However, linearity only exists in limited circumstances and intrinsically it is one limitation of such a study. The parameters used were based on a real mountain farm, which was representative of similar farms in the same locational area. Parameters, such as prices and costs, however can vary from year to year. Likewise, performance data are not static. Whilst the model was representative of one period in time, parameters could be changed as time progresses, to truly reflect any modelled situation at any point in time.

Additionally, the model in this paper could not focus in detail on the particularities of woodland planting and of individual farm situations. Forestry economic activity can indeed be inappropriate due to site conditions, especially given the variety of soils and altitudes in mountain areas. Tenancy agreements equally may prevent any plantation, as could many individual farm financial situations, such as the amount and types of debt. Likewise, succession issues, linked with the age of 'Adaptive Farmers', could not be quantified in this study but should be mentioned, especially given the long-term nature of diversifying into forestry.

The study also relied on typology results (Morgan-Davies et al., 2012). However, how well this typology is reflected at national scale could be investigated further. Farmers' views and attitudes can also change over time (Wilson et al., 2013) and thus the identified groups in the typology could eventually shift. The model also only considered financial objectives in the objective function, associated with farmers' views. This could also be seen as one limitation of the LP, considering attitudes and behaviours are related according to the theory of planned behaviour (Ajzen, 2011).

However, this study also highlighted areas of future research in Scotland and across Europe that would be useful. The model, by its nature, automatically requires consideration of an inventory of technical coefficients. There are thus opportunities to explore further these coefficients and their efficiency to alter the model. The issue of risk in the activities could also be added to the model. The objective function at present focused on financial reward; this could be changed to carbon efficiency for instance, to bring a different focus to such a study in marginal areas, where carbon sequestration and GHG emissions are increasingly topical (Lasanta et al., 2015). It would also be feasible and useful to add negative (e.g. GHG emissions by the livestock) or positive externalities (e.g. increased biodiversity value for mixed grazing of sheep and cattle) to some of the activities in the model. Likewise, tangible or non-tangible factors could be also added (e.g. social and cultural value of livestock in these areas). These latter considerations are most likely those that should be further researched, given the actual debate of ecosystem services for mountain areas (Bernúes et al., 2016). Using this study as a basis for developing regional models would also most useful, both for Scotland and Europe. Although this paper used the mountain farming areas of Scotland as a case study, the issues highlighted (particularly those linked to farm labour, income and reliance on financial support) are equally valid for other LFA and HNV farming systems areas in Europe, which suffer from similar constraints. Hence the modelling approach taken in this paper could also be replicated across other European livestock mountain areas.

5. Conclusions

This study showed that different farmer management styles lead to different responses to policy.

This optimisation approach, based on a variety of farm management styles, has provided information of possible effects of policy and market change scenarios on potential financial, land use and labour employment in mountain areas in Europe. Increased livestock productivity and/or efficiency, opportunities for diversified income, greater flexibility in farm labour and in land use were all found to be important to achieve HNV farming systems viability. However, unless farmers' motivations and intentions are taken into account, any effort to lessen the effects of external intervention on their businesses may be ineffective. It is imperative that policy makers acknowledge this heterogeneity in the farming population and refrain from devising policies that may only reach their full potential under an ideal set of parameters, which is ultimately unrepresentative of the wider farming population.

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Table 1. The 24 model runs (6 scenarios x 4 management styles)

Table 2. Some final outputs (livestock numbers, labour hours, variable costs (£), subsidies (£) and areas (ha) of planted woodlands on improved, semi-improved and native pastures) for the 6 scenarios under the 4 management styles

Figure 1. Farm Business Income (£K) across the 6 alternative scenarios and the 4 management styles

Figure 2. Land Use (% of farm area) under the 6 different scenarios for the four management styles (Unconstrained Farmer UF, Adaptive Farmer AF, Focused Farmer FF, Constrained Farmer, CF). *Note that the scale varies as the incomes increase or decrease dramatically between the scenarios.*

Figure3. Farm labour (in hours) and Farm Business Income (FBI) (in £) between all the scenarios, for the four management styles (Unconstrained Farmer UF, Adaptive Farmer AF, Focused Farmer FF, Constrained Farmer, CF) *Note that the scale varies as the incomes increase or decrease dramatically between the scenarios)*

Figure 4. Average percentage change in LFA sheep and cattle farm labour for the four management styles (Unconstrained Farmer UF, Adaptive Farmer AF, Focused Farmer FF, Constrained Farmer, CF) under the 6 different scenarios.