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

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15

16 **Abstract**

17

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

45

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

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48

49 **Highlights:**

50 • HNV farmers' management styles dictate how they react to the policy-making process

51 • Public support is crucial to economic survival of the farmers

52 • Public support must acknowledge disparities in farmers' motivations

53 • High market prices could ensure a land use mix favourable to HNV biodiversity on farm

54 • Labour flexibility is a barrier to diversification and higher efficiency in HNV farming

55 systems

56 **1. Introduction:**

57

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

67 Moreover, the High Nature Value (HNV) farming system concept recognises that many
68 European habitats and landscapes considered to be of high nature conservation value are
69 intimately associated with the continuation of specific low-intensity farming systems (Bignal
70 and McCracken, 2000). Although some HNV farming systems occur in association with
71 traditional cropping systems in southern Europe, in general the majority of Europe's remaining
72 HNV farming systems are now largely associated with livestock grazing systems on semi-
73 natural habitats in the mountains and other remote areas of Europe (Bignal and McCracken,
74 2009). Ensuring the maintenance of the farmland biodiversity value associated with such
75 areas therefore depends on ensuring the continuation of appropriate farming systems in those
76 areas. This requires an understanding not only of how the different elements of HNV farming
77 systems interact to maintain the high nature conservation habitats and species of interest, but
78 also of how HNV farming systems and practices are influenced by changes in agricultural
79 support policies. Formulating policies for these HNV farming systems and areas becomes
80 challenging and can lead to conflicts (Morgan-Davies et al., 2006; 2010).

81

82 Land use policies are also a key driver of change in such marginal areas, and following
83 the announcement of the latest agricultural reforms, studies have been conducted in Europe
84 to determine how these could affect farming (e.g. Acs et al., 2010; Matthews et al., 2013;
85 Oñate et al., 2007; Veysset et al., 2014). Most of these studies used simulation models to

86 investigate the likely outcomes under a series of scenarios (e.g. Hanley et al., 2012). Whole-
87 farm computer models can certainly help assess implications of any change to the farming
88 systems studied (Pannell, 1996). Whilst simulation models can be valuable and have been
89 widely used (e.g. Villalba et al., 2006; 2010, on mountain beef systems; Moore et al., 1997, on
90 Australian grazing enterprises; Milne and Sibbald, 1998, for grazing systems; Villalba et al.,
91 2015, for sheep systems), optimisation models can offer an insightful alternative viewpoint.
92 One of the advantages of using an optimisation farm model is that many activities can be
93 considered simultaneously and the effects of changing parameters can be easily assessed
94 (Janssen and van Ittersum, 2007). An optimisation model can also use a combination of
95 existing models outputs to inform and predict likely outcomes.

96 As well as being fragile in the broadest sense, these European HNV mountain farming
97 systems are also diverse, and the concept of rural diversity is now increasingly recognised
98 (e.g. van Eupen et al., 2012) and accepted. This diversity is apparent not only among and
99 within the HNV farming systems, but is also evident within the farmers themselves. For
100 instance, as shown by O'Rourke et al. (2012) in Southwest Ireland and by Morgan-Davies et
101 al. (2012) in Western Scotland, extensive farmers are not a homogenous group, neither in
102 their farming practices nor in their views and their management styles. Janssen and van
103 Ittersum (2007) demonstrated the usefulness of "so-called" farming styles to distinguish
104 groups of farms with different strategies. Farmers' views, attitudes and goals play a very
105 important role in the day to day management of their business (Brodt et al., 2006; Fairweather
106 and Keating, 1994; Girard et al., 2008), and incorporating their motivations into economic
107 models would be useful (Howley et al., 2015). Morgan-Davies et al. (2012) underlined the
108 importance of mountain farmers' motivations and constraints in their responses to policy
109 reforms, as well as the effectiveness of a typology approach based on farmers' opinions and
110 motivations, rather than government census farm types. Likewise, Morgan-Davies et al.
111 (2014) suggested that mountain beef farmers appear to not only adapt their production
112 systems according to their current bio-physical and financial circumstances, but also from
113 personal experience.

114

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

124

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

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

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145 **2. Methods**

146

147 2.1. Overview

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

157 The general structure of the linear programming model was:

158 Maximize $Z = c_1x_1 + c_2x_2 + \dots + c_nx_n$

159 Subject to $b_1 \geq a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n$

160 $b_m \geq a_{m1}x_1 + a_{m2}x_2 + \dots + a_{mn}x_n$

161 and $x_1 \geq 0, x_2 \geq 0, \dots, x_n \geq 0,$

162

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

166 A procedure was used to provide input parameters and adjust outcome values
167 associated with the optimisation model. In this instance, energy requirements by livestock at
168 different times of the year were used as the primary connections between animal enterprises
169 and land use. Established computer programs were employed to estimate the energy
170 production of different areas of vegetation (Armstrong et al., 1997a, b) and to calculate animal
171 energy requirements throughout the year (AFRC, 1993). Local values of parameters relating
172 to animal performance, labour requirements, fertiliser application as well as market values of
173 animal sales and input costs were estimated (SAC, 2010). Adjustments needed to be made to
174 the resulting overall objective function to take into account those costs and benefits which do

175 not exhibit linear relationships with the scale of activity. Consequently, to calculate the impact
176 on the farm's overall estimated trading margins, items such as the farm's fixed costs, Single
177 Farm Payment (SFP) and Less Favoured Area Support Scheme (LFASS) receipts were
178 included subsequent to running the LP model.

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

194 The model has been parameterised using historical (1987-88) physical data from the model
195 farm, when it carried 2689 breeding ewes and 66 cows. The SFP and the LFASS payments
196 have been calculated using these levels of livestock and a total grazing area of 2200 ha
197 (Morgan-Davies, 2014). Once the model had been parameterised, it was run without the fixed
198 livestock numbers. Instead, the upper limits on ewe and cow numbers have been added
199 (respectively 2700 and 70). The resulting farm business income, labour and outputs were
200 compared against published results from farm survey data (Quality Meat Scotland, 2012) and
201 Scottish Government Farm Account Data Network Survey results (Scottish Government,
202 2011b), to check the reliability of the parameterisation. They corresponded with data for
203 average to large LFA sheep and cattle farms in Scotland, which was representative of
204 extensive HNV farms in the mountain areas (Morgan-Davies, 2014).

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

207

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

218 Six alternative scenarios have been devised, using current literature (Dumont et al.,
219 2014; Godfray et al, 2010; Morgan-Davies and Waterhouse, 2010; Slee et al., 2014): Free
220 choice, Abandonment of the hill, No support, Woodland grant only, High market prices,
221 Increased efficiency.

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

224

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

226

227 2.2. Farmers' management styles (Table 1)

228 2.2.1. Management style for the Adaptive Farmer (AF)

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

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

236

237 *2.2.2. Management style for the Focused Farmer (FF)*

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

243

244 *2.2.3. Management style for the Constrained Farmer (CF)*

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

259

260 *2.2.4. Management style for the Unconstrained Farmer (UF)*

261 The unconstrained management style was created to represent an ideal
262 management, not limited by any personal values, attitudes or motivations. All activities in the
263 model were available under that management style, with no other limits on animal numbers,

264 land or labour than those described in the initial model (2200 ha, 2700 ewes, 70 cows, 50
265 deer).

266

267 2.3. Description of the scenarios (Table 1)

268 2.3.1. *Free choice (FC)*.

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

274

275 2.3.2. *Land Abandonment*

276 In this scenario, all activities in the model linked to the unfenced semi-natural
277 vegetation areas (hill) were disabled. The total area of the farm was reduced to 718 ha
278 (improved and semi-improved pastures only). Woodland plantation on the hill was not
279 possible and no wild deer shooting was available. All other activities remained. This scenario
280 was created to investigate the impact of agricultural reforms (SAC Rural Policy Centre, 2008;
281 2011) on land abandonment.

282

283 2.3.3. *No support*

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

288

289 2.3.4. *Woodland support only*

290 There is a drive in Scotland for afforestation and woodland expansion (Scottish
291 Government, 2009); at the same time, farming and forestry have been long in conflict and
292 seen as mutually exclusive (Morgan-Davies et al., 2015; Slee et al., 2014) This scenario was
293 devised to both represent this expansion drive and investigate its impacts on a mountain

294 farm, when no livestock-subsidies based were available. In the model, no agriculturally-based
295 subsidies were available, but the woodland plantation was supported through a woodland
296 grant (up to a maximum of £750,000).

297

298 *2.2.5 HMP – High market prices for the livestock outputs*

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

305

306 *2.2.6. Increased animal efficiency*

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

312

313

314 **3. Results**

315

316 3.1. Management styles

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

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

323

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

326

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

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

335

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

345

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

352

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

357

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

362

363

364 3.2. Impact on land use and labour

365 3.2.1. Land Use

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

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

373

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

378

379 Although the land abandonment scenario was not financially disastrous for individual land
380 managers, as it still provided positive incomes, it would release 67% of the land from use by
381 farming and would result in abandonment of this area. This 67% restriction was imposed by

382 the model; however, the remaining mix of land use between forestry and animals was derived
383 from the model.

384

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

390

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

396

397 *3.2.2. Labour use*

398 The use of labour also varied greatly under the different scenarios (Figure 3).

399 The scenarios with high market prices or with higher animal efficiency would be the only ones
400 to provide enough labour during the year to justify the employment of one permanent labourer
401 (1900 hours/year).

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

407

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

412

413 The 2015 Scottish agricultural census specified that the 14,327 holdings in the LFA sheep
414 and cattle farms type represented the equivalent of 19,218 Standard Labour Requirements
415 (SLR) (Scottish Government, 2015). On average, this equates to 1.3 SLR per holding, or
416 2460 hours of labour per year.

417

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

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

425

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

429

430

431 **4. Discussion**

432

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

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

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

467 In the case of the Focused Farmer management style, the reluctance to plant trees
468 was also extended to farm diversification in general as these farmers clearly indicated that
469 farming came first in their motivation (Morgan-Davies et al., 2012). Although this study
470 showed that diversification in general does bring financial benefits, some farmers have a
471 strong feeling of identity, of ‘what farmers should do’, regardless of financial reasons. For

472 example, Brandth and Haugen (2011) reported that French farmers refuse to diversify as they
473 see it as a “*betrayal of the agricultural profession*”. They also argued that in the UK, farmers
474 are still “*dominated by productivist self-concepts despite post-productivist undertakings*”.
475 Warren (2009) mentioned this mentality as well, and further explained that farmers are
476 “*uncomfortable with the multifunctional roles being expected of them*”. In a study in South
477 West England, Lobley and Butler (2010) found that only a minority of farmers will take on the
478 opportunities offered by decoupling. However, if the local rural environment encourages the
479 expansion of strictly farming activities, such as collaborations between farmers and meat
480 processors, or the development of branded meat products, these farmers might respond
481 favourably (Morgan et al., 2010). López-i-Gelats et al. (2011), in the mountain areas of the
482 Pyrenees, equally found that farmers will accept different degrees of farm diversification, with
483 more than a quarter still having a farm adjustment strategy focusing on either no
484 diversification, or on purely agricultural diversification (e.g. new farming products such as calf
485 fattening).

486 Although not included in this study, as all management styles were allowed in the model to
487 consider any activity, tenancy and ownership status would also have an effect on
488 diversification activities and on their type (Maye et al., 2009). Indeed in Scotland, 24% of the
489 land and 29% of farms are rented (Edwards and Kenyon, 2014), a figure lower than other
490 parts of Europe. For instance, Dramstad and Sang (2010) reported higher levels of rented
491 land in Norway (44%) and parts of Spain (Navarra, 41%). Nonetheless, tenant farms tend to
492 have higher overheads, lower value of assets and higher debt ratio (Scottish Government,
493 2016), and are restricted in their diversification activities as they need agreement from the
494 landlord before they can consider them.

495

496 The results of this study also confirmed the matter of continuity of farming and the
497 problem of succession. Whilst the Adaptive Farmer management style was the best-off
498 financially, it was made up of older farmers. What will happen in a decade or two, when these
499 farmers retire? Bernúes et al. (2011) identified this issue as one of the main critical points of
500 viability for livestock-based farming systems. Gaskell et al. (2010), in the English uplands,
501 also argued that attachment to a farming ‘way of life’ was not enough for the younger

502 generation to contemplate farming in these areas. In France, Madelrieux and Dedieu (2008)
503 also reported changes in farming work perceptions and expectations. Lobley et al. (2010)
504 appealed to governments, educational institutions and farming institutions for measures to
505 encourage young people into farming. They also argued that proper succession plans are
506 needed for that purpose. Moreover, this issue of continuity of farming may not be the same
507 across the scenarios, and, for instance, the No support scenario would potentially exacerbate
508 the problem. Latruffe et al. (2013) found in their French study that, if the subsidies (such as
509 the CAP) were removed, it would induce a substantial share of farmers to exit farming,
510 particularly in the LFA.

511

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

528

529 Additionally, although afforestation showed to be a financially attractive option, there
530 are still conflicting views about it amongst local stakeholders, who tend to dislike forestry as a
531 land use option for the mountain areas (Morgan-Davies and Waterhouse, 2010). Farmers'
532 attitudes towards forestry, as illustrated by the FF, would also have to be changed which, at

533 present, is not an easy task (Warren, 2009), not least because schemes are perceived to be
534 costly, time-consuming or too restrictive (Lawrence and Dandy, 2014; Urquhart et al., 2010).
535 Perhaps if forestry and woodland creation were seen as integrated and complementary with
536 other land-use objectives (Morgan-Davies et al., 2015) then conflicts could be reduced and
537 mentalities changed. These mountain areas are also not always appropriate for economic
538 forestry activity, and the environmental limitations of such sites should not be underestimated
539 (Morgan-Davies et al., 2008). The type of forestry planted is also an issue. Monoculture
540 conifer plantations provide feedstock for the wood processing and biomass energy industries,
541 whilst native woodlands, that incorporate open areas, have a higher value for biodiversity
542 (Skerratt et al., 2016).

543

544 Very few of the modelled scenarios, however financially attractive, created demand
545 for farm labour. Converting HNV farming systems to forestry cannot be an answer to the local
546 farm labour problem, even if arguably, farm labour could be used for forestry tasks, with
547 retraining as an option. However, at present, most of the labour force within the forestry
548 industry is employed at the national contractual level and is therefore highly transient. At the
549 local level, it offers very few job opportunities (Robinson, 2011). The other issue is the cost of
550 farm labour compared to the value of the farm output. Over the past twenty years, farm wages
551 have increased faster than lamb and cattle prices. At present, to cover the wages of a
552 permanent shepherd (around £25,000), 520 store lambs need to be sold, whereas in 1988/89,
553 260 lambs were sufficient (SAC, 1988; 2010). This issue over farm wages is also illustrated in
554 Figure 3 where farm incomes stay similar between some scenarios (e.g. Free choice, Land
555 abandonment and Higher efficiency), whilst labour hours greatly increase (e.g. labour
556 required for High efficiency scenario). Such a disparity may be a barrier to uptake by farmers,
557 despite scenarios being potentially financially rewarding. Nonetheless, labour change is
558 central in these alternative scenarios, and its impacts can also have wide-ranging implications
559 to the rest of the rural structure and social fabric linked to such HNV farming systems. Manos
560 et al. (2013) in their modelling study in Southern Europe, equally stressed the impacts of the
561 reduction of labour (particularly family and casual labour), induced by changes in land use
562 policy support, on social cohesion and social inclusion.

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

579

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

588 Additionally, the model in this paper could not focus in detail on the particularities of woodland
589 planting and of individual farm situations. Forestry economic activity can indeed be
590 inappropriate due to site conditions, especially given the variety of soils and altitudes in
591 mountain areas. Tenancy agreements equally may prevent any plantation, as could many
592 individual farm financial situations, such as the amount and types of debt. Likewise,

593 succession issues, linked with the age of 'Adaptive Farmers', could not be quantified in this
594 study but should be mentioned, especially given the long-term nature of diversifying into
595 forestry.

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

603

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

623

624 **5. Conclusions**

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

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

637

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643

644

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933 Table 1. The 24 model runs (6 scenarios x 4 management styles)
934
935 Table 2. Some final outputs (livestock numbers, labour hours, variable costs (£), subsidies (£)
936 and areas (ha) of planted woodlands on improved, semi-improved and native pastures) for
937 the 6 scenarios under the 4 management styles
938
939 Figure 1. Farm Business Income (£K) across the 6 alternative scenarios and the 4
940 management styles
941
942 Figure 2. Land Use (% of farm area) under the 6 different scenarios for the four management
943 styles (Unconstrained Farmer UF, Adaptive Farmer AF, Focused Farmer FF, Constrained
944 Farmer, CF). *Note that the scale varies as the incomes increase or decrease dramatically*
945 *between the scenarios.*
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947 Figure3. Farm labour (in hours) and Farm Business Income (FBI) (in £) between all the
948 scenarios, for the four management styles (Unconstrained Farmer UF, Adaptive Farmer AF,
949 Focused Farmer FF, Constrained Farmer, CF) *Note that the scale varies as the incomes*
950 *increase or decrease dramatically between the scenarios)*
951
952 Figure 4. Average percentage change in LFA sheep and cattle farm labour for the four
953 management styles (Unconstrained Farmer UF, Adaptive Farmer AF, Focused Farmer FF,
954 Constrained Farmer, CF) under the 6 different scenarios.
955

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

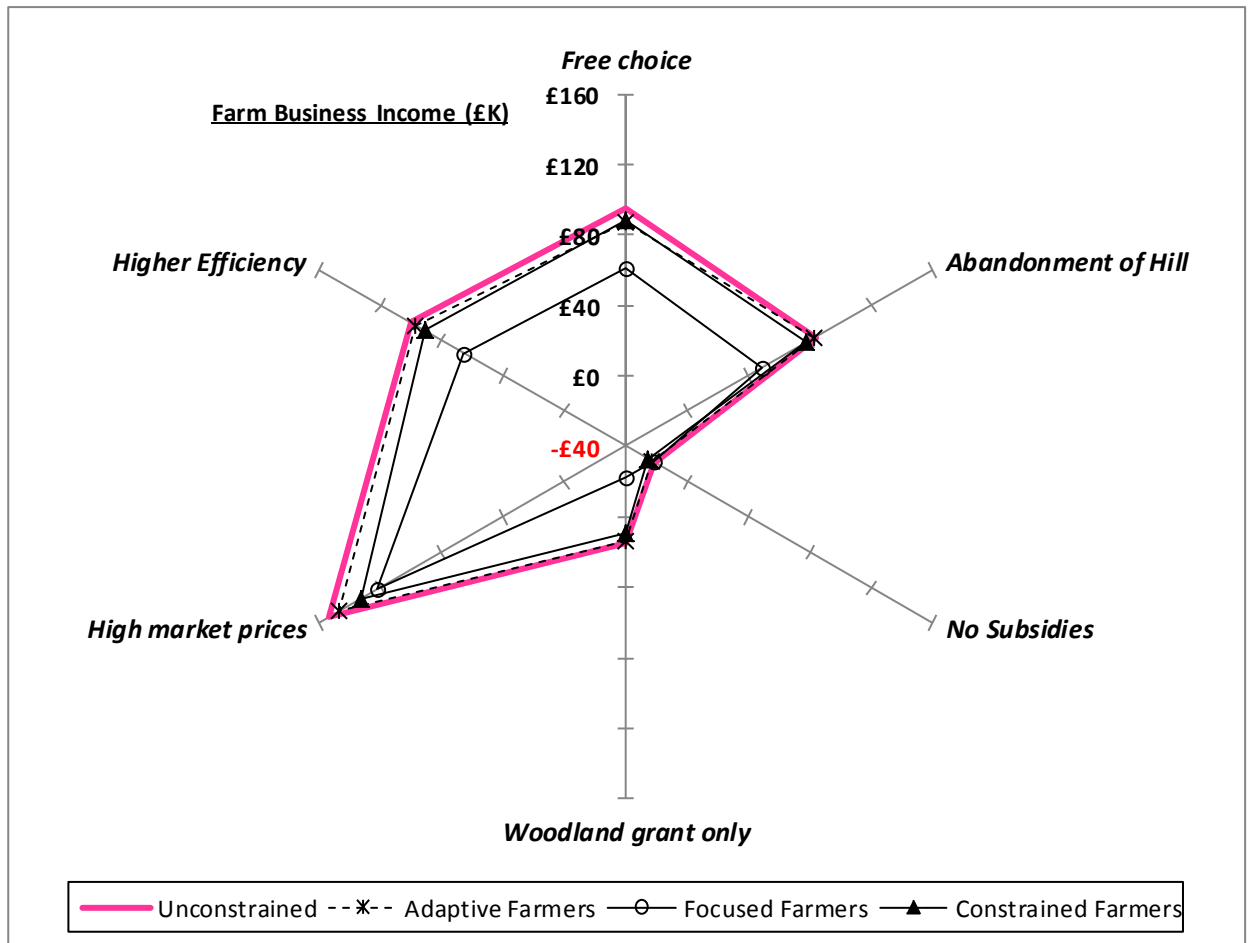


Figure 2. Land Use (% of farm area) under the 6 different scenarios for the four management styles (Unconstrained Farmer UF, Adaptive Farmer AF, Focused Farmer FF, Constrained Farmer, CF). Note that the scale varies as the incomes increase or decrease dramatically between the scenarios.

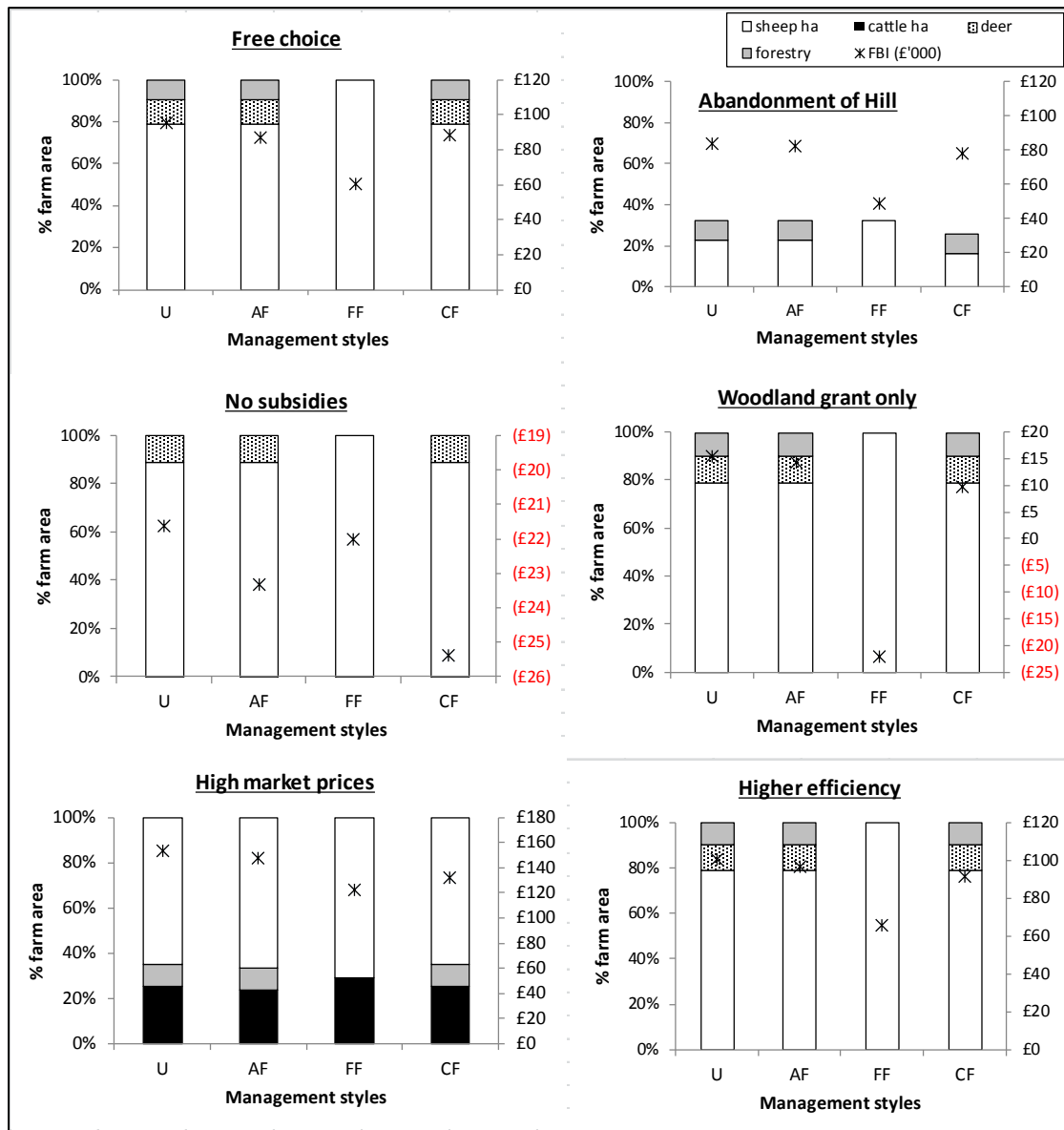


Figure3. Farm labour (in hours) and Farm Business Income (FBI) (in £) between all the scenarios, for the four management styles (Unconstrained Farmer UF, Adaptive Farmer AF, Focused Farmer FF, Constrained Farmer, CF) *Note that the scale varies as the incomes increase or decrease dramatically between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

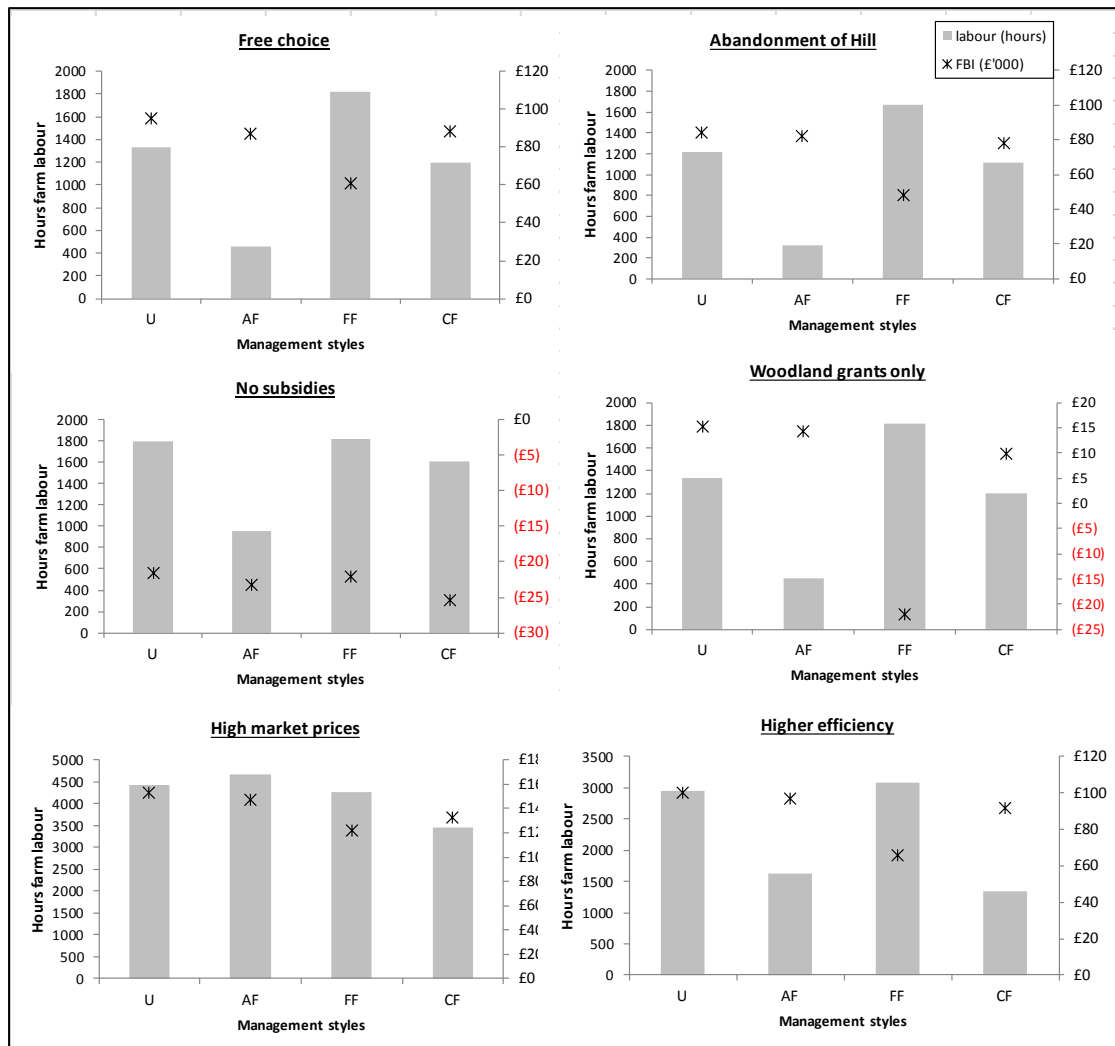


Figure 4. Average percentage change in LFA sheep and cattle farm labour for the four management styles (Unconstrained Farmer UF, Adaptive Farmer AF, Focused Farmer FF, Constrained Farmer, CF) under the 6 different scenarios.



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

SCENARIOS	MANAGEMENT STYLES			
	Unconstrained Farmers (UF)	Adaptive Farmers (AF)	Focused Farmers (FF)	Constrained Farmers (CF)
Free choice	1482 ha semi-natural pasture 486 ha semi-improved pasture 232 ha improved pasture Up to 2700 ewes, 70 cows, 50 deer, woodland All subsidies (LFASS ¹ , SFP ² , woodland grant)	1482 ha semi-natural pasture 486 ha semi-improved pasture 232 ha improved pasture Up to 2700 ewes, 70 cows, 50 deer, woodland. All subsidies (LFASS ¹ , SFP ² , woodland grant) Labour demand is increased by 10%	1482 ha semi-natural pasture 486 ha semi-improved pasture 232 ha improved pasture Up to 2700 ewes, 70 cows, no woodland, no deer. Only agricultural subsidies (LFASS ¹ , SFP ²)	1186 ha semi-natural pasture 389 ha semi-improved pasture 185 ha improved pasture Up to 2160 ewes, 56 cows, 40 deer, woodland. All subsidies (LFASS ¹ , SFP ² , woodland grant), 20% less labour resources
Land abandonment	as Free choice but only 718 ha of area (no hill), no deer	As above but only 718 ha of area (no hill, no deer)	As above but only 718 ha of area (no hill)	As above but only 574 ha of area (no hill)
No support	As Free choice, but no subsidies	As Free choice (AF) but no subsidies	As Free choice (FF) but no subsidies	As Free choice (CF) but no subsidies
Woodland support only	A Free choice but only woodland subsidies	As Free choice (AF) but only woodland subsidies	N/A	As Free choice (CF) but only woodland subsidies
High market prices for livestock outputs	As Free choice but higher output prices for sheep and cattle	As Free choice (AF) but higher output prices for sheep and cattle	As Free choice (FF) but higher output prices for sheep and cattle	As Free choice (CF) but higher output prices for sheep and cattle
Increased animal efficiency	As Free choice but increased animal performance and longevity	As Free choice (AF) but increased animal performance and longevity	As Free choice (FF) but increased animal performance and longevity	As Free choice (CF) but increased animal performance and longevity

¹LFASS : Less Favoured Area Support Scheme

²SFP: Single Farm Payment

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

MANAGEMENT STYLES	SCENARIOS					
	Free choice	Land abandonment	No support	Woodland support only	Higher Market Prices	Increased animal efficiency
Unconstrained						
Farm Business Income (£)	95,500	83,900	-21600	15,300	153,000	100,000
Ewes Numbers.	1420	1290	1940	1420	2700	2430
Cows Numbers.	0	0	0	0	70	0
Labour (hrs)	1335	1215	1793	1335	4423	2951
Variable costs (£)	-34,300	-32,800	-41,400	-34,300	-93,200	-61,400
Subsidies (£)	126,200	118,200	0	46,000	125,100	127,500
Woodland area on improved pasture (ha)	214	214	0	214	150	214
Woodland area on semi-natural pasture (ha)	0	0	0	0	64	0
Adaptive Farmers						
Farm Business Income (£)	87,000	82,400	-23,300	14,300	147,200	96,700
Ewes Numbers.	466	330	978	462	2700	1436
Cows Numbers	0	0	0	0	59	0
Labour (hrs)	458	323	958	454	4678	1633
Variable costs (£)	-5,400	-3,900	-12,500	-5,400	-90,300	-34,400
Subsidies (£)	118,700	117,600	0	46,000	129,800	126,300
Woodland area on improved pasture (ha)	214	214	0	214	194	214
Woodland area on semi-natural pasture (ha)	0	0	0	0	20	0
Focused Farmers						
Farm Business Income (£)	60,800	48,300	-22,000	-22,000	122,000	65,800
Ewes Numbers	1966	1807	1966	1966	2700	2700
Cows Numbers	0	0	0	0	70	0
Labour (hrs)	1,817	1,673	1,817	1,817	4,257	3,074
Variable costs (£)	-41,700	-39,900	-41,700	-41,700	-88,700	-61,100
Subsidies (£)	82,800	73,500	0	0	87,700	82,800
Constrained Farmers						
Farm Business Income (£)	88,400	78,000	-25,400	9,800	132,400	9,100
Ewes Numbers	1274	1174	1739	1274	2160	1286
Cows Numbers	0	0	0	0	56	0
Labour (hrs)	1201	1110	1614	1201	3460	1336
Variable costs (£)	-32,500	-31,300	-38,800	-32,500	-75,200	-32,600
Subsidies (£)	122,100	114,600	0	43,400	118,000	122,100
Woodland area on improved pasture (ha)	186	186	0	186	118	186
Woodland area on semi-improved pasture (ha)	29	29	0	29	0	29
Woodland area on semi-natural pasture (ha)	0	0	0	0	96	0