EXTENSIFICATION OF SHEEP GRAZING SYSTEMS: EFFECTS ON SOIL NUTRIENTS, SPECIES COMPOSITION AND ANIMAL PRODUCTION

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ABSTRACT
The effects of ceasing fertiliser inputs to perennial ryegrass/white clover swards, combined with patterns of seasonal grazing, on soil nutrient status, floristic composition and animal production (ewes and single lambs) were studied in a long-term experiment at three upland sites in Scotland. Four unfertilised treatments had a factorial combination of seasonal grazing in summer and autumn at two sward heights (4 and 8 cm). There was also an ungrazed, unfertilised control and a fertilised treatment (140 kg N/ha plus maintenance P and K), grazed at 4 cm sward height in both seasons. All treatments were imposed annually from 1990/91. By 1995 there had been no significant changes in soil pH or soil nutrients following the removal of fertiliser inputs. Sown species were dramatically reduced in the ungrazed swards. In contrast, changes in species composition were smaller in the unfertilised, grazed treatments and consequently there was little reduction in lamb performance in some treatments.

KEYWORDS
Sown swards, fertiliser, seasonal grazing, ryegrass, white clover, lamb growth

INTRODUCTION
Changes in agricultural policies in the European Union, resulting from concern about overproduction of meat from sheep and cattle and increasing public awareness of environmental and nature conservation issues, now encourage farmers to adopt less intensive production systems. Sheep farmers may choose to reduce the costs of fertiliser inputs and adopt more extensive grazing systems, but with our present level of understanding we cannot accurately predict the rate and direction of changes in soil nutrient status and sward floristic composition or the consequent impact on animal production. Our experiment describes the effects of cessation of fertiliser inputs and different patterns of seasonal grazing on soil, plant and animal variables in established sown swards of *Lolium perenne* (perennial ryegrass)/ *Trifolium repens* (white clover).

MATERIALS AND METHODS
A long-term experiment was set up at three upland sites in Scotland with different climatic and edaphic conditions: Hartwood, on a poorly draining non-calcareous gley soil; Sourhope, on a freely draining brown forest soil; Fasque, on a freely drained humus iron podzol with some areas of poorly draining non-calcareous gleys. The initial composition of the swards was approximately 60% ryegrass, 10% white clover and 30% other species, mainly unsown grasses. The experimental plots (each of 0.5 ha) received one of six treatments, which were replicated twice and imposed annually from 1990/91 onwards. These were a control, which was neither fertilised nor grazed, and five treatments grazed by Scottish Blackface ewes and single lambs (until weaning in mid-August). Four treatments were unfertilised and grazed at two sward heights (4 and 8 cm) in summer, April-end of September, and autumn, October to mid-November (4/4 cm, 4/8 cm, 8/8 cm and 8/4 cm). The remaining grazed treatment received annual dressings of 50 kg N/ha in March and August and a compound fertiliser supplying 40, 20, 20 kg N, P and K/ha in May, and was grazed in both grazing seasons at a sward height of 4 cm (treatment 4 cmF). Grazing height treatments were achieved by weekly adjustments of sheep numbers. Each year, the swards were stocked when they reached their target height. Swards maintained at 8 cm in autumn required little or no grazing.

Before each grazing year composite soil samples were taken from each sward, air dried and analysed for pH, total N and P (P_2O_5) and exchangeable cations. The floristic composition of the swards was measured biennially in June using an inclined point quadrat. The liveweights of six core lambs in each grazed plot were determined on a weekly basis between birth (approximately early May) and weaning. In this paper we compare the soil, plant and animal data from the first year of the experiment with that collected in 1994/1995, to determine the extent of changes after four years of imposition of treatments.

RESULTS AND DISCUSSION
There were significant differences in pH, total N, total P, K and Ca between sites, e.g. mean Ca contents were 3.74, 8.38 and 17.24 meq/100g dry soil (s.e.d.=1.34, P<0.01) for Fasque, Hartwood and Sourhope sites respectively. However there was no evidence of changes in these soil parameters at any site after four years of removal of fertiliser. Any changes in soil variables following the removal of fertiliser are likely to be slow, even at sites such as Fasque which have an inherently low fertility. In Dutch hay meadows, van der Woude et al. (1994) found no effect of treatment on pH, N, P and K status of the soil nine years after imposing unfertilised and fertilised treatments on previously fertilised areas. In their experiment the only input of nutrients was from the atmosphere, while in our grazed swards nutrients were recycled via excretal return. Since 60-90% of the nutrients in ingested herbage is returned to the sward in urine and faeces, the grazing animal has a key role in nutrient cycling, particularly in less intensively managed systems (Haynes and Williams, 1993).

Changes in the contribution of ryegrass and white clover to the swards are shown in Table 1. Species composition of swards changed dramatically in the absence of grazing. The sown species virtually disappeared from the ungrazed, unfertilised swards, and were replaced by *Ranunculus repens*, *Poa trivialis* and *Agrostis* species at Hartwood, and *Agrostis capillaris, Festuca rubra*, *Dactylis glomerata, Poa pratensis* and *P. trivialis* at Sourhope and Fasque. In contrast, there were smaller changes in the grazed swards. There was a higher white clover content in the unfertilised, swards grazed at 4 cm in summer. In consequence, the amount of fixed N_2 may be expected to be greater than in the fertilised swards (Grant et al., 1986). As a result of nutrient inputs from N_2 fixation and excretal return, sown species were unlikely to experience nutrient limitations which would affect their competitive ability in the sward. This may explain why the proportion of sown species remained high in the unfertilised, grazed swards.

The two sites from which lamb liveweight gain data were collected showed differences in response over a four-year period (Table 2). At Hartwood there was a significant reduction in individual lamb performance across all unfertilised treatments, whereas at Sourhope there was no general decline. This may be related to differences in temporal changes in white clover content at the two sites. Marriott et al. (1996) found that the white clover content at Hartwood remained similar in 4/4 cm and 4/8 cm swards, while at Sourhope there was a three-fold increase. They also found no decline in the number of grazing days across the treatments over five years at these sites, and hypothesised that this was related to the higher clover content of the swards. The results from the lamb liveweight gain data suggest that individual lamb performance is more sensitive to changes in fertiliser and grazing regime, particularly at Hartwood, than is the number of grazing days.

In conclusion, our results show that over the time scale of the experiment the reduction in the proportion of sown species in grazed swards following removal of fertiliser and reductions in grazing intensity was small. The responses in terms of animal performance were primarily related to changes in the white clover content of the swards.

Table 1
Changes in the percentage contribution of perennial ryegrass and white clover to the species composition of the sward after four years of imposing extensive management treatments, averaged over three upland sites.

	Ryegrass		**Clover**	
Treatment	Year 0	Year 4	Year 0	Year 4
4/4 cmF	60	44	7.8	7.0
4/4 cm	55	27	11.2	15.9
4/8 cm	47	36	13.1	16.2
8/8 cm	51	35	12.7	7.8
8/4 cm	52	29	11.2	9.9
ungrazed	51	0.3	16.0	0.3
s.e.d[1]	3.7		1.61	

[1] except when comparing within the same

treatment	2.8	1.57
year	3.8	1.50

Table 2
Changes in lamb liveweight gain (g/day) after four years of imposing extensive management treatments on two sites. The values in parentheses are the treatment values relative to the conventional 4/cmF treatment for that year. This corrects for year-to-year variation in liveweight gain.

	Hartwood		**Sourhope**	
Treatment	Year 0	Year 4	Year 0	Year 4
4/4 cmF	159	179	203	255
4/4 cm	193 (+21%)	174 (-3%)	196 (-3%)	287 (+13%)
4/8 cm	241 (+52%)	181 (+1%)	203 (0%)	293 (+15%)
8/8 cm	251 (+58%)	227 (+27%)	265 (+31%)	319 (+25%)
8/4 cm	256 (+61%)	216 (+21%)	270 (+33%)	311 (+22%)
s.e.d.	23.2	10.8	17.6	10.2

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