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SID 5 Research Project Final Report

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Project identification

1. Defra Project code: OF0319
2. Project title: Organic Production in the hills and uplands
3. Contractor organisation(s): ADAS Consulting Ltd
   ADAS Redesdale
   Rochester
   Otterburn
   Newcastle upon Tyne
   NE19 1SB
4. Total Defra project costs (agreed fixed price): £ 336,754.00
5. Project: start date .... 01 April 2002
   end date .... 31 March 2005

6. It is Defra's intention to publish this form.
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Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

Summary

It is Government policy to provide a framework in which organic farming can develop, promoting more sustainable and environmentally sound systems of livestock production. Scientific information is required on the development, performance and limitations of organic systems, to facilitate informed decision-making and to aid policy formulation. Using the established organic unit at Redesdale, the overall objective of this project was to evaluate and demonstrate the long-term potential of organic livestock production in the hills and uplands.

The experiment was a systems study sited on one discrete farm unit covering 518 ha. Approximately 400 ha had been put into conversion in 1991, so that the experimental period (2002 - 2005) represented years 9 to 12 years of full organic production. Approximately 600 Scottish Blackface ewes were involved in the study, in four self-replacing flocks. At the start of conversion, one original heft (Dargues Dipper) was split to form two sub-hefts of equal stock carrying capacity. One sub-heft (Organic Dipper) was converted to organic production, while the second (Conventional Dipper) continued to be managed conventionally. The two other hefts (Cairn and Burnhead) were both converted to organic production. Beef production was based on spring calving suckler cows, managed in three sub-herds - two a direct comparison of organic and conventionally managed Angus cross cows put to a continental sire; the third consisting of organically managed Angus cows put to an Angus sire. Grassland management was based on a modified ‘Two Pasture’ hill system, integrating native hill, improved hill and inbye land for beef and sheep production.

On the native hill, detailed long-term monitoring of vegetation change showed that botanical composition was more affected by previous and current stocking levels, and events such as heather beetle infestation, than by organic and or conventional management. On improved hill land, the underlying trend was regression to rush pasture, leading to reduced productivity on both organic and conventionally managed areas. On the more intensively managed inbye fields, soil fertility levels were adequately maintained on the organic areas, which received only farmyard manure and slurries. Soil pH was more stable than on conventional fields, which received soluable nitrogen fertiliser. Organic inbye fields were sown predominately with short term leys, based on Italian ryegrass and Red or Alsike clover, to provide greater competition for weeds. Production levels were approximately 70% that of fertilised conventional fields. Self sufficiency in winter forage averaged 107% and 93% for the organic and conventional livestock (both sheep and cattle enterprises) respectively. Established infestations of docks production proved difficult to control. Historically, the greatest success was obtained where dock numbers were sufficiently low to enable the plants to be removed manually, or semi-mechanically using a tractor/digger. Data collected as an observation study suggested that for heavy infestations a fallow period and grazing by pigs could have good potential for dock control.

Consistent with earlier the phases of the study, sheep production levels were higher in the conventionally managed sheep. Organically managed ewes were significantly lighter and had lower body condition scores at most stages of the production cycle. Average lamb rearing percentages over the three years of the study were 124, 108,108 and 111 for Conventional Dipper, Organic Dipper, Cairn and Burnhead flocks respectively. Average lamb weaning weights (kg) were 31.8, 29.5, 31.3 and 32.9 respectively. Of the total crop, 65% of Conventional Dipper lambs were sold finished at a mean liveweight of 38.1 kg, returning an average of £40.03 (£1.05/kg). The balance (35%) were ewe lambs retained within the flock or sold for breeding. Depending on the flock, the majority of the organic lamb crop (55%-61%) were sold after weaning as stores for further finishing, at a price of approximately £1.15 per kg liveweight. Store hill lambs performed well finishing on an organic lowland farm, returning typical carcass weights of 18.5 kg and a mean sale date of mid-March. An arrangement was entered into to spread the financial risk, sharing the feeders margin between the store lamb producer and lowland finisher. This could be a useful model for wider application, between different farmers or regions with complementary resources. Across all four flocks, the three year average for ewe and hogg mortality was less than 5%. Lamb mortality averaged less than 10%, which compares well with quoted industry figures of 15%-20%. Parasite burdens were low and anthelmintic input was limited to a few individual lambs. No adverse effects were recorded as a result of the long-term withdrawal of clostridial and pasteurella vaccination from one of the three organic flocks (Cairn). Lower levels of performance in the organic flocks could be a multi-component effect of reduced forage availability, lower veterinary inputs, higher levels of subclinical disease etc. However, the most likely factor was the difference in how the improved hill and inbye land was managed under an alternate grazing regime, which allows access by sheep to only half the area of improved hill in any given year.

There was little difference in the physical performance of directly comparable organic and conventional sub-herds producing continental cross calves. Conception rates were consistently high, averaging 94%. Calf weaning weights (kg) averaged 292, 297 and 298 for conventional halfbred, organic halfbred and organic Angus sub-herds respectively. Prices achieved (p/kg live weight) for store prices cattle were 102, 127 and 133 respectively. Despite higher prices for organic cattle sold as stores, carcass data from animals sold finished indicated poorer conformation and higher levels of fatness in Angus sired calves.

Gross returns were £683 and £648 for continental and Angus calves respectively, representing a difference of £0.10/kg carcass weight (£2.24 Vs £2.34). The main technical issue associated with the organic suckler herd was ensuring an adequate supply of conserved fodder for a 200-day winter. Disease challenges were low and the only veterinary treatment given on a herd basis was a single treatment for lice during the winter period.

Average gross margins (£/ewe) before forage costs were £56, £44, £46 and £49 for Conventional Dipper, Organic Dipper, Cairn and Burnhead flocks respectively. Whole flock gross margins averaged £7635, £4609, £5561 and £4315. Lower performance in the organic flocks resulted from a combination of lower sheep numbers, reduced lambing percentages, and the sale of store rather than finished animals. Countryside Stewardship Scheme payments could potentially have increased gross margin in the Burnhead flock to £7915. Gross margins (£/cow), before forage costs, for rearing and finishing enterprises combined were £755, £636 and £527 for conventional halfbred, organic halfbred and organic Angus sub-herds respectively. Forage costs (£/adjusted hectare) averaged £11 and £21 for organic and conventional sub-units respectively. The biggest single contributor to gross margin was stocking rate, which for the organic unit as a whole, was 54% that of the conventional (1.3 LU/adjusted ha Vs 0.7 LU/adjusted ha). For sheep and cattle enterprises combined, gross margins per Livestock Unit (LU), including forage costs, were £451 and £479 for conventional and organic sub-units respectively. The organic unit as a whole returned a gross margin per adjusted hectare 44% less than the conventional (£590 Vs £335). It could be suggested that in reducing stocking rate in pursuit of environmental gain, and adjusting management for better parasite control, the organic system at Redesdale has had to carry a disproportionate financial burden. To offset these effects would require an improvement in output, for example retaining a greater proportion of organic animals for finishing, or entry into an agri-environmental scheme.

The period of the study coincides with the last three years of subsidy payments based primarily on the numbers of livestock carried. Historically, stocking rates have been a prime determinant of profitability when measured on a per hectare basis. Under organic management it was not possible to support sheep numbers at previous levels and maintain the same level of individual performance. The advent of support based on Single Farm Payment, further devolves stocking rate from overall profitability. More farmers may be tempted to convert, given that the opportunity cost of conversion is reduced. Decisions will be driven more by the relative strength of the organic market, technical or attitudinal constraints such as feeding 100% organically produced diets, and relative impacts on overall fixed costs.

The case for organic farming conferring environmental benefit is clearer in lowland situations than in the hills. In theory, the difference between organic and conventional systems should be less stark under less intensive production prevalent in the hills and uplands. As yet, little has been done to determine the extent to which organic and conventional farmers have adopted practices with positive or negative impact on biodiversity or the agri-environment. Much depends on the attitude of the individual landowner. From a survey conducted by ADAS in Wales, the greatest benefits tend to occur where an organic farm is also participating in another agri-environmental scheme. The extent to which organic, and evolving conventional, systems complement or conflict with cross compliance or Water Framework Directive requirements has yet to be determined. At Redesdale, long-term studies of vegetation change on the native hill, showed a continuing decline in heather cover at the higher stocking rates. Where stocking rates were reduced significantly to accommodate a more balanced organic system there were indications of a positive, albeit slow response in botanical composition. Key to this is the ability to manage moorland in a more proactive way, and to have cattle available to graze *Molinia* and *Nardus*. This complementary effect of cattle not only controls the competitive effects of these grassy species with heather, but as demonstrated in other research projects, also benefits sheep performance. If the economics of cattle production becomes very adverse organic farmers may be forced to reduce cattle numbers, which could make some sheep-dominated systems less sustainable.

The results indicate that for many hill and upland units, converting to an organic system is not likely to be a matter of minimal changes to existing management. In particular, stocking rate and balance of sheep and cattle at the start of conversion will have a major impact on the management required to achieve acceptable levels of animal performance, financial performance, input reduction and environmental gain. Recommendations were made for further research in the following areas:- Current behaviours and management practices for organic and conventional farmers; the interface of organic farming practice, and that of other agri-environmental schemes; environmental impact at the whole farm, or aggregated farm level; practices to enhance environmental benefit which can be used more widely on organic farms; control of weeds (rushes, thistles, bracken and docks); tightening regulations on non-organic feed allowances; internal and external parasite control; nutrient budgeting; wider cropping options for energy, protein and mineral nutrition; the potential to exploit co-operative effort to overcome technical issues and limitations, and increase environmental benefit.

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:
   - the scientific objectives as set out in the contract;
   - the extent to which the objectives set out in the contract have been met;
   - details of methods used and the results obtained, including statistical analysis (if appropriate);
   - a discussion of the results and their reliability;
   - the main implications of the findings;
   - possible future work; and
   - any action resulting from the research (e.g. IP, Knowledge Transfer).

Organic production in the Hills and Uplands (OF0329)

1.0 Introduction

It is Government policy to provide a framework in which organic farming can develop, promoting more sustainable and environmentally sound systems of livestock production. Scientific information is required on the development, long-term performance and limitations of organic systems, to facilitate informed decision-making and to aid policy formulation. Using the established organic unit at Redesdale, the objective of this project was to evaluate and demonstrate the long-term potential of organic livestock production in the hills and uplands.

2.0 Objectives

The overall objective was to evaluate the physical and financial performance of upland organic beef and sheep production. Specific objectives were to:-

- To maintain an organic unit of 438 ha, and associated sheep and cattle enterprises, to Soil Association Standards.
- To compare the long-term physical and financial performance of a conventionally managed sheep system, with an organic system at three differing stocking levels.
- To determine the technical and financial implications of combining Countryside Stewardship with an organic farming system.
- To compare the performance of organic and conventional suckler herds.
- To determine impacts of organic farming on animal health and welfare.
- To provide effective knowledge transfer
- To provide a resource for further research work by a range of research contractors

3.0 Materials and Methods

The project was a continuation of a systems study based on the organic unit at ADAS Redesdale. The experiment was sited on one discrete farm unit covering 518 ha. Approximately 400 ha had been put into conversion in 1991, so that the experimental period (2002 - 2005) represented years 9 to 12 years of full organic production.

The management and implementation of the research was overseen by a Project Steering Committee, chaired by Defra, and made up of representatives from The Soil Association, Elm Farm Research Centre, organic farmers, Ecostopes Consultancy, and a farm veterinary surgeon.

3.1 Soil and grassland

At the start of conversion, one original heft of 175 hectares (Dargues Dipper) was split to form two sub-hefts of equal stock carrying capacity. One sub-heft (Organic Dipper) was converted to organic production, while the second (Conventional Dipper) continued to be managed conventionally. The two other hefts (Cairn and Burnhead) were both converted to organic production.

3.1.2 Management

Grassland management was a modification of the 'Two Pasture' system of hill land management, making strategic use of three types of grazing (native hill, improved hill and inbye fields) to optimise sheep and beef production. The native hill was predominately peat, of varying depths, supporting typical hill vegetation of *Molinia* (purple moor grass), *Calluna* (heather) and *Carex spp*. (sedges). Improved pastures (reseeds) were established during the 1970's and 1980's by reseeding drier areas of the native hill. The improved swards still contained a proportion of sown species (ryegrass and white clover), but there was a high content of *Holcus* (Yorkshire fog) and *Poa* (meadowgrass) species. The inbye fields contained a range of mineral and peaty soils, and represented the best land on the unit. Sown species content on inbye fields was high (typically 60%-80%).

No inputs were made to organic or conventional areas of native hill. Conventionally managed hill reseed received 50 kg N ha $^{-1}$ each spring, apart from in 2004 when adverse ground conditions prevented tractor access. There were no inputs on organic managed reseeds. Both organic and conventional reseeds were topped each year to control rushes. Given the small proportion of total land area, management on the inbye fields was relatively intensive, with these areas expected to produce early season grazing, conserved fodder, and autumn grazing for finishing stock or replacement ewe lambs. Conventionally managed inbye land received an average of 166 kg N ha $^{-1}$ as soluble fertiliser. Phosphate and potash inputs per hectare averaged 110 kg K_2O and 30 kg P_2O_5. In addition, 5 tonnes of lime per hectare were applied in 2003, to maintain soil pH. Inputs to the organically managed inbye fields were solely from slurry or FYM.

On areas infested with docks, short term leys containing Italian and Westerwolds ryegrass, and Red Clover were used to provide greater competition for the dock. In addition, three plots (each approximately 0.4 ha) were specifically monitored as a non-replicated observation study, having been fallowed and repeatedly cultivated, or grazed with outdoor pigs. The three treatments were 1) ploughing followed by pigs grazing for 6 weeks, 2) ploughing followed by a potato harvester to bring the docks to the surface and 3) ploughing, repeated tined cultivation, then a potato digger used on three occasions. All three plots were resown with a Red Clover/ Italian Ryegrass/ Westerwolds seeds mixture.

3.1.2 Assessments

Measurements were made of soil fertility, botanical composition and forage output.

Soil

Soil cores were taken in December/January from all hill reseeds and inbye fields. Soil nutrient status was determined from samples taken from the 0-7.5 cm horizon, and analysed using standard techniques for pH, extractable P, extractable K, extractable Mg, total and available nitrogen.

Botanical composition

Assessment of botanical composition concentrated on the native hill and inbye fields. In addition, data from 1999 was used as a baseline to assess changes in vegetation over a five-year period. In botanical terms, the less dynamic hill reseeds were not surveyed during the three-year period of the study.

Native Hill

A number of approaches were used to assess botanical composition and condition on organic and conventionally managed areas of native hill.

Rapid grid

A 100m x100m grid was superimposed on the directly comparable Organic and Conventional Dipper hefts. A 1m x 1m quadrat divided into 100 10cm x 10 cm cells was placed at each of 129 intersections.

In each cell, presence/absence of live *Calluna vulgaris,* and grazing of *Calluna* were recorded annually during the spring and autumn. An estimate of plant species' abundance was carried out by recording the dominant species in each cell. All species present in the quadrat were also recorded. This had been done in 1999, and repeated in 2004. Changes in the abundance of individual species from 1999 to 2004 were analysed by Analysis of Variance using arcsine-transformed data. In the model, vegetation group was a fixed factor, and year was a repeated-measure. Where a main or interaction effect was detected, Tukey HSD tests were applied to clarify where differences had occurred.

Fuzzy cluster analysis (Equiha, 1990) was applied to the species abundance data from 1999, in order to classify the main vegetation types present, based on the National Vegetation Classification (NVC) communities (Rodwell, 1992). To assess overall changes in species composition, 1999 abundance data were analysed by Detrended Correspondence Analysis (Hill, 1979), and 2004 data then added to the ordination as supplementary variables. The mean axis1 and axis2 scores for each vegetation group, and each year, were calculated and then plotted in order to detect changes in ordination space over time.

JNCC monitoring

The condition of the Dipper Organic, Dipper Conventional, Burnhead and Cairn hills were also assessed using the Joint Nature Conservancy Council Common Standards Monitoring (JNCC 2004). A minimum of ten locations in approximating a W shape were chosen on each heft, using GPS prior to going out on the site. At each location, assessments were made according to the assessment criteria for wet heath. The percent pass rate for each criteria was calculated, as was the mean pass rate for each heft.

Inbye fields

Species frequency was measured in September each year, using 30 randomly located 0.5m x 0.5m nested quadrats each containing four cells, the first being a pinhit.

On the areas infested with docks, percent cover of *Rumex obtusifolius* (broad-leaved dock) was estimated, using 1m x 1m quadrats at 20 locations within each of the three plots. This assessment was carried out pre-treatment in May 02, and was repeated in April 03, June 03 and May 04.

Forage output

The number and fresh weight of silage and hay bales were recorded, and forage dry matter determined from oven-dried samples. In addition, for the inbye fields only, the number of sheep and cattle grazing days was calculated. To take account of grazing and conservation, total forage output was expressed as Livestock Unit Grazing Days (Pollott and Kilkenny, 1976).

3.2 Hill sheep production

The sheep on the unit were managed in four distinct flocks (Table 1). Following the splitting of one original heft in 1991, to form two areas of equal stock carrying capacity, two sub-flocks (Organic and Conventional Dipper flocks) provided a direct comparison of organic and conventional management. Sheep numbers were reduced by 25% in the Cairn in 1995, and by 20% in the Organic Dipper flock in 2000. Ewe numbers in the Burnhead flock were reduced by 40% in 2001, to levels appropriate to the Countryside Stewardship Scheme. Therefore, overall sheep numbers on the organic unit were 33% lower than at the start of conversion.

Table 1. Mean sheep stocking rates on the unit (2001- 2004)

	Con. Dipper	Org. Dipper	Cairn (Org)	Burnhead (Org)
Breeding ewe numbers	182	140	153	112
Ewe hogg replacements	56	42	46	33
Land area: Native hill	58 (71%)	77 (74%)	130 (79%)	86 (71%)
Improved hill	19 (23%)	21 (20%)	30 (18%)	30 (25%)
Inbye land	5 (6%)	6 (5%)	5 (3%)	5 (4%)
Total hectares	82 (100%)	104 (100%)	165 (100%)	121 (100%)

3.2.1 Management

Scottish Blackface ewes were mated in November, to lamb from mid-April. Over a four-year cycle, the same Scottish Blackface rams were used across all four flocks. The ewes were pregnancy scanned in February, and twin-bearing ewes segregated for better feeding. Twin-bearing ewes were housed in late March, and were retained on inbye fields for 5 weeks after lambing. Feed blocks were used only during winter 2001/02, and were completely replaced by sugar beet nuts for the subsequent two years. Mean feed inputs are given in Table 2.

Table 2. Winter supplementary feeding - mean annual inputs (kg/dry matter)

		Con. Dipper	Org. Dipper	Cairn (Org)	Burnhead (Org)
Ewes	Hay	29.62	27.15	22.58	29.49
	Silage	5.17	4.11	4.49	5.62
	Total forage	***34.79***	***31.26***	***27.07***	***35.11***
	Feed blocks	0.38	0.09	0.09	0.10
	Purchased concentrate	11.62	-	-	-
	Sugar beet nuts	17.42	19.59	19.30	18.38
	Home mixed concentrate	-	6.53	5.96	8.49
	Total concentrate supplement	***29.42***	***26.21***	***25.35***	***26.87***
Hoggs	Hay	5.27	6.37	5.46	5.75
	Silage	33.85	33.51	29.07	30.28
	Total forage	**39.02**	**39.88**	**34.53**	**36.03**
	Sugar beet nuts	19.13	6.73	6.45	6.45
	Home mixed concentrate	-	13.80	14.01	15.28
	Total concentrate supplement	**19.13**	**20.53**	**20.46**	**20.73**

No routine anthelmintic was given to organic ewes or lambs. For roundworm control, organic inbye fields and hill reseeds were grazed by sheep and cattle in alternate years. Native hill continued to be grazed each year, but at low stocking rates. Conventionally managed sheep were grazed on the same areas of inbye land, hill reseed and native hill each year. Under both management regimes, sheep were moved ('raked') daily between the hill reseeds and the native hill, in order to ensure botanical diversity in the vegetation consumed over the summer period. Ewes in the conventional flock were routinely drenched twice (pre tupping and at marking), and lambs three times (marking, clipping and weaning).

Three flocks (Conventional Dipper, Organic Dipper and Burnhead) were managed on a full clostridial and pasteurella vaccination programme. Vaccination had been removed from the Cairn flock in 1995, to monitor the effect of organic management under a reduced veterinary programme.

3.2.2 Assessments

Detailed flock records were maintained to assess physical and financial performance. The incidence of disease, stock deaths and post-mortem results were recorded. Detailed parasitological data were taken including routine faecal and blood samples.

Performance data were analysed by Analysis of Variance across all four flocks. Differences between flocks were subjected to Duncans Multiple Range Test. In addition, a separate ANOVA was carried out to compare the Organic and Conventional Dipper flocks.

3.3 Suckler herds

The suckler herd of 60 cows was made up of three components, calving from mid-April each year. Two sub-herds (one conventional, and one managed organically) were put to a continental bull (Charolais or Limousin). The conventionally managed herd had been formed by removing from the original organic herd animals from herds where the required declaration of BSE-free status could not be obtained. Cows in both sub-herds were therefore of similar breed and parity. The third sub-herd was made up of younger, predominately Angus (¾ and ⅞ Angus) cows, put back to an Angus bull (Table 3).

Table 3. Redesdale organic unit - suckler cow sub herds

Dam type	Terminal sire	Management	Cow live weight (kg) at weaning (Nov 02)	Body condition score at weaning (Nov 02)
Angus x Friesian	Charolais	Organic	576	2.28
Angus x Friesian	Charolais	Conventional	582	2.49
¾ and ⅞ Angus	Angus	Organic	616	3.26

All three herds were managed under a similar spring (April/May) calving regime, and integrated with sheep, grazing improved areas of the hill from June to October. The cows were housed in November, and the calves weaned in December/January. Winter rations for the cows were based on baled silage (Table 4), with any concentrate supplement given according to body condition and silage quality.

Table 4 Total conserved forage dry matter consumed by the suckler herd (kg/head)

		Conventional	Organic
Cows	2004	2097	1612
	2003	2256	2435
	2002	4224	2696
	Three-year average	2859	2248
Calves	2004	737	829
	2003	1106	1168
	2002	1164	1188
	Three-year average	*1002*	*1062*
Total herd	*Three-year average*	*3861*	*3310*

Over the housed period, less than 1% of the total dry matter consumed by the suckler cows (representing minerals and molasses in the home mix) came from non-organic sources. A concentrate based on organic barley and organic beans was introduced to the calves at housing and increased to 2.5 kg/day fresh weight as the cattle grew over the winter. Over the three-year period, calf concentrate inputs averaged 287 kg per head over a 200-day housing period (Table 5).

Table 5 Total concentrate dry matter consumed (kg/head)

		Conventional	Organic
Cows	2004	161.9	106.6
	2003	24.3	12.6
	2002	21.6	34.9
	Three-year average	69.3	51.4
Calves	2004	214.3	225.7
	2003	236.8	222.7
	2002	434.0	386.0
	Three-year average	*295.0*	*278.1*

Of the total concentrate supplement fed to organic cows during winter 2002, 2003 and 2004 respectively, 15.6 kg, 0.8 kg and 6.5 kg came from approved non-organic sources. This represented minerals and trace elements, together with some molasses used as a binder. The total annual amounts of non-organic feed given to organic calves were 13.5 kg, 14.9 kg and 14.7 kg for each year respectively.

4.0 Results

4.1 Soil and grassland

4.1.2 Soil fertility

On organically managed land, soil pH ranged from 5.9 (on peaty soil) to 6.3 (mineral soil). On conventionally managed mineral soil, pH tended to be more variable (range 5.2 to 6.5), a likely consequence of higher silage yields, and the use of soluble ammonium nitrate, which could be expected to have an additional acidifying effect.

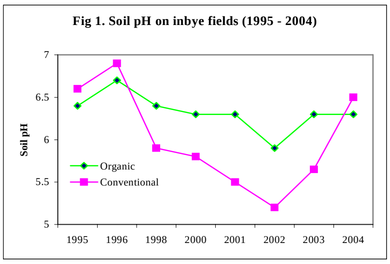
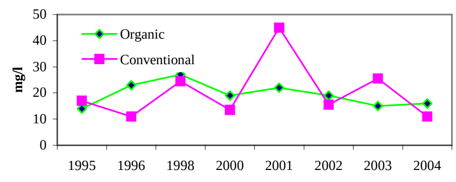


Fig 1. Soil pH on inbye fields (1995 - 2004)

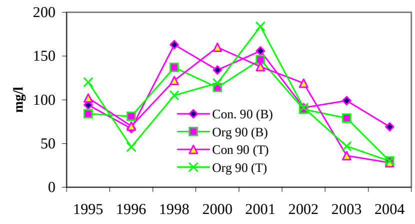
Fig. 2 Soil potassium levels on inbye fields (1995 - 2004)



Soil phosphate (range 15 mg/l – 19 mg/l) and potassium (range 139 mg/l – 271 mg/l) levels on organic inbye land, were at soil Index 2. On the conventionally managed areas, soil phosphate (range 11 mg/l – 25 mg/l) was more variable (Index 1-2), while potassium (range 73 mg/l - 122 mg/l) was lower (Index 1), despite the addition of compound P and K fertiliser each year.

On the improved hill, there were few differences in soil fertility between organic and conventionally managed areas. On comparable areas the long-term pattern in soil nutrients was very similar under both management regimes. Over the three year period, soil pH for both systems ranged from 5.1 to 6.2 - within the expected range for a peaty soil. Soil phosphate (range 4 mg/l -18 mg/l) and soil potassium (range 30 mg/l – 119 mg/l) were both at Index 0 to1.

Fig. 3 Soil potassium levels on improved hill (1995 - 2004)



4.1.2 Botanical composition

Native hill

Grazing assessments

In comparison with 1999 data, which coincided with an outbreak of heather beetle, the state of heather (*Calluna*) on both Organic and Conventional Dipper hefts had shown some improvement by 2004. The increased numbers of quadrats and cells with heather (Table 6) were due mainly to recovery of existing heather, rather than new areas of spread.

Table 6 Percentage frequency of *Calluna* grazed (number of quadrats in which *Calluna* was present is given in brackets)

	Autumn 02	Spring 03	Autumn 03	Spring 04	Autumn 04
Organic	20 (7)	35 (7)	60 (7)	76 (8)	33 (13)
Conventional	46 (5)	9 (7)	82 (5)	96 (4)	96 (6)
Total	37 (12)	16 (14)	77 (12)	90 (12)	68 (19)

A reduction in the percentage of cells grazed on the organic sub-heft was probably due in part to the reduction in stocking rate, and partly to the recovery from heather beetle attack. Although the recovery in heather was encouraging, it is worth noting that on a carefully managed hill, heather would hardly be grazed at all during the summer. The trend on both hefts was still one of long-term heather degradation.

Individual species analysis

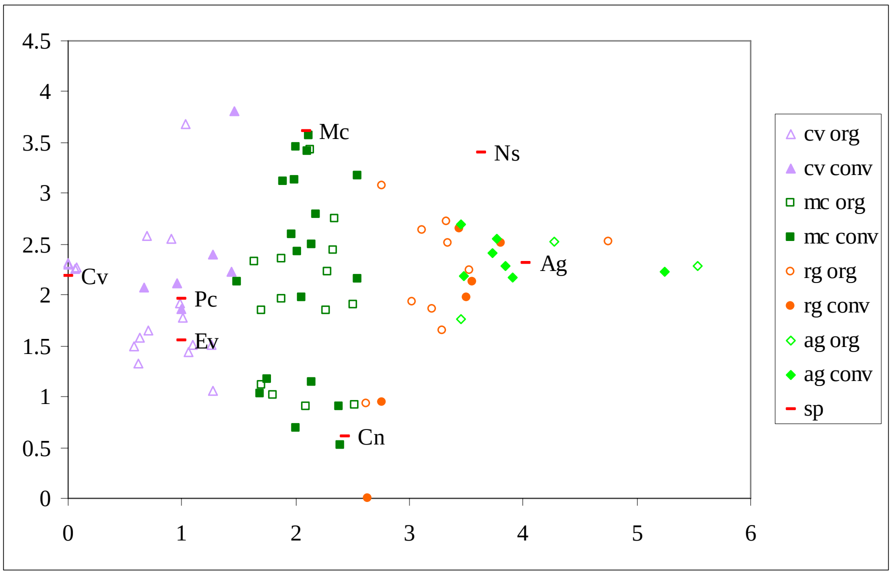
The overall trend in species composition away from heath and palatable grassland communities towards rough grassland was consistent with previous years. *Calluna* dominance was still in decline in both units, probably as a result of continued heavy grazing. There was no evidence of any difference in recovery rates from heather beetle damage under the different stocking rates in the organic and conventional units. *Calluna* replacement by *Eriophorum* in the organic unit might however be an early response to the reduced grazing intensity there since 2001. It is likely that the *Eriophorum* already present was able to respond to reduced grazing pressure more quickly than *Calluna* as the increased shoot biomass of *Eriophorum* would result in its overtopping the *Calluna*.

An increase in *Agrostis* was unexpected, because it had not been detected during the earlier phases of monitoring. This suggests some eutrophication in both organic and conventional units, which may be a consequence of the long-term heavy grazing to which both have been subjected. An increase in *Polytrichum* on the conventional unit was also noted. At this higher stocking density, palatable species might be replaced by the unpalatable *Polytrichum*, whereas under the lower stocking density in the organic unit other species were grazed less heavily, so that *Polytrichum* remained sub-dominant in the canopy.

Community analysis

From analysis of the 1999 data, four vegetation groups were determined:- 1. *Calluna* dominated, 2. *Molinia* dominated, 3. rough grasses and 4. Agrostis dominated. The ordination diagram (Figure 4) showed that applying these vegetation groups resulted in a reasonably good separation of quadrats, though there was some overlap between the rough grass and *Agrostis* groups.

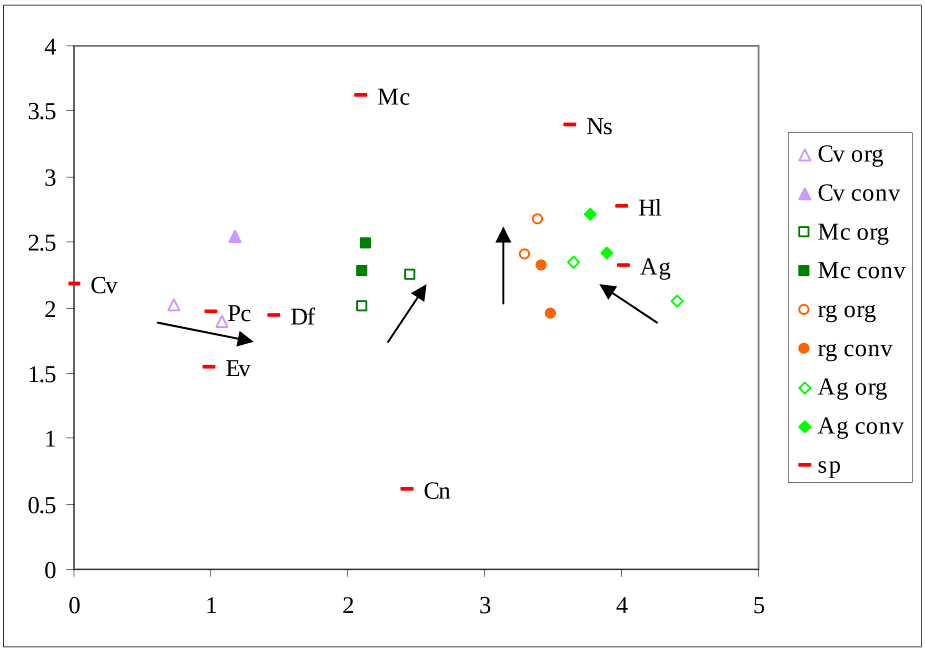
Figure 4 Detrended correspondence analysis of 1999 data from the native hill



Key: Cv=*Calluna*; Pc=*Polytrichum commune;* Ev=*Eriophorum vaginatum ;* Mc=*Molinia;* Cn=*Carex nigra;* Ns=*Nardus;* Ag=*Agrostis* spp.

The ordination diagram given in Figure 5 suggested that there was a general move away from *Calluna* dominated or palatable grassland, towards rough grassland. The reduction in *Calluna* on both the organic and conventional sub-hefts (as indicated by the individual species analysis) provides evidence for this, though the increase in *Agrostis* spp. and reduction in *Carex nigra* are inconsistent. The inability to explain the movement in ordination space in terms of the observed changes in *Agrostis* (and *Carex*) suggested that movements occurred in individual species that were too small to detect using the methods and scales adopted. Although the reduction of *Calluna* appeared to have halted in the conventional *Calluna* group, it was still evident across the sub-heft as a whole. The lost *Calluna* on the organic *Calluna* group was replaced by *Eriophorum vaginatum,* and was probably reflected in a transition from M19 to M20, which is typically occurs in heavily grazed mire communities.

Figure 5 **Detrended correspondence analysis depicting mean locations of each of the four vegetation groups for 1999 and 2000 (arrows show direction of change).**



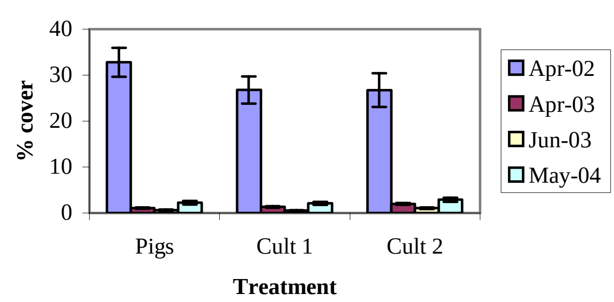
JNCC monitoring

The overall percent pass rates across the JNCC assessment criteria were 61, 71, 86 and 91 for Organic Dipper, Conventional Dipper, Burnhead and Cairn hefts respectively. According to JNCC guidelines, scores should not fall below 90% for each criterion. In common with other assessment approaches, JNCC standards may have some site-specific limitations. However, the overall results are consistent with those of more detailed assessments reported above, and confirm the extent of degradation in heather cover on the Conventional and Organic Dipper hefts.

Inbye land

Traditionally, the inbye fields at Redesdale were resown on a 5 to 7 year cycle. Long-term monitoring indicated a typical pattern following reseeding. The tendency was for an initial increase in annual weeds such as chickweed (*Stellaria*), followed by the establishment of sown species i.e. ryegrass and clover. Depending on the field, further succession included the invasion of non-sown grass species, and a gradual increase in perennial weeds such as docks and buttercup. On 5-year old organic ley assessed during 2003, mean cover of clover reduced significantly between April 2002 and April 2003, from 36% to 19% ($P<0.001$), whilst grass and weeds both increased significantly from 65%-80% and 17% to 25% respectively ($P<0.001$). Within the observation trial, dock cover in the plot grazed by pigs (Figure 6) was reduced from 33% pre-treatment in 2002 to 0.6% in 2003, then increasing to 2% by 2004. On the two plots which were repeatedly cultivated, cover fell from 27% to 1%, before increasing to 2% and 3% cover respectively. Observations indicated that the pigs did not consume many dock roots, however in searching out other food, they tended to bring the docks to the surface and move them around continually.

Fig 6. Change in dock cover following three cultural control treatments



The effectiveness of this type of cultural control is likely to be very weather dependent. June 2002 was particularly wet, which limited both the potential of cultivation to kill off dock root and the grazing period available to the pigs. As ground conditions deteriorated, the pigs had to be removed and housed for welfare reasons. Although the docks showed signs of increasing, they did so slowly. The treatments imposed are less suited to all-grass farms, but demonstrate the potential for this approach to give a reasonable degree of control in badly infested areas.

An area of organically managed inbye land which had not been reseeded since 1991 continued to diversify in terms of botanical composition, at the expense of agricultural productivity. A total of 21 species were identified in 2004, compared with 17 in 2003 and 19 in 2002. *Lolium perenne* (perennial ryegrass) and *Holcus* spp. (creeping soft grass and Yorkshire Fog) were most common species at scale 1 whilst *Poa trivialis* (rough meadow grass) was most common at the other scales, occurring along with *Ranunculus repens* (creeping buttercup) at scale 3. Non-sown species, typical of mesotrophic unimproved meadows, occurred less commonly: *Veronica serpyllifolia* (thyme-leaved speedwell), *Cerastium fontanum* (common mouse-ear), Cardamine spp. all decreased between 2003 and 2004. *Bellis perennis* (daisy) increased, while *Alchemilla glabra* (lady's-mantle) was absent in 2004. Species recorded for the first time in 2004 were *Dactylis glomeratus* (cocksfoot), *Bromus hordeaceus* (soft brome), *Trifolium pratense* (red clover), *and Brachythecium rutabulatum* (moss). It is notable that docks have virtually been eliminated from this area, having been dug out manually in the mid-1990's. Lack of cultivation since then has not provided conditions for docks to re-establish.

4.1.3 Forage output

Forage output on inbye fields (measured as Livestock Unit Grazing days per ha) is given in Table 7. Output across the organic inbye land was 66% that of the conventional area. If newly reseeded pasture was excluded in the year of sowing, output across the organic inbye fields was 69% that of the conventional.

Table 7. Forage output on organic and conventionally managed inbye fields

	South Hayfield (conventional)	North Hayfield (organic)	West Hayfield (organic)	Bridge Haugh (organic)	Ford Haugh (organic)
2002	956	* 382	488	690	714
2003	879	776	737	559	* 453
2004	900	644	613	581	700
Mean	**912**	**601**	**613**	**610**	**623**

* reseeded.

4.2 Hill sheep production

4.2.1 Ewe live weight and body condition score

Compared with the conventionally managed sheep, ewes were significantly lighter in the organically managed flocks (Table 8). The main exception was the 2003/04 grazing season when ewe live weights, at marking and at weaning, were much more comparable. This also coincided with a good grass production year.

Table 8. Ewe live weight (kg) at key stages of the production cycle

Flock		Con. Dipper	Org. Dipper	Cairn (Org.)	Burnhead (Org.)	Level of significance: All flocks	Level of significance: Con *v*. Org Dipper
Mating	03/04	55.1^{c}	49.5^{b}	50.1^{b}	53.4^{a}	***	***
	02/03	58.5^{c}	51.1^{b}	50.7^{b}	52.9^{a}	***	***
	01/02	56.7^{b}	52.5^{a}	53.9^{a}	52.9^{a}	***	***
Scanning	03/04	50.2^{a}	46.5^{c}	48.4^{b}	51.7^{a}	***	***
	02/03	50.4^{d}	45.7^{c}	47.2^{b}	48.7^{a}	***	***
	01/02	53.5^{b}	50.1^{a}	49.8^{a}	50.9^{a}	**	**
Marking	03/04	53.2^{b}	52.8^{b}	52.3^{b}	56.5^{a}	***	N/S
	02/03	53.5^{c}	49.4^{b}	51.2^{a}	52.0^{a}	***	***
	01/02	57.3^{c}	50.0^{b}	53.7^{a}	54.3^{a}	***	***
Weaning	03/04	57.4^{a}	54.5^{b}	54.7^{b}	58.2^{a}	***	***
	02/03	58.1^{d}	51.4^{c}	53.1^{b}	55.4^{a}	***	***
	01/02	58.7^{c}	52.1^{b}	53.2^{b}	54.8^{a}	***	***

Note: Within each year, differences between data sharing the same superscripts are not statistically significant (Duncans Multiple Range Test)

Although recorded differences in ewe body condition score were less marked (Table 9), there was a consistent tendency towards leaner ewes in the organically managed flocks.

Table 9. Ewe body condition score

Flock		Con. Dipper	Org. Dipper	Cairn (Org.)	Burnhead (Org.)	Level of significance	
						All flocks	Con *v.* Org Dipper
Mating	03/04	2.76 [c]	2.70 [abc]	2.68 [b]	2.77 [a]	**	N/S
	02/03	2.64 [ab]	2.48 [c]	2.60 [b]	2.67 [a]	***	***
	01/02	2.53 [b]	2.40 [a]	2.52 [b]	2.44 [a]	***	***
Scanning	03/04	2.52 [a]	2.45 [c]	2.43 [bc]	2.57 [a]	***	**
	02/03	2.41 [c]	2.34 [b]	2.33 [b]	2.47 [a]	***	**
	01/02	2.44 [b]	2.51 [a]	2.38 [b]	2.49 [a]	***	**
Marking	03/04	2.54 [b]	2.59 [b]	2.49 [b]	2.68 [a]	***	N/S
	02/03	2.43 [b]	2.32 [c]	2.41 [b]	2.55 [a]	***	**
	01/02	2.51 [c]	2.33 [b]	2.45 [a]	2.44 [a]	***	***
Weaning	03/04	2.59 [a]	2.61 [a]	2.47 [b]	2.64 [a]	***	N/S
	02/03	2.69 [a]	2.40 [c]	2.55 [b]	2.75 [a]	***	***
	01/02	2.51 [c]	2.35 [ab]	2.30 [b]	2.39 [a]	***	***

Note: Within each year, differences between data sharing the same superscripts are not statistically significant (Duncans Multiple Range Test)

Further analysis of lifetime performance for each cohort (annual intake) of homebred flock replacements, showed that organic breeding ewes were significantly lighter at each of first to fifth mating (Table 10).

Table 10. Long-term trend in ewe live weight (kg)

Flock		Con. Dipper	Org. Dipper	Cairn (Org.)	Burnhead (Org.)	Level of significance	
						All flocks	Con *v.* Org Dipper
As hoggs	Weaning	33.6 [b]	31.9 [a]	33.9 [b]	32.0 [a]	***	***
	Housing	34.0 [b]	32.7ac	34.4 [b]	33.1 [a]	***	***
	Turnout	36.2 [a]	35.1 [b]	36.0 [a]	36.5 [a]	N/S	**
As ewes	Mating 1	53.5 [c]	50.5 [b]	52.1 [a]	51.6 [a]	***	***
	Mating 2	56.4 [b]	53.5 [a]	53.7 [a]	53.9 [a]	***	***
	Mating 3	60.8 [b]	57.1 [a]	57.7 [a]	57.3 [a]	***	***
	Mating 4	62.6 [b]	57.8 [a]	58.3 [a]	57.4 [a]	***	***
	Mating 5	61.7 [b]	58.2 [a]	60.2 [ab]	55.4 [a]	**	**

Note: Within each year, differences between data sharing the same superscripts are not statistically significant (Duncans Multiple Range Test)

4.2.2 Ewe reproductive performance

Poorer condition in organically managed ewes at mating was reflected in higher barren rates (6.3% Vs 3.8%) and lower numbers of lambs at scanning, which over the three-year period, averaged 115% and 133% for organic and conventional flocks respectively (Table 11). As a proportion of lambs present at scanning, 95% and 93% were successfully reared in the organic and conventional flocks respectively.

Table 11. Ewe reproductive performance

Flock		Con. Dipper	Organic Dipper	Cairn (Org.)	Burnhead (Org.)
Barren rate (February)	2004	3.8	10.3	7.3	7.1
	2003	3.2	3.5	4.5	8.0
	2002	4.4	7.7	5.8	2.7
	3-year mean	***3.8***	***7.2***	***5.9***	***5.9***
Scanning (February)	2004	124	106	104	114
	2003	132	109	109	113
	2002	143	130	122	129
	3-year mean	***133***	***115***	***112***	***119***
Lambs born alive (April)	2004	118	105	105	114
	2003	125	104	103	105
	2002	131	114	118	121
	3-year mean	***125***	***108***	***109***	***113***
Lambs reared (September)	2004	116	104	103	107
	2003	123	104	104	105
	2002	133	117	116	122
	3-year mean	***124***	***108***	***108***	***111***

4.2.3 Lamb performance

In terms of lamb live weight, statistically significant differences were recorded between Conventional and Organic Dipper flocks (Table 12). This occurred despite the potentially dampening effect of increasing prolificacy i.e. the tendency for greater numbers of twin lambs to reduce mean lamb live weight at weaning. The highest weaning weights were obtained in the Burnhead flock, which had the lowest stocking rate on the organic unit. Daily liveweight gain also compared favourably with the conventionally managed sheep.

Table 12. Lamb liveweight and daily liveweight gain (DLWG)

Flock		Con. Dipper	Org. Dipper	Cairn (Org.)	Burnhead (Org.)	Level of significance	
						All flocks	Con *v.* Org Dipper
Birth (kg)	2004	3.9^{a}	4.0^{a}	4.1^{b}	4.1^{b}	N/S	N/S
	2003	3.8^{a}	3.9^{a}	4.0^{b}	3.9^{a}	N/S	N/S
	2002	3.5^{a}	3.4^{a}	3.7^{b}	3.7^{b}	**	**
Marking (kg)	2004	12.7^{a}	12.6^{a}	14.1^{b}	14.0^{b}	***	N/S
	2003	12.8^{a}	12.6^{a}	12.8^{a}	13.0^{a}	N/S	N/S
	2002	14.8^{a}	12.3^{b}	14.2^{ac}	13.9^{c}	***	***
Weaning (kg)	2004	32.7^{a}	32.0^{a}	34.4^{b}	34.9^{b}	***	N/S
	2003	30.7^{a}	27.0^{b}	30.0^{a}	30.7^{a}	***	***
	2002	31.9^{a}	29.4^{b}	29.4^{b}	33.1^{c}	***	***
DLWG (g)	2004	202^{a}	203^{a}	217^{b}	218^{b}	***	N/S
	2003	198^{a}	171^{b}	194^{a}	197^{a}	***	***
	2002	204^{a}	187^{b}	184^{b}	209^{c}	***	***

Note: Within each year, differences between data sharing the same superscripts are not statistically significant (Duncans Multiple Range Test)

4.2.3 Marketing and disposals

Of the total lamb crop, approximately 25%-30% were retained as ewe lambs to maintain the breeding flock (Table 13). A further 2% -10% were sold as ewe lambs for breeding, or transferred to other flocks at Redesdale as breeding animals. For a particular flock, the proportion of lambs making the grade as breeding stock, was strongly correlated with the overall level of sheep performance. A total of 35% of the lamb crop on the Conventional Dipper flock were retained or sold for breeding. A small proportion of organic lambs were sold finished on the conventional market. These were either unsuitable for sale as stores e.g. entire lambs, or lambs which were close to finish at the point of weaning.

Table 13. Lamb disposals (% distribution)

Flock		Con. Dipper	Organic Dipper	Cairn (Org.)	Burnhead (Org.)
Retained for breeding	2004	25	30	30	34
	2003	27	28	26	28
	2002	24	26	29	24
	3-year mean	***25***	***28***	***28***	***29***
Sold for breeding	2004	13	6	3	15
	2003	6	1	1	16
	2002	10	1	2	3
	3-year mean	***10***	***3***	***2***	***11***
Sold finished	2004	62	4	4	5
	2003	67	14	15	3
	2002	66	5	22	8
	3-year mean	***65***	***8***	***14***	***5***
Sold store	2004	0	60	63	46
	2003	0	57	58	53
	2002	0	68	47	65
	3-year mean	***0***	***61***	***56***	***55***

Under a long-standing arrangement, the majority of the organic lambs were sold as stores for further finishing on an organic lowland farm. Typical performance levels are given in Table 14.

Table 14 Performance of organic lambs finishing on a lowland farm (2001/2 lamb crop)

Lamb livewgt at sale	30.1 kg	
Losses	1.4%	4 lambs (3 in Oct 02: 1 in Feb 03)
Left on farm (May)	1.6%	3 lambs
Mean carcass weight	18.6 kg	
Mean sale date	16 March	

The arrangement included a mechanism to spread the financial risk, sharing profit between store lamb producer and lowland finisher (Table 14). Transport costs to the finishing farm were shared. The first £10 of the feeders margin went to the finisher, with the remainder split equally with the store lamb producer.

Table 14 An example of profit sharing in store lambs finishing (2001/2 lamb crop)

	No.	£ (total)	£ (per head)
Purchase price	280	8428	30.10
Transport (@ 50% from Redesdale to finishing farm)	280	297	1.06
Transport (from finishing farm to the abattoir)	276	546	1.98
Total costs		9271	33.14
Sales	276	14100	51.95
Feeders margin	276	4829	17.50
Share of finishing margin profit to finisher			13.75
Share of finishing margin profit to store producer			3.75

Critically in the example above, the finisher attributed no feed costs to the lambs, as they were grazed on dairy pastures, stubbles and winter cereals over the winter. Any feed costs were deemed to have been offset by the crop management value of winter grazing, and the extra fertility building from grazing lambs. If specialist finishing crops have to be grown, the feeders margin could be expected to fall. In the figures quoted above, no allowance was made for interest on the capital invested in purchased lambs.

4.3 Suckled beef production

4.3.1 Cow liveweight and body condition score

As mature cows, the purer bred Aberdeen Angus cows were consistently heavier than the Angus Friesian cross, and tended to carry more body condition at weaning (Table 16).

Table 16. Cow live weight and body condition score

		Conventional Halfbred	Organic Halfbred	Organic Angus
Liveweight (kg)	2004	606[a]	555 [a]	650[b]
	2003	581 [a]	576 [a]	616 [a]
	2002	625 [b]	567 [a]	590[ab]
	3-year mean	***604***	***566***	***617***
Body condition score	2004	2.75 [ab]	2.54 [b]	2.89 [a]
	2003	2.77 [ab]	2.48 [b]	2.95 [a]
	2002	3.42 [a]	2.83 [b]	3.32 [a]
	3-year mean	***2.98***	***2.62***	***3.05***

Note: Within each year, differences between data sharing the same superscripts are not statistically significant (Duncans Multiple Range Test)

4.3.2 Cow reproductive performance

Conception rates were consistently high, averaging 94 % over the three-year period (Table 17). Calf mortality was generally very low, and occurred mainly before or at calving.

Table 17. Suckler herd reproductive performance

	Conventional Halfbred	Organic Halfbred	Organic Angus
Conception rate (%)	94.9	94.9	93.4
Calving %	97.4	92.4	93.4
Calf mortality (%)	5.0	2.7	3.3
Calves reared (%)	97.4	92.4	90.6
Cow mortality (%)	0	0	3.1

Note: calving rate may differ from conception rate, due to pre-calving losses and incidence of twin births

4.3.3 Calf performance to weaning

As expected, calves from the Angus herd were consistently lighter at birth than those in the other two sub-herds (Table 18). However apart from 2002, when the cows were still relatively immature, Angus calves achieved comparable live weights at weaning. The Angus cows appeared to milk less well than halfbred dams, which accentuated good calf performance following the introduction of concentrate feed after housing.

Table 18. Suckled calf performance (Kg)

		Conventional Halfbred	Organic Halfbred	Organic Angus
Birthweight (kg)	2004	43.9[a]	41.0 [a]	35.8 [b]
	2003	42.2 [a]	43.0 [a]	39.4 [a]
	2002	47.7[b]	46.3 [b]	34.6 [a]
	3-year mean	***44.6***	***43.4***	***36.6***
Weaning weight (kg)	2004	270.2 [a]	257.9 [a]	283.3 [a]
	2003	270.4 [b]	287.3 [a]	300.0 [a]
	2002	334.7 [b]	345.3 [b]	309.8 [a]
	3-year mean	***291.8***	***296.9***	***297.7***
DLWG (kg, birth to weaning)	2004	1.10 [a]	1.04 [a]	1.13 [a]
	2003	0.96 [a]	0.98 [a]	1.02 [a]
	2002	0.97 [b]	1.01 [b]	0.90 [a]
	3-year mean	***1.01***	***1.01***	***1.02***

Note: Within each year, data carrying the same superscript are not statistically different (Duncans Multiple Range Test)

4.3.4 Cattle disposals and carcass gradings

A total of 143 animals were sold from the suckler herd over the three years of the study; 25% were sold finished and 75% were sold as stores (Table 19).

The conventional cattle were all sold as forward stores at a mean live weight of 488 kg. Conventional store prices averaged £486.89 gross, or £473.31 net after deductions for commission (£13.58). This equated to a store price of £1.02 per kg gross, or £1.00 per kg net of commission. Organic cattle sold at the same time averaged 448 kg and 467 kg, for steers out of the Organic ¾ bred sub-herd (sired by an Angus bull) and Organic ½ bred sub-herd (sired by a continental sire) respectively. The gross prices were £593.64 and £582.03 respectively, or £577.45 and £565.99 net of commission. These gross prices equated to £1.33 per kg and £1.27 per kg live weight for Angus and continental cross calves respectively.

Table 19. Suckler herd – cattle disposals

	Calves born	Conventional Halfbred	Organic Halfbred	Organic Angus
Sale weight – heifers (kg)	2003	382	415	447
	2002	459	*579	*562
	2001	415	*563	*579
	3-year mean	***419***	***519***	***529***
Sale weight – steers (kg)	2003	417	427	419
	2002	470	441	411
	2001	467	561	479
	3-year mean	***451***	***476***	***436***
DLWG birth to sale – heifers	2003	0.90	0.96	1.05
	2002	1.00	*0.91	*0.85
	2001	0.93	*0.89	*0.81
	3-year mean	***0.94***	***0.92***	***0.90***
DLWG birth to sale – steers	2003	0.90	*1.01*	*0.98*
	2002	*0.94*	*1.01*	*1.05*
	2001	*1.02*	*0.97*	*0.79*
	3-year mean	***0.95***	***1.00***	***0.94***

Note: * sold finished

Finished carcass weight was similar for both organic sub-herds, averaging 290 kg. The prices received reflected carcass grades achieved for conformation, and compare well with prices achieved for conventional cattle over the same period.

Table 20 Distribution (%) of carcass gradings – finished organic cattle sold Jan 2002 to Feb 2004

Carcass conformation			**U**	**R**	**O+**	**O-**		**Total**
Number	**Herd**							
	Organic ½ bred		0	12	3	0		15
	Organic ¾ bred		0	1	8	1		10
Percentage	Organic ½ bred		0	80	20	0		100
	Organic ¾ bred		0	10	80	10		100
Carcass fatness		**3**	**3H**	**4L**	**4H**	**5L**	**5H**	**Total**
Number	**Herd**							
	Organic ½ bred	1	2	9	3	-	-	15
	Organic ¾ bred	-	-	5	2	2	1	10
Percentage	Organic ½ bred	7	13	60	20	-	-	100
	Organic ¾ bred	0	0	50	20	20	10	100

Despite higher prices for cattle sold as stores, the carcass data indicated poorer conformation and higher levels of fatness in Angus-sired calves, compared with continental crosses. Angus sired calves also had a slightly lower killing out percentage (50% Vs 51%). Price per kg for organic cattle sired by a continental bull was £0.10 higher per kg carcass weight, compared with Angus sired animals (£2.34 Vs £2.24). Gross returns per head were £682.98 Vs £647.62 for continental and Angus sired cattle respectively, representing net prices of £666.01 and £625.16.

4.4 Animal health and welfare

4.4.1 Hill sheep

Across all four flocks, the three-year average for ewe and hogg mortality was less than 5% (Table 21). Lamb mortality averaged less than 10%, which compares well to quoted industry averages of 15% to 20%.

Table 21. Mortality rates and ewe lamb performance as indicators of flock health

Flock		Con. Dipper	Organic Dipper	Cairn (Org.)	Burnhead (Org.)
Ewe mortality (%)	2004	1.1	0.7	2.6	1.8
	2003	5.4	6.3	5.8	4.4
	2002	2.8	4.2	2.6	0.9
	3-year mean	***3.1***	***3.7***	***3.7***	***2.4***
Lamb mortality (%)	2004	10.2	10.0	9.8	11.3
	2003	9.2	5.2	7.2	5.7
	2002	9.2	10.1	6.5	7.6
	3-year mean	9.5	8.4	7.8	8.2
Hogg mortality (%)	2004	1.7	2.4	2.3	3
	2003	7.3	2.3	10	3
	2002	3.6	4.6	2	3
	3-year mean	4.2	3.1	4.8	3
Proportion of ewe	2004	98.3	97.6	97.7	97.0
lambs entering the	2003	97.7	97.7	80.0	97.0
as shearlings	2002	96.4	95.4	98.0	97.0
	3-year mean	97.5	96.9	91.2	97.0

Parasite burdens, as measured by lamb faecal egg output at weaning were low, and anthelmintic input was limited to a few individual lambs. No adverse effects were recorded as a result of removing clostridial and pasteurella vaccination from the Cairn flock.

4.4.2 Suckler herd

Consistent with previous years, the overall health status of the spring calving herds was very good. The only routine veterinary input was a single treatment for ectoparasites (deltamethrin) at housing given to both conventional and organic stock. A homeopathic preparation was given to new-born calves as a preventative against calf scour, and again before weaning for potential respiratory problems. No anthelmintic was used, even on an individual basis.

4.5 Financial performance

4.5.1 Sheep Gross Margins

The conventionally managed flock consistently produced a higher gross margin per head (Table 22). This was largely due to higher output, in terms of total lambs sold, but also in terms of average price per lamb. The majority of organic lambs were sold for further finishing after weaning in September, at approximately £1.10 per kg live weight. On average, conventional lambs were sold finished by the end of November. Mean liveweight at sale was 38.1 kg, returning an average of £40.03 per head before deductions (£1.05 per kg live weight). Mean carcass weight was 16.8 kg (at £2.40 per kg carcass weight), which equated to a killing out percentage of 44%.

Table 22. Sheep gross margin (£/head) excl. forage costs

Production year	Con. Dipper	Organic Dipper	Cairn (Org.)	Burnhead (Org.)
2001/02				
Total output (per ewe)	58.12	47.94	49.93	57.57
Total variable costs excl forage (per ewe)	14.74	10.90	10.02	11.17
Gross margin excl forage costs (per ewe)	43.38	37.05	39.91	46.40
Flock gross margin	7851	5297	6146	5196
Flock gross margin (incl. CS payments)	7851	5297	6146	9021
2002/03				
Total output (per ewe)	55.01	39.68	43.05	44.03
Total variable costs excl forage (per ewe)	13.67	10.51	9.26	11.16
Gross margin excl forage costs (per ewe)	41.34	29.17	33.79	32.87
Flock gross margin	7606	4142	5237	3714
Flock gross margin (incl. CS payments)	7606	4142	5237	6839
2003/04				
Total output (per ewe)	53.82	43.14	44.28	46.00
Total variable costs excl forage (per ewe)	12.90	10.87	9.19	9.97
Gross margin excl forage costs (per ewe)	40.92	32.27	35.09	36.03
Flock gross margin	7447	4389	5299	4035
Flock gross margin (incl. CS payments)	7447	4389	5299	7885

For conventional animals, gross margin per ewe and per flock, was very consistent over the three year period. Flock gross margins for the Organic Dipper were 54% - 67% that of the Conventional Dipper – a result of 20% less ewes, 13% less lambs sold, and 21% lighter lambs at sale in September. The cumulative effect was equivalent to approximately 60% the total lamb output of the conventional flock. Total variable costs (excluding forage) were £3-£4 higher in the conventional flock, a result of increased veterinary costs and the need to supplement greater numbers of twin-bearing ewes. Variable costs were lowest in the Cairn flock, due to reduced veterinary inputs, notably clostridial and pasteurella vaccination.

The highest level of flock gross margin was in the Burnhead flock, once the calculations included a 70%-100% uplift from imputed Countryside Stewardship Scheme payments. Of the three organic flocks, the Burnhead flock also tended to have the best gross margin per head, possibly a reflection of the lower sheep stocking rates.

4.5.2 Suckler herd Gross Margins

A single gross margin figure (£/cow) for both rearing and finishing activities is given in Table 23. The high levels of total output achieved reflect the additive effect of both activities, and includes total subsidy payments, which ranged (depending on the herd, and year) from £246 to £360.

Table 23. Suckler cow gross margin (£/head) excl. forage costs

Production year	Organic ½ bred	Conventional ½ bred	Organic ¾ bred
2001/02			
Total output	929.03	869.14	617.02
Total variable costs excl forage	172.51	129.78	197.33
Gross margin excl forage costs	756.53	739.35	419.69
2002/03			
Total output	847.97	621.41	593.38
Total variable costs excl forage	149.20	95.50	150.06
Gross margin excl forage costs	698.76	525.91	443.32
2003/04			
Total output	947.91	753.58	840.53
Total variable costs excl forage	139.12	110.77	123.51
Gross margin excl forage costs	808.79	642.81	717.02

Total variable costs (excluding forage) were higher in organically managed cattle, due to the higher cost of organic cereals. There was little difference in other variable costs including veterinary inputs. For the directly comparable half bred herds, gross margin averaged £755 and £636 for under organic and conventional management respectively (an advantage of 19% to the organic herd). Gross margin in the three quarter bred Angus herd steadily improved as the herd matured.

4.4.3 Whole unit gross margin

The combined gross margin for sheep and cattle enterprises is given in Table 24.

Table 24. Combined gross margin for sheep and cattle enterprises excl. forage costs

Total livestock enterprise gross margin (excl forage)	**Conventional**	**Organic**
2001/02	17463	41264
2002/03	14443	34297
2003/04	15803	43539
Total forage costs		
2001/02	643	1518
2002/03	561	1125
2003/04	502	1673
Total livestock enterprise gross margin (incl. forage)		
2001/02	16820	39745
2002/03	13882	33172
2003/04	15301	41865

Adjusting for the scale of both enterprises, gross margin per adjusted hectare and per Livestock Unit are given in Table 25.

Table 25. Total gross margin per adjusted hectare and per Livestock Unit (L.U.)

Total adjusted hectares	27.44	125.25
Gross margin per adjusted hectare		
2001/02	613	317
2002/03	506	265
2003/04	558	334
Gross margin per adjusted hectare incl. HFA		
2001/02	644	347
2002/03	537	294
2003/04	589	364
Livestock Units (LU)		
Cattle LU	14.3	39.6
Sheep LU	21.6	48.0
Total LU	35.9	87.6
Gross margin £/LU		
2001/02	492	496
2002/03	411	421
2003/04	450	520

Across the organic unit as a whole (and excluding Countryside Stewardship payments to the Burnhead flock), gross margin per adjusted hectare ranged from 54% to 62% that of the conventional system. The organic system had a slight advantage (1% - 16%) in gross margin per Livestock Unit, but this was insufficient to offset the financial penalty arising from lower stocking rates. The average deficit was equivalent to £255 per adjusted hectare. If these figures are adjusted for self sufficiency in winter forage (93% and 107% respectively for conventional and organic systems) the difference in gross margin per adjusted hectare is reduced to £191.

It should be noted that, with the exception of the Organic Dipper, stocking rates on the organic areas were inherently lower than the Conventional Dipper at the start of conversion. Therefore, making direct comparison on a whole unit basis not strictly valid. For the purposes of comparison, FBS data for low and high performing hill rearing farms, recorded by the University of Newcastle, is given in Table 26. This suggests that financial performance of the organic unit is within expected parameters for a typical hill farm in the North of England.

Table 26. Comparison of whole farm performance with FBS data (University of Newcastle)

	University of Newcastle (2004/05)		Redesdale Organic Unit (3-year mean data)
	FBS Low	High	
Herd size (beef cows)	29	34	36
Flock size (breeding ewes)	609	1286	400
Total adjusted forage area (ha)	124	276	125
Total Grazing Livestock Units (GLU)	97	165	88
GLU's per adjusted forage area	0.76	0.58	0.70
Gross margin (£) per GLU	407	729	479

5.0 Knowledge transfer

Three one-day technical workshops were held during the period of the project. The aim of these workshops was to bring together on each occasion 30 – 40 scientists, farmers and extension workers to consider some key issues for organic farming in the hills and uplands. Written proceedings were made available after each event.

5.1 Workshop 1 - Positive Health and Welfare in Organic Beef and Sheep Production (10 April, 2003)

The aim of the workshop was to examine three main issues relating to positive health and welfare:- a) working with the immune system; b) exploiting genetic resistance to roundworms; and c) animal health planning.

An introductory paper from the Soil Association set out the preventive approach adopted within in the organic standards, emphasised the role of health planning in disease control, and addressed the use of vaccines on organic farms. In practice, a pragmatic view has been taken by sector bodies in applying the standards, based on individual circumstances. Cited as fundamentally important were the level of livestock production where immunity and disease could reach a balance, and an improved understanding of the underlying mechanisms governing immunity. A paper from the Moredun Research Institute (MRI) described the evolutionary background to the immune system, distinguishing between innate and adaptive immunity. A further paper from MRI gave background information on vaccine type, current manufacturing processes (including the use of adjuvants) and recent developments in vaccine technology. The characteristics and relative merits of live and killed vaccines were described. Also introduced was the concept of 'herd' immunity, where animals may be protected even if all the individuals within the population are not vaccinated. The discussion centred on the issue of vaccine use within the organic standards. While vaccines could sometimes be viewed as a prop for poor husbandry, in the correct circumstances vaccination could also be considered a legitimate component of good preventive animal health management. Also noted was the recent development at Reading University of a decision support tool for animal health planning, which included vaccination. In comparing the potential effects of multivalent and single vaccines on the immune system, MRI suggested there was little difference given the ability of the immune system to deal with an incoming 'antigen soup', irrespective of whether or not it was presented as a vaccine. Multivalent vaccines were now tested for potential interference between the various antigens present, an issue which had sometimes given problems in the past.

Introducing the role of genetic resistance, an organic hill farmer suggested that based on his practical experience, the key factors for parasite control were:-targeted management of single and twin lambs; minimising nutritional and physical stress at critical times; adopting mixed grazing on known problem fields; and close attention to the management of male and female animals within the flock. Latterly, he had become increasingly interested in genetic resistance, and was combining participation in a sire referencing scheme with faecal egg counting to select for more resistant stock. In addition, he had imported from New Zealand embryos from more resistant stock. However, some questions remain as to the best strategies for practical application. A presentation from Roslin Research Institute set out the genetic basis of resistance, and the level of observed heritabilities involved. One advantage of genetic selection is that the development of resistant strains of parasite is much less likely, when compared with repeated anthelmintic intervention. Of the selection tools available, faecal egg counts (FEC) were the most practical and cost effective. In most organic systems the level of parasite challenge could be expected to be sufficient to allow meaningful selection based on FEC.

In terms of effects on production traits, the current consensus is that the genetic correlation between FEC and growth rate is negative and moderate (approximately –0.20). The third paper on breeding for resistance, from Moredun, concentrated on the epidemiological impact. The potential epidemiological benefits were likely to be reduced pasture contamination, leading to less pressure for anthelmintic intervention. In terms of animal performance, theoretical benefits have been demonstrated in some systems but not in others. New Zealand data from Romney breeding lines indicated that differences of over 35 fold in faecal egg output could be achieved over a 20 year period, but the benefits of selection only became apparent when selected and unselected lines were grazed separately. Consequently, breeding programmes have begun to look at both resistance (low faecal egg counts) and resilience (animals more tolerant of worm burdens).

The final three papers covered animal health planning. The view by an independent sheep specialist, dealing with both organic and conventional flocks, was that many of the problems encountered were common to both systems. Therefore the underlying principles of health planning were the same. A research project was presented by Bristol University Veterinary School which identified the requirement for output-based animal measurables, rather than the standard approach taken by farm assurance schemes, which were good at describing and inspecting inputs to livestock systems. To have a meaningful impact, emphasis should be on animal health and management plans, with ongoing monitoring, and continuing review of results and husbandry practices. Key features were that a health and management plan should be drawn up by the farmer, preferably with veterinary involvement, it should be farm specific and it should detail an evolution of farm practices towards a reduction in dependency on conventional veterinary medicinal inputs. Experience at the University of Reading, suggested there were four broad categories of health plan – compliance (e.g. Farm Assurance Schemes), aspirational (descriptive essays, with limited practical use), combinations of the previous two with tactical planning (in the face of a problem), and strategic planning (based on the current situation, and on the farmers long-term goals). On organic farms health and welfare plans should be based on breeding, feeding, housing and husbandry (i.e. those factors enshrined in the standards). The existence of health plan templates may aid consistency across farms and sector bodies, but they may also act to stifle specificity to individual circumstances. Survey data was presented on the attitude of organic farmers to health plans. The results seemed to confirm that in practice plans were at least covering the intended target areas. Amongst inspectors, advisors and particularly vets, implementation of animal health plans was a priority, in addition to appropriate training for stockpersons. However, an assessment of 29 inspection visits, with four different inspectors, found that an improvements in practical application were required. It was recommended that animal health plans should be used by sector bodies, not just for paper compliance, but also to provide a balance between input reduction and system redesign. There should be a move towards an evidence-based approach to health and welfare status (possibly welfare indices) using summary statistics of a given list of outcomes, and cross-farm benchmarking, where appropriate. A genuine risk assessment approach to inputs should be considered, moving away from input substitution, cost-based decisions, or panic measures when problems arise. A farm-specific approach should be taken to assessing these risks, which itself should be an iterative process based on actual outcomes, and regular monitoring.

5.2 Workshop 2 - Managing forage for organic beef and sheep production (25 February 2004)

This workshop brought together expertise from ADAS, IGER, Cotswold Seeds, and The Glenside Group to consider key technical aspects of forage production and management. A paper from ADAS described the nutrient value and effective use of organic manures when applied to grassland. Recommendations were given for practical measures to improve the accuracy of spreading, optimise uptake in growing crops, and minimise losses to the atmosphere or to groundwater.

A presentation from the Glenside Group challenged participants to consider a more holistic view of soil processes and the assessment of underlying soil fertility. In particular, the Albrecht approach to soil analysis (incorporating measurements of base saturation) was compared with conventional laboratory analyses. Emphasis was given to the role of a healthy soil life (earthworms, aeration and soil conditioning) for improving productivity and reducing the need for exogenous inputs. Two presentations by IGER focussed on grass and clover management in the uplands. Grasses and clovers were described in terms of biology and growth habit, and the dynamics which occur when both crops are grown together. Management guidelines were presented to optimise the productivity of mixed swards, and reduce the risk of clover 'crashes'. Potential roles for alternative legumes and herbs were discussed, and survey data presented from organic and conventional farmers on the characteristics they required of forage species and varieties. A paper from Cotswold Seeds considered the subject of seeds mixtures, contrasting the current trend towards ryegrass/white clover swards with more complex mixes such as Robert Elliot's Clifton Park mix. The complimentarity and potential synergistic effects, between different species were described. Practical recommendations were given on sward establishment, pasture rejuvenation and the use of forages as catch crops or green manures. The final two papers from ADAS described cultural approaches to weed control in grassland, and forage systems to extend the year-round supply of organic lamb.

5.3 Workshop 3 - Does organic farming offer environmental benefits in the uplands (30 March, 2005)

The case for the environmental benefit of organic farming in lowland agriculture is generally accepted. However, benefits in the more extensive hills and uplands are the subject of continuing debate. The objective of this workshop was to consider what is known about the potential benefits of organic farming in hill and upland areas, what can be inferred from lowland studies, and to identify gaps in the information available. An introductory paper from the Soil Association set out the framework for environmental protection under existing organic standards. This was followed by a presentation from English Nature reporting on a review of 76 studies comparing the biodiversity effects of organic and conventional farming in the lowlands. The interpretation of these findings was then extrapolated to the uplands. Two papers were presented from Wales. The first was a report by the Institute of Rural Sciences on a desk study investigating potential environmental and biodiversity impacts of organic farming in the hills and uplands. This was supported by a paper from ADAS Wales reporting on environmental survey data from 30 converting and 10 established organic farms in Wales. The question as to whether organic farming can offer benefits for soil and water management was the subject of a paper from ADAS Gleadthorpe. The likely impacts of organic farming on upland invertebrates as well as vegetation were covered in a further ADAS presentation. Two case studies were presented from ADAS Redesdale describing long-term change in botanical composition, and the development of a conservation plan for the organic unit. The relationship of organic farming, and wider aspects of developing agricultural and environmental policy, were summarised by Defra.

Despite theoretical benefits, it was universally acknowledged that there was a dearth of information specifically related to the hills and uplands. The use of synthetic pyrethroid dips was frequently cited as a potential problem in organic farming, yet Welsh survey data indicated a higher level of usage on conventionally managed farms. On the most extensively managed hill land little intrinsic differences in environmental impact might be expected, given that few, if any, inputs are made to these areas on conventional farms. The long term botanical data collected at Redesdale underlined the effect of previous and current stocking rates, and the quality of existing vegetation (condition and distribution) on the likely speed and extent of botanical improvement. Neither of these factors are necessarily related to conventional or organic management. Furthermore, the level of motivation and the specific practices adopted by farmers themselves, can have a larger impact than the system of farming. Welsh survey data suggests that organic farming will deliver most benefit when combined with another agri-environmental scheme. The importance of accurate baseline mapping of botanical diversity before entry to conversion was also highlighted. Some of the farms surveyed had BAP (Biodiversity Action Plan) habitats which had been overlooked, and may otherwise have been ploughed up at conversion. The future of organic farming in the hills and uplands is intrinsically linked to CAP reform, and wider policy instruments such as the Water Framework Directive. Levels of single farm payment projected for some hill and upland farms, declining enterprise profitability (particularly cattle), and the lower rate of payment under OELS for land over 15 ha, will affect the management decisions made by farmers. The precise manner in which organic farming will interact with cross-compliance is yet to be determined.

6.0 Summary and conclusions

Generally, soil fertility levels were adequately maintained on the organic unit. Although P and K status had fallen in some fields, recorded levels of extractable nutrients (soil Index 1) were unlikely to seriously impair productivity. Soil pH was much more stable on organically managed inbye land. Although silage production for cattle removed significant amounts of nutrients as conserved forage, the return of composted manures were sufficient to offset this depletion. With a limited land area available on many hill and upland farms suitable for manure application, care is required to ensure adequate redistribution of soil nutrients as livestock manures, beyond the most accessible and better drained fields.

Detailed, long-term monitoring of vegetation change on the native hill showed that botanical composition is more affected by previous and current stocking levels, and events such as heather beetle infestation, than by organic and or conventional management *per se*. This not surprising given that little or no exogenous inputs are likely on native unimproved hill under either management regime. On the directly comparable, and most heavily stocked areas of the organic unit (Organic and Conventional Dipper), the poor condition of heather was consistently observed, irrespective of the type and scale of assessment used. On the Cairn and Burnhead hefts, botanical composition was better initially, and there were indications of a slow improvement, following substantial reductions in sheep stocking rate. In terms of heather restoration, there is ample evidence from this, and other Defra–funded studies, that stocking rate reductions alone are not sufficient to improve heather condition and cover. Management needs to take into account interactions with other plant species present, in particular the competitive effects of grass species such as *Molinia*, as well as broader aspects of moorland management, for example, burning policy.

During the period of the current report, vegetation change was not measured on improved hill land. This was on the basis that little or no differences were apparent between organic and conventional management, when assessed during earlier phases of the study. Under both management regimes, the underlying trend was regression to rush pasture, and previous analysis of aerial photography have shown rush infestation up to 38% cover on some areas, resulting in a considerable reduction in productivity on both organic and conventionally managed land. Rush pasture has a valuable role as a habitat for wading birds, however, these benefits can be realised with much lower levels of cover. Some conventional areas on the unit were treated with herbicide, but even this approach would need to be repeated, given impeded drainage and associated establishment opportunities for rushes. Under an organic system, cutting is the main option for cultural control. However, the best realistic outcome is weed containment, and rushes are viewed by many hill and upland farmers as a significant challenge to their long-term involvement in organic farming.

On inbye fields, the productivity of organically managed grass and clover swards was approximately two thirds that of the conventional fertiliser-based system. Short term leys of red clover and Italian ryegrass, were introduced to provide greater competition to docks. While these yielded well, some loss of sward productivity occurred during the establishment phase. In addition, a two or three cut silage regime with no grazing by sheep in alternate years, is unlikely to be as efficient as a conventional two pasture system, which integrates intensive sheep stocking with conservation on an annual basis. Established infestations of docks production proved difficult to control. The greatest success was obtained where dock numbers were sufficiently low to enable the plants to be removed manually, or semi-mechanically using a tractor/digger. On upland and better hill farms, docks can be a significant problem, further affecting the attitudes of farmers to organic production. Integrated strategies (involving composting manures; reduced use of slurry; rotation of cutting and grazing fields) hold out better long-term prospects than single control measures used in isolation. A high proportion of converting farms may carry over potential weed problems, as seed bank, which need to be carefully managed from an early stage once the option of herbicide is no longer available.

While sheep stocking rates on the Organic Dipper were reduced by 20% in 2000, the long-term comparison with the Conventional Dipper flock remains the most direct method of comparing the two production systems. Consistent with earlier phases of the study, sheep production levels were lower in the organically managed flock. This could be a multi component effect of reduced forage availability, lower veterinary inputs, higher levels of subclinical disease etc. However, the most likely factor is the difference in how the areas of improved hill were used. For better control of stomach worms, hill reseeds on the organic hefts were managed on a grazing regime which alternated between cattle and sheep. This meant that sheep were excluded from half the total area of improved hill previously available. Because of the relative numbers of both species, there is likely to have been a disproportionately higher impact on sheep. The pattern in ewe live weight and body condition score at tupping (November) and at scanning (February) suggests that it is forage supply at either end of the grazing season that is most restricting. Supporting evidence comes from comparable performance in both flocks during the early years of conversion, up to the change in grazing management recommended at that time by the Project Steering Group. In addition, the performance of the organic flock increased significantly during the 2003 grazing season, which was a good year for forage production. Individual animal performance in the less intensively stocked Cairn and Burnhead flocks was consistently higher than that of the Organic Dipper. Furthermore, the fact that individuals or groups of organically managed animals were able to respond to improved grazing, points towards forage supply as the first limiting factor.

No problems were experienced in selling organic cattle, finished or as stores. Both store cattle and store lambs were sold to direct to other organic farms. In the case of lambs, a profit sharing agreement was entered into with the finisher, which provided an interesting working model for more equitable sharing of profit and risk. There is now increasing potential for these linkages to be made at more local, or regional level, depending on the complimentarity of resources. Nationally, hill and upland production has a significant role to play in assisting the year-round supply of organic beef and lamb, strategically balancing supplies during the period from Jan-April.

The long-term performance of the sheep flocks at Redesdale suggests that, for a given stocking rate and species mix, there is a balance to be struck between management for forage production and management for parasite control. The overall level of stocking is important in reaching an acceptable equilibrium for disease control and economic performance. The advent of Single Farm Payment and the increasing emphasis on agri-environmental schemes, should create circumstances less economically dependent on maintaining high stocking rates. The difference in sheep performance between Organic and Conventional Dipper flocks was accentuated by the fact that the latter was consistently one of the highest performing conventionally managed flocks at ADAS Redesdale. In earlier phases of the organic project at Redesdale, the price differential (p/kg) between organic and conventional prices for finished lambs was up to 50%. This helped offset lower levels of lamb output (kg/hectare) in the organically managed sheep. However the price gap has steadily narrowed, as conventional prices recovered from their low point during the mid-1990's.

The main technical issue associated with the organic suckler herd was ensuring an adequate supply of conserved fodder for a 200-day winter. Self sufficiency in winter forage averaged 107% and 93% for the organic and conventional livestock (both sheep and cattle enterprises) respectively. Although organic feedstuffs (organic cereals, organic beans) were more expensive than conventional, they were readily available for home mixing such that the proportion of non-organic fed given to housed cattle was less than 1%. There was little difference in the physical performance of directly comparable organic and conventional sub-herds producing continental cross calves. Lower financial returns were obtained from Angus cross calves, due to their slower growth rates and tendency towards fatter carcasses. Although organic store cattle were sold at a premium of approximately 10% over conventional, their full differential value (approximately 20%) as finished animals was not realised due to the limited finishing capacity on a hill farm. Disease challenges were low and the only veterinary treatment given on a herd basis was a single treatment for lice during the winter period.

Financial performance of the suckler herds over the reporting period was underpinned by a high level of headage payments (suckler cow premium, beef special premium, and extensification top-ups) typically worth approximately £250 per cow per annum. Under the Single Farm Payment, the economics of beef production are much more marginal, particularly when fixed costs are taken into account. While the presence of cattle in the species mix with sheep is highly desirable from an organic and environmental management point of view, future support arrangements dictate that economically it will be increasingly difficult to do so.

Without any agri-environmental payments, the organic unit as a whole returned a gross margin per adjusted hectare 40%-50% less than the conventional. The biggest single contributor to gross margin was stocking rate, which for the organic unit as a whole was 54% that of the conventional (1.3 LU/adjusted ha Vs 0.7 LU/adjusted ha respectively). Compared with the conventional system, gross margin per head (excl. forage costs) was 19% higher for the directly comparable organic suckler herd. However, flock gross margins were significantly lower, a combination of lower sheep numbers, reduced lambing percentages and the sale of store rather than finished animals. To offset these effects would require an improvement in output, for example retaining a greater proportion of organic animals for finishing, or entry into an agri-environmental scheme. It could be suggested that in reducing stocking rate for environmental gain, and adjusting management for better parasite control, the organic system at Redesdale has had to carry a disproportionate financial burden.

7.0 Relevance to policy

The results indicate that for many hill and upland units, converting to an organic system is not likely to be a matter of minimal changes to existing management. In particular, stocking rate and balance of sheep and cattle at the start of conversion will have a major impact on the management required to achieve acceptable levels of animal performance, financial performance, input reduction and environmental gain.

The period of the study coincides with the last three years of subsidy payments based primarily on the numbers of livestock carried. Historically, stocking rates have been a prime determinant of profitability when measured on a per hectare basis. Under organic management it was not possible to support sheep numbers at previous levels and maintain the same level of individual performance. The results of this study showed the importance of exploiting any opportunities to draw down payments from another agri-environmental scheme, to support twin objectives of maintaining financial viability and accommodating a more balanced organic system. The advent of support based on Single Farm Payment, further devolves stocking rate from overall profitability. Therefore more farmers may be tempted to convert, given that the opportunity cost of conversion is reduced. Those decisions will be driven more by the relative strength of the organic market, technical or attitudinal constraints such as feeding 100% organically produced diets, and relative impacts on overall fixed costs.

The imbalance in hill and upland organic store lamb production relative to finishing capacity on lowland farms, suggests a potential seasonal oversupply of organic stores, with adverse effects on price and producer confidence. Policies to increase the attractiveness of conversion on arable farms, would have a beneficial impact, both on the supply of organic feedstuffs and potential finishing capacity on lowland farms. From a structural point of view, it would be more logical to focus the hill and upland sector on producing breeding stock and store lambs, and the lowland sector on finishing, which is much less reliant on specialist infrastructure and livestock skills required for breeding animals.

The case for organic farming conferring environmental benefit is clearer in lowland situations than in the hills. In theory, the difference between organic and conventional systems should be less stark given less intensive production in the hills and uplands. Yet, little has been done to determine the extent to which organic and conventional farmers have adopted practices with positive or negative impact on biodiversity or the agri-environment. Much depends on the attitude of the individual landowner. From a survey conducted by ADAS in Wales, the greatest benefits tend to occur where an organic farm is also participating in another agri-environmental scheme.

The relative dynamics between organic and conventional farms in their pursuit of environmental objectives will also be affected by Entry and Higher Level Countryside Stewardship Schemes (and their organic derivatives). Both provide significant opportunities for conventional and organic producers to benefit financially from maintaining or enhancing the conservation value of their farm. The extent to which organic, and evolving conventional, systems complement or conflict with cross compliance or Water Framework Directive requirements has yet to be determined.

At Redesdale long-term studies of vegetation change on the native hill, shows a continuing decline in heather cover at the higher stocking rates. The effect is the same whether grazed by organic or conventionally managed stock. Where stocking rates have been reduced significantly to accommodate a more balanced organic system there are already good indications of a positive, albeit slow response in botanical composition. Key to this is the ability to manage moorland in a more proactive way, and to have access to cattle for grazing management of *Molinia* and *Nardus*. This complementary effect of cattle not only controls the competitive effects of these grassy species with heather, but as demonstrated in other research projects, also benefits sheep performance. Organic farmers are perhaps more likely than conventional farmers to try to maintain cattle numbers following the loss of headage payments. However, if the economics of cattle production becomes very adverse organic farmers may be forced to reduce cattle numbers, which could make some sheep-dominated systems less sustainable.

The increased availability and reduced cost of organically produced cereals and proteins, has meant that for animals fed indoors or from troughs on inbye fields, the proportion of non-organic feed required in the diet can be reduced to minimal levels. Thus for the suckler herd and housed twin bearing ewes at Redesdale, organically produced feed represents over 99% of dry matter consumed. The balance is made up of selected minerals and vitamins, and molasses as a binder. However, for extensively managed animals receiving a small amount of supplementary feed, it is the physical presentation of the supplement which restricts meeting the requirement for wholly organic feed. At present, sugar beet nuts are a convenient and cost effective method of feeding on the open hill. Some forms of feed block are also commercially available, suitable for feeding in organic systems. A fully organic feed block, or commercial nut or cob, suitable for feeding outside without troughs is required before ending of the derogation in 2007.

8.0 Further research

Over three years, the land resources on the organic unit at Redesdale were available to other contractors for potential research use. The fact that no major work materialised in the main reflected the fact that few research tenders were let over the period. However, the unit did provide facilities for collaborative research within Defra-funded Project OFO185 – Controlling internal parasites in organic livestock without the use of pharmaceutical anthelmintics.

In terms of further research and development, effort is required to:-

- Determine current behaviours and management practices for organic and conventional farmers
- Examine the interface of organic farming practice, and that of other agri-environmental schemes
- Consider environmental impact at the whole farm, or aggregated farm level
- Identify specific practices to enhance environmental benefit which can be used more widely on organic farms
- Address technical constraints such as weed control of weeds (rushes, thistles, bracken and docks), tightening regulations on non-organic feed allowances, internal and external parasite control, nutrient budgeting (including micro-nutrients and trace elements).
- Wider cropping options for energy, protein and mineral nutrition, for use in breeding stock and in finishing
- Quantify the potential to exploit co-operative effort to overcome technical issues and limitations, and increase environmental benefit

References to published material

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.

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