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SID 5 Research Project Final Report

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Project identification

1. Defra Project code: OF0368
2. Project title: Long-term performance of organic farming in the hills and uplands - Redesdale and Pwllpeiran Units
3. Contractor organisation(s):
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   Woodthorne
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4. Total Defra project costs (agreed fixed price): £ 113, 496
5. Project: start date .... 01 April 2005

   end date .... 31 March 2007

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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.

Two experimental hill and upland organic units were established at ADAS Research centres, at Redesdale (Northumberland) and Pwllpeiran (mid Wales), in 1991 and 1993 respectively. These were set up as systems studies, to evaluate the physical and financial impacts of conversion to organic production. The overall objective of this work was to complete data collection on the organic unit at Redesdale from April 2005 to March 2006, and to use the information collected at both centres over the previous ten-year period, to assess the long-term performance of organic beef and sheep production in the hills and uplands.

Approximately 400 ha were put into conversion at Redesdale. Originally, the sheep enterprise comprised approximately 800 pure-bred Scottish Blackface ewes and 220 female flock replacements. These were run in four discrete flocks derived from the three original flocks on the unit. One of the original hefts (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 other two hefts (Cairn and Burnhead) were both converted to organic production. At the outset, the research objective was to maintain a high level of output from the organic system. Stocking rates (ewes/hectare) at the start of conversion were 2.3, 2.3, 1.3 and 1.9 for the Conventional Dipper, Organic Dipper, Cairn and Burnhead flocks respectively. Since 1995, sheep stocking rates (ewes/hectare) have been reduced in the organically managed flocks, in pursuit of a better balance of animal performance and environmental benefit, ultimately to levels of 1.8, 1.0 and 1.0 for Organic Dipper, Cairn and Burnhead flocks respectively. Ewe numbers in the Conventional Dipper flock remained constant throughout. The unit also carried 55-60 suckler cows, latterly in three experimental sub-herds - organic and conventionally managed Angus x Friesian (mated with a continental bull), and three quarter bred Angus (mated with an Angus).The overall farming system 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. Originally, 111.5 ha were converted at Pwllpeiran, increasing to 379 ha by 2003. The unit carried 10 Welsh Black suckler cows and 160 Welsh Hill Speckle-face breeding ewes.

On the native hill at Redesdale, 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 or conventional management *per se*. On improved hill land, the underlying trend in vegetation was a regression to rush pasture, leading to reduced productivity on both organic and conventionally managed areas. Soil phosphate and potash declined steadily under both management regimes. On the most 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 soluble nitrogen fertiliser. Originally, the organic inbye fields were sown with grass/white clover, but latterly this policy changed to include short term leys, based on Italian ryegrass and Red or Alsike clover, to provide greater competition for weeds. Annual herbage production levels were approximately 88% that of fertilised conventional fields. Annual conservation yields were 97% that of the conventional, enhanced by the requirement to rest pasture from sheep grazing in alternate years for parasite control. Self sufficiency in winter forage ranged from 95%-107%. Established infestations of docks on inbye land, 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. At Pwllpeiran, similar problems were experienced with rush and dock control. Average silage yields (t dry matter per ha) varied from 2.8t to 4.0t, reflecting mainly cyclical changes in sward clover content. Yields were further constrained by the management of certain areas under ESA upland hay meadow prescriptions.

Organic ewes in the directly comparable Dipper flock were consistently lighter than those managed conventionally. Over a ten year period, barren rates per 100 ewes mated were 3.8, 6.8, 4.8 and 5.7 in Conventional Dipper, Organic Dipper, Cairn and Burnhead flocks respectively. The percentage of lambs weaned averaged 127, 110, 111 and 115, respectively. There was little difference between organic and conventionally managed flocks in terms of lamb birth weight. However, statistically significant differences tended to emerge as the lambs grew. Weaning weights (kg) for single lambs averaged 34.3, 32.1, 34.7 and 34.0 for Conventional Dipper, Organic Dipper, Cairn and Burnhead flocks respectively. Comparable data (kg) for twin-reared lambs were 31.5, 28.9, 30.1 and 30.0. In single reared lambs, growth rates (g/day) were 219, 198, 224, and 215 in the Conventional Dipper, Organic Dipper, Cairn and Burnhead flocks respectively. Corresponding growth rates (g/day) in twin lambs were 200, 180, 194 and 189. The mean total weight of lambs weaned annually, over the ten-year period reported, was 7433, 5286, 5381 and 5232 for each of the four flocks respectively. Using performance over four years from 1991 to 1995 as a reference base (= 100), output in the Conventional Dipper flock ranged from 104 to 130. Comparable data for the organic flocks were 56 to 100, 62 to 87 and 43 to 82 for Organic Dipper, Cairn and Burnhead respectively, a result of lower stocking rates, reduced prolificacy and lighter lambs at weaning. Similar downward trends in ewe live weight were observed at Pwllpeiran, where ewe barren rate ranged from 2% to 6%. Mean lamb crop at pregnancy scanning was 116 lambs per 100 ewes mated, leading to an overall weaning rate of 99%. Daily liveweight gain in lambs, from birth to weaning, were 191g and 159g for single and twin lambs respectively. The performance of organic suckler cattle compared favourably with the conventional system. Cow fertility averaged 95.1% and 94% at Redesdale and Pwllpeiran respectively. Calf daily liveweight gain from birth to weaning ranged from 0.85 kg to 1.13 kg.

At Redesdale, no problems were experienced in selling organic cattle, either finished or as stores. Both store cattle and store lambs were sold direct to other organic farms, at a price premium of approximately 10% to 15%. In the case of lambs, a profit sharing agreement was entered into with a finisher, which provided an interesting working model for more equitable sharing of profit and risk. At Pwllpeiran, the benefit of collaboration was seen through an arrangement with the Welsh Botanical Gardens farm, which provided the additional resources needed to take organic cattle to higher weights and to over-winter hoggs. At Pwllpeiran, the practicalities and economics of finishing lambs were marginal, and the majority of organic lambs produced were sold as stores. Price premia for specialist native beef breeds, such as Welsh Black, were initially more difficult to achieve when selling store, compared with selling direct to slaughter.

The main health issues addressed in the organic flocks at Redesdale were stomach worms, fly strike and foot conditions. Stomach worms were adequately controlled by a combination of an alternate grazing system with cattle and the sale of lambs as stores. Using this approach, routine anthelmintic was eliminated from the flocks, and any treatment limited to small numbers of individual lambs, drenched at marking or weaning. Withdrawing clostridial vaccination from the Cairn flock did not have adverse consequences over the ten year period. Health issues in the organic cattle herd at Redesdale were minimal. The only veterinary input required on a herd basis was winter treatment for ectoparasite control. Farm and geographic differences were evident from the experiences at Pwllpeiran, where stock required annual treatment against fluke and periodic trace element supplementation. In the absence of clean grazing, anthelmintic inputs to the sheep were also higher than at Redesdale. Joining a Herd Health Scheme was shown to confer significant benefits on the performance of the organic herd at Pwllpeiran.

In the early years following conversion, Gross Margin per ewe in the Organic Dipper compared favourably with the Conventional Dipper. Even as differences in physical output emerged in the period 1995 – 2000, the organic flock remained competitive. Largely this was due to the poor prices being obtained for conventional lambs towards the end of the 1990s. Since November 2000, when ewe numbers were cut in the Organic Dipper flock, Gross Margin per ewe has varied between approximately 70% and 90% that of the conventional. However, due to the reduction in ewe numbers Gross Margin on a flock basis has been half to two thirds that of the conventional. The inclusion of Countryside Stewardship Payments, theoretically available on the Burnhead heft, would have increased flock Gross Margin on that heft by between 74% and 104%. Over the ten year period, Gross Margin (before forage) per cow in the organic half-bred herd has averaged £614. Since the herd was split in 2000, gross margin performance in the organically managed sub-herd (£610 – £809) has consistently exceeded that of the conventional herd (£489 - £739).

Over the ten-year period, Gross Margin per adjusted hectare ranged from £291 to £440. Using the average unit Gross Margin over the first five years following conversion as a baseline, Gross Margin fell to between 76% that of the reference period (£377/adj. ha). This reflected a combination of reduced sheep performance and reduced sheep numbers. From a low point in 2000/01, unit Gross Margin began to recover as HFA payments were paid on an area rather than a headage basis. The 2004/05 year represented the first year of Single Farm Payment (SFP), again paid on an area basis. The loss in financial output due to reduced numbers of lambs, was compensated for by SFP so that unit Gross Margin was restored to approx 115% that of the reference period. At Pwllpeiran, payments under Tir Mynydd were a critical source of additional revenue, to counterbalance the reduction in output under the organic system. From a long-term study of commercial organic farms associated with the unit at Redesdale, income from other environmental schemes has been an important source of additional revenue for organic farms.

The long-term results of the studies at Redesdale and Pwllpeiran indicate that organic farming is feasible in the hills and uplands. The results and experiences have been very consistent for both sites. The data suggest 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. Even on extensively managed farms, changes are likely in feeding regimes and approaches to disease control. Careful planning is required prior to conversion, to address the full range of implications, and specific technical issues, which will undoubtedly arise to challenge the long-term sustainability of the organic system. A number of technical issues were identified, which in some circumstances could become system-limiting. These included maintaining soil fertility levels, particularly on improved areas of the hill (exacerbated where cattle do not form a major part of the farming system), weed control (notably rushes, docks and bracken), changing disease patterns (fluke and ticks), and the ending of the derogation for non-organic feed. A number of potential economic and structural issues were also identified – role and future viability of cattle production in the hills and uplands, the impact of CAP reform on the relative economic performance of organic and conventional production, the interface of organic farming with other agri-environment schemes and prescriptions, the potential for collaborative effort between farms, for example, linking production systems to increase finishing capacity or marketing options. A technical guide to organic farming in the hills and uplands was produced drawing from the results of this work.

Project Report to Defra

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:
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   - 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).

OF0368: Long-term performance of organic farming in the hills and uplands - Redesdale and Pwllpeiran Units

1.0 Introduction

Hill and upland organic units were established at two ADAS Research centres, Redesdale (situated on the North Pennines, in Northumberland) and Pwllpeiran (Cambrian Mountains, mid Wales), in 1991 and 1993 respectively. These were set up as systems studies, to evaluate the physical, financial and environmental impacts of conversion to organic production. Research was also undertaken into technical aspects, to better understand the constraints and potential of organic farming in the hills and uplands. Project reports have been submitted for each phase of the work. This report presents an assessment of the long-term performance of both farming systems.

2.0 Objectives

The overall objective of this work was to complete data collection on the organic unit at ADAS Redesdale from April 2005 to March 2006, and to use the information collected over the previous ten-year period, to assess the long-term performance of organic beef and sheep production in the hills and uplands. This analysis was supported by additional information from the organic unit at ADAS Pwllpeiran collected over the same period.

Specific objectives were, to:-

- Analyse long-term performance of organically managed upland sheep and beef systems at Redesdale and Pwllpeiran, up to and including the production year ending November 2005;
- Draw together the physical, financial and environmental issues affecting organic hill and upland farming, making recommendations for future policy, and research needs; and
- Provide for effective communication of the results, by producing a technical guide to organic farming in the hills and uplands

3.0 Materials and Methods

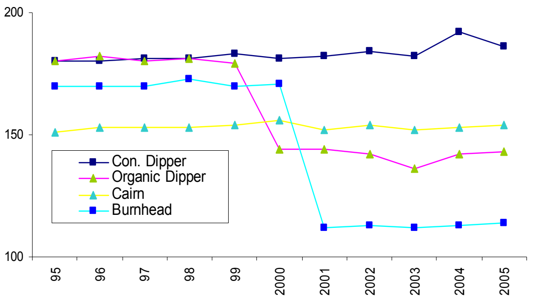
3.1 Redesdale Unit

At ADAS Redesdale, approximately 400 ha were put into conversion in 1991 with the aim of evaluating the impact of converting a progressive hill unit to organic production.

3.1.1 Livestock enterprises

At conversion, the sheep enterprise consisted of approximately 800 pure-bred Scottish Blackface ewes and 220 female flock replacements (hoggs). These were run in four discrete flocks derived from the three original flocks on the unit. One flock (Dipper) was carefully split, as was the land area (170 ha) on which the sheep grazed, to form two comparable sub-units, each with 180 breeding ewes. One of these sub-flocks (Conventional Dipper) continued to be managed conventionally, while the second (Organic Dipper) was converted to organic production, between November 2001 and November 2003. This provided the facility to directly compare the effects of organic and conventional management practices. The remaining two flocks, Cairn and Burnhead, were managed organically and carried 200 and 210 breeding ewes respectively at conversion.

Fig. 1 Number of ewes to the tup (1995 - 2005)



At the start of conversion, the research objective was to maintain a high level of output. This would help quantify the level of aid to conversion payments - designed to provide financial compensation for loss of productivity during the conversion phase, which might be required. Since 1995, sheep stocking rates have been reduced in the organically managed flocks, in pursuit of a better balance of animal performance and environmental benefit. From November 1995, breeding ewe numbers were reduced by 25% in the Cairn flock to 150, and by 20% on the Burnhead to 170. Numbers were reduced by a further 20% and 45% in the Organic Dipper and Burnhead flocks, from November 2000 and 2001, respectively (Figure 1).

In the case of the Organic Dipper, the decision to reduce sheep stocking levels was taken in conjunction with the Project Steering Group, and was based on the long-term downward trend in individual performance in the flock.

The further reduction in sheep numbers on the Burnhead was made for experimental reasons, to simulate the impact of entering the land into a Countryside Stewardship Scheme. Ewe numbers in the Conventional Dipper flock have been constant since 1991.

The changes in sheep stocking rates are presented in Table 1, for each heft (self-contained and managed area of land). Although the land areas differ on the Conventional and Organic Dipper hefts, on the basis of detailed botanical survey both sub units were calculated to be comparable in terms of stock carrying capacity. Therefore, the stocking rate shown for the Organic Dipper sub-heft has been adjusted to take this into account. Mathematically, the stocking rate of sheep on the ground was 1.9 ewes ha^{-1}, at the start of conversion.

Table 1. Sheep numbers and stocking rates (maintained on native and improved hill areas) - ADAS Redesdale

	*Con. Dipper	*Org. Dipper	Cairn (Org.)	Burnhead (Org.)
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%)
Breeding ewes: 1991 – 1994	180 (2.3 ha^{-1})	183(2.3 ha^{-1})	200 (1.3 ha^{-1})	219(1.9 ha^{-1})
1995 – 2000	181 (2.4 ha^{-1})	180(2.3 ha^{-1})	153 (1.0 ha^{-1})	171(1.5 ha^{-1})
2001 – 2005	185 (2.4 ha^{-1})	141(1.8 ha^{-1})	153 (1.0 ha^{-1})	113(1.0 ha^{-1})

* the same effective stocking rate at the start of conversion

At conversion, the existing herd of 35 spring calving Limousin x Holstein/Friesian suckler cows was put into organic management. In 1995, these were replaced by a new herd of smaller Angus x Friesian/Holstein cows, purchased as bulling heifers. In 2000 the herd was split, for experimental reasons, into organic and conventionally managed sub-herds (mated with a continental bull), and a third sub-herd was added by purchasing three-quarter bred Angus heifers (mated with an Angus). This added the contrast of a traditional breed (Angus) more suited to a specialist outlet, and a continental cross more suited to the whole sale market, a structure which was maintained until the herd was dispersed in spring 2006.

3.1.2 Management system

The overall system 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). Other than heather burning, no inputs were made to organic or conventional areas of native hill.

Improved pastures (reseeds) were established during the 1970s and 1980s 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* (meadow grass) species. Conventionally managed hill reseeds received 50 - 60kg N ha^{-1} each spring. Lime was applied as required. Both organic and conventional areas were topped in August to remove surplus grazing and to control rushes. Depending on the results of soil sampling, leatherjackets were controlled by spraying on conventionally managed reseeds. Periodic spraying or weed wiping to control weeds was also undertaken on conventional reseeds. For five years from the start of conversion, the reseeds continued to be grazed each year by cattle and sheep. From 1996 the organic area was split, to be grazed in alternate years by sheep and cattle. The adjustment was made to provide cleaner grazing for parasite control. Between 1996 and 1999, big bale silage was taken opportunistically from selected areas, as too much herbage was available for the size of the grazing herd. This strategy improved the supply of winter fodder for the suckler herd, and in the absence of sufficient cattle over the summer period, increased the overall efficiency of grass utilisation. Where silage was taken, composted FYM was applied to balance P and K off-take in the silage crop.

The inbye fields comprised a range of mineral and peaty soils, and represented the best land on the unit. Given the small proportion of total land area, management on the inbye fields was relatively intense, with these areas expected to produce early season grazing, conserved fodder, and autumn grazing for finishing stock or replacement ewe lambs. These fields were capable of being cultivated, and under conventional management were reseeded on a 5-7 year rotation. On the conventional areas, reseeding was typically achieved by undersowing arable silage with a grass seed mixture. Total annual fertiliser inputs to conventional fields (kg ha^{-1}) were typically 180 kg N, 35 kg P_2O_5 and 125 kg K_2O. Herbicide was applied, routinely as required, to control docks.

Originally, grass seeds mixtures on the organic fields were based on ryegrass and white clover. However, on heavily dock-infested fields, shorter-term leys based on red (or alsike) clover and Italian ryegrasses were introduced to try to suppress weeds through competition. Between 1991 and 1996, pelleted chicken manure, sulphate of potash, or ground rock sources of phosphate and potash were applied to increase nutrient status. Since 1996, organically managed areas received only slurry or composted FYM.

3.1.3 Sheep husbandry and management

Scottish Blackface ewes were mated in November each year, to lamb from mid-April. Over a four-year cycle, the same Scottish Blackface rams were used across all four flocks, to prevent the introduction of genetic bias to observed performance. 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 five weeks after lambing. Organic silage was fed to housed hoggs from January to March, and to twin bearing ewes up to a week before lambing. Organic hay was used for feeding on the hill, and over the lambing period. For twin-bearing ewes, home mixed concentrate supplements were based on organic beans and cereals. For single bearing ewes, and for feeding on the hill, supplements were based either on approved non-organic feed blocks or sugar beet nuts, as these were available in a form suitable for feeding outside without troughs. On an annual basis the proportion of total organic feed (grazed and supplemented) ranged from 90.0% – 97.2%, for breeding ewes, and from 81.0% to 97.9% for hoggs. For breeding ewes, annual concentrate inputs (kg/DM/head) averaged 29.6 and 29.8 for conventional and organically managed ewes respectively. Forage inputs (hay and silage) averaged 40.4 kg and 28.5 kg respectively. Comparable figures (kg/DM/head) for hoggs were 26.4 and 29.8 for concentrate supplement, and 45.1 and 45.6 for forage, respectively. From the results of soil and herbage analysis, a specific 'Redesdale' mix of minerals and trace elements were included in the home mixed concentrate fed over the winter. Single bearing ewes were fed sugar beet pulp, unsupplemented with extra minerals and vitamins.

No routine anthelmintic was given to organic ewes or lambs. To assist with 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 by sheep 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.

3.1.4 Cattle husbandry and management

Suckler cows were managed under a 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 were based on baled silage with concentrate supplement given only to leaner cows. 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. Two specific mineral and trace element mixes were commissioned and fed successfully to cows and growing cattle.

Less than 1% of the total dry matter consumed by the suckler herd (representing minerals and molasses in the home mix) came from non-organic sources. Silage consumption (kg DM/head) ranged from 2097 to 4224 for cows, and from 737 to 1188 in calves. Calf concentrate inputs ranged from 226 kg to 386 kg fresh weight. The organic standards currently allow limited grazing of organic land by non-organic stock. Dry pregnant cows from the conventional autumn-calving herd were also used as a means of controlling sward height on both organic and conventional hill reseeds.

3.2 Pwllpeiran Unit

The organic unit at ADAS Pwllpeiran was put into conversion in 1993, and comprised a series of separate enclosures dispersed across the farm. Originally, 111.5 ha (representing 10% of the whole farm) was converted, including inbye fields (both grazing and conservation), hill reseeds, and native hill (semi-natural rough grazings - SNRG). Native hill accounted for approximately 60% of the land area (Table 2). Full organic status was achieved in May 1995. A further 150 ha of native hill was put into conversion in February 2002, achieving full organic status in March 2004. Since 2003, the unit has also been integrated with a further 114 ha of organic lowland at the National Botanic Gardens of Wales' Pantwgan Farm. Although comparisons can be made between the organic unit and the performance of other conventionally managed areas and associated livestock, there were no directly comparable organic and conventional sub-units as at Redesdale.

Table 2. Land area of the Organic Unit at ADAS Pwllpeiran

Phase	Land Type	ha
Phase 1 (1993)	Inbye fields (Previously improved grassland)	24.5
	(of which suitable for forage conservation)	(9.1)
	Hill reseeds (Mosaics of SNRG & improved grazing)	39.9
	SNRG (*Calluna* dominated)	47.1
Phase 2 (2002)	SNRG (*Molinia* dominated)	150.0
	Total area	261.5

3.2.1 Livestock enterprises

The unit carried Welsh Black suckler cows and Welsh Hill Speckle-face breeding ewes, grazing similar proportions of conservation land, in-bye, middle hill and semi-natural rough grazing land, and representative of the farm as a whole. The number of ewes on the organic unit has typically been around 160. This was increased to 196 ewes mated in October 1998, but this number proved unsustainable, with heavy pressure on autumn grazing and winter forage. Ewe numbers were then cut back to 166 by November 1999 tupping, and reached a low of 150 ewes in 2002 due to a greater number of deaths that year (11) in comparison with other years (2 or 3).

The organic cattle herd comprised 10 Welsh Black cows, and two replacement heifers.

3.2.2 Grassland Management

Production was based on the strategic use of improved and native hill grazings. Pwllpeiran lies in the Cambrian Mountains Environmentally Sensitive Area (CMESA), and management of the SNRG and hill mosaics was carried out according to ESA prescriptions, which limited stocking rate to 1.24 sheep/ha/day from 15 April to 15 October. In practice, the area was grazed by replacement ewe lambs from April until September, and dry ewes between weaning and tupping. Single bearing ewes were grazed with their lambs on hill mosaics, from May until weaning.

The improved fields ('inbye') on the lower land lie between 300m and 400m, on mineral soils, and were used for conservation, early season grazing and autumn grazing. Two of the four fields were reseeded at approximately six year intervals prior to conversion. These were the main forage conservation areas. In order to maximise grant payments, two areas were entered under hay meadow conversion agreements, which excluded nutrient application, pasture renovation, and haymaking before 15th July. One of these fields was removed from the hay meadow agreement in 2001, after silage yields had fallen to a level that was insufficient to provide stocks of winter feed. Weed species, including docks and buttercups, were beginning to dominate the sward, and clover content had fallen to less than 5%. Removing this field from the ESA hay meadow prescription allowed the field to receive additional nutrients, and to be reseeded with more productive species.

On the basis of low trace element levels in soil analyses, and an increasing problem with cobalt deficiency in lambs, a blend of trace elements (2.3% copper, 0.1% cobalt, 0.03% selenium, 1.1% zinc, 0.1% iodine) was applied to hill reseeds in 2000, and to improved fields in 2001/2002.

3.2.3 Sheep husbandry and management

At conversion, the organic unit carried Welsh Hill Speckle-face ewes. The ewes were originally mated with Welsh Hill speckle-face tups, however in more recent years a proportion of the flock has been mated with a Texel to improve carcass quality. Female offspring from the Texel cross have also been retained for breeding. Lambing started in the 2nd week of April, with the lambs weaned in the 1st week of September.

Sheep and cattle were rotated around the farm, but it has not been possible to devise a clean grazing system, given restrictions due to the physical layout of the unit and the ESA prescriptions. The organic ewes were lambed later than the conventional flock to try to reduce the challenge from roundworm parasites. Clostridial and pasteurella vaccination was used as routine.

3.2.4 Cattle husbandry and management

The cattle were bred pure, to calve during March to May. Heifers were bulled as two year olds, to calve down at three years. Cows and calves grazed on *Molinia* dominated hill from June to September, but have previously alternated with sheep grazing on areas of native hill and hill mosaics. All the cattle were housed from November.

3.3 Assessments

A comprehensive range of measurements were made to compare the physical and financial performance of organic and conventional systems. Due to the pattern of funding, data collection was more comprehensive on the Redesdale site. Soil cores were taken in December/January from 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. Over the period, a number of approaches were used to assess botanical composition and condition, including rapid grid, fixed quadrat, Joint Nature Conservancy Council Common Standards Monitoring (JNCC), and aerial photography. Initially, efforts concentrated on the improved hill and inbye fields. From 1995, the focus switched to assessing botanical change on the native hill, following adjustments in sheep stocking rates. On inbye fields, the number and fresh weight of silage and hay bales were recorded, and forage dry matter determined from oven-dried samples. To take account of grazing and conservation, the number of sheep and cattle grazing days was calculated, and total forage output expressed as Livestock Unit Grazing Days (LUGDs - Pollott and Kilkenny, 1976). Detailed flock and herd 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 also taken including routine faecal and blood samples

3.4 Statistical analyses

Redesdale livestock performance data were analysed in two ways. For each production year, sheep and cattle data were subjected to analysis of variance (ANOVA). In order to look at trends in ewe performance over years a separate analysis was undertaken. This focussed on live weight and body condition score parameters, collected four times through the production year (tupping, scanning, marking and weaning), for animals born between 1994 and 2000 inclusive. The model used was one of each of the four experimental flocks nested in year of birth/year of assessment. For statistical significance, the year effect used the Mean Square (MS) error for flock nested in year of birth, to derive a variance ratio and hence a p-value. Where appropriate Duncans Multiple Range test was used to give some guidance on the relative magnitude of the flock effect. Body condition score data were subjected to a Median test.

4.0 Results - Soil Fertility

4.1 Redesdale unit

4.1.1 Hill reseeds

Soil analysis results for pH, extractable P and extractable K are given in Table 3.

Table 3. Soil nutrient status on the improved hill reseeds at ADAS Redesdale

Grazing season	91	92	93	94	95	96	97	98	99	00	01	02	03	04	Final
Soil pH															
Org. grazed	5.6	5.9	6.4	6.0	5.8	5.5	5.8	5.7	5.4	5.3	5.4	5.1	5.2	*6.2	5.4
Con. Grazed	5.6	6.2	6.1	5.8	5.5	*6.9	6.3	6.3	6.1	5.8	5.7	5.4	5.5	5.9	5.2
**Org. silaged (1)	5.7	*6.0	6.4	6.0	6.0	5.9	5.9	5.6	5.4	5.2	5.3	5.4	5.3	6.0	5.7
***Org. silaged (2)	-	-	-	-	-	5.6	5.8	6.0	5.9	5.2	5.2	5.2	5.7	6.1	5.3
Soil ext. P (mg/l)															
Org. grazed	17	30	23	23	19	14	12	27	16	19	25	18	9	4	7
Con. Grazed	17	32	21	19	23	15	7	22	17	22	24	18	7	8	7
**Org. silaged (1)	17	25	19	14	21	18	16	22	25	18	16	16	9	10	8
***Org. silaged (2)	-	-	-	-	-	16	21	20	25	26	18	19	8	6	11
Soil ext. K (mg/l)															
Org. grazed	110	305	201	84	120	46	61	105	104	119	184	91	47	30	70
Con. Grazed	110	335	105	70	102	70	62	122	110	160	138	119	36	28	68
**Org. silaged (1)	120	239	117	78	111	90	149	63	109	116	100	83	37	103	73
***Org. silaged (2)	-	-	-	-	-	120	54	105	173	171	129	107	31	57	79

* limed
** field split in 1996, cut for silage in 1996 and 1998
*** field split in 1996, cut for silage in 1997 and 1999

Since conversion, soil pH was maintained at levels over 5.0, and generally in the target range of 5.5 – 6.0 for a peaty soil. On the reseeds which had been grazed only, lime was applied once (at 5t ha $^{-1}$) to the conventional and organically managed areas, in 1996 and 2004 respectively. The area of organically managed reseed, which was cut for silage twice during the period 1996 – 1999, had been previously limed in 1992. This overall pattern was consistent with experience of this soil type at Redesdale, which normally required liming at approximately 7 to 10 year intervals.

Phosphate levels were high at the start of conversion, but declined steadily on both conventional and organically managed areas. In 1991, prior to conversion, both organic and conventional areas received 25 kg P_2O_5 ha $^{-1}$ in a compound fertiliser. In 1992 and 1993, the organic areas received a 15 kg P_2O_5 ha $^{-1}$ as an approved pelleted poultry manure. Phosphate levels were maintained by the addition of FYM on those organic reseeds which were taken for silage twice during the period 1996 – 1999, but have declined progressively since the inputs of FYM were removed.

There was little difference in the pattern of potash status according to organic or conventional management. At conversion, potash status on the hill reseeds was high. The converted area benefited from potash (K_2O) inputs in 1991 (25 kg ha $^{-1}$), 1992 (11 kg ha $^{-1}$) and 1993 (15 kg ha $^{-1}$). However, potash levels have fallen sharply and on the grazed areas have remained at moderate (Soil potash index 1) and relatively stable levels. On the organic areas taken for big bale silage, there was considerable year to year fluctuation in levels of extractable potassium, which mirrored closely the application of FYM. Over the final three years, P and K levels have been marginal (Soil index 1) on all reseeds.

4.1.2 Inbye fields

Changes in nutrient status on inbye fields are presented in Table 4.

Table 4. Soil nutrient status on the inbye fields at ADAS Redesdale

	91	92	93	94	95	96	97	98	99	00	01	02	03	04	Final
Soil pH															
South (con.)	*6.8	6.2	6.3	*7.1	6.6	6.9	6.5	5.9	6.0	5.8	5.5	5.2	5.7	*6.5	5.9
North (org.)	7.1	6.3	6.5	6.6	6.4	6.7	6.3	6.4	6.1	6.3	6.3	5.9	6.3	6.3	5.6
West (org.)	*6.8	6.1	6.1	6.2	6.2	6.7	6.3	6.3	5.9	5.8	5.9	5.9	5.8	6.0	5.8
Bridge (org.)	n/a	n/a	n/a	5.8	*6.7	6.6	6.5	6.3	6.3	6.1	6.3	6.2	6.3	6.3	6.0
Soil ext. P (mg/l)															
South (con.)	16	12	8	13	9	11	15	25	16	14	19	16	26	11	19
North (org.)	13	29	20	19	14	23	18	27	17	19	22	19	15	16	14
West (org.)	25	15	12	17	17	21	14	20	12	18	17	12	10	18	10
Bridge (org.)	n/a	n/a	n/a	23	17	16	10	15	19	20	19	21	17	21	12
Soil ext. K (mg/l)															
South (con.)	112	62	49	120	170	117	80	81	98	73	77	79	61	133	179
North (org.)	109	118	52	58	47	114	109	179	128	134	224	139	271	186	105
West (org.)	55	92	56	120	117	115	166	101	76	115	146	132	118	223	105
Bridge (org.)	n/a	n/a	n/a	139	210	75	98	91	158	156	151	204	187	255	244

* limed

Generally, adequate levels of soil pH were maintained on all inbye fields. The lowest values were recorded on the conventionally managed area, where liming was required three times over a 14-year period, possibly reflecting higher yields, and the acidifying effect of nitrogenous fertiliser. The organically managed areas were limed once or not at all depending on individual field pH levels, over the same period.

Soil phosphate levels were typically Soil Index 2 (16-25 mg/l). The West Hayfield received 128 kg P_2O_5 ha^{-1} in December 1991, applied as Highland Slag. Further phosphate inputs (kg P_2O_5 ha^{-1}), as approved pelleted poultry manure), were 68, 50, 32, 18 from 1992 to 1995 respectively. The North Hayfield was reseeded in 1991, and received 180 kg P_2O_5 ha^{-1} as Triple Super Phosphate into the seedbed, prior to conversion. A further 128 kg was added in December as Highland Slag. The Bridge Haugh was also reseeded in 1991, and received a total of 340 kg P_2O_5 ha^{-1}, either as Triple Super Phosphate into the seedbed before conversion, or as Highland Slag applied in the autumn. Further inputs (kg P_2O_5 ha^{-1}) were 73, 50, 60, and 16 kg from 1992 to 1995 respectively, from pelleted poultry manure. On the conventionally managed South Hayfield phosphate (kg P_2O_5ha^{-1}) was applied at 76, 38, 20, 20, 20, 19, 230, 20, 20, 0, 0, 30, 0, 17, 0 from 1991 to 2005 respectively (equivalent to an average of 34 P_2O_5 ha^{-1} per annum) as compound fertiliser or Triple Super Phosphate.

Although some low levels were recorded, soil potash levels generally were above Soil Index 1 (61 - 120 mg/l). On the organically managed fields a dip in potash levels occurred after conversion, which was gradually restored through the use of FYM and slurry. In April 1991, prior to conversion, the West Hayfield received 56 kg K^2O ha^{-1} as K-nitro, with a further 20 kg K_2O ha^{-1} applied in the autumn as Highland Slag. Inputs (kg K_2O ha^{-1}) of 54, 46, 131 and 16 kg, were made from 1992 to 1995 respectively. This included approved applications of sulphate of potash and Cumulus K in 1994. On the North Hayfield, potash inputs (kg K_2O ha^{-1}) were 20, 58, 46, 101, and 15 kg from 1991 to 1995 respectively, including sulphate of potash and Cumulus K in 1994. Potash inputs to the Bridge Haugh were 65 kg K_2O ha^{-1} as K nitro, applied in the spring 1991, prior to conversion. This was followed by 25 kg in the autumn as Highland Slag. Inputs (kg K_2O ha^{-1}) of 57, 46, 119 and 16 kg, were made from 1992 to 1995. Potash inputs (kg K_2O ha^{-1}) to the conventionally managed South Hayfield were 76, 38, 132, 205, 129, 59, 235, 118, 197, 126, 121, 163, 56, 115 and 63 kg from 1991 to 2005 respectively (equivalent to an average of 122 kg K_2O ha^{-1} per annum) .

4.2 Pwllpeiran unit

4.2.1 Inbye fields

Soil pH on improved fields which were used for conservation (Cae Felin and Brignant) remained close to the optimum (pH 6). Brignant continued under the ESA agreement for hay meadow conservation, which did not permit application of FYM or other nutrients. The field was limed just prior to conversion, and its pH has dropped slowly from 6.8 to 5.5. Cae Felin was withdrawn from ESA management in 2001. Soil pH ranged from 5.7 to 6.2. An application of 3.5t ha^{-1} ground magnesium limestone was given in 2002 when the field was reseeded.

Phosphate levels have also gradually declined. In Brignant, total soil phosphate fell from 17 mg/l to 7 mg/l. Cae Felin originally had a higher level of 45 mg/l, which has fallen to 30 mg/l.

Since conversion, potash levels have varied from 65-218mg/l, due to a combination of off-take in silage, and variation in the application of FYM from one year to the next. Potash levels in Brignant varied from 52 to 108mg/l. In September 1999, Cae Felin received an application of Cumulus K, which raised soil index for potash from Index 1 to Index 2. In 2001, 17 tonnes per acre of FYM was applied, 5 tonnes per acre in 2002, and 2.7 tonnes per acre in 2005. During this period, potash K levels on Cae Felin generally increased, in response to FYM.

Magnesium levels have also generally decreased since conversion.

4.2.2 Hill reseeds (mosaics)

On the better areas of the mosaic, Parc y Llyn maintained a reasonably high pH (5.7 to 6.5). Llechwedd Brith had a slightly lower, but adequate pH (5.3 to 6.0). As expected, the mountain mosaic pastures generally had a lower pH of around 5.4. On Llechwedd Brith, soil phosphate levels fell from 15 mg/l to 5 mg/l, and on Parc y Llyn from 15mg/l to 7mg/l. Potash levels on Llechwedd Brith ranged from 38 mg/l to 107mg/l, increasing steadily in recent years. Parc y Llyn had potash levels of 126mg/l during conversion, which had fallen sharply to 45mg/l by 1996, and to 39mg/l by 2000 before slowly recovering to a level of 61mg/l.

5.0 Results - Botanical Composition

5.1 Redesdale unit

5.1.1 Native hill

Five vegetation types were identified in the directly comparable, and most heavily stocked, Dipper Hill. These were *Calluna* wet heath, *Calluna – Molinia* wet heath, *Molinia* wet heath, *Nardus* grassland and acid grassland. Over the period, all communities in the Dipper Hill (organic and conventional) showed a similar trajectory towards rough grass and sedge dominated vegetation. This suggests an overall loss in the diversity of plant communities towards a more uniform type of vegetation. The loss of heather between 1991 and 2001 appeared to have been affected by heather beetle attack, which may have been exacerbated by the affects of overgrazing. By 2004, the state of heather on both Organic and Conventional Dipper hefts had shown some improvement. However, the increased numbers of quadrats and cells containing heather were due mainly to recovery of existing heather, rather than new areas of spread. A reduction in the percentage of cells grazed on the organic sub-heft was probably due partly to the reduction in stocking rate in 2000, and partly to the recovery from heather beetle attack. However, on a carefully managed hill, heather would hardly be grazed at all during the summer, and the trend on both hefts was still one of long-term heather degradation.

The area assessed on the Cairn consisted mainly of *Calluna* heath, with also some *Calluna – Eriophorum* wet heath/blanket mire and *Nardus* grassland. From the outset, heather cover was greater on the Cairn, and sheep stocking rates lowest of the three organic flocks. Damage to the heather community due to overgrazing did not occur as it had on the Dipper. From the results of botanical assessment in 2001, plant communities appeared to have stabilised. An increase in *Nardus stricta* might have been due to the reduction in grazing pressure in 1995, resulting in a general increase in biomass.

The Burnhead Hill comprised *Molinia* dominated wet heath, rough *Carex* (sedge) dominated heath/grassland, and drier *Calluna* heath. By 2000, there were encouraging signs on specific areas of the hill, with the recovery of *Calluna* and associated heath vegetation after burning. This was also reflected by a decline in dominance of *Vaccinium myrtillus* (Blaeberry). This is the expected response of heathland vegetation where regeneration is successful. In the *Calluna/Molinia/Nardus* group, heather appeared to have out competed *Molinia*, aided by moderate grazing pressure and the fact the heather was in a vigorous building or mature phase.

An additional overview of the condition of vegetation on each of the native hill areas was conducted according to JNCC guidelines. Under this system, target scores should not fall below 90% for each assessment criterion. The overall percent pass rates across JNCC assessment criteria were 61, 71, 86 and 91 for Organic Dipper, Conventional Dipper, Burnhead and Cairn hefts respectively. 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.

5.1.2 Hill reseeds

Sown species content (ryegrass and white clover) declined on both organic and conventionally managed areas, continuing the long-term regression in these swards following land improvement 20 – 25 years previously. By 2000, analysis of aerial photographs estimated rush cover to vary from 18% to 49%, representing losses in usable dry matter of 21% to 25%. On the areas taken for silage between 1996 and 1999, an increase in the Ellenberg N index (Ellenberg, 1988) suggested that input of farmyard manure had caused a slight overall increase in productivity. Species richness increased between 1998 and 2000 from 9.2 to 11.5 species per m^2 ($P<0.01$), as did the G (grazing) suited species score ($P<0.05$).

5.1.3 Inbye land

Traditionally, the inbye fields at Redesdale were resown on a 5 to 7 year cycle. Without the addition of artificial nitrogen fertiliser, clover content was high on the organically managed fields, typically 20% – 45% cover, when assessed in August each year. Long-term monitoring indicated a typical pattern following reseeding with ryegrass and white clover. 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 (*Rumex*) and buttercup (*Ranunculus*). On one area, docks increased to 30% cover before reseeding in 2001. Several strategies were tried in an attempt to control docks including repeated cultivation and fallowing, the use of pigs on ploughed areas, and introducing Red clover/Italian ryegrass swards to increase competition.

In terms of botanical composition, an area of organically managed inbye land which had not been reseeded since 1991, gradually diversified at the expense of agricultural productivity. By 2004, a total of 21 species had been identified, compared with 17 in 2003 and 19 in 2002. It was also notable that docks had virtually been eliminated from this area, having been dug out manually in the mid-1990's. Lack of cultivation since then had not provided conditions for docks to re-establish.

5.2 Pwllpeiran unit

5.2.1 Native hill and hill mosaics

Clover levels have been difficult to maintain on the mountain pastures, struggling to remain at 5% cover, due to lower pH, P and K status. Rushes increased on the improved areas of the hill, despite topping in July most years. Following conversion, an overall increase in plant species was recorded in the improved grassland and mountain re-seeds. Surveys of the Brignant organic fields showed that in 1993, there were 14 plant species present in reseeded fields and 19 species in permanent pasture, by 1995 the numbers of plant species recorded had risen to 23 and 35 respectively.

5.2.2 Inbye fields

Clover content increased following conversion. There was a sudden, marked decrease in clover content in 1999, which recovered during 2000, to reach 16%-20% on silage fields by 2001. Cae Felin was removed from the ESA hay meadow conversion prescriptions when docks and buttercup began to predominate, and silage yield fell to a disappointing 2.3t ha^{-1}. The field was reseeded initially with a one year ley of Italian ryegrass and red clover in an attempt to control docks. In addition, the field was limed and given a heavy application of FYM. Docks were suppressed initially, but soon started to recover again. The ESA prescription might have contributed to the weed problem, as the delay in cutting would have allowed plants an increased chance to seed.

6.0 Results - Grassland Productivity

On both units, measurements of grassland productivity concentrated on inbye fields and in particular, the output of conserved fodder.

6.1 Redesdale unit

Total forage output (grazing and conservation) on inbye fields, measured in LUGDs per hectare, is given in Table 5. The performance of organic and conventionally managed fields is not absolutely comparable. Each field varies in production potential. There were differences in the type and level of nutrient inputs applied, in sward type, and in how the fields were managed. The conventionally managed area was reseeded twice over a 14 year period (in 1992 and 1997). The organic fields were reseeded more frequently, initially on a 5 -7 year cycle when perennial ryegrass and white clover swards were sown. Subsequently, greater use was made of Red Clover and Italian ryegrass swards, to provide increased competition against weeds, and the frequency of reseeding increased to a three to four year cycle. On this basis, the North Hayfield was reseeded three times (1991, 1999, 2002), the West Hayfield twice (1991, 1999), and the Bridge Haugh four times (1991, 1996, 2001, 2003). In addition, the organic areas were grazed by sheep only one year in two, the intervening year being used primarily for conservation and some autumn grazing by cattle. The conventional area continued to provide sheep grazing and conservation each year, from a heavily fertilised ryegrass sward. Despite these fundamental differences in management approach, the output data collected over a 10-year period are a good indicator of the relativity between organic and conventional production.

Table 5. Forage output on inbye fields - Livestock Unit Grazing Days (LUGD) per ha (ADAS Redesdale)

Year	South Hayfield (Con.)	North Hayfield (Org.)	North as a % of South	West Hayfield (Org.)	Bridge Haugh (Org.)	Ford Haugh (Org.)	Org. as % of Con.
1995/6	654	627	96	555	728	N/A	97
1996/7	712	534	75	595	700	N/A	86
1997/8	493	620	126	562	746	N/A	130
1998/9	886	601	68	674	798	N/A	78
1999/00	693	516	74	446	692	N/A	80
2000/01	847	244	29	456	874	N/A	62
2001/02	661	159	24	488	853	N/A	76
2002/03	956	382	40	488	690	714	79
2003/04	879	776	88	737	559	453	96
2004/05	900	644	72	613	581	700	94
Mean	768	510	69	573	722	620	88

Overall, the organically managed areas were able to produce 88% of the output obtained from conventional management. In the most directly comparable fields (North and South Hayfields) the relativity was approximately 70%. However, this included two seasons (2000 and 2001) when output was dramatically reduced due to the field carrying experimental plots of Birdsfoot trefoil (*Lotus corniculatus*) and red clover. Across the other eight years, production on the organic area was 80% that of the adjacent conventional field. This result is in close agreement with the results of replicated plot studies at Redesdale which compared organically managed plots receiving slurry and FYM, with a conventional sward receiving 240 kg N ha. The control plots yielded, on average, 78% of the herbage dry matter of the conventional sward, which increased to 86%-89% when the organic treatment included the addition of composted FYM.

In terms of conservation yields, output on an annual basis was very similar for organic and conventionally managed fields (Table 6). There was considerable between year variation, with a greater proportion of second cuts taken in alternate years, from the organic fields rested from sheep.

Table 6. Conservation yields on inbye land at ADAS Redesdale (kg DM ha^{-1})

Year	South Hayfield (Con.)	North Hayfield (Org.)	North as a % of South	West Hayfield (Org.)	Bridge Haugh (Org.)	Ford Haugh (Org.)	Org. as % of Con.
1st cut	5545	5228	94	5583	5026	3764	88
2nd cut	2980	3592	121	2031	3119	2293	93
*Annual	6869	6768	99	5809	8146	6057	97

* Annual mean does not equal the sum of the mean for first and second cuts, as two cuts were not taken in every year

6.2 Pwllpeiran unit

Conservation yields were not as high at Pwllpeiran. Typically, 23.8 ha were taken for round bale silage, ensiled at around 30% dry matter in July. At the start of conversion, it was calculated that the organic unit would be self sufficient for silage at yields of 3t DM ha^{-1}. Average silage yield each year varied from 2.8t-4.0 t DM ha $^{-1}$, reflecting cyclical changes in sward clover content. Due to higher silage yields in 1996 (3.8t DM ha^{-1}) a strategic decision was taken to increase the sheep flock. However, in 2000 insufficient forage (2.9t DM ha^{-1}) was produced, so that non-organic hay and in-conversion silage had to be bought in. As a result, sheep numbers were reduced again. Following reseeding of Cae felin, silage output improved to 3.9t DM ha^{-1}.

7.0 Results - Sheep performance

7.1 Redesdale Unit

7.1.1 Ewe live weight

At all stages of the annual production cycle, organic ewes in the directly comparable Dipper flocks were consistently, and significantly (P< 0.001) lighter than those managed conventionally (Appendix 1).

When the data was analysed across years, there were no statistically significant differences in ewe live weight at tupping, scanning, marking or weaning, between Organic and Conventionally managed Dipper flocks for year of assessment/birth (1994 to 2000 inclusively). There were a number of downward trends in these data, but these were usually mirrored by trends in the mean live weights for flocks, such that the year of birth effect was not significant.

Fig 2 Ewe live weight at 1st mating (Dipper flocks)

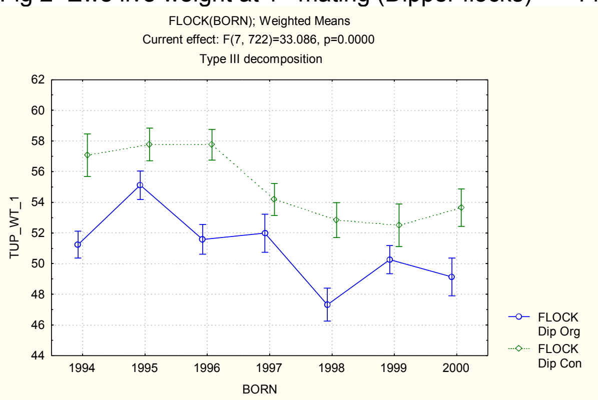
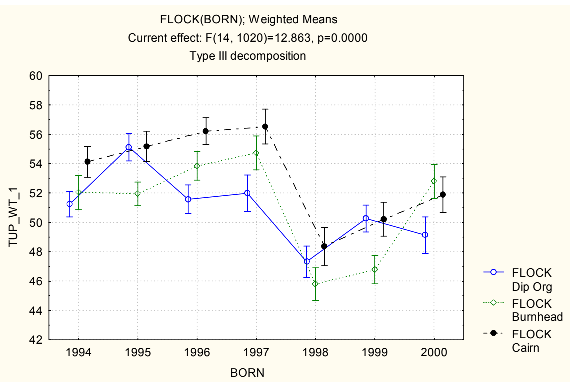


Fig 3 Ewe live weight at 1st mating (organic flocks)



Due to inherent imbalances in the statistical design, care needs to be taken in the interpretation of the analyses. However, of the three organically managed flocks, ewe live weight tended to be higher in the less intensively stocked Cairn flock (Table 7).

Table 7. Ewe live weight at first mating (Redesdale organic flocks)

Flock	Year of birth						
	1994	1995	1996	1997	1998	1999	2000
Burnhead	52.0^{f}	51.9^{f}	53.8^{gh}	54.7^{hi}	45.8^{a}	46.8^{a}	52.8^{fg}
Cairn	54.1^{gh}	55.2^{hi}	56.2^{i}	56.5	48.4^{bc}	50.2^{de}	51.9^{f}
Dip Org.	51.2^{ef}	55.1^{hi}	51.6^{ef}	52.0^{f}	47.3^{ab}	50.3^{de}	49.1^{cd}

Note: Differences between data sharing the same superscripts are not statistically significant (Duncans Multiple Range Test)

7.1.2 Ewe body condition score

In the Dipper flocks, organically managed ewes also tended to have lower body condition scores (p<0.05). In the less intensively stocked Cairn and Burnhead flocks, ewe body condition was generally on a par with the conventionally managed sheep.

7.1.3 Ewe fertility

Long-term trends in ewe fertility, in terms of ewe barren rate and potential lamb crop at scanning, are given in Table 8.

Table 8. Ewe barren rate and potential lamb crop at scanning (ADAS Redesdale)

Year	Ewe barren rate (per 100 ewes)				Lambs per 100 ewes mated			
	Con. Dipper	Organic Dipper	Cairn	Burnhead	Con. Dipper	Organic Dipper	Cairn	Burnhead
1995/6	5.6	3.3	4.0	3.5	133	139	138	142
1996/7	1.7	6.0	1.9	2.3	141	124	125	127
1997/8	3.9	4.4	2.0	4.7	138	127	140	130
1998/9	3.3	9.4	4.6	8.1	135	111	115	118
1999/00	4.4	14.5	7.1	9.4	145	94	108	112
2000/01	4.9	8.3	7.2	7.5	144	115	118	115
2001/02	3.9	6.3	5.2	2.7	143	130	122	129
2002/03	3.3	3.5	4.5	8.0	132	109	109	113
2003/04	3.8	10.3	7.3	7.1	124	106	104	114
2004/05	3.1	2.1	3.9	3.5	136	124	128	141
Mean	3.8	6.8	4.8	5.7	137	118	121	124

The conventionally managed flock had a consistently high level of fertility, and provided a good benchmark for a well managed, productive hill flock. Barren rates were greater (mean 5.8%) and more variable in the three organic flocks, with a corresponding reduction in the overall potential lamb crop (mean 121%). Of the three organically managed flocks, barren rates were lowest in the less densely stocked Cairn flock, peaking at 14.5% in the Organic Dipper flock in February 2000, further evidence of the production pressure this flock had come under.

Table 9. Lamb birth and weaning rates (per 100 ewes mated) – ADAS Redesdale

Year	Lambs born alive				Lambs weaned			
	Con. Dipper	Organic Dipper	Cairn	Burnhead	Con. Dipper	Organic Dipper	Cairn	Burnhead
1995/6	131	134	127	132	129	129	115	121
1996/7	136	117	117	123	135	117	117	120
1997/8	138	129	141	129	128	121	129	121
1998/9	128	104	107	115	123	97	103	111
1999/00	136	91	103	111	134	88	97	103
2000/01	131	111	111	109	127	106	106	108
2001/02	131	114	118	121	130	115	114	119
2002/03	125	105	103	105	123	104	104	105
2003/04	118	94	105	114	116	104	103	107
2004/05	127	117	123	135	129	116	123	131
Mean	**130**	**112**	**116**	**119**	**127**	**110**	**111**	**115**

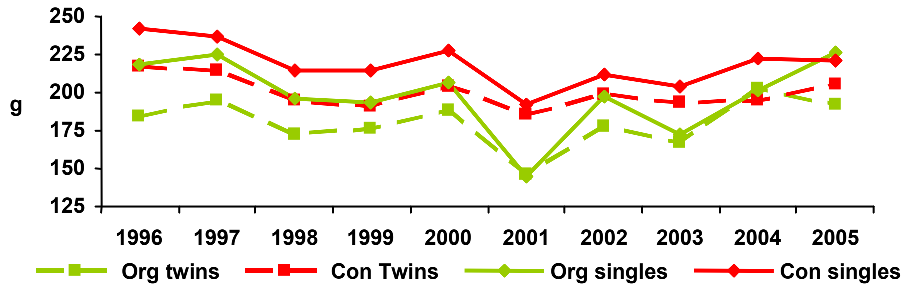
On average, a 5% - 7% difference was recorded between the potential lamb crop at scanning and live births. At an average of 110% to 115%, weaning rates in the organic flocks were good for a hill system of production. However, the percentage of lambs weaned in the conventional flock was exceptionally high at 127%.

7.1.4 Lamb performance

Detailed lamb live weight and growth performance data are presented in Appendix 2.

Within the Organic and Conventional Dipper flocks, there was little difference in lamb birth weight, suggesting that winter nutrition from forage and concentrate supplementation were adequate. Statistically significant differences tended to develop as the lambs grew, a reflection of the milking ability of the ewes (affected by maternal body condition and the availability of spring and summer grazing) and the performance of the lambs as they consumed more herbage. In addition, average lamb growth rates in the conventional flock were moderated by a higher ratio of twin to single reared lambs, reflecting greater prolificacy. Over 10 lamb crops, single lambs grew 10% (224 vs 204g/day), 7% (206 vs 192g/day), 13% (228 vs 202g/day) and 11% (221 vs 199g/day) faster than those reared as twins in the Conventional, Organic Dipper, Cairn and Burnhead flocks respectively.

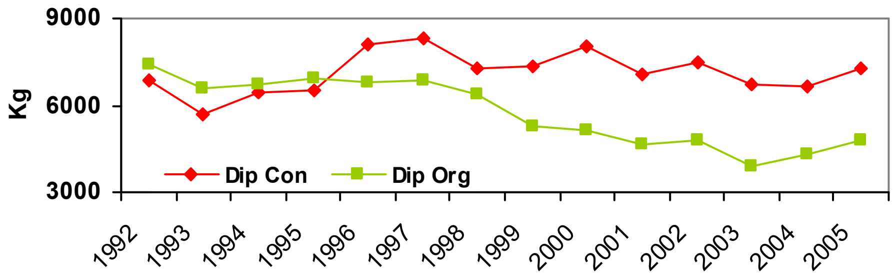
Fig 4 Lamb daily liveweight gain (Organic and Con Dipper)



In the directly comparable Dipper flocks, a growth rate of organic single lambs was comparable to twins managed conventionally (Figure 4). Lamb performance in the organic flock reached a low point in 2000, adding further weight to the decision to reduce sheep numbers from November 2000.

If the four years (1992 to 1995) are used as a reference base, the total weight of lamb weaned was 6386 kg, 6905 kg, 7164 kg and 8139 kg for the Conventional Dipper, Organic Dipper, Cairn and Burnhead respectively. The corresponding averages for the ten-year period reported here were 7433 kg, 5286 kg, 5381 kg and 5232 kg respectively.

Fig 5 Total lamb output (kg) at weaning



During the years immediately after conversion (1992 to 1995), performance in the organic flock compared favourably with the conventional (Figure 5). From 1995, the performance of both sub-flocks started to diverge. Output in the conventionally managed flock actually went up. Similar ewe numbers were maintained from 1998 to 2000, but the performance of the organic flock went into steep decline. Ewe numbers in the organic flock were cut by 25% from mating in November 2001, and the output of weaned lamb stabilised, albeit at significantly lower levels than the conventional flock.

Total lamb output (kg) at weaning relative to the mean of four base years, is given in Table 10. Lamb performance data for each year are given in Appendix 2. Ewe numbers were reduced by 25% in the Cairn flock in November 2005. This reduction in numbers is reflected in the initial drop in output in 1996, but levels of output have been consistently maintained since then. A 25% reduction in sheep numbers has been directly translated into an average of 25% lower weight of weaned lamb over the 10 year period. Weaned lamb output in the Burnhead flock, also showed a slow decline until 2001, when sheep numbers were cut by 45% to simulate entry to the Countryside Stewardship Scheme.

Table 10. Total output of lamb (Kg) at weaning (ADAS Redesdale)

	Base	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Dip Con.	100	127	130	114	115	126	111	117	106	104	114
Dip Org.	100	98	100	92	76	74	68	70	56	62	69
Cairn	100	78	87	84	71	67	72	72	62	72	86
Burnhead	100	75	82	78	68	70	66	54	43	49	57

7.1.5 Lamb disposals

The pattern of lamb disposals across flocks (Table 11) was very consistent. Apart from the summer following the FMD outbreak (2001), the majority of organic lambs were sold as store. On average, 13% to 19% were sold finished onto the conventional market, mainly very forward single lambs and other lambs unsuitable for sale as stores. Up to 30% of the lamb crop was retained as hoggs, for further breeding. In addition, 9% of lambs in the conventional flock were sold or transferred for breeding.

In the organically managed flocks, the proportion sold for breeding was much lower (1%-4%). This was possibly a reflection of size and quality, but also may be due to the fact that 2% to 4% more were retained within the flock as replacements, from a smaller lamb crop overall.

Table 11. Lamb disposals (%) – ADAS Redesdale

	Conventional Dipper	Organic Dipper	Cairn	Burnhead
Ewe lambs retained for breeding (%)	26	28	30	27
Lambs sold store (%)	1	58	52	51
Lambs sold finished (%)	65	13	15	19
Ewe lambs sold or transferred for breeding (%)	9	1	4	3

Under a long-standing arrangement, the majority of the organic lambs were sold as stores for further finishing on an organic lowland farm. Prices have varied between £1.10 and £1.30 per kg live weight as measured at weaning. Typical lamb performance levels achieved on the receiving unit, including carcass weight at slaughter, are given in Table 12.

Table 12. Performance of organic lambs finishing on a lowland farm (2001/2 lamb crop)

Lamb live weight at sale	30.1 kg
Losses	1.4%
Left on farm (May)	1.6%
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. 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. The typical enhancement ranged from £1.50 to £3.75 per head (Table 13).

Critically in the example below, 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.

Table 13. 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

7.2 Pwllpeiran Unit

7.2.1 Ewe live weight

Overall, ewe live weights were lower at Pwllpeiran than at Redesdale due to the effect of breed. Mean tupping weights varied from 37.9 kg to 42.7 kg. Shearing weights were more constant at 45.9 kg to 48.2 kg. Average weaning weights have decreased since conversion, from 49.1 kg to 43.4 kg, reaching a low point of 42.4 kg in 1999. Compared with ewe live weight at shearing, weaning weight has tended to decrease over time, suggesting that herbage availability was tight during the summer.

7.2.2 Ewe body condition score

Ewe body condition score varied from season to season, but broadly followed a similar pattern to changes in live weight. Over a ten-year period, body condition score at mating averaged 2.68, and ranged annually from 2.24 to 2.83.

7.2.3 Ewe fertility

The average scanning percentage for the organic flock was 116%, which translated to an average of 99% by weaning. Scanning rate and barren rate were reasonably well correlated with ewe body condition at mating (Table 14). Lambing percentage has decreased every year since 1997.

Table 14. Ewe barren rate and potential lamb crop at scanning (ADAS Pwllpeiran)

Year	Body condition score at mating	Barren rate (%)	Predicted lamb crop at scanning
1995/6	2.55	2	120
1996/7	2.83	4	118
1997/8	2.30	N/A	136
1998/9	2.76	6	132
1999/00	2.74	5	119
2000/01	2.35	6	114
2001/02	2.24	6	107
2002/03	2.51	2	104
2003/04	2.40	4	104
2004/05	2.48	4	101

7.2.4 Lamb performance

Over the ten year period to 1995, lamb birth weight averaged 3.76 kg. Single lambs were 1.86 kg heavier than twin born lambs. Mean weaning weight was 26.6 kg. Male lambs were generally 3.8 kg heavier than females, with singles typically 6.7 kg heavier than twins. Lamb daily liveweight gains from birth to weaning were typically 191 g and 159 g for single and twin reared lambs respectively.

In some years ewes were in good condition score at weaning, but the lambs recorded disappointing weight gains, suggesting that grass availability early in the season may be a significant factor in lamb performance. Good grass growth during the summer may help ewe condition, but the lambs may be unable to compensate for poor grass growth in the spring adversely affecting milk yield. In recent years, daily liveweight gain has been increasing, as the total number of lambs reared has fallen, and as more Texel sired lambs have been born.

Of the total lamb crop, 26%-35% were retained as flock replacements. The aim was to away winter approximately 50 hoggs from the end of October until the following April. This is normal practise on hill farms to ensure well grown ewes. In the first few years it was difficult to find suitable organic lowland farms, and disappointing daily liveweight gains were achieved. Since 2003, flock replacements have been wintered at the National Botanic Gardens of Wales, and good performance levels have been achieved over the winter period.

7.2.5 Lamb disposals

The approach to lamb marketing was driven by market forces each year. Some years a large proportion of the organic lambs were sold finished direct to the slaughter house between September and November. Between 1993 and 1999, finished lambs were slaughtered at a local organic certified abattoir and sold to an independent butcher. Typically for a hill breed, lambs tended to grade O3L for conformation, although grades improved with the sale of more Texel cross lambs. Due to the cost of supplementary feed, the lack of premium prices, and increased competition with ewes for autumn grazing, a decision was taken in 2000 and 2001 to sell lambs as stores Store lambs sold in September 2000 for £1.40 kg, at a mean 26.1 kg live weight, and returned an average price of £35.21. The comparable figure for 1999 when most but not all, of the lambs had been sold finished was £32. In 2002, some of the lambs were finished and sold to a local slaughter house, and the remainder sold as stores, or transferred to the conventional unit. Seventy six lambs from the 2003 lamb crop were sold to an organic box scheme, but due to lack of demand and lack of premium, the remainder were sold as conventional lambs. In 2004, a few lambs were sold finished, but again the bulk were sold as stores to a local producer.

8.0 Results - Cattle Performance

8.1 Redesdale Unit

8.1.1 Herd fertility

Over the ten-year period, cow fertility from July mating was consistently high, averaging 95.1%.

8.1.2 Cow live weight and body condition score

Cow live weight in the original Limousin cross cows ranged up to 750 kg, excessively large for a forage-based hill system of production. As mature cows, live weight in the Angus cross cows was lower (585 kg). Cow body condition at weaning was at or above a target score of 2.5, however there was a tendency for cows in the conventionally managed Angus cross to be slightly heavier and fitter at weaning. Pure bred Aberdeen Angus cows were consistently heavier than the Angus Friesian cross, and tended to carry more body condition at weaning.

Table 15. Mature cow live weight and body condition score at weaning (ADAS Redesdale)

		Conventional Halfbred	Organic Halfbred	Organic Angus
Live weight (kg)	2004	606 [a]	555 [a]	650 [b]
	2003	581 [a]	576 [a]	616 [a]
	2002	625 [b]	567 [a]	590 [ab]
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]

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

8.1.3 Calf performance to weaning

From 1995 to 2000, the progeny of Limousin cross cows mated to a Limousin bull achieved liveweight gains of approximately 1.0 kg, 0.7 kg and 0.7 kg during their first grazing season, first winter and second grazing season respectively.

From 2000 onwards, calves from the purebred Angus herd were consistently lighter at birth than those from the Angus cross sub-herds (Table 16). 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 half-bred dams, which accentuated good calf performance following the introduction of concentrate feed after housing.

Table 16. Calf performance from birth to weaning (ADAS Redesdale)

		Conventional Halfbred	Organic Halfbred	Organic Angus
Birth weight (kg)	2005	40.8 [a]	40.9 [a]	38.2 [a]
	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]
	2001	43.2 [b]	45.8 [b]	35.0 [a]
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]
	2001	345.8 [a]	306.0 [b]	260.3 [c]
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]
	2001	1.10 [a]	1.01 [b]	0.85 [c]

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

8.1.4 Cattle disposals and carcass gradings

A total of 191 cattle were sold from the three directly comparable sub-herds in the period 2002 to 2005; 19% were sold finished and 81% as stores. The conventional cattle were all sold as forward stores averaging 420 kg and 451 kg live weight for heifers and steers respectively (Table 18), at an average store price of £1.01 per kg live weight. Organic store cattle averaged 447 kg and 467 kg, for steers out of the organic three quarter bred sub-herd (sired by an Angus bull) and organic half-bred sub-herd (sired by a continental sire). Prices averaged £1.27 and £1.36 per kg live weight for organic Angus and continental cross steers respectively. Prices for store heifers peaked at £1.26 for 2004 born animals, sold in 2005, and were generally 15-20p less per kg than for steers.

Table 17. Finishing performance of conventional and organic cattle (ADAS Redesdale)

	Calves born	Conventional Halfbred	Organic Halfbred	Organic Angus
Sale weight – heifers (kg)	2004	425	399	434
	2003	382	415	447
	2002	459	*579	*562
	2001	415	*563	*579
Sale weight – steers (kg)	2004	448	434	479
	2003	417	427	419
	2002	470	441	411
	2001	467	561	479

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 18. Carcass weight and gradings (ADAS Redesdale)

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 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.

8.2 Pwllpeiran Unit

8.2.1 Herd fertility

Cow conception rates have also been very high at Pwllpeiran, averaging 94%. There were rarely more than two barren cows (out of a herd of 10), and twin births were relatively common. Calving rate peaked at 110%. Only four calves were lost between 1995 and 2006, one being an accidental death.

8.2.2 Cow live weight and body condition score

Welsh Black cows averaged 607 kg in live weight, and body condition score 3.23, at housing.

8.2.3 Calf performance

Average calf birth weight in purebred Welsh Black cattle was 41.8 kg (range 33 kg to 50 kg). The 200 day weight varied from 236 kg to 260 kg, averaging 246 kg or approximately 1.0 kg (range 0.85 to 1.14 kg) daily liveweight gain from birth to 200 days. The average 300-day weight was 281kg.

8.2.4 Cattle disposals

The majority of the Welsh Black calves were initially sold as stores at 11 months of age. The average weight of the beef cattle sold declined between 1995 and 2000. In 2000 it was decided to keep the calves for a further 3 months for sale as stores at 14 months. When ADAS entered into a land management agreement with the Welsh Botanic Gardens of Wales, weaned calves were transferred at weaning, and sold at around 18 months through specialist Welsh Black Society organic markets. Steers are sold as forward stores and in recent years have made top market prices, exceeding £1.40p/kg. With increasing awareness of the potential benefits of cattle for environmental management, coupled with an appreciation that Welsh Black cattle can utilise natural vegetation, there has been an increased demand for both organic and conventional Welsh Black heifers. As a result, surplus heifers have been sold in-calf at about 30 months achieving up to £650 per head.

9.0 Results - Health and Welfare

9.1 Redesdale Unit

9.1.1 Overall

Ewe mortality rates were very low for a hill sheep system. Lamb mortality was higher in the conventionally managed flock, but this was likely to be due to the greater number of twin lambs born. Overall lamb mortality was low for a hill system, and well below estimated national averages (15% - 20%). No adverse effects were recorded as a result of removing clostridial and pasteurella vaccination from the Cairn flock.

Table 19. Ewe and lamb mortality rates (ADAS Redesdale)

Year	Ewe mortality (%)				Lamb mortality (%)			
	Con. Dipper	Organic Dipper	Cairn	Burnhead	Con. Dipper	Organic Dipper	Cairn	Burnhead
1996	2.8	1.7	1.3	1.8	10.0	8.0	9.0	9.0
1997	2.2	1.6	0.0	2.3	12.0	12.0	11.0	10.0
1998	2.8	1.1	3.9	1.2	10.0	7.0	8.0	10.0
1999	2.2	5.5	0.6	1.7	13.0	11.0	10.0	12.0
2000	3.3	2.8	6.5	5.9	8.0	4.0	5.0	4.0
2001	3.9	2.8	5.2	4.0	15.0	12.0	13.0	6.0
2002	2.8	4.2	2.6	0.9	8.0	10.0	6.0	5.0
2003	5.4	6.3	5.8	4.4	11.0	6.0	5.0	6.0
2004	3.3	4.4	5.3	7.1	7.0	9.0	7.0	7.0
2005	1.6	2.1	5.2	0.9	10.0	6.0	6.0	5.0
Mean	**3.0**	**3.3**	**3.6**	**3.0**	**10.4**	**8.5**	**8.0**	**7.4**

Hogg mortality rates were also low, but with considerable seasonal variation. The main cause of mortality was sporadic outbreaks of pastuerella pneumonia during the winter and spring. Across the organic flocks, average hogg mortality was 2.1% compared with 1.3% in the conventionally managed flock.

Table 20. Hogg mortality and performance (ADAS Redesdale)

Year	Hogg mortality (%)				Hoggs joining the flock as shearlings (%)			
	Con. Dipper	Organic Dipper	Cairn	Burnhead	Con. Dipper	Organic Dipper	Cairn	Burnhead
1996	0.0	0.0	1.9	0.0	89.5	100.0	92.3	98.3
1997	0.0	0.0	0.0	0.0	98.2	100.0	92.6	90.0
1998	0.0	3.3	0.0	3.7	100.0	76.7	100.0	89.5
1999	0.0	0.0	2.0	1.9	96.7	95.0	86.5	66.7
2000	0.0	4.4	4.0	0.0	92.7	94.5	92.2	94.4
2001	0.0	8.9	2.0	1.8	96.4	74.1	96.0	62.5
2002	3.6	4.7	2.1	3.0	96.4	88.6	95.8	97.0
2003	7.4	2.3	4.0	3.0	94.2	88.4	90.0	87.5
2004	1.7	2.4	2.4	3.0	93.3	95.1	95.1	97.0
2005	0.0	2.4	0.0	0.0	98.0	92.9	100.0	100.0
Mean	**1.3**	**2.8**	**1.8**	**1.6**	**95.6**	**90.5**	**94.1**	**88.3**

Not all hoggs selected for breeding as ewe lambs will enter the flock a year later as shearlings. Some will be culled out on the basis of size and quality. However, the proportion of hoggs which ultimately enter the flock as shearlings is a reasonably good indicator of hogg performance over their first winter.

The percentage of animals successfully joining the breeding flock was 96% in the conventional flock, compared with an average of 91% across the three organically managed flocks. Particularly low figures for the Burnhead flock in 2001, reflected an outbreak of pneumonia which significantly affected hogg growth rates over the winter period. Performance of home bred female replacements is particularly important in a hill system, as there is restricted opportunity to top up with purchased stock.

The overall health status of the spring calving herds was very good. Calf mortality was very low, and occurred mainly before or at calving.

9.1.2 Specific conditions

Since 1995, stomach worms have been adequately controlled in sheep by a combination of alternate grazing with cattle, and the sale of lambs as stores in September. Anthelmintic input was eliminated from the ewes. Parasite burdens (measured by faecal egg output) in lambs were low and drenching was limited to a few individual lambs at marking or weaning. Nematodirus did not occur as a problem in lambs.

Treatment of sheep for fluke was eliminated soon after the start of conversion, and fluke did not appear to be a risk until 2004, when routine sampling detected the presence of fluke eggs. On veterinary advice the ewes and hoggs were drenched in November.

Ectoparasites have been adequately controlled using approved products, such as cryomazine, and pyrethroid dips. Ticks have not been a problem, and no specific treatment was undertaken. However, more recently there was evidence locally, and elsewhere on the farm, of an increasing tick population.

Blood copper levels in lambs grazing on the native hill have been found to be double those of lambs whose dams were restricted to the hill reseeds, confirming the value of the diverse range of vegetation on the native hill for trace element nutrition. As part of traditional shepherding practice on the unit the sheep were moved ('raked') on a daily basis between the reseeds and native hill. Traditionally, one flock (Burnhead) had been given additional slow-release copper capsules before lambing, to prevent swayback. This was stopped for a period in the mid 1990's, but reinstated on the basis of ewe performance. Depending on the season, selenium levels (as measured by blood GSH-Px) were variable, frequently marginal to low. Cobalt levels, measured in weaned lambs, were generally adequate. The results of a large scale investigation, conducted over three years, showed that while supplementation with a trace element bolus increased blood trace element levels, no significant response was obtained in terms of ewe or lamb performance.

The only routine veterinary input to the suckler herd 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.

9.2 Pwllpeiran unit

9.2.1 Overall

Recorded ewe mortality was less than 3% (Table 21), with lamb mortality averaging less than 13% (4.5% born dead, and 8.4% dying subsequently). These figures are less than the expected average where ewe mortality is about 5% and lamb mortality about 20%.

Table 21. Sheep mortality rates (%) (ADAS Pwllpeiran)

	Ewe	Lambs born dead	Lambs dying after birth	Total lambs lost
1995/96	1.23	6.15	15.38	21.54
1996/97	0.57	9.76	6.34	16.10
1997/98	n/a	5.43	9.95	15.38
1998/99	n/a	6.67	8.44	15.11
1999/00	3.61	7.07	11.11	18.18
2000/01	0.62	3.80	8.70	12.50
2001/02	0.63	4.09	2.92	7.02
2002/03	7.33	1.92	6.41	8.33
2003/04	4.27	0.59	3.53	4.12
2004/05	2.45	1.22	7.93	9.15
2005/06	3.68	2.53	12.03	14.56

9.2.2 Specific conditions

The use of anthelmintics has decreased since conversion and was only carried out when egg counts were high. Both the organic and conventional flocks were shown to have some anthelmintic resistance to white drenches, although efficacy was still in excess of 90%. Fluke was a problem, and the ewes were strategically drenched as routine. In the early years of conversion, cobalt deficiency resulted in cases of pine in lambs. In the autumn of 2003 and 2005, lambs were given a Vitamin B12 injection. During the housed period, cattle were been treated with deltemethrin in most years. If fluke eggs were found in faecal samples, the herd was treated. In 2000, blood tests indicated copper deficiency and cattle were given a copper bolus, and injected.

The conventional and organic cattle at Pwllpeirian were treated as one herd under a whole farm herd health scheme. Tests were carried out for Johne's Disease, BVD, IBR and Leptospirosis. The herd has been confirmed free of Johne's, BVD and IBR, but a high incidence of Leptospirosis has been identified and a vaccination programme adopted. The herd health scheme also resulted in a review of management practices, which improved conception rates and the number of calves born alive.

10.0 Results - Financial Performance

10.1 Redesdale Unit

10.1.1 Sheep Gross Margins

Sheep Gross Margin (£ per ewe) before forage costs are given in Table 22.

Table 22. Sheep gross margins (ADAS Redesdale)

	Production year									
	1995/6	1996/7	1997/8	1998/9	1999/00	2000/1	2001/2	2002/3	2003/4	2004/5
GM £/ewe										
Dipper Con.	63.41	54.41	34.55	34.27	31.19	33.81	43.38	40.64	43.56	22.24
Dipper Org.	58.59	51.47	42.88	35.39	32.89	26.40	37.05	28.54	36.39	20.55
Cairn	56.21	57.25	48.38	42.39	32.42	30.51	39.91	33.16	36.19	27.72
Burnhead	56.70	53.34	43.84	36.97	37.97	32.76	46.40	32.23	40.25	32.97
Dipper Org. as % of Dipper Con.	92	95	124	103	105	78	85	70	84	92
GM £/flock										
Dipper Con.	11414	9848	6254	6203	5708	6120	7852	7478	7928	4270
Dipper Org.	10546	9368	7718	6406	5887	3802	5298	4053	4949	2939
Cairn	8488	8817	7402	6486	5025	4668	6146	5140	5465	4269
Burnhead	9639	9174	7497	6396	6455	5667	5197	3642	4508	3693
Dipper Org. as % of Dipper Con.	92	95	123	103	103	62	67	54	62	69

In the early years following conversion, Gross Margin per ewe in the Organic Dipper compared favourably with the Conventional Dipper. Even as differences in physical output emerged in the period 1995 – 2000, the organic flock remained competitive. Largely this was due to the poor prices being obtained for conventional lambs towards the end of the 1990's. Since November 2000, when ewe numbers were cut in the Organic Dipper flock, Gross Margin per ewe has varied between approximately 70% and 90% that of the conventional. However, due to the reduction in ewe numbers flock gross margin has been half to two thirds that of the conventional.

The inclusion of Countryside Stewardship Payments (£3864 per annum), theoretically available on the Burnhead, would have increased flock Gross Margin on that heft by between 74% and 104%. The average gross margin £8083 (2001/2 to 2004/5), compared favourably with the mean flock gross margin (£7270) for the period 1995-2000.

10.1.2 Cattle Gross Margins

Over the ten year period, Gross Margin (before forage) per cow in the organic half-bred herd, has averaged £614.

Since the herd was split in 2000, performance in the organically managed sub-herd has consistently exceeded that of the conventional (Table 23).

Table 23. Cattle gross margins (ADAS Redesdale)

	Production year									
	1995/6	1996/7	1997/8	1998/9	1999/00	2000/1	2001/2	2002/3	2003/4	2004/5
GM £/cow										
Conventional	N/A	N/A	N/A	N/A	N/A	498	739	526	643	521
½ organic	549	503	586	533	450	647	757	699	809	610
¾ bred organic	N/A	N/A	N/A	N/A	N/A	412	420	443	717	294
½ bred organic as % of con.	N/A	N/A	N/A	N/A	N/A	130	102	133	126	117

10.1.3 Whole unit profitability

Sheep and cattle Gross Margins (before forage) are combined for the unit in Table 24. Forage costs are deducted to produce a total livestock Gross Margin.

Table 24. Organic Unit Gross Margins (£) (ADAS Redesdale)

	Production year									
	1995/6	1996/7	1997/8	1998/9	1999/00	2000/1	2001/2	2002/3	2003/4	2004/5
GM (excl. forage)										
Suckler herd	19214	17610	20512	18657	22520	23052	24623	21203	29816	23050
Sheep flocks	28673	27359	22617	19287	17367	14137	16641	12834	14922	10900
Total	47887	44968	43130	37944	39887	37190	41264	34038	44738	33950
Forage costs	2727	1329	1028	1070	806	717	1518	1125	1673	1004
GM (incl forage)	45159	43640	42102	36874	39081	36473	39746	32913	43065	32947
Aid to conversion	2265									
HFA							3678	3678	3678	3678
SFP										17636
Total	47423	43640	42102	36874	39081	36473	43424	36591	46743	54261
GM £/adj ha	401	369	356	311	330	291	346	292	372	440
GM relative to conversion years	106	98	94	82	87	77	92	77	99	115

Over the period, Gross Margin per adjusted hectare ranged from £291 to £440. Using the average unit Gross Margin over the first four years following conversion as a baseline, Gross Margin fell to 76% that of the reference period (£377/adj. ha). This reflected a combination of reduced sheep performance and reduced sheep numbers. From a low point in 2000/01, unit Gross Margin began to recover as HFA payments were made, paid on an area rather than a headage basis. The 2004/05 year represented the first year of Single Farm Payment (SFP), again paid on an area basis. The loss in financial output due to reduced numbers of lambs, was compensated for by SFP so that unit Gross Margin was restored to approx 115% that of the reference period.

10.2 Pwllpeiran Unit

Gross Margin analyses have not been carried out since 2001. However, it is possible to give an overview of the general trend in profitability. By 1998/99, the unit outperformed conventional returns in terms of Gross Margin per hectare, without taking into account ESA payments. The difference reflected the premium prices achieved for organic beef and lamb, and the collapse of the conventional lamb market. Premium prices for organic lamb and beef continued in 1999/2000, but as a result of higher input costs and lower subsidy payments the Gross Margin per hectare fell to the lowest recorded. Financial performance improved in 2000/2001, in response to additional Beef Special Premium payments and the effect of the area-based Tir Mynydd scheme (replacing the headage-based Hill Livestock Compensatory Allowance). This underlined the importance of other agri-environmental payments for financial viability.

11.0 Discussion

On both organic units, soil levels of extractable phosphate and potash fell substantially from the first year of conversion. In part, the reduction at Redesdale was exacerbated by the deliberate application of nutrients prior to conversion. The pattern differed depending on land type (inbye or hill reseed) but the overall trend was similar on conventional and organically managed areas. Over the ten year period (1995/6 – 2004/5) reported here, P and K status have generally been at Soil Index 1 to 2. Potash levels have also been under pressure on the conventionally managed fields, and regular applications of soluble fertiliser have been required. Soil pH was more stable on organically managed inbye land, where lime was applied on a 7-10 year cycle. However, there was some evidence for a sharper decline in pH on conventionally managed inbye land, possibly because of higher nutrient off-take, or greater acidification from the levels of nitrogenous fertiliser applied.

Although silage production for cattle removed significant amounts of nutrients as conserved forage, at Redesdale the return of composted manures were sufficient to offset this depletion. FYM had a very direct effect on nutrient levels, for example, where silage was taken from hill reseeds (1996 – 1999), P and K levels held up well when FYM was applied. When silaging and the application of FYM ceased, P and K levels fell sharply. Certain areas of inbye land, accumulated P and K to Soil index 3, due to the location and trafficability of some fields relative to others. With lower numbers of cattle, the system at Pwllpeiran had greater difficulty in returning sufficient nutrients to the organic pasture. 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.

Moderate to low soil nutrient status on some organic fields did not appear to significantly compromise herbage yield. From a replicated plot experiment conducted at Redesdale, comparing fertiliser regimes on inbye land over a 6 year period, there was some evidence for better biological activity from areas under organic management. It may be that on inbye land, better biological processes, are in part compensating for lower levels of readily extractable soil nutrients. Furthermore, on some mineral soils potash may be mineralised from the clay fraction, so that assessments of fertility solely on the basis of extractable nutrients is not a measure of total soil nutrients potentially available.

Detailed, long-term monitoring of vegetation change on the native hill at Redesdale 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 is 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.

On the hill reseeds at Redesdale, the underlying trend in vegetation was a regression to rush pasture, on both organic and conventionally managed areas. Previous analysis of aerial photography has shown rush infestation up to 38% cover on some areas, resulting in a considerable reduction in productivity under both management regimes. 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 needed to be repeated, given impeded drainage and associated establishment opportunities for rushes. Rushes were also observed to be spreading on the unit at Pwllpeiran. Under an organic system, cutting was 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.

At Redesdale, a well defined progression in vegetation composition was observed following reseeding of inbye fields with ryegrass and white clover. Initially there was a high content of annual weeds e.g. chickweed, which gave way in the second year to the establishing ryegrass and clover. High levels of white clover were recorded, typically varying from 20% to 40% ground cover. As the ley continued to develop, perennial weeds e.g. docks and buttercups became more numerous. Despite attempts at manual control prior to reseeding, ploughing and subsequent cultivations, were very effective in spreading dock infestation. The spread of perennial weeds (docks, thistles and buttercups) was also an issue at Pwllpeiran.

Established infestations of docks proved difficult to control, and several approaches were tried at Redesdale. 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.

The productivity of inbye fields on the organic unit at Redesdale was 70% - 80% that of the conventional fertiliser-based system. In later years, the type of sward sown on the organic inbye land was increasingly driven by the need to provide competition against perennial weeds. Therefore, short term swards based on red clover and Italian ryegrass, replaced medium term white clover/ryegrass leys. While these short term leys 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. Conservation yields varied on the unit at Pwllpeiran according to seasonal clover content. Yields were further constrained by the management of certain areas under ESA upland hay meadow prescriptions.

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. Since 1995/96, 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 sub clinical 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 for sheep grazing. This segregation of both species may have had a disproportionately higher impact on sheep, due to the restricted area available for grazing each year, or the beneficial impact cattle have in controlling summer grass growth. The pattern in ewe live weight and body condition score at tupping (November) and at scanning (February) suggests that it is forage supply or quality 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. 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. A similar downward trend in ewe live weight and prolificacy was observed at Pwllpeiran although, in this instance, the imposition of a clean grazing system cannot be implicated as a contributory factor.

The main technical issue associated with organic suckler production was ensuring an adequate supply of conserved fodder for a 200-day winter. At Redesdale, self sufficiency in winter forage ranged from 95% to 107%. Although organic feedstuffs (organic cereals, organic beans) were more expensive than conventional, they were readily available for home mixing over most of the period, 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

The main health issues addressed in the organic flocks at Redesdale, were stomach worms, fly strike and foot conditions. Stomach worms were adequately controlled by a combination of an alternate grazing system with cattle and the sale of lambs as stores. Using this approach, routine anthelmintic was eliminated from the flock, and any treatment limited to small numbers of individual lambs, drenched at marking or weaning. Ectoparasites were controlled effectively using approved pour-on or dipping products, while regular footbathing in zinc sulphate was generally effective in maintaining foot health. Withdrawing clostridial vaccination from the Cairn flock did not have adverse consequences over a ten year period. Fluke and tick control had not been required since conversion of the unit at Redesdale but, on the basis of faecal analysis, ewes and hoggs were treated for fluke in 2004 and 2005. While no specific treatments have been undertaken for ticks, there was evidence from elsewhere on the farm that tick numbers are increasing, possibly due to milder winters or in response to rougher vegetation where sheep numbers have been reduced. Health issues in the organic cattle herd at Redesdale were minimal. Losses were very low and animal performance very good for a hill system of production. No anthelmintic or additional trace element treatment was needed. The only veterinary input required on a herd basis was winter treatment for ectoparasite control.

Farm and geographic differences were evident from the experiences at Pwllpeiran, where stock required annual treatment against fluke and periodic trace element supplementation. In the absence of clean grazing, anthelmintic inputs to the sheep were also higher than at Redesdale. Joining a Herd Health Scheme was shown to confer significant benefits on the performance of the organic herd.

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. At Redesdale, no problems were experienced in selling organic cattle, either finished or as stores. Both store cattle and store lambs were sold 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 complementarities of resources. At Pwllpeiran, the benefit of collaboration were seen through an arrangement with the Welsh Botanical Gardens farm, which provided the additional resources needed to take organic cattle to higher weights and to over-winter hoggs. However, the practicalities and economics of finishing lambs were marginal, and the majority of organic lambs produced at Pwllpeiran were also sold as stores.

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.

Historically, the financial performance of suckler herds was also 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 achieve this species mix.

Compared with the conventional system at Redesdale, Gross Margin per head (excl. forage costs) was 2% to 33% higher for the directly comparable organic suckler herd. However, flock Gross Margins were significantly (up to 46%) lower - a combination of lower sheep numbers, reduced lambing percentages and the sale of store rather than finished animals. By 2005, area based HFA payments and Single Farm Payment, had restored profitability to previous levels. Similarly at Pwllpeiran, payments under Tir Mynydd were a critical source of additional revenue.

From the organic unit at Redesdale, there was no evidence to indicate higher labour costs associated with animal husbandry. Where additional inputs were made, these tended to be marginal and likely to have been offset by savings in other areas, such as time taken in drenching conventional animals. However, certain activities may be more unique to the organic system – composting of FYM, manual and mechanical weed control (particularly for docks), and more frequent reseeding of inbye fields. Much of this input was absorbed in general farm overheads. However, with labour increasingly at a premium on all farms, pinch points may arise on organic farms either for labour availability or labour cost. From data, collected under a Defra-funded study on commercial organic farms linked to the unit at Redesdale, other fixed costs (including rent, capital repayments, power and machinery etc) are the key factor in determining farm profitability (measured as Net Farm Income).

12.0 Conclusions and implications for policy

The long-term results of the studies at Redesdale and Pwllpeiran indicate that organic farming is feasible in the hills and uplands. The messages from both studies are remarkably consistent. 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. Even on extensively managed farms, changes are likely in feeding regimes and approaches to disease control. During the 1990s a significant number of extensive commercial hill units were put into organic production, a reaction to poor market conditions for conventional lamb and the levels of aid to conversion payments available in England and Wales. A number of these have reverted to conventional production. Careful planning is required prior to conversion, to address the full range of implications, and specific technical issues, which will undoubtedly arise to challenge the long-term sustainability of the organic system. The fact that the performance of organically managed sheep has gradually declined on both units underlines the challenge involved.

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. Identifying the correct stocking rate at the start of conversion can be challenging. Most hill and upland units would adopt a policy of simultaneous conversion across all or the majority of the farmed area. Compared to arable farms, where a staged conversion is the norm, this has the advantage of greater simplicity and a more rapid conversion. However, the disadvantage is that there is less opportunity to tackle problems sequentially, or to evolve towards optimum stocking rates. On the basis of the performance obtained, stocking rates at Redesdale had to be reduced from those at the start of conversion. At Pwllpeiran, sheep numbers were reduced by 40% at conversion, then were increased temporarily, before being reduced once more in line with forage output on the unit. A reduction in the number of stock carried means that financial viability is dependent on additional sources of revenue, delivered independently of stocking rate – single farm payment, other agri-environmental payments, or price premia for each unit of output.

On most hill and upland units, sheep and cattle are the only viable enterprises. When properly integrated with sheep, cattle make a valuable contribute to better parasite control and more efficient utilisation of summer grazing. 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 based 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 potential financial benefit of selling finished animals over store was very evident, in terms of greater saleable weight and more secure premia for organic status. Many hill farms do not have the resources to finish animals during the autumn and winter. A particular problem in organic hill sheep production is that the majority of lambs produced tend to be offered for sale in September and October, with adverse effects on price and producer confidence. This is usually a period of oversupply, when significant numbers of crossbred lambs are also available from lowland flocks. Seasonality of production, distance from markets, individual skills and resources, are practical constraints to greater direct selling. Furthermore, the progression towards 100% organic feed, together with likely increases in the price of organic cereals, may mean home finishing will become even less attractive. An alternative approach may be to form links with lowland organic farms who have finishing capacity in the autumn and winter. Evidence from Redesdale indicates the value of this strategy to share a proportion of the risks and the profit. This may be attractive to a proportion of organic arable and mixed farms, which do not wish to carry the overheads associated with a breeding flock. Furthermore, crossing a proportion of hill sheep with a terminal sire, could improve the carcass quality and finishing ability of purebred hill lambs. This may become more feasible where stocking rates are reduced, for example, on entry to another agri-environmental scheme.

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 the livestock skills required for breeding animals.

While trading conditions for organic lambs have generally been difficult, the market for organic store and finished cattle has been relatively strong over recent years. Due to the relatively low number of organic breeding animals and longer generation interval, this is likely to continue. Selling store cattle, price premia for specialist native breeds may be more difficult to achieve than if selling direct to slaughter. Traditional breeds tend to have less total output, and poorer conformation, than continental genotypes. However, the evidence from Pwllpeiran indicates that a good market can be developed over time by adjusting the production system, and being prepared to exploit other market opportunities, for example, the sale of breeding stock with high health status. In addition, there may be increasing opportunity to brand the combination of traditional breeds, grazing environmentally sensitive areas or vegetation types, with local or regional food production.

A number of technical issues were identified, which in some circumstances could become system-limiting. On both sites, soil fertility levels have declined since organic conversion, particularly on the improved land. Without maintaining nutrient inputs, swards are likely to deteriorate botanically from improved to semi improved condition, with a corresponding fall in herbage production and stock carrying capacity. The implications for inbye fields could be to increase the requirement for expensive bought-in forage, or reducing the quantity of aftermath grazing available, for ewes at mating or for finishing lambs. While cattle have the disadvantages of disproportionately high requirements for winter forage and high overhead costs, they are the primary producers of FYM.

On hill reseeds there was a significant increase in rush cover. On better fields, docks were a particular problem, which proved difficult to control. Integrated control strategies, and continual effort, are essential to contain and control both species. If the infestation is allowed to develop, a stage may be reached where deregistration and chemical treatment may be the only short term solution.

Disease challenges varied between sites. Treatment for fluke and trace element deficiency were essential at Pwllpeiran. There is evidence that disease patterns will continue to evolve at weather patterns change, for example, the risk from fluke at Redesdale, and the general observation of a rise in tick numbers. While organic farming is less reliant on external inputs, the system is not immune to factors such as the development of anthelmintic resistance or restrictions on the use of products for ectoparasite control. Indeed pressures may increase, given the link between the hills and uplands, and catchment sensitive farming. During the early 1990s organic standards had not been applied in hill farming to any great extent. They have evolved since then to take account of the nature of hill farming. Differences in organic approaches between lowland and hill/upland farms are likely to remain and need to be recognised, where appropriate, in the continuing development of organic standards.

Although market conditions are changing, the increased availability and reduced cost of organically produced cereals and proteins over recent years, meant that for animals fed indoors or from troughs the proportion of non-organic feed required in the diet could be reduced to minimal levels. 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.

For farming as a whole, future profitability will depend on controlling overhead costs, achieving good levels of technical performance, optimising inputs, and exploiting opportunities for added value. Organic farmers will face the same pressures. Historically, stocking rates have been a prime determinant of profitability, 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 show the importance of exploiting opportunities to draw down payments from other agri-environmental schemes, to support the 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 gross financial output and overall profitability. For a proportion of farmers at least, the pendulum has swung away from the need for intensive production. In the short-term, 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, perceptions over weeds, and relative impacts on overall fixed costs. However, the current Single Farm payment regime runs out in 2012. Without an underpinning level of area-based support, the reduced output from an organic system could once again become financially punitive.

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. In terms of conflicts and additional benefits, the effects of combining organic farming with another scheme are not well understood. At Redesdale, the Moorland Scheme of the mid-1990's and latterly, the Countryside Stewardship Scheme could theoretically be overlaid on the existing organic system. While a reduction in sheep numbers was required, other requirements of the schemes were not onerous as they impacted mainly on management of the native and improved hill. At Pwllpeiran, the entry of forage conservation ground into an ESA scheme was in direct conflict with the needs of the organic system for sufficient good quality forage.

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. Unless a level of separation is maintained between the respective roles and financial rewards for organic and conventional farmers, the long-term trend may be for both systems to coalesce under the broader agri environmental agenda. Continuing to farm conventionally with, for example, access to limited herbicides (when required), may be an easier option than farming to full organic standards.

13.0 Research and development needs

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

- Address technical limitations such as 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);
- 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; and
- Quantify the potential to exploit co-operative effort to overcome technical issues and limitations, and increase environmental benefit

Ewe live weight (kg) at key stages of the production cycle (ADAS Redesdale)

Flock		Con. Dipper	Org. Dipper	Cairn (Org.)	Burnhead (Org.)	Level of significance All flocks	Con v. Org Dipper
Mating	95/96	59.8	56.3	57.6	56.0	***	***
	96/97	62.3	57.2	59.1	57.0	***	***
	97/98	61.2	57.0	59.5	58.5	***	***
	98/99	57.7	54.1	58.0	57.1	***	***
	99/00	58.1	51.3	55.0	53.0	***	***
	00/01	57.9	53.0	53.0	50.6	***	***
	01/02	55.1	49.5	50.1	53.4	***	***
	02/03	58.5	51.1	50.7	52.9	***	***
	03/04	56.7	52.5	53.9	52.9	***	***
	04/05	n/a	54.0	54.0	58.3	***	n/a
Scanning	95/96	54.1	52.1	53.3	52.0	***	***
	96/97	58.5	53.1	54.7	53.7	***	***
	97/98	53.2	49.7	52.3	53.0	**	***
	98/99	52.7	49.4	50.8	51.3	***	***
	99/00	52.3	49.6	53.4	52.2	***	***
	00/01	58.9	53.9	54.0	53.2	***	***
	01/02	53.5	50.1	49.8	50.9	**	**
	02/03	50.4	45.7	47.2	48.7	***	***
	03/04	50.2	46.5	48.4	51.7	***	***
	04/05	n/a	51.7	56.4	57.9	***	n/a
Marking	95/96	56.7	53.9	58.4	56.7	***	***
	96/97	58.6	55.3	63.0	60.5	***	***
	97/98	58.3	54.7	60.8	61.2	***	***
	98/99	57.2	52.5	57.7	56.9	***	***
	99/00	56.2	52.6	57.8	55.6	***	***
	00/01	51.4	48.1	53.0	49.1	***	***
	01/02	57.3	50.0	53.7	54.3	***	***
	02/03	53.5	49.4	51.2	52.0	***	***
	03/04	53.2	52.8	52.3	56.5	***	N/S
	04/05	n/a	50.3	60.8	57.9	***	n/a
Weaning	95/96	62.6	59.0	60.5	62.1	***	***
	96/97	59.5	61.7	61.7	61.4	***	***
	97/98	57.5	54.9	60.0	58.8	***	***
	98/99	57.5	54.9	60.0	58.8	***	***
	99/00	59.3	53.6	59.2	55.8	***	***
	00/01	58.0	54.2	57.0	55.2	***	***
	01/02	58.7	52.1	53.2	54.8	***	***
	02/03	58.1	51.4	53.1	55.4	***	***
	03/04	57.4	54.5	54.7	58.2	***	***
	04/05	n/a	54.4	59.4	56.3	***	n/a

Lamb live weight and growth performance data (ADAS Redesdale)

Flock		Con. Dipper	Org. Dipper	Cairn (Org.)	Burnhead (Org.)	Level of significance All flocks	Con v. Org Dipper
Birth (kg)	95/96	4.0	3.7	4.2	4.1	***	***
	96/97	4.0	3.8	4.2	3.9	***	**
	97/98	3.9	4.1	4.0	4.1	**	N/S
	98/99	4.1	4.1	4.1	4.3	**	N/S
	99/00	3.8	3.9	4.2	4.0	***	N/S
	00/01	4.0	4.4	4.4	4.2	***	***
	01/02	3.5	3.4	3.7	3.7	**	**
	02/03	3.8	3.9	4.0	3.9	N/S	N/S
	03/04	3.9	4.0	4.1	4.1	N/S	N/S
	04/05	4.1	4.2	4.3	4.2	**	*
Marking (kg)	95/96	16.1	14.3	15.3	15.2	***	***
	96/97	16.2	14.0	15.2	15.0	***	***
	97/98	15.8	15.8	16.3	14.2	N/S	***
	98/99	15.3	13.9	14.4	14.9	***	***
	99/00	15.1	14.9	13.9	13.6	***	N/S
	00/01	15.1	16.7	16.1	16.0	***	***
	01/02	14.8	12.3	14.2	13.9	***	***
	02/03	12.8	12.6	12.8	13.0	N/S	N/S
	03/04	12.7	12.6	14.1	14.0	***	N/S
	04/05	13.0	12.8	12.5	12.9	N/S	N/S
Weaning (kg)	95/96	36.6	31.7	34.7	32.6	***	***
	96/97	36.5	31.1	34.5	32.6	***	***
	97/98	34.6	33.3	35.8	32.9	***	***
	98/99	32.8	30.0	31.6	32.5	***	***
	99/00	33.1	30.9	32.7	30.1	***	***
	00/01	33.7	32.9	33.6	33.3	N/S	N/S
	01/02	31.9	29.4	29.4	33.1	***	***
	02/03	30.7	27.0	30.0	30.7	***	***
	03/04	32.7	32.0	34.4	34.9	***	N/S
	04/05	29.4	29.3	32.8	32.0	N/S	***
DLWG (g)	95/96	229	199	234	216	***	***
	96/97	227	196	229	214	***	***
	97/98	223	211	235	218	***	***
	98/99	202	183	207	213	***	***
	99/00	202	188	210	188	***	***
	00/01	214	204	215	212	***	***
	01/02	204	187	184	209	***	***
	02/03	198	171	194	197	***	***
	03/04	202	203	217	218	***	N/S
	04/05	212	212	220	210	**	N/S

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.

Ellenburg, H. (1988). *Vegetation Ecology of Central Europe*. Cambridge. University Press: Cambridge.

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