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MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

Research and Development

Final Project Report

(Not to be used for LINK projects)

Date project completed:
31/03/1998

- 5 JUN 1998

Section 1 : Identification sheet

1. (a) MAFF Project Code: **OF0111**

(b) Project Title: Organic beef and sheep production in the uplands

(c) MAFF Project Officer: Dr David Garwes

(d) Name and address of contractor: ADAS, Oxford Spires Business Park, The Boulevard, Kidlington.

Postcode OX5 1NZ

(e) Contractor's Project Officer

(f) Project start date 1/4/95 END DATE 31/3/98

(g) Final year costs:

(h) Total project costs / total sta

(i) Date report sent to MAFF

(j) Is there any Intellectual Proj

***staff years of direct science eff**

Approved for final payment

David Garwes

5/6/98

Section 2 : Scientific objectives / Milestones

2. Please list the scientific objectives as set out in CSG 7 (ROAME B). If necessary these can be expressed in an abbreviated form. Indicate where amendments have been agreed with the MAFF Project Officer, giving the date of amendment.

1. Manage approx. 600 breeding ewes and a herd of 30 suckler cows to UKROFS Standards.
2. Compare the physical and financial performance of organic and conventional hill farming systems
3. Collect further data on 5 commercial hill/upland farms linked to the main study
4. Assess the performance and implications of adopting a lower input organic system
5. Assess the effect of organic management on botanical composition and vegetation change
6. Establish a three year plot experiment to assess the performance of approved sources of nitrogen.
7. Complete the a five year plot experiment measuring the performance of approved sources of P & K
8. Establish a Project Steering Committee
9. Provide for adequate dissemination and technology transfer

3. List the primary milestones for the final year.

It is the responsibility of the contractor to check fully that ALL primary milestones have been met and to provide a detailed explanation if this has not proved possible

Milestones	Target date	Milestones met?

If any milestones have not been met in the final year, an explanation should be included in Section 5.

Section 3 : Declaration

4. I declare that the information I have given in this report is correct to the best of my knowledge and belief. I understand that the information contained in this form may be held on a computer system.

Signature R Keatinge

Date 27/05/1998

Name R Keatinge

Position in Organistation Research Consultant

Section 4 : Executive summary

The overall objective of the organic project at ADAS Redesdale is to evaluate the physical and financial implications of converting a hill and upland unit to an organic farming system. Conversion of 400 hectares, 600 breeding ewes (in 3 flocks) and 35 suckler cows was completed in 1993. The current evaluation (1995-1998) took place under full organic production. The assessment is based on comparing organic and conventional farming systems, supported by data collection from commercial organic farms linked to the main project, and a number of replicated experiments.

Grassland management on the Unit integrates three distinct types of grazing; inbye fields (3%), improved hill (17%) and unimproved native hill (80%) for sheep and cattle production. Native hill receives no inputs under organic or conventional management, so that potential differences in output are very much reduced. Low levels of fertiliser and pesticide inputs are made to conventionally managed improved hill land, with only small differences in output and livestock performance. The largest potential differences occur on the more productive inbye land, which receive a high level of inputs conventionally. Relying mainly on clover organically managed swards, have been able to achieve 80%, or more, of the forage output from conventional swards receiving over 200 kg N ha^{-1} . Newcastle University undertook an assessment of botanical composition on native hill, improved hill and inbye fields, producing a modelling framework to predict future change in botanical composition. On the native and improved hill few changes have been detected, mainly due to the maintenance of comparable stocking rates on the organic and conventional systems. However in one flock , where stocking rate was reduced by 25% there were some indications of an improvement in heather cover.

Good levels of livestock performance have been achieved for a hill farming system. However at the same stocking rate, organically managed ewes were consistently lighter and leaner than those managed conventionally. Lambs in the conventional flock grew 5 to 10% and 2 to 17% faster for single and twin lambs respectively. In the organically managed suckler herd, high levels of fertility were achieved. Stocking rates were reduced by 15% and 25% in two further organic flocks, and as a consequence, individual performance remained at a high level for a hill system. Calf growth rates averaged 0.8 kg from birth to sale, as forward stores at 16-17 months of age. Premium markets have been found for organic store lambs and cattle, demonstrating the potential for better integration of organic hill and lowland systems. The health status of organically managed stock has also been good. The main health issues were trace element nutrition and parasite control. A system of alternate sheep and cattle grazing has been implemented to give better control of stomach worms, reducing the requirement for anthelmintic use compared to the conventional flock. Observation studies using homeopathy for orf and pasteurella pneumonia have shown promising results.

Payments made under the Organic Aid Scheme, a premium of approx. 10% on the sale of organic store animals, and reduced forage costs have enabled an organic system to achieve similar, or improved, Net Farm Income relative to the conventional. At lower stocking densities, the individual performance of organic livestock animal was improved, and in appropriate circumstances, the use of agri-environmental scheme payments can offset the reduction in output where stocking rates are reduced to accommodate an organic system.

The results continue to show that an organic hill and upland system can be competitive with conventional production. The unit is recognised as a valuable source of research and information on organic production. The next stage of the project will capitalise on this investment, using the resources available on the Unit to promote and further develop organic farming systems. Further evaluation is planned (1998-2001) to take account of longer term trends in grassland and livestock performance, the continuing evolution of markets for organic produce and the development of production standards for organic livestock.

SCIENCE REPORT - OF0111. Organic beef and sheep production in the uplands, ADAS Redesdale (1995-1998).

A. Objectives

The overall objective of the organic research project at ADAS Redesdale is to evaluate the physical and financial implications of converting a hill and upland unit to an organic farming system. During the first phase of this project (OF0101), approximately 400 hectares of hill and upland grazing , carrying 600 breeding ewes and 35 spring calving suckler cows was converted to organic production. A report was produced summarising the effects of conversion on management, performance and profitability. The objective during the current phase of the project (1995-1998) was to assess performance under sustained organic production. Within the original level of funding, some carry-over of work has been allowed into the first half of 1998/99 to complete collation and final reporting of data relating to the 1997/98 financial year. This includes a refereed paper to summarise the overall results of the project. The agreed scientific objectives as set out in the CSG 7 for the project are given below. These objectives have been met in full.

1. To continue to manage the Unit to UKROFS standards, maintaining organic status on approximately 600 breeding ewes and a herd of 30 suckler cows.
2. To compare the physical and financial performance of organic and conventional hill farming systems, identifying constraints to sustained organic production, effects on animal health and soil nutrient status.
3. To establish 5 commercial hill/upland farms, organically managed or undergoing conversion. From the information collected, to provide a summary report and prepare financial analysis of performance.
4. To assess the performance and implications of adopting a lower input organic system from November 1995.
5. To assess the effect of organic management on botanical composition and vegetation change (Newcastle University sub-contract), providing a framework to develop a model to predict any changes in botanical composition arising from organic management practices.
6. To establish a three year plot experiment to assess the performance of approved sources of nitrogen.
7. To complete the final two years of a five year plot experiment measuring the performance of approved sources of phosphate and potash.
8. To establish a Project Steering Committee
9. To provide for dissemination of information in the scientific literature and popular farming press, at conferences and other fora, and at specialised organic events.

B. Milestones

Primary milestones, taken from the full list of milestones for the project (Annex A) are given below.

01/03	1/5/97	Produce fourth crop of organic lambs\fifth crop of organic calves
02/01	31/5/95	Complete data collection/analysis of Unit performance, annually thereafter
03/01	30/10/95	Establish 5 linked farms
04/02	30/11/95	Reduce ewe numbers (Cairn flock) to establish lower input organic flock heft
05/01	31/7/95	Employ post-grad researcher to undertake botanical assessment (Newcastle Univ.)
06/02	30/9/95	Lay down experimental plots for sources of nitrogen experiment
07/02	31/12/96	Complete final data collection for sources of P and K experiment
08/01	22/8/95	First meeting of Project Steering Committee
09/10	30/9/97	Organic seminar (Redesdale)

Milestone 09/03, Unit Report of third production year will be delivered to the agreed deadline by 30 June 1998.

C. Experimental approach

The overall comparison is based on a systems approach, supported by data collection from commercial organic farms linked to the main project, and a number of replicated experiments.

Management is a 'Two Pasture System', integrating native hill, improved hill and inbye land for beef and sheep production. The sheep enterprise is run in four self-contained flocks, each grazing a distinct area of the hill (heft). Three flocks (Organic Dipper, Cairn and Burnhead) are managed to organic standards: one of these (Organic Dipper) was set up to provide a direct comparison with a fourth flock (Conventional Dipper) managed conventionally as a control. Similar stocking rates have been maintained in the directly comparable Organic and Conventional Dipper flocks. To assess the implications for flock health and productivity of adopting a lower input organic system, stocking rates were reduced by 25% in the Cairn flock from mating in November 1995. Stocking rates on the Burnhead flock was reduced by 15%.

D. Results

A summary of progress during the period 1995-1998 is given below, for each of the scientific objectives agreed for this phase of the project. Comprehensive Unit Reports for each production year have also been produced.

Objective 1. To compare the performance of organic and conventional systems

The performance of comparable organic and conventional flocks (Dargues Dipper), at similar stocking rates, provided a direct comparison of organic and conventional management.

Soil nutrient status

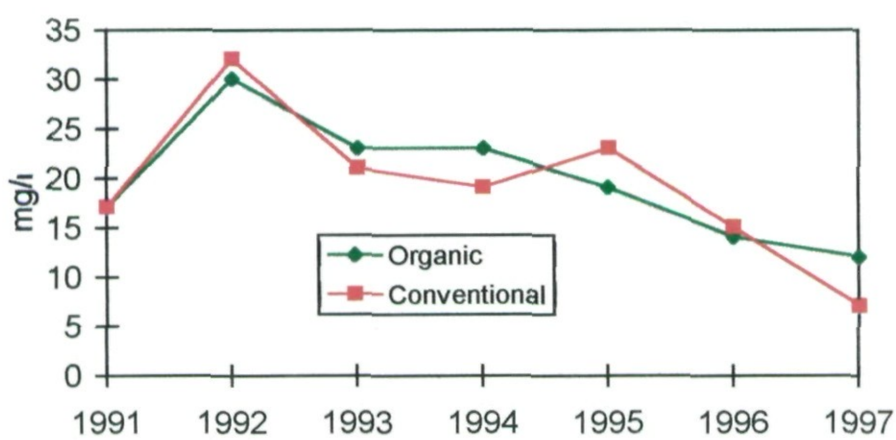
Native hill

As no inputs are made to organic or conventional areas of native hill, any potential differences in soil fertility will take a considerable period to develop. Baseline soil fertility data were collected at the start of conversion. To date no further measurements have been taken.

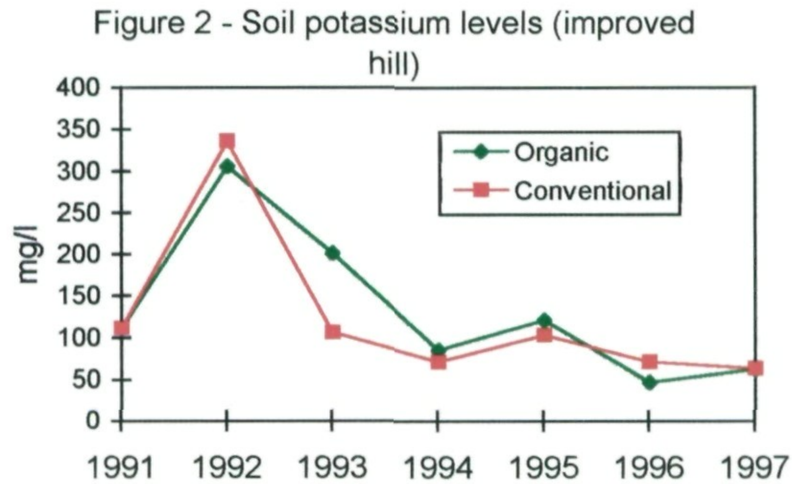
Improved hill

In terms of soil phosphate and potash, there were no consistent differences between organic and conventional management on grazed areas of improved hill.

Figure 1 - soil phosphate (improved hill)



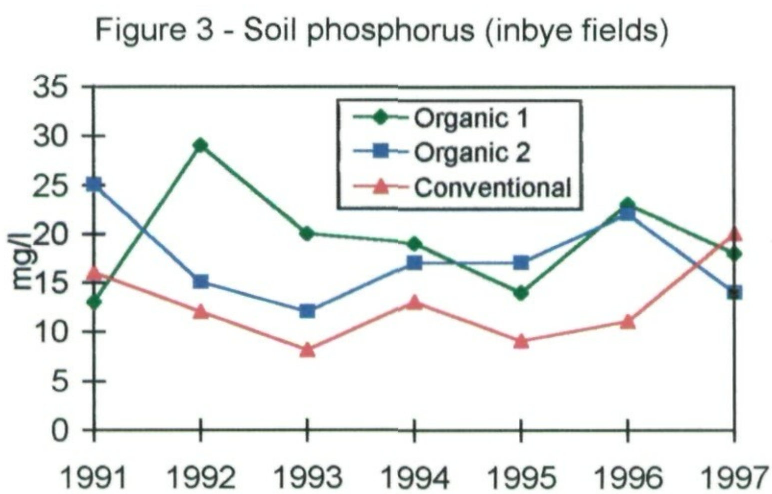
Following conversion, phosphate levels gradually declined under both management regimes, reaching soil Index 0 on the conventionally managed area by the end of 1997 (Figure 1). At soil Index 1, phosphate levels on the organically managed improved hill were still adequate for grass production. Potassium levels also declined under both systems (Figure 2).



On other organically managed areas of improved hill, which had been taken for silage, levels of both nutrients increased to soil Index 2 following application of FYM.

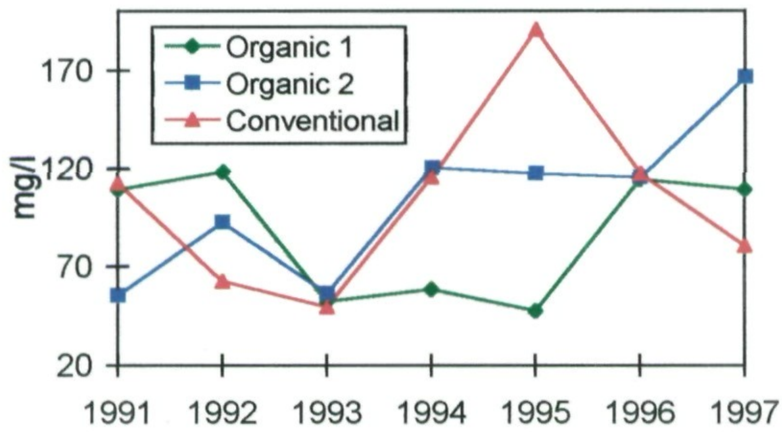
Inbye fields

On inbye fields, soil phosphorus levels were generally satisfactory at Index 1-2 (Figure 3).



However, soil potassium levels were lower and more variable (Figure 4), reaching soil Index 0 on one organically managed field in 1995. Since then, soil potassium has improved following the application of composted FYM.

Figure 4 - Soil potassium (inbye fields)



Forage output

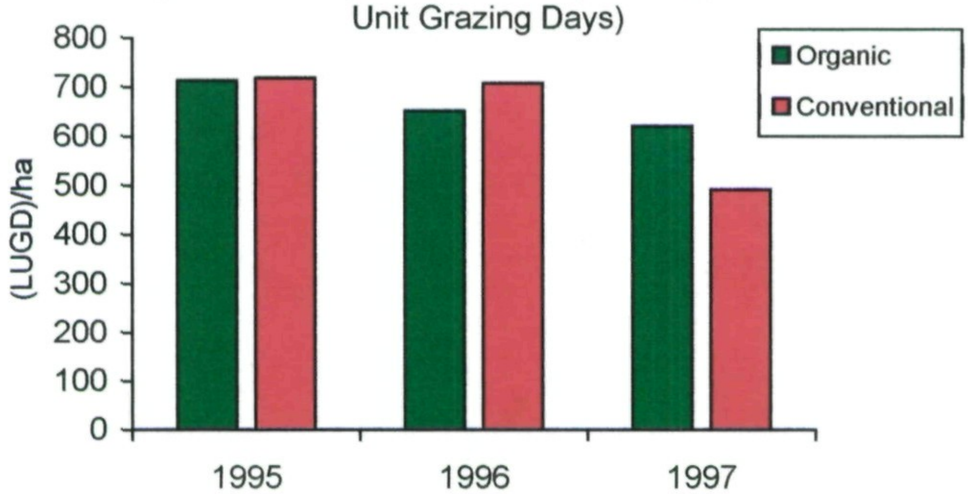
Native and improved hill

As the differences in management between organic and conventionally managed areas were small, no direct measurements of forage output were undertaken on the native or improved hill. However, there was some circumstantial evidence for a reduction in forage output on organic areas of improved hill, compared to the conventional system which received an annual application of 64 kgN ha^{-1} applied in the spring.

Inbye fields

On inbye land, the effects of conversion were potentially much greater. However, output from the organically managed sward (Figure 5) compared favourably with a conventional sward of similar age, receiving 220 kg N ha^{-1} per annum. The result is consistent with earlier years of the project and from the results of replicated trials on the unit, which found that output from a grass clover swards was at least 80% that of heavily fertilised conventional fields. In 1997, output from the conventionally managed area was temporarily reduced because of reseeding.

Figure 5 - Forage output on inbye fields (Livestock Unit Grazing Days)



In terms of botanical composition, sown species content on the organic inbye fields was still high 6 years after reseeding. Clover content was typically double that of the conventionally managed area, peaking at 55% ground cover.

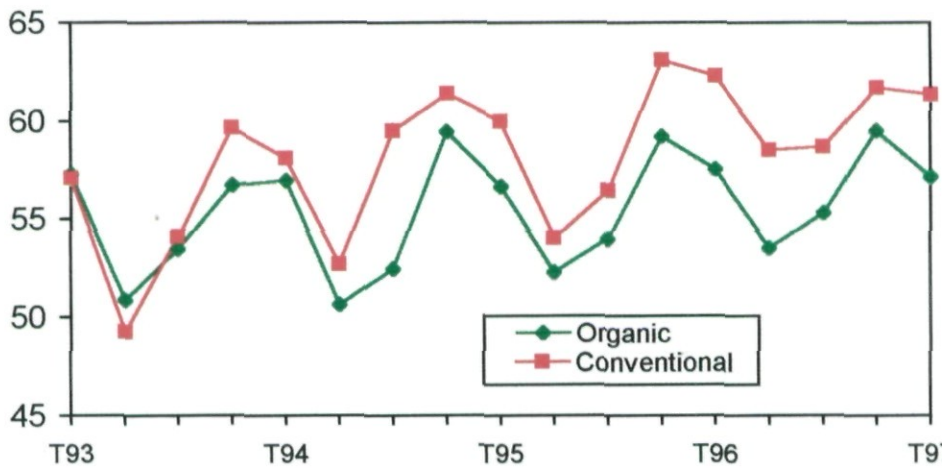
Docks were a problem on one area of organic inbye land, to the extent that dock plants were manually dug out on one portion of the field, while the remainder was ploughed and resown. Other measures, such as composting of FYM, removal of dock seed-heads and more moderate soil potassium levels have helped to mitigate against the dock plants. However, once established on semi permanent grassland docks remain very difficult to control organically.

In some fields and in some years, large numbers of larvae were recovered on the improved hill following routine monitoring for leatherjackets (*Tipula spp.*). No control measures were undertaken on organically managed areas. Although some damage to the pasture occurred during the spring the sward had recovered by the summer, with little apparent loss in overall forage output.

Livestock performance

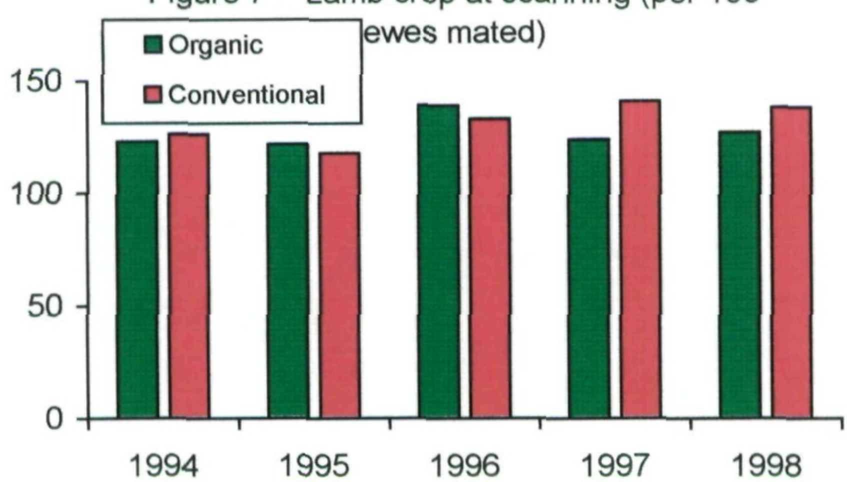
The main comparison of sheep performance was of two comparable flocks, one organic and one managed conventionally, at similar stocking rates. For a hill unit good overall levels of physical performance were achieved from both systems. However, organically managed animals tended to have lower individual performance. Organic ewes were consistently lighter (Figure 6) and leaner, compared to those in the conventional flock.

Figure 6 - Ewe liveweight change



Longterm fertility, expressed as lamb crop at scanning (1993-1998) was similar at 124% and 125% for organic and conventional flocks respectively (Figure 7).

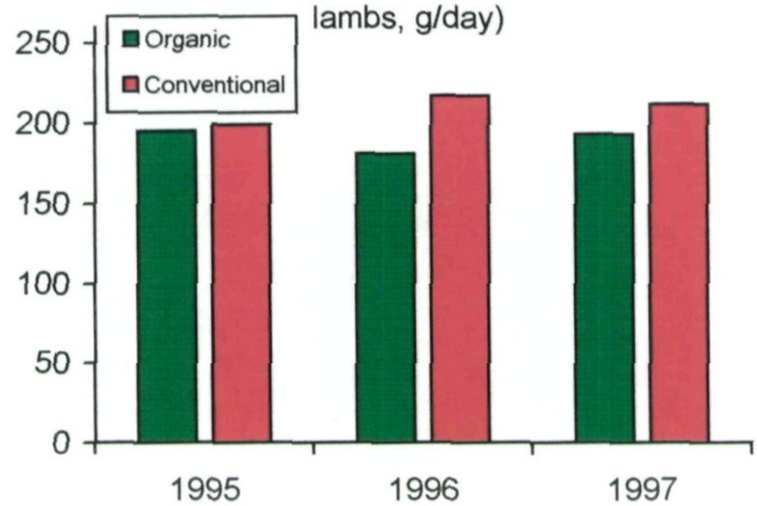
Figure 7 - Lamb crop at scanning (per 100 ewes mated)



However, the conventional flock has tended to be more prolific in recent years. This may be a direct reflection of better body condition at mating. A further period of study will be required to confirm whether reduced prolificacy is becoming a consistent long-term effect of organic management.

Across both flocks, lamb growth rates (1995-1997) from birth to weaning were very acceptable for a hill system at 227 and 200g/day for singles and twins respectively. However, lambs in the conventional flock grew 5 to 10% faster for single and 2 to 17% (Figure 8) faster for twin lambs respectively.

Figure 8 - Lamb growth rates (Twin lambs, g/day)



Suckler herd performance

High levels of fertility have been achieved in the suckler herd. Calf growth rates averaged 0.8 kg from birth to sale to an organic finisher, as forward stores at 16-17 months of age.

Health and welfare

A comprehensive programme of veterinary monitoring was undertaken to quantify effects of management on disease control. The health status of organically managed stock was generally very good. The main health issues were trace element nutrition and parasite control. A significant development was the implementation of an alternate sheep and cattle grazing system to give better control of stomach worms. This reduced the requirement for anthelmintic use compared to the conventional flock, equivalent to a saving of £465 for a flock of 1000 ewes. For the next phase of the project, additional work on parasite control is proposed to reduce further, or eliminate, anthelmintic use in organic sheep systems. As part of a lower input strategy (Objective 4) the elimination of routine flock vaccination has, to date, not increased mortality rates. Observation studies using homeopathy in sheep for orf and pasteurella pneumonia have shown promising results.

Marketing

Premium markets have been obtained for organic store lambs and cattle. The premia obtained from organic finishers have been approximately, 10% for lambs and 10-155 for store cattle. In 1997, the final price differential between organic store lambs sold in September, and conventional finished lambs sold October/November, was approximately 25% due to the slump in conventional lamb prices over that period. A system of store lamb production is very compatible with a hill system, reducing pressure for grazing in the autumn and eliminating any build up in parasitic burden after weaning. However, the market for organic store lambs nationally is still developing and would benefit greatly from a significant expansion in lowland organic production.

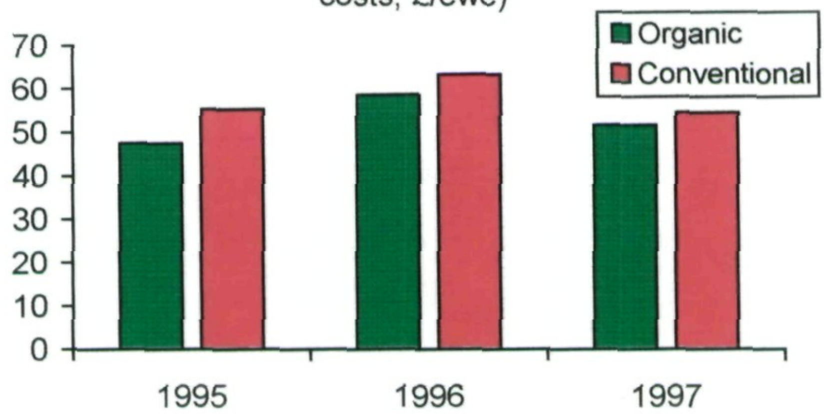
Objective 2. To record and analyse the costs of production

Gross margin

Each flock/enterprise has been fully costed to Gross Margin level.

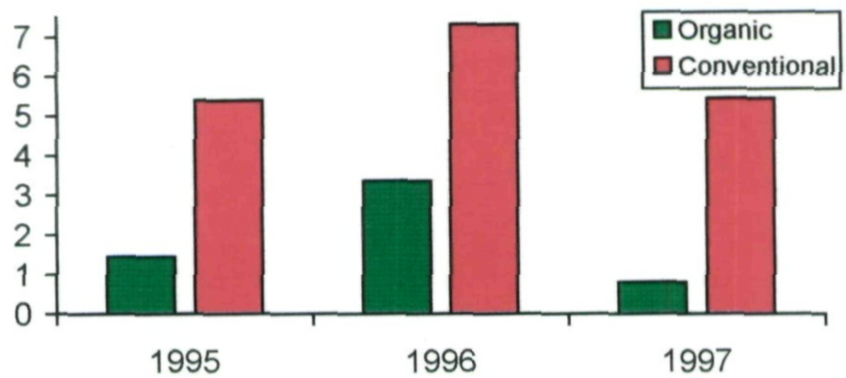
Compared to the conventional flock, the financial performance of the organic system has been very encouraging. Gross margin (before forage costs) has tended to be higher for the conventional flock (Figure 9) mainly due to heavier lambs at weaning and, in 1997, greater numbers of lambs sold. Total variable costs (excluding forage) have been similar. Although veterinary inputs have been significantly reduced, some approved products are significantly more expensive e.g. pour-ons for ectoparasite control, than the conventional products. Organic concentrates were typically twice as expensive as conventionally produced feeds.

Figure 9 - Flock Gross Margin (before forage costs, £/ewe)



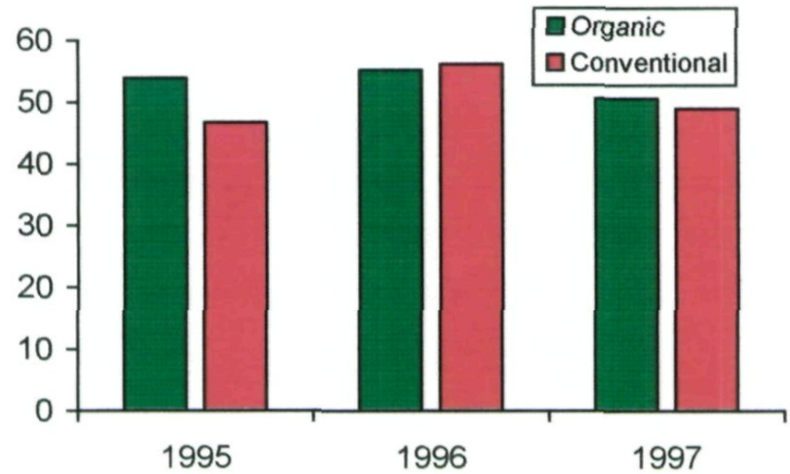
Forage costs for the organic system were considerably lower (Figure 10), due to the absence of artificial fertiliser inputs (predominantly on inbye land) and pesticide applications for leatherjacket control on improved hill. The conventional area of inbye was reseeded in 1997, and the costs have been written off over five years.

Figure 10. Forage costs (£/ewe)



Over the period (1995-1998), Gross Margin per ewe varied from £50.67 to £53.91 in the organic flock , or 98% to 116% that of the conventional flock (Figure 11).

Figure 11 - Flock Gross Margin (£/ewe)

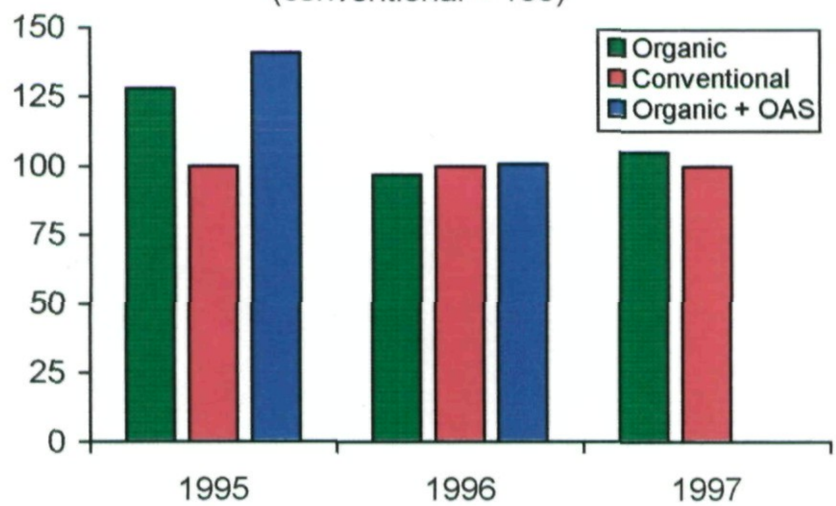


Gross margin in the organic suckler herd ranged from £417 to £504/cow.

Net Farm Income

Whole farm data have been produced by extrapolating enterprise Gross Margin data to a typical hill farming unit (based on Newcastle University survey data) of 1000 ewes and 35 suckler cows. Typical levels of farm fixed cost, and Aid to Conversion Scheme payments were taken into account to provide a Net Farm Income for simulated organic and conventional farming systems (Figure 12) . Although Aid to Conversion payments were on a decreasing scale, ceasing by 1996/97, relative Net Farm Income (conventional = 100) for the organic system was 141, 101 and 105 in 1994/95, 1995/96 and 1996/97 respectively.

Figure 12 - Relative Net Farm Income
(conventional = 100)



Objective 3. To establish a network of linked farms.

The establishment of linked farms has expanded the base of data collection to cover a range of commercial farming conditions. The information collected has been compared with results from conventional farms in FBS surveys by University College Wales and Newcastle University, and with the performance of the organic unit at Redesdale. Financial output from the linked farms is made available to Welsh Institute of Rural Studies, for inclusion in a broader economic analyses of organic farming systems.

Two years financial data (1995/96 and 1996/97) have been reported from seven linked farms (including ADAS Pwllpeiran). For 1997/98, nine farms will be included in the survey increasing to meet a target of ten farms from 1998 onwards. Data for the financial year ending March 1998 will be reported by September 1998. All farms have less favoured area status, and most have completed conversion to organic production. All keep sheep, and most have suckler herds. Mean stocking rate across all farms is estimated to be approximately 0.8 Grazing Livestock Units (GLU) per adjusted hectare.

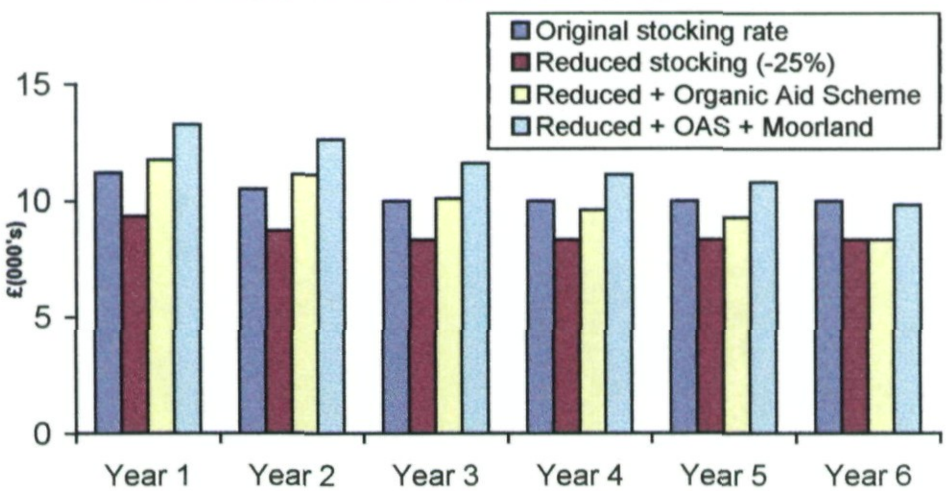
Sheep physical and financial performance were typical for hill farming systems, but under comparable circumstances tended to be lower than that achieved at Redesdale. Financial output per adjusted hectare varied considerably, depending on the mix of enterprises. Variable costs tended to be lower than for conventional units, particularly for forage costs. Although mainly self-sufficient in forage, the majority of farms relied on purchased (usually conventionally produced) feed to meet concentrate feeding requirements. Half of the farms surveyed did not achieve a premium on organic stock sales.

The majority of farms participated in additional agri-environmental schemes, such as Tir Cymen, Farm Woodland scheme etc. Fixed costs varied greatly, but generally high levels (reflecting farm size) significantly reduced Net Farm Income relative to FBS costed conventional farms. Given the small sample size, the results to date need to be treated with caution. However, continuation of the study for a further three years, and an expansion in the number of participating farms to 10, will provide increasing confidence in the validity of conclusions drawn.

Objective 4. To assess the implications of adopting a lower input organic system

The performance of a further two organically managed flocks (Cairn and Burnhead) was assessed following reductions in stocking rate of 25% and 15% respectively. High levels of individual performance have been achieved, particularly where breeding ewe numbers were reduced by 25%. Lamb growth rates for the Cairn flock in 1997 were 247g/day and 217g/day for single and twin lambs respectively. Lamb crop at scanning in February 1998 was 140%.

Figure 13. Results - Effect of OAS and Moorland Scheme payments on Flock Gross Margin



While gross margin per ewe has tended to increase this has been insufficient to compensate for reduced sheep numbers, and flock gross margins have fallen (Figure 13). However, stocking rate adjustments on the Cairn would have been suitable for entry to the Moorland Scheme, which provides a payment of £30 per ewe removed. Combination of Aid to Conversion and Moorland Scheme payments were projected to offset the effects of reduced stocking rate, especially during the first years of conversion.

Objective 5. To assess effects of organic management on vegetation change.

The aim of this research was to investigate the effects of adopting an organic farming system on key plant and animal groups. The central hypothesis tested was whether consequences of organic farming could be predicted from models linking management and life history characteristics of plants and animals. The first phase of the research (1991 to 1994, Project Code OFO101) assessed effects on the dynamics of vegetation and earthworm communities during conversion. Subsequently research effort has concentrated on vegetation dynamics.

The vegetation was monitored using fixed $1m^2$ quadrats, surveyed annually (inbye and improved hill land) or biennially (native hill). The vegetation data were used to quantify differences in species abundance over time, and as inputs for a community level model. The model used the National Vegetation Classification (NVC) as a reference point for comparison with the vegetation communities identified at Redesdale. The major plant community types found at Redesdale were placed in ordination space along with fixed positions of the NVC communities which typify these community types. The temporal movement of plant communities indicated the response to organic or conventional regime.

Native hill

There has been little evidence of any differences in botanical composition between directly comparable organic and conventionally managed areas of the native hill. Both systems respond to environment more than minor differences in the minimal levels of management applied. However, where stocking rate had been reduced (Cairn heft - see Objective 4.) analysis of the data indicated an increase in the cover of *Calluna vulgaris* between 1995 and 1997. This increase was not statistically significant, especially given the short interval between assessments. The changes were not simply due to re-growth on the burnt areas, suggesting an effect of reduced stocking rate. However, a further period of monitoring is required to confirm whether this is a consistent long-term trend.

Improved hill

On marginal hill land, improved swards are frequently invaded by *Agrostis* spp. and *Holcus lanatus*. Over time, improved pasture subcommunities of *Lolium perenne- Cynosurus cristatus* grassland (NVC - MG6) would tend to degenerate to *Festuca ovina-Agrostis tenuis-Galium saxatile* grassland *Holcus-Trifolium* subcommunity (NVC- U4b).

At Redesdale, the dynamics of both organic and conventional communities on the improved hill were affected by interactions between *Lolium perenne, Trifolium repens, Holcus lanatus* and *Agrostis* spp. Although there were large populations of *Agrostis* spp. and *Holcus lanatus*, there was no evidence from the ordination model to suggest that the MG6 to U4b degeneration was occurring on the improved hill swards, under either regime.

Inbye land

In the case of the organic in-bye communities, vegetation dynamics now appear to be dominated by interactions between three major species (*Lolium perenne, Trifolium repens* and *Phleum pratense*). For both types of in-bye system, the highly productive *Lolium perenne* and *Phleum pratense* are strongly competitive because they are growing on soils with a high nutrient status and where environmental conditions favour rapid plant growth.

The quality of the organic in-bye swards has been consistently better in terms of raised *Trifolium repens* and reduced weed populations than in the conventional in-bye. However, this does not imply large changes to NVC classification. The initial classification of in-bye swards as *Lolium perenne* ley (MG7d or MG7f), reflected low cover of *Trifolium repens* at conversion. As *Trifolium repens* established on the organically managed fields, there was a movement towards the *Trifolium* subcommunity MG7a. The subsequent change in the composition of in-bye swards to one of the *Lolium perenne-Cynosurus cristatus* grassland (MG6) subcommunities represents in part, the establishment of other grass and herb species.

The quality of these swards is maintained by the intensive levels of management, which prevent succession to communities such as U4b (*Festuca ovina-Agrostis tenuis-Galium saxatile* grassland, *Holcus-Trifolium* subcommunity). However, this potential succession is not simply averted because of the management. The swards also respond to site-specific environmental forcing variables, such as proximity to sources of weed invasion and sensitivity to factors favouring weed invasion, such as ground disturbance. Weed sources which contributed to sward deterioration or poor sward quality during establishment were generally a persistent seed bank e.g. *Stellaria media*, directly via seed-shed e.g. *Bromus mollis*, or by invasion from adjacent land e.g. *Alopecurus geniculatus, Holcus mollis.* Most of the cultural techniques of either the organic regime adopted here, or of a conventional regime, do not differ sufficiently to suggest them as sources of differences in the vegetation dynamics.

In addition a formal Conservation Plan has been drawn up, and is currently being implemented on the Unit.

Objective 6. Replicated experiment - Approved sources of nitrogen

Composting of solid manure or aeration of slurry, is frequently advocated for organic farming systems. European research has demonstrated the potential for both processes to reduce nutrient losses at spreading, limit disruption to soil processes and reduce the viability of weed seeds and pathogens. However, there has been relatively little comparative research on the agronomic effects of treatment within UK organic systems.
The aim of this experiment was to compare the performance of treated and untreated farmyard manure and slurry, with zero nitrogen and conventional nitrogen controls when applied to sown upland pasture under an organic system of management.

Seven treatments were imposed in a randomised complete block design. The treatments were; composted (Treatment A) and uncomposted (B) FYM; aerated (C) and unaerated (D) cattle slurry; ammonium nitrate (E); and zero nitrogen control (F). A further control treatment (G), to which slurry was applied in 1996, was added to provide a common control treatment over both years of the experiment. For the organic unit as a whole, it was assumed that 150 kg/ha total N would be available from livestock wastes. This rate of total N was applied to untreated slurry and FYM treatments (treatments B, D and G). Following aeration, a similar volume of slurry was applied to treatment C as to unaerated slurry treatments. Ammonium nitrate was applied at a rate equivalent to 240 kg/ha N, consistent with conventional management at Redesdale. Because composted and uncomposted FYM were not available from the same original source, composted FYM was applied at a rate to supply 80% (120 kg/ha) of total N compared to untreated FYM treatment. The experiment was originally intended to run for three years, and two years harvest data have been collected.

Compared to the untreated control, relative herbage yields were 111, 109, 102, 107, 121 and 113 for treatments A to E, and G respectively ($P = 0.005$). The yield response was 11.3 kg, 4.1 kg, 1.8 kg, 6.0 kg, 10.5 kg, and 10.2 kg herbage DM per kg total N applied. Compared to all slurry and FYM treatments, ammonium nitrate significantly increased herbage yield ($P = 0.012$), and reduced clover content in the sward ($P = 0.007$). Highest nutrient uptake occurred where ammonium nitrate had been applied, representing 132%, 117% and 153% of the untreated control for potassium, phosphate and nitrogen respectively. The yields achieved in 1996 were consistent with previous research on grass/clover systems and confirm the results of field scale comparisons of organic and conventional management at ADAS Redesdale.

However, in the second year (1997) yield differences were greatly reduced, possibly due to a rapid depletion of potash, which may have limited responses to high levels of artificial N. It is intended to complete the third year of the experiment during 1998/99, having restored soil potash levels.

Objective 7. Replicated experiment - Approved sources of P and *K*

The objective of this experiment was to assess the response in herbage yield, botanical composition and soil nutrient status to approved sources of P and K, when applied to organically managed grassland. Two sites were involved; on inbye land under a grazing and cutting regime, and on improved hill under a simulated grazing regime.

Inbye site

A total of 18 treatments were imposed in a randomised block design, with three replicates of each treatment. Treatments consisted of various sources and combinations of P and K fertiliser. Sulphate of Potash and Triple Super Phosphate were used to simulate conventional treatments. On organically managed plots, Kali vinesse and Rock Potash were used as sources of potassium, while Ground Rock Phosphate and Reddzlagg were used as phosphate fertilisers. The experiment ran for five years from 1991 to 1996. Across all treatments, mean herbage yield (kg/dry matter ha^{-1}) was 6530, 9402, 7292, 9154 and 8735 for 1992 to 1996 harvest years respectively. Mean clover content (%) was 2.5, 3.0, 8.7, 12.2 and 8.0. Statistically significant differences in herbage yield were obtained only in 1994 and 1996. Treatment differences in clover yield (kg/dry matter ha^{-1}) were significant in three out of five years. The response to fertiliser application (irrespective of source) was small. There was little evidence of any response in total herbage yield or in botanical composition from the use of additional phosphate. However, there was a tendency for potassium fertiliser (particularly the more soluble forms) to improve clover content and total clover yield. The source of potassium fertiliser used had a direct effect on potassium content of the herbage. The highest rates of nutrient release into the soil and uptake in herbage were obtained from Sulphate of Potash, Triple Super Phosphate, and from Kali vinesse. Rock Potash was particularly insoluble. Levels of extractable P in the soil were maintained only where Triple Super Phosphate had been applied. Levels of extractable K were highest following the use of Sulphate of Potash and Kali vinesse.

Improved hill site

Five treatments were applied in a randomised block design. The treatments were; control, Rock Potash, Kali vinesse, Ground Rock Phosphate, and Rock Potash plus Ground Rock Phosphate. For each year of the experiment, mean dry matter yields (kg/dry matter ha^{-1}) were 9690, 6584, 2798, 3989 and 10,562 respectively. There were no statistically significant treatment differences in herbage yield or in mean clover content. However, in four out of five years the highest mean clover content was obtained where Kali vinesse had been applied.

For both sites lower inherent fertility, or a longer period of study, may be required in order to obtain significant responses to applied fertiliser. However, the relative cost and in some cases very low solubility, of these permitted materials underlines the continuing importance of animal manures for nutrient cycling on organic farms.

Objective 8. Project Steering Committee.

A Project Steering Committee was established in 1995, combining a cross section of interested parties (MAFF, organic farmers, researchers, regulatory bodies) under the chairmanship of MAFF Science Division. The committee has been very successful, providing valuable scientific and commercial perspective on the management of the organic unit and the research work undertaken. In particular it has provided a forum to discuss the balance of economic objectives within the project and the wider principles of organic farming.

Objective 9. Dissemination of information.

Technology transfer has been given a high priority, particularly given the accumulation of research results during the life of the project. Dissemination has been targeted at both organic and conventional audiences.

Full technical and financial reports for the project have been submitted to MAFF annually.

A well attended **Organic Seminar Day** was held at Redesdale in August 1997, promoting research results to a wide cross section of interested bodies, press and producers.

Conference Papers were presented at;
- Trawsgoed Organic Seminar (May 1995)
- Crop Protection in Northern Britain (March 1996).
- Sheep 96 (Seminar paper, July 1996)
- Organic Farming Conference, Cirencester (January 1997)
- RASE Conference at Stoneleigh (November 1997)
- Beef for the Market (Seminar paper, February 1998).

Technical articles were written for:
- New Farmer and Grower (Winter 1996, and Autumn 1997)
- The Grass Farmer (Summer 1997)

Interviews were broadcast by BBC TV (Landward - August 1996) and BBC Radio 4 (September 1997).

The project has been publicised widely in the **popular press**;
- Farmers Weekly, Farmers Guardian, Scottish Farmer, The Journal, Yorkshire Post.
- ADAS Publications such ADAS Alliance (circulation 25,000) and ADAS Research.
- and at the Royal Show, 1996 and 1997.

Specific presentations have been given to;
- ELM Farm Beef and Sheep Group (August 1997, October 1997)
- Annually to agricultural students from Newcastle University and Newton Rigg college.
- A meeting of EC suckler cow researchers (September 1997).
- The National Trust
- presentations are planned for FRCA and a party of Nuffield Scholars.

Visitors to the project have included;
- Individuals and farmer groups (totalling several hundred)
- Scientists/extension workers from UK, France, Germany, Chile and Uruguay.
- Representatives of two major supermarket retailers
- Dr John Sherlock (MAFF Science Division) and Mr Dudley Coates (Conservation Policy Division).

A refereed scientific paper, summarising the results of the work (1995-1998) will be prepared by September 1998.

E. Implications of results

Ten million hectares in the UK are classified as Less Favoured Areas, of which 65% is hill and upland. Uptake of organic farming in hill areas, particularly by medium/large farms, continues to be slow. This is mainly because farmers remain less convinced about the longterm viability of the organic system, perceived risks to animal health and the availability of a sustained organic premium.

For most hill and upland farmers, a decision to convert to an organic management system will be an economic one. To date, the results from Redesdale have been very positive, indicating that an organic system can achieve a good level of physical and financial performance. Payments made under the Organic Aid Scheme, a premium on the sale of organic store animals, and reduced forage costs have enabled the organic system to achieve similar, or *improved,* Net Farm *Income relative to the conventional.*

At lower stocking densities, the individual performance of organic livestock animal may be improved, and in appropriate circumstances, the use of agri-environmental scheme payments can offset the reduction in output where stocking rates are reduced to accommodate an organic system. Successful links have been established with lowland farms for the sale of organic store animals, indicating the potential for better integration of hill and lowland organic systems. The development of organic markets in the UK, EU policy, and EU standards for organic production are further factors, which will influence the long-term performance and potential uptake of organic farming in hill and upland areas.

F. Future work

The established organic unit at ADAS Redesdale provides an ideal resource to continue the promotion of organic farming in hill and upland areas. The unit is now recognised as a valuable source of research and information on organic production. The next stage of the project (OFO147) will capitalise on this investment, using the resources available on the Unit to promote and further develop organic farming systems. This will take account of longer term trends in grassland and livestock performance, the continuing evolution of markets for organic produce and the development of production standards for organic livestock. Detailed measurements will continue of physical and financial performance, animal health and welfare, and botanical change. Specific investigations are proposed into aspects of parasite control and trace element nutrition. Data from 10 commercial organic farms linked to the main project will be used to broaden the information base, particularly for financial performance. Results from the project will continue to be communicated through appropriate media to current and prospective organic farmers, to research and extension workers and to MAFF, thereby aiding policy formulation on organic farming.

G. Other

As yet there are no issues relating to **Intellectual Property** arising from this study.

Proposals for the development of 'farmer friendly' literature to better exploit the findings and technical messages arising from the study have been presented to MAFF.

File reference: RSC

ANNEX. A

Milestone no.	Target date	Description
01/01	1/5/95	Produce second crop of organic lambs/third crop organic calves
01/02	1/5/96	Produce third crop of organic lamb\fourth crop organic calves
01/03	1/5/97	Produce fourth crop of organic lambs\fifth crop of organic calves
02/01	31/5/96	Complete data collection and analysis for financial appraisal
02/02	31/5/97	Complete data collection and analysis for financial appraisal
02/03	31/5/98	Complete data collection and analysis for financial appraisal
03/01	30/10/95	Establish 5 linked farms
03/02	31/11/95	Commence data collection
03/03	31/12/96	Complete annual data collection for 1995/96
03/04	31/12/97	Complete annual data collection for 1996/97
04/01	31/10/95	Complete botanical survey of Cairn heft
04/02	30/11/95	Reduce ewe numbers to establish lower input organic flock (Cairn)
05/01	31/7/95	Employ post-grad researcher to undertake botanical assessment
05/02	22/8/95	Prepare detailed project proposals for Project Steering Committee Meeting
05/03	30/12/95	Complete annual data collection on the Unit, thereafter Dec 96, Dec 97.
05/04	31/3/96	Annual report of vegetation dynamics & modelling, March 97 March 98
05/05	31/3/98	Provide modelling system for predicting vegetation dynamics (6 yrs data)
06/01	31/8/95	Agree treatments (sources of Nitrogen) to be imposed
06/02	30/9/95	Lay down experimental plots
06/03	31/10/95	Complete pre-treatment sampling
06/04	31/1/96	Commence treatments
07/01	31/10/95	Complete annual data collection for P/K experiment
07/02	31/12/96	Complete final data collection
07/03	31/3/97	Final report
08/01	22/8/95	First meeting of Project Steering Committee
08/02	31/3/96	Second meeting of Project Steering Committee
08/03	30/9/96	Third meeting of Project Steering Committee
08/04	31/3/97	Fourth meeting of Project Steering Committee
08/05	30/9/97	Fifth meeting of Project Steering Committee
08/06	31/3/98	Sixth meeting of Project Steering Committee
09/01	30/6/96	Unit Annual Report (1994/1995)
09/02	30/6/97	Unit Annual Report (1995/1996)
09/03	30/6/98	Unit Annual Report (1996/1997)
09/04	31/5/95	Presentation to Trawsgoed Organic Seminar, May 1995
09/05	31/12/95	Presentation at British Grassland Soc. 50th Anniversary Meeting, Dec 95.
09/06	31/3/96	Presentation at Crop Protection in Northern Britain Conference, March 96.
09/07	31/8/95	Submit presentation to Assoc. Applied Biologists Meeting, March 96
09/08	31/12/96	Submit presentation to Biennial Organic Food Conference, January 97.
09/09	31/3/97	Submit presentation to British Ecological Society, Winter 1997
09/10	30/9/97	Organic seminar (Redesdale)