Annual ARGOS Sheep/Beef Sector Report 2010

Compiled by David Lucock

December 2010
Executive summary

The Agriculture Research Group On Sustainability (ARGOS) is investigating the environmental, economic and social characteristics of primary production systems in NZ with the goal of assessing the sustainability and resilience of farming. In the Sheep/beef sector, three main production systems are being compared i.e. organic, integrated and conventional. This report describes the main features of these and the differences between them and is set out in four sections; Farm management, Economics, Environment and Social

Farm management

Farm management gives an overview of farms involved in the ARGOS project and continues to extend the changes over time for stocking rate, stock ratios, lambing percentage, supplement management, fertiliser and labour inputs and how these differ between the 3 management systems.

An alternative metric

Meat production as a key performance indicator is introduced and analysed to describe

- Net meat exported from the farm
- The cost of producing a kilogram of meat
- Monthly meat ‘flows’ (when meat leaves the farm as a proportion of total meat exported.
- Net lamb (meat) exported as a proportion of sheep wintered. Sheep include support stock (rams and replacement hoggets as well as breeding ewes)
- Correlations between meat production, expenses and economic farm surplus

An energy return on investment is also introduced comparing management systems and sectors (sheep/beef and kiwifruit) in ARGOS and challenges thoughts on ways to become more energy efficient.

Economics

Farm financial analysis

Financial data for the 2008/09 production season have been collected and seven year’s financial data from the ARGOS sheep/beef farms have now been analysed to determine the impacts of management system on farm financial performance. The financial position of the ARGOS sheep/beef farms, which had deteriorated throughout the first six years of the ARGOS programme, improved during 2008/09. A similar trend was observed in the reported results of the MAF farm monitoring survey for that year.

Capital indicators

The capital based approach argues that for future generations to be as well off as the present than the capital base should at least be maintained. ARGOS has found a number of significant differences for different measures of capital. These included human-made capital (i.e. land & buildings, plant and machinery) and natural capital (e.g. soil quality and biodiversity). However, there is no right or wrong level for many of these. What is more important is change over time.
Environment

Bird monitoring on ARGOS farms

Birds were surveyed for the third time in 2009/10. Overall, introduced species were much more abundant (per hectare) than native species and there was no evidence that bird densities varied in relation to management panel within the sheep-beef sector for any of the subsets of species considered in the analyses.

Soil

The comparison of soil properties between sheep and beef and dairy sectors showed that although there were large differences in energy inputs and EROI values, there were few differences that indicated these increased with an increase in farming intensity. A greater number of differences in soil properties were observed in response to management effects between organic and conventional/integrated systems across both sectors, mainly those related to soil fertility. Most of the overall difference in soil properties found between sectors and panels was due to soil order and land-use characteristics rather than management system effects. With dairy Organic an establishing group, further differences in soil properties between organic and conventional panels may still yet develop.

Social

During the past year, the ARGOS social research team initiated a new round of interviews to examine the historical experience of crisis and change in each of the project’s sectors: sheep/beef, kiwifruit and dairy. While it is too early to report on findings from these interviews (that are only in the initial stages of coding and analysis), we expect them to provide good insight to the capacity for resilience demonstrated by ARGOS participants as well as the pathways that have contributed to or enhanced this capacity. It appears that the variation in farmers’ approaches to management is a vital element in the resilience of the sector as a whole. Each panel or type of farmer contributes to the capacity of the sector to provide consistent supply and to continually explore and experiment with alternative practices and technologies. For example,

- Conventional farmers ensure that a continuity of supply to an industry currently focused on export commodity production.
- Integrated farmers enable processing firms to explore the potential of quality assured production contracts, testing the waters with the assistance of those more willing to assume some of the risks and new practices involved.
- Finally, organic farmers provide a real world laboratory in which alternative and less chemically intensive practices can be attempted, tested and perfected as potential future options for the whole of the sector.

The understandings of farmers’ actions and attitudes developed during the first six years of the ARGOS project also help us to assess a variety of pathways to sustainability.
Preface

ARGOS was formed at the end of 2003 with work beginning in earnest in 2004. The first Annual ARGOS Sector Report for Sheep/beef was produced in 2005 and contained findings from the first 12 – 18 months of the programme. The following three annual reports presented the results of subsequent research. This fifth instalment focuses on findings from the last 12 months.

Full reports for much of the content in this report are available from ARGOS; many can be downloaded freely from www.argos.org.nz

Every effort has been made to ensure that all the information within is accurate. However, if there are any errors, please let us know as soon as possible so that we can correct our data for future analyses.

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Disclaimer

Every effort has been made to ensure the information in this report is accurate and free of errors. ARGOS does not accept any liability for any losses or damage caused by the use of information in this report.
Acknowledgments

This work is funded by the Foundation for Research, Science and Technology (Contract Number AGRB0301). ARGOS also acknowledges financial assistance from Industry stakeholders including ZESPRI, a meat company, Fonterra, Merino New Zealand Inc., COKA (Certified Organic Kiwifruit Growers Association) and in-kind support from Te Runanga O Ngāi Tahu.

The ARGOS programme has been designed and implemented with the intention of providing quality information to both farmers and orchardists and their associated industries to ensure that they are broadly sustainable, internationally competitive and profitable. To facilitate this we greatly value the involvement of all the participants and industry partners.

Each sector in the programme has an oversight committee which typically meets twice a year to review progress and provide suggestions on how ARGOS can enhance its overall performance. ARGOS is grateful to the contribution of everyone on these committees.

A number of ARGOS staff and affiliated researchers have contributed content to this report and this is gratefully acknowledged.
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1 ARGOS Overview

Introduction
The Agricultural Research Group on Sustainability (ARGOS) is an unincorporated joint venture between the AgriBusiness Group, Lincoln University, and the University of Otago. It is funded by the Foundation for Research, Science and Technology (FRST) and various industry stakeholders and commenced in October 2003. ARGOS is a longitudinal research project with the aim to model the economic, environmental, and social differences between organic, and conventional systems of production. The aim is to detail the impact of these systems and develop indicators which reflect the interactions across the social, economic and environmental factors.

1.1 Levels of focus in the ARGOS Project
The prime aims of this study are to undertake a comparison between agricultural sectors and between management systems within those sectors. Landforms, management units (i.e. paddocks) and soil monitoring sites are also being studied, at the individual farm level.

Agricultural Sector. ARGOS is studying dairy, high country and farms owned by Ngai Tahu landowners in addition to kiwifruit and sheep & beef farms.

Management System. For sheep and beef properties, the following three management systems are being studied:
- Organic
- Integrated - follow a broad base industry assurance programme
- Conventional
These 3 management systems may also be referred to as 'Panels' i.e. there is a panel of organic farms, a panel of integrated farms and a panel of conventional farms.

Cluster. ARGOS farms are arranged in clusters with one farm from each panel within a cluster i.e. each cluster has one organic farm, one integrated farm and one conventional farm. There are 11 clusters situated between Blenheim and Gore. Within each cluster, farms are as close together as possible to minimise differences in background variables like soil type and climate.
2 Farm Management

Introduction

Farm Management, in ARGOS, is studied from a management systems approach in 3 main areas; economic, social and the ecological environment. ARGOS’s economics objective looks at the production aspects (both financial and non-financial) through to the socio-economics of production systems. The social objective of ARGOS studies the ‘people’ implications of the systems, motivational drivers, life cycles, whilst the environment objective looks at the impact/implications of the farming system on the environment. Boundaries of the three objectives overlap, leading to overarching research that is an optimal transdisciplinary study of farming systems. It was recognised that generic descriptors, of the farms under study, need to be supplied to the three objectives and this led to ARGOS’s fourth objective, the farm management objective. The role of the farm management objective includes collecting physical and managerial style farm data and the preliminary analysis of this data, where appropriate.

2.1 Overview of farms

The ARGOS Sheep/Beef farms cover a total of 14,346 hectares, carrying 119,000 stock units, in eleven locations from Scargill to Gore (Figure 1). Farm sizes range from 145 to 1370 hectares, with a mean size of 340 hectares. Rainfall ranges from approximately 400 to 1100 mm/yr. The farms have similar overarching farming strategies in that their management is based around pastoral based systems with varying degrees of cropping. Cropping types range from fodder to cereal to small seeds production, mainly in mid Canterbury to predominantly fodder crops in Southland. Livestock production on most farms is predominantly lamb sales.

Figure 1 Location of Properties under study by ARGOS
2.2 Differences between organic, integrated and conventional farm systems

The 2009 annual management report contained an analysis of physical attributes of sheep/beef farms involved in the ARGOS project. In this edition we continue to add another years data (another point on the graph), but without the statistical analysis as we expect there to be little change in this between the years.

2.2.1 Stocking rate

The average stocking rate per hectare remained fairly constant for both organic and conventional systems and decreased by approximately 1 stock unit per hectare for the integrated management system.

![Stocking density on ARGOS sheep and beef farms](image)

**Figure 2** Stocking density on ARGOS sheep and beef farms

2.2.2 Stock ratios

Stock ratios stayed fairly constant for all management systems.

![Percentage of sheep to cattle and/or deer](image)

**Figure 3** Sheep to cattle ratios (su) between organic, integrated and conventional systems
2.2.3 Lambing percentage
Lambing percentages lifted for all management systems for the 2008/09 season with the greatest increases coming from organic and conventional farms having the sharpest increases.

Figure 4 Lambing percentages on ARGOS sheep and beef farms

2.2.4 Supplement management
Interestingly the amount of supplement on hand at June 1 (2009/10) had reduced by approximately 20% on average across all panels (Figure 5) compared with the previous season. Likewise, on average, 60% less supplement was fed out per hectare and per stock unit in 2009/10 season compared with the previous season (Figure 6). Organic farmers tend to store larger amounts of supplements possibly due to difficulty in sourcing organic supplements.

Figure 5 Supplements on hand 1 June on ARGOS sheep and beef farms.
Supplements fed out annually on ARGOS sheep and beef farms.

2.2.5 Fertiliser use
Tonnage, type of fertiliser purchased, and the application rate have now been broken down to a nutrient per hectare basis for seven years from 2003/2004 to 2009/2010. Compost and Biodynamic Teas were not included in the analyses due to lack of information on their nutrient content.

The charts (Figures 7 to 12) show that integrated and conventional farmers use on average higher amounts of, phosphate, sulphur, potassium and nitrogen than organic farmers, whereas organic and integrated farmers applied more amounts of calcium than conventional.

Conventional forms of nitrogen were not applied to organic farms. The vast majority of nitrogen applications were at rates of less than 50 Kg/ha with less than ten applications of 100 - 250 Kg/ha. The majority of both potassium and phosphorus applications were less than 30 Kg/ha and generally less than 10 Kg/ha. Year-to-year consistency of N application was similar between conventional and integrated farms with applications on 75% and 82% of the farm years recorded for these groups respectively.

A similar trend is evident in the application of phosphorus, where relative to the conventional group the integrated group was slightly higher and the organic group lower.

For potassium, applications by the conventional group tended to be slightly higher than the integrated group and significantly higher than the organic group. Likewise conventional and integrated applied significantly more Sulphur.
**Figure 7** Nitrogen inputs on ARGOS farms over 6 years

**Figure 8** Phosphate inputs on ARGOS farms over 6 years

**Figure 9** Potassium inputs on ARGOS farms over 6 years
Figure 10 Sulphur inputs on ARGOS farms over 6 years

Figure 11 Calcium inputs on ARGOS farms over 6 years

Figure 12 Magnesium inputs on ARGOS farms over 6 years
2.2.6 Labour
Labour ranges from part time unpaid (family members) to fulltime staff. Managing the workload can have a financial impact on the profitability of the business and there is often a balance required between how much time the farm owner can spend working on the farm and social and long term economic consequences if not enough time is spent away from farm work. Therefore, the system that farmers adopt to manage their workload is one that requires careful consideration. Below we quantify the time per stock unit that it takes to run a property and how this varies across properties over 2 years in hours per week per 100 ha and hours per week per 1000 su.

![Figure 13](image1.jpg)

**Figure 13** Time quantified to manage ARGOS sheep/beef properties

Hours/week/1000 su only differed at the 10% level and this was because of 3 organic properties. Removing these 3 properties from the analysis would remove all significant differences between management systems. Despite the similarities when the management systems are averaged, the degree of variability within management systems is large as shown in Figure 14 and Figure 15. The numbers along the x axis represent the geographical clusters that the farms belong to. For example organic 2 is in the same geographic location as integrated 2 and conventional 2.

![Figure 14](image2.jpg)

**Figure 14** Labour hours per week per 100 hectares
Organic properties 2, 3 and 5 have increased labour input due to incorporating further food processing into their businesses. Cluster 7, (integrated) converted to a dairy farm, which now has an increased labour density and clusters 4, 5 and 6 have a large degree of cropping.

As expected the correlation between hours worked per week per 100 hectares and the cost of labour (including non-paid and wages of management) was strong ($r = 0.86$), however this decreased to ($r = 0.72$) when compared with labour hours worked per week per 1000 stock units possibly highlighting the influence of cash cropping enterprises on the overall result.

### 2.3 Meat Production

This section outlines differences found in total meat production, distribution of animal sales and purchases, and costs per kilogram of meat exported amongst ARGOS farms. It attempts to develop a richer picture of physical farm performance by using ‘net meat export’ as a key performance indicator, and discusses the difficulty of developing measures that illustrate differences between management systems where there is high variability between farms employing the same management system.

The net meat exported from a farm in any season was defined as the difference between the total weight of livestock on hand at opening (May 31) and the weight on hand at closing (June 1) plus the difference between the total weight of stock sold and purchased during the season. This data was collected for four seasons from 2006/07 to 2009/10.

Net meat export data was benchmarked with matching Beef + Lamb NZ stock classes and farm types and showed similar trends with lamb as the dominant meat sold, followed by cattle (Table 1). Interestingly lamb sales for organics were less than Meat + lamb NZ, integrated and conventional in 2007/08 and 2008/09 under the S.I Hill country and S.I Finishing categories, but very similar under S.I Mixed Finishing. This suggests intestinal parasites may be less challenging under a mixed cropping regime because farmers are able to ‘cleanse’ land of parasite larvae with a cropping phase.

Low or negative values for individual years may indicate that more stock was retained due to increasing land size (see table 1, S.I Hill Country, ARGOS conventional total for 2008/2009); therefore it is more important to monitor values over time.
Table 1 ARGOS net meat exported data (kg/ha) benchmarked with Beef + Lamb New Zealand

<table>
<thead>
<tr>
<th>ARGOS - All</th>
<th>2006/07</th>
<th>2007/08</th>
<th>2008/09</th>
<th>2009/10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lambs</td>
<td>51.1</td>
<td>58.7</td>
<td>59.2</td>
<td>43.8</td>
</tr>
<tr>
<td>Sheep</td>
<td>9.3</td>
<td>-7.8</td>
<td>6.5</td>
<td>1.0</td>
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<tr>
<td>cattle</td>
<td>4.4</td>
<td>28.4</td>
<td>5.7</td>
<td>30.2</td>
</tr>
<tr>
<td>Deer</td>
<td>-0.2</td>
<td>0.0</td>
<td>0.0</td>
<td>-0.0</td>
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<tr>
<td>Total</td>
<td>64.6</td>
<td>80.3</td>
<td>71.5</td>
<td>75.0</td>
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<tbody>
<tr>
<td>Lambs</td>
<td>39.4</td>
<td>38.8</td>
<td>116.4</td>
<td>108.2</td>
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<tr>
<td>Sheep</td>
<td>-3.1</td>
<td>-1.8</td>
<td>-2.8</td>
<td>0.6</td>
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<tr>
<td>cattle</td>
<td>18.6</td>
<td>19.6</td>
<td>44.2</td>
<td>42.5</td>
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<tr>
<td>Deer</td>
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<td>0.5</td>
<td>3.8</td>
<td>2.3</td>
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<td>Total</td>
<td>55.4</td>
<td>57.0</td>
<td>153.5</td>
<td>161.6</td>
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<tbody>
<tr>
<td>Lambs</td>
<td>59.1</td>
<td>79.6</td>
<td>59.4</td>
<td>70.8</td>
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<tr>
<td>Sheep</td>
<td>36.6</td>
<td>4.0</td>
<td>27.9</td>
<td>-0.2</td>
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<tr>
<td>cattle</td>
<td>42.3</td>
<td>21.1</td>
<td>43.9</td>
<td>37.4</td>
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<tr>
<td>Deer</td>
<td>-0.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>Total</td>
<td>137.6</td>
<td>96.6</td>
<td>131.2</td>
<td>108.0</td>
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<tr>
<td>Lambs</td>
<td>85.3</td>
<td>74.8</td>
<td>92.7</td>
<td>28.9</td>
</tr>
<tr>
<td>Sheep</td>
<td>-28.1</td>
<td>-14.6</td>
<td>-15.3</td>
<td>-2.2</td>
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<tr>
<td>cattle</td>
<td>-3.4</td>
<td>42.9</td>
<td>-81.4</td>
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<tr>
<td>Deer</td>
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<td>0.0</td>
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<tr>
<td>Total</td>
<td>54.9</td>
<td>102.9</td>
<td>-4.0</td>
<td>21.4</td>
</tr>
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</table>

Table 2 shows meat production for organic management systems differed from integrated and conventional in that they had a net export of significantly less lamb (kg/ha) than the other two systems and this may be linked to the lower carrying capacity for organic farms, however cattle and sheep sales were similar. There were fewer lamb and cattle sales through spring and early summer (for organics) with the majority of their sales in April and May. This is mainly a function of the integrated and conventional management systems ability to use management options to assist in increasing daily lamb growth rates that are unavailable to the organic management systems such as:

- Nitrogen based fertilisers use (eg Urea) to promote seasonally strategic feed supply.
- Chemical anthelmintic use for parasite control
- A greater number of options for purchasing stock feed to overcome seasonal feed deficits

Premiums paid by processors for organic lamb typically ceased at the end of April (although this has been extended in some cases in the past) influencing farmers to sell, where possible, for the market premium. Additionally organic farmers tend to farm to pasture supply as part of their risk management strategy, which means carrying capital, as opposed to trading, stock only through the winter.

1 The lack of significance may also be due to the wide variability within the three management systems.
### Table 2 Results for analysis of net carcass weight exported per hectare

<table>
<thead>
<tr>
<th>Net carcass weight exported kg/ha</th>
<th>Management system</th>
<th>Factor</th>
<th>Covariates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Organic n=10</td>
<td>Cluster (p-value)</td>
<td>Effective ha (p-value)</td>
</tr>
<tr>
<td>Lamb</td>
<td>54.9 b</td>
<td>0.064</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td>91.1 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>91.2 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mutton</td>
<td>3.8</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>11.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td>34.3</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>17.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40.4</td>
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<td></td>
</tr>
<tr>
<td>Total</td>
<td>89.4 b</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>125.9</td>
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<tr>
<td></td>
<td>147.5 a</td>
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</table>

Note: Different superscripts indicate a significant difference at the 5 % level.

The pattern of lamb sales (Figure 16) for integrated management systems was similar to organic except a greater proportion of lamb was sold through the spring summer period and less through the late autumn period. Sales for conventional management systems differed from the other two systems in that they had a less proportion of sales through the autumn months and more through the winter and early spring months.

![Proportion of carcass sold monthly - Lambs](image)

**Figure 16** Monthly distribution of lambs sold comparing organic, integrated and conventional farm management systems in the ARGOS project.
Organic individual carcass weights tended to be lower for lamb, mutton and beef than the other two management systems although this did not test as significant. The market dictates their carcass specifications and farmers will target these, so the carcass weights in Figure 17 are influenced by market wants rather than different farm management system performance.

Figure 17 Average carcass weights of stock sold for organic, integrated and conventional management systems in the ARGOS project

Net lamb exported as a percentage of sheep wintered is an efficiency measure and is not just a reflection of a good lambing percentage but looks at productive and rearing ability of the ewe of any size as well as management policy for wintering lamb production support stock such as ewe hoggets, rams and ewes not in lamb. The reason this did not test as significantly different between the farm management systems could be due partly to the wide range of data within each of the management systems. Figure 18 shows the average values of four years of data for the individual farms in the ARGOS project with a ‘T’ representing those farms that traded in lambs.

Figure 18 Average of four years of Net lamb meat exported as a percentage of sheep wintered data for organic, integrated and conventional farms in the ARGOS project.
The majority of the farms returned results of approximately 20 to 60% suggesting that there is potential for an increase in efficiency leading to productivity and financial gains.

For example, increasing the efficiency of 2 similar farms, of approximately 350 hectares with 2000 breeding ewes, (Figure 18), from 44 to 61% would result in an extra 12,315 kilograms of lamb meat relating to an additional $67,732.50 in gross revenue. This is substantiated in Table 4 (next page) that shows that a positive correlation between a farm's economic farm surplus and the percentage of net lamb exported to sheep carried increases.

Cost of producing meat
Here farm expenses and their associations with production and profitability are explored in detail. This approach provides a measure of efficiency on farms.

Table 3 describes the main costs included in the analysis. Figure 19 shows the proportion of costs to produce a kilogram of net meat exported with labour as the greatest expense followed by pasture. Labour was the only cost that tested significantly different with integrated farmers spending less (p<0.005) than the other 2 management systems (Figure 20).

**Table 3** Definitions of farm expenses assessed in cost per kilogram of meat produced

<table>
<thead>
<tr>
<th>Expense type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td>Permanent &amp; casual wages, ACC, agricultural contracting, shearing costs</td>
</tr>
<tr>
<td>Feed</td>
<td>Does not include change in inventory</td>
</tr>
<tr>
<td>Other</td>
<td>Electricity, Freight, Shelter &amp; plantings, and Other expenditure</td>
</tr>
<tr>
<td>Overheads</td>
<td>Accountancy, communication costs, legal and consultancy, other administration, insurance, rates (incl water)</td>
</tr>
<tr>
<td>Pasture</td>
<td>Seeds, fertiliser and lime, contract cultivation, weed and pest control</td>
</tr>
<tr>
<td>R &amp; M</td>
<td>Repairs &amp; Maintenance</td>
</tr>
<tr>
<td>Stock</td>
<td>Animal health, breeding</td>
</tr>
<tr>
<td>Vehicle</td>
<td>Vehicles and fuel</td>
</tr>
</tbody>
</table>
Figure 19 Average farm working expenses as a percentage of cost to produce one kilogram of net meat exported from a farm for non-cropping ARGOS farms.

Figure 20 Average farm working expenses to produce one kilogram of net meat exported from a farm for non-cropping ARGOS farms.

The strength of associations (i.e. correlations) was determined between farm working expenses and profitability key performance indicators such as economic farm surplus (EFS). Generally a correlation greater than 0.8 is considered strong and less than 0.5 as weak.
However due to sheep/beef farm system multi-enterprise complexity lower correlations were considered strong.

Pasture expenses correlated strongly with net meat export (Table 4) suggesting that increased spending on pasture related items (seeds, fertiliser and lime, contract cultivation, weed and pest control) resulted in increased net meat exported. However increased meat exported did not necessarily result in increased EFS, which had a weaker correlation of 0.155. One possible reason for this could be the prices paid for replacement stock as stock are traded. There was a stronger association between EFS and net lamb (meat) exported from sheep carried (through the winter) (NLESC) of 0.368. This is logical because NLESC is essentially the lambing percentage that includes support stock (hogget replacements and rams) and supports the argument that increased lambing can lead to an increase in profitability. The strongest correlation was a negative correlation between EFS and the total farm working expenses as a percentage of gross farm revenue. In other words the farmers with the highest EFS kept their spending under control.

To summarise, the key messages from these findings are:

- Increases in net meat export will not necessarily result in increased profitability. This may be influenced by prices paid for replacement stock and other factors such as economies of scale (the size of the operation relative to the capital and non-capital inputs).

- Farmers with higher pasture related expenses had a net export of more meat.

- Farmers with higher a higher NLESC percentage tended to have a higher EFS and a lower percentage of total farm working expenses to gross farm revenue

**Table 4** Correlations ($r$) values between expenses, productivity and economic farm surplus for farms in the ARGOS project

<table>
<thead>
<tr>
<th></th>
<th>Net meat export</th>
<th>NLESC</th>
<th>EFS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NLESC</td>
<td>0.285</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EFS</td>
<td>0.155</td>
<td>0.368</td>
<td></td>
</tr>
<tr>
<td>FWE:GFR</td>
<td>-0.297</td>
<td>-0.398</td>
<td>-0.755</td>
</tr>
<tr>
<td>Feed</td>
<td>-0.094</td>
<td>0.096</td>
<td>-0.020</td>
</tr>
<tr>
<td>C&amp;NC Feed</td>
<td>-0.068</td>
<td>0.156</td>
<td>-0.125</td>
</tr>
<tr>
<td>CFE</td>
<td>0.047</td>
<td>-0.083</td>
<td>-0.280</td>
</tr>
<tr>
<td>Pasture</td>
<td>0.673</td>
<td>0.138</td>
<td>0.326</td>
</tr>
<tr>
<td>R &amp; M</td>
<td>-0.065</td>
<td>-0.157</td>
<td>-0.367</td>
</tr>
<tr>
<td>Overheads</td>
<td>-0.048</td>
<td>-0.341</td>
<td>-0.326</td>
</tr>
<tr>
<td>C&amp;NC Labour</td>
<td>0.317</td>
<td>0.019</td>
<td>-0.531</td>
</tr>
<tr>
<td>Vehicle</td>
<td>0.490</td>
<td>0.116</td>
<td>-0.308</td>
</tr>
<tr>
<td>Other</td>
<td>-0.142</td>
<td>-0.242</td>
<td>-0.228</td>
</tr>
<tr>
<td>GFR</td>
<td>0.533</td>
<td>0.310</td>
<td>0.479</td>
</tr>
</tbody>
</table>

**Summary**

Net meat export is useful as a key performance indicator describing a properties’ productive ability/potential. For example portraying a farm as one that produces 200kg/ha of net meat exports per annum indicates the productivity under a certain management style and can be used as part of a suite of key performance indicator tools to assessing farms forming the
basis for farm valuation, production targets and general benchmarking amongst farmer, rural professionals and policy makers.

2.4 An Energy return on investment (EROI) analysis

An EROI analysis is essentially a ratio of outputs to inputs. It is a flexible method for measuring the energy cost of energy and is well suited to evaluating the energetic efficiency and intensity of agricultural production systems. For instance high input systems have been compared with low input systems financially. In this section two systems, organic and conventional, are compared in terms of energy.

Over 6 years the energetic intensity and efficiency (EROI, energy return on investment) of production was evaluated under conventional or organic management of the sheep/beef farms (SB) and dairy farms in ARGOS. Two EROI ratios (outputs: inputs) were calculated where the boundary of the system was defined as within the physical boundary of the farm.

The first ratio contained energy embodied in fertiliser, supplementary feed and electricity as inputs. Output from the SB farms was energy embodied in liveweight, crops, and wool. Output from the dairy farms was energy embodied in milk and cull cows. The second EROI ratio was calculated for the SB group only and included the additional inputs of energy embodied in animal remedies, agrichemicals, and capital items (Table 5).

The organic farms were clearly less intensive than their conventional counterparts as reflected in their having significantly less input and output energy per unit area. The greatest single difference between the groups was the omission of urea from the organic farms.

However, the organic farms were no more efficient at converting input energy into output energy, as indicated by similar EROI values to the conventional farms. This result is consistent with two earlier studies (Pimentel 2006; Refsgaard et al. 1998) but contrasts with a MAFF UK simulation study which estimated EROI values of 1.10 and 2.47 for conventional and organic upland livestock production systems (Cormack 2000).

Table 5

<table>
<thead>
<tr>
<th>Term</th>
<th>Sheep and Beef</th>
<th>Dairy</th>
<th>Kiwifruit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conventional</td>
<td>Integrated</td>
<td>Organic</td>
</tr>
<tr>
<td>Outputs</td>
<td>2.2</td>
<td>1.9</td>
<td>1.6</td>
</tr>
<tr>
<td>(GJ ha$^{-1}$)</td>
<td>(1.7-2.4)</td>
<td>(1.6-3.0)</td>
<td>(1.4-2.1)</td>
</tr>
<tr>
<td>Inputs</td>
<td>3.7</td>
<td>4.2</td>
<td>2.8</td>
</tr>
<tr>
<td>(GJ ha$^{-1}$)</td>
<td>(3.2-4.6)</td>
<td>(3.2-9.0)</td>
<td>(2.2-3.4)</td>
</tr>
<tr>
<td>EROI ratio</td>
<td>0.36</td>
<td>0.38</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>(0.33-0.40)</td>
<td>(0.23-0.56)</td>
<td>(0.25-0.46)</td>
</tr>
</tbody>
</table>

1 Sheep and beef inputs were fertiliser, electricity, supplementary feed, agrichemicals, animal remedies, and capital items including buildings and machinery, fences, and races. Outputs were animals as live weight leaving the farm, wool, and crops harvested; 2 Dairy inputs were fertiliser, electricity and supplementary feed, does not include fuel, agrichemicals and capital items. Outputs were milksolids and cull cows; 3 Kiwifruit inputs were fertiliser, electricity, agrichemicals, and capital items including buildings and vine support structures. Output was kiwifruit.
The reason for this contrast could not be deduced from the summarised MAFF UK report available, while the full report was confidential. It must be stressed that the comparison of EROI studies should be made with great care because EROI values depend on the system boundary and the methodology with which system components are evaluated. The efficiency with which input energy was converted into output energy was far greater for the crops than for the animal based products. Crop EROI values were consistent with previous research (Pimentel 2006; Wells 2001) and indicate that if the goal of sustainability was simply to improve energy efficiency, it could be achieved through the focus of agriculture shifting from animal production more toward plant-based products. The aim of this study was to compare the intensity and efficiency of different management systems based on output energy and the energy contained in key inputs rather than to conduct a comprehensive EROI analysis. Consequently the EROI values studied here provide a sound basis for comparisons within this study but would be considerably larger (indicating greater efficiency) than the true values which would include other important inputs such as the energy embodied in sunlight reaching the farm area, human labour, and diesel.

Sustaining or increasing present levels of energy output from agriculture will become increasingly difficult as resources are constrained by either physical or legislative means. For example, demand for oil is predicted to outstrip supply within a decade, according to the synopsis of available models on the Oil Drum website (www.theoildrum.com), causing price spikes of increasing regularity and severity. The oil price spike in July 2008 caused the price of urea to more than double (Profercy Report 2009) and the negative impact of this on agricultural output could have been substantial if the spike had persisted.

To sustain current levels of energetic output in the face of fewer or more expensive inputs agriculture must become more efficient. This study has demonstrated that the gains in energy efficiency required cannot be achieved by converting from conventional to organic management but could be met by shifting the focus of production from animal products more toward plant based products. Such a shift is unlikely given the present thinking that New Zealand ought to focus on selling high value protein products into the top end of world markets, but it may find more favour as the wider impacts of resource constraints develop.
3 Economics

3.1 The Farm Financial Analysis

Introduction

Financial data for the 2008/09 production season have been collected and seven year’s financial data from the ARGOS sheep/beef farms have now been analysed to determine the impacts of management system on farm financial performance. The addition of an extra year’s data has altered the average values of each of the financial parameters during the period, but has had little impact on the overall conclusions. The panels (management systems) are defined as:

- Certified organic;
- Involvement in a quality-assurance audited supply chain (integrated);
- Minimally audited (conventional)

The number of farms included in the analysis has declined further as a result of farm sales and landuse changes but the analytical approach taken does not require the removal of farms for which the dataset is incomplete. For the 2008/09 year financial data were available for eight organic and integrated farms, and seven conventional farms. The data used in the analysis have been converted to 2008/09 values to take out the effects of inflation and ensure that the results are directly comparable over time.

3.1.1 Panel Differences

The levels of costs and returns on ARGOS sheep/beef farms, which are located throughout the South Island, are influenced by their geographic location, seasonal conditions and enterprise balance; in particular the relative contribution of cash cropping to farm turnover. In order to separate the impacts of differences in management system on revenues, costs and other variable from differences due to these other factors, a type of statistical analysis known as Analysis of Variance has been used. Figure 21 shows the average values of several of the major financial indicators over the seven year period that have been estimated by this method. If farmers compare the values presented in this report with those in individual farm reports they will notice some differences, as the individual farm reports present simple averages of all the farms in the ARGOS programme, which are not corrected for the influence of factors other than management system.

The definitions of the financial indicators that are discussed in this section include:

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>CFR</td>
<td>Cash farm revenue = All cash returns to farming less livestock purchases</td>
</tr>
<tr>
<td>GFR</td>
<td>Gross farm revenue = CFR + change in the value of inventory</td>
</tr>
<tr>
<td>FWE</td>
<td>Farm working expenses = Cash costs of operation less debt servicing costs</td>
</tr>
<tr>
<td>CFE</td>
<td>Cash farm expenses = FWE plus debt servicing</td>
</tr>
<tr>
<td>CFS</td>
<td>Cash farm surplus = CFR-CFE</td>
</tr>
<tr>
<td>NFPBT</td>
<td>Net farm profit before tax = Cash surplus adjusted for changes in the value of inventory</td>
</tr>
<tr>
<td>EFS</td>
<td>Economic farm surplus = Net return after accounting for cash and non-cash inputs and outputs</td>
</tr>
</tbody>
</table>
The higher revenues and costs generated by farms in all panels during 2008/09 have led to an increase in the estimated long-term average values of indicators over previously reported levels. As previously, organic sheep/beef farms had lower total costs and revenues over the period compared with their conventional and integrated counterparts, but there were no significant differences in costs and revenues on conventional and integrated farms. Statistically significant differences between organic and other farms were found in Cash Farm Revenue (CFR), Gross Farm Revenue (GFR), Farm Working Expenses (FWE) and Cash Farm Expenditure (CFE).

Figure 21 Sheep/Beef panels financial indicators over seven years

The average stocking rate on organic farms over the period has been 8.3 stock units per hectare, compared with 10.0 and 10.6 stock units per hectare on conventional and integrated farms respectively.

Despite the large differences in average revenues and costs between organic and other farm panels none of the “bottom-line” indicators of farm profitability have been shown to differ significantly. However, this does not mean that there are no differences. The high level of variability amongst farms within panels with respect to CFS, NFPBT and EFS means that an analysis of this kind, based on small numbers of farms, is not powerful enough to allow us to say with certainty that there are no differences in profitability between panels.

The extent of the within-panel variation on ARGOS farms in 2008/09 is shown in Figure 22 which shows the NFPBT of the farms remaining in the programme during the last season. There is less variability within the organic panel and the NFPBT range of the organic farms is encompassed by the ranges of the other two farming systems. Similar patterns can be observed in the data for both CFS and EFS. These differences are consistent with both the international literature and with New Zealand farm management understanding.

There are several factors which may contribute to the lack of between-panel differences.

- Firstly, the range of management skills, adaptive behaviour and learning patterns, which are key determinants of farm financial sustainability, between farmers in any sector, is very wide and a skilled farmer is likely to achieve good results under any management or production system.
• Financial differences between management systems may be more apparent in intensive monocultural systems where the differences between organic and conventional systems are more extreme.

• In the arable and pastoral sectors where an organic practice is shown to be effective and lower-cost than conventional practice, it will be adapted for inclusion into conventional systems by others.

• Six years is a comparatively short period in which to be able to detect relative shifts in the resilience of soil/plant/animal ecosystems under different management systems, and their translation into changes in financial performance.

**Figure 22** Sheep/Beef farms Net Farm Profit before Tax 2007/08

The financial position of the ARGOS sheep/beef farms, which had deteriorated throughout the first six years of the ARGOS programme, improved during 2008/09. A similar trend was observed in the reported results of the MAF farm monitoring survey for that year. Figure 23 shows the trends in the estimated average Net Farm Profit before Tax of the ARGOS panels between 2002/03 and 2008/09. The dramatic decrease in estimates for the integrated panel in 2005/06 largely reflects a change in panel composition at that time when two farms were sold and there was major structural change on two more.
There are significant differences between the organic panel and others with respect to the breakdown of costs, as well as in total costs. In particular, animal health, cash feed costs, pasture maintenance and fertiliser costs have been very much lower on organic farms than on conventional and integrated farms throughout the analysis period. These differences reflect the lower stocking rates carried on organic farms and the restrictions that organic certification schemes impose on the use of animal health products, weed and pest control, and inorganic fertiliser use. The fact that organic farms incur the costs of maintaining organic certification is not reflected in significantly higher overhead costs on these farms.

On conventional and integrated farms fertiliser is the single largest individual cost, followed closely by wages, then by feed, pasture and vehicle costs. On organic farms, overhead costs come second to labour costs, with “Other Working Costs” almost as high. Figure 24 shows the mean real values of individual cost elements for each of the panels.
3.1.3 Other Key Performance Indicators

Although no significant differences were detected in the ratios of FWE:GFR and CFE:GFR between panels, these differences are approaching significance (F=.075,) with average ratios estimated to be lowest for the integrated panel and highest for the conventional panel. Both ratios declined in 2008/09 on conventional and integrated farms but rose on organic farms, but for all panels they continue to be considerably above the farm management guidelines for financial sustainability as Figure 25 shows. This is consistent with the position of the average sheep and beef farm according to MAF and MWNZ data.

While the debt servicing ratios ((interest and rent)/GFR) estimated for the organic and integrated panels are similar on average for the period as a whole, the debt servicing ratio on conventional farms is significantly higher, and continued to rise steeply during 2008/09.

Figure 25 Key financial ratios over six years
3.1.4 Farmer Type Differences

The ARGOS social team has classified farmers into two types, based on the causal maps of their farm decision-making processes drawn by farmers during interviews. Type B farmers placed more emphasis in their decision-making processes on off-farm themes such as customer requirements, on social factors including family needs, succession and satisfaction and on environmental factors, than Type A farmers. Type A causal maps emphasised on-farm factors. Three of the farmers for whom financial data are available were unable to be classified into farmer types.

The properties farmed by these two groups do not differ in average size, properties framed by Type A farmers are significantly more heavily stocked at 10.3 compared with 9.1. units per hectare (F=.050). Separation of farms by the Q-sort scores derived from the causal maps drawn by farmers, rather than by management systems, created groups that differ significantly with respect to farm profitability and costs, although no significant differences were found in total revenues. Farmers who have a narrower, more farm/business-oriented focus (Type A) have achieved greater profitability than those who base their decisions on a wider range of factors. They do so through tighter cost control rather by generating significantly higher revenues as Figure 26 shows.

![Average Financial Indicators per Hectare 02/03-08/09](image)

**Figure 26** Sheep/Beef farmer types financial aggregate measures over seven years

With the exception of cash and total labour costs, which do not differ by farmer type, and pasture and fertiliser costs, which are lower for Type B farmers, all working expenses are significantly lower (or the difference is approaching significance) for Type A farmers. It is surprising that, despite the fact that the Type B group includes almost all of the organic farms, whose operators comprise 53 percent of all Type B farmers, on average, Type A farmers incur lower stock and feed costs as Figure 27 shows.
The most frequently quoted and perhaps most widely accepted definition of sustainable development is the one articulated by the Bruntland Commission –

*development that ‘seeks to meet the needs and aspirations of the present without compromising [the] ability to meet those of the future‘ (WCED 1987, p. 43).

*This requires ‘a non-declining capital stock over time‘ (Solow, 1986, and Repetto, 1986)

where capital stock is understood in its broadest terms to include human capital, social capital, cultural capital, human-made capital and natural capital.

**Human capital** includes knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being. It is created through lifelong experience as well as formal education. **Social capital** has been defined as the ‘network of shared norms, values and understanding that facilitate co-operation within and between groups‘ (OECD 2001). **Human-made capital** refers to public and private capital such as buildings, factories, office blocks, plant and machinery, computers, infrastructure, airports, seaports, highways, roads, railways, schools and hospitals.

**Natural, or environmental, capital** in economics is generally classified into three types:

I. extractive resources such as soil, minerals, forests, fish and water;

II. amenity values (direct and indirect) such as landscapes, native bush, recreational fishing; and

III. assimilative capacity which is the ability of the environment to ‘process‘ waste pollution.
Natural capital is different from the other types of capital discussed in the previous paragraph because of the irreversibility of some forms of natural capital when used. Another factor in assessing natural capital (and indeed other forms of capital) is the multi-functionality of this capital and hence whether all the associated benefits are properly assessed. This is related to the stability and/or resilience of the natural system, resilience being the ability of an ecosystem to maintain itself when shocked by natural or human disturbance. Sustainability therefore requires that human interactions with the environment should consider the impact on ecosystems as a whole rather than just on resources themselves with care to avoid threatening the stability of the ecosystem (Common and Perrings, 1992).

While there is likely to be varying views about what is required within the various components in ensuring sustainability within a given situation, when it concerns agriculture, in all cases there is a strong dependence on the availability of a range of different types of resources (van Loon et al., 2005). In fact, agricultural activities appear to rely on all five types of capital discussed above. As noted by van Loon et al. (2005, p. 48) these include:

- Natural capital – the soil resource, water from rainfall or other sources, the air, animals used for their labour and as a source of manure, the surrounding natural vegetation
- Human capital – humans who supply labour, not only physical labour but also intellectual input for planning production strategies
- Social capital – systems providing labour and marketing support as well as information related to agriculture and health services
- Financial capital – markets for purchase and sale of goods, a credit system supplying funds to all levels of agricultural workers
- Human-made capital – implements needed for agriculture, roads and means of transport, factories for processing of farm produce.

Initial research in ARGOS has provided the opportunity to identify and report on three of the above indicators, human-made, social and natural capital, and to determine whether they are useful in characterising different forms of capital. While only a small number of farms were used within the current work, it enables a brief look at the feasibility of using such measures, and the ability to identify any differences that exist between the different management systems used by farmers. Not all data collected is presented here, rather a selection of different measures collected for the different types of capitals.

Six years of data were available for the human-made capital analysis (2002/03 to 2007/08) for the sheep and beef farms, however a significant difference is only observed for stock units per hectare (F=0.031), showing that conventional and integrated farms both have a significantly higher number of stock units per hectare than do organic farms.

No significant difference were found between management systems for the four measures of social capital used; voting in national elections; voting in local elections; providing cash financial support to community activities; and agreement with the statement ‘my orchard is contributing to the local community’. A range of differences were found Olsen P in the natural capital variables used. However there were no differences within the other natural variables in the analysis namely Soluble C; Microbial biomass N; pH; and the number of earthworms.

Although this initial work does show a number of significant differences for different measures of capital, what is important to note is that many of these measures have no right
or wrong level as to what is acceptable. What is more important are the changes that are occurring over time. For most measures, remaining consistent or increasing over time is more important than level itself. For example, for many of the social capital measures, the level of, say, voting participation should remain the same over time, if not increase to show how involvement in the local community is increasing (or remaining constant). Having said that, there are some measures that need to remain constant or decrease, e.g., greenhouse emissions. Similarly, many of the natural capital measurements are likely to have an ‘ideal’ range at which they should fall between (to ensure that deterioration is not occurring to the natural environment).
4 Environment

4.1 Bird monitoring on ARGOS farms

Birds were selected as potential indicators for the ARGOS environmental programme for three reasons: (a) they are good indicators of the wider ecosystem health and functioning, (b) they are generally well recognised and familiar to farmers, politicians and the public, and (c) some species have potential as indicators of good farming system practices for increased farm produce market access. For the same reasons, a similar indicator was developed in the UK (Box 1).

Box 1: Birds used to measure quality of life

The UK government recently introduced 15 headline indicators of ‘quality of life’ for measuring the country’s progress towards sustainable development (Anon. 2002). The wild bird index was one of the 15 indicators, as it is considered ‘a good indicator of the broad state of the wildlife and countryside.’

The wild bird index shows that while bird population trend based on all species is relatively stable, species associated with farmland, and to a lesser extent woodland, habitats have declined significantly. Declines in farmland populations were particularly high during the 1970s and 1980s when farming practices intensified. However, since the introduction of agri-environmental schemes in the late 1990s to mitigate the adverse impacts of intensification, overall the farmland populations have stabilised.

ARGOS’ bird monitoring scheme is New Zealand’s first large-scale scheme for the agricultural landscape. It is, therefore, providing novel information about the composition, distribution and abundance of bird species within three different sectors. Our analysis is based on data collected during three surveys over a six-year period (2005—2010).
Bird densities (i.e. the average number of birds per hectare) were calculated for 25 species, with 12 introduced species (Blackbird, Chaffinch, Dunnock, Feral pigeon, Goldfinch, Greenfinch, House sparrow, Mallard, Redpoll, Skylark, Song Thrush, Yellowhammer) and 13 native species (Bellbird, Black backed gull, Fantail, Grey Warbler, Harrier, Magpie, Paradise shelduck, Pied oystercatcher, Silvereye, Spur-winged plover, Tomtit, Tui, Welcome swallow, White-faced heron). Total bird densities for introduced species were approximately five times higher than native ones (Figure 28). Introduced insectivorous species (Blackbird, Thrush, Chaffinch, Dunnock) were also about five times more abundant than native insectivores (Fantail, Grey Warbler, Welcome swallow, Tomtit).

Table 6 Introduced insectivores and granivores (photos courtesy of Kevin Drew)

<table>
<thead>
<tr>
<th>Insectivores</th>
<th>Granivores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blackbird</td>
<td>House Sparow</td>
</tr>
<tr>
<td>Chaffinch</td>
<td>Goldfinch</td>
</tr>
<tr>
<td>Song Thrush</td>
<td>Yellow Hammer</td>
</tr>
<tr>
<td>Starling</td>
<td></td>
</tr>
</tbody>
</table>
There was no evidence that bird densities varied in relation to management panel within the sheep-beef sector for any of the subsets of species considered in our analyses (Figure 28), including introduced seed-eating species or granivores (House sparrow, Goldfinch, Greenfinch, Redpoll, Yellowhammer, Skylark) and native nectar-feeders (Silveryeye, Tui, Bellbird). The next step in our analyses is to investigate whether bird densities vary in relation to habitat composition and land management practices on sheep-beef farms.

**Figure 28** Bird densities in relation to management panel and ‘your farm’ within the sheep-beef sector (2004–10) for all introduced and native bird species, introduced and native insectivores, introduced granivores (seed-eating species) and native nectar feeder.
4.2 A perspective on differences in soil properties between organic and conventional farming in dairy and sheep and beef sectors

The following is a summary of a report presented at a recent Grasslands Association Conference by Peter Carey (LRS (Land Research Services) Ltd.). He introduces energy to an already comprehensive report comparing organic and conventional management systems of the Dairy and Sheep/beef sectors in participating in ARGOS.

**Introduction**

A major part of any comparison of sustainability and resilience between agricultural production systems is soil quality and whether an organic system produces fewer detrimental effects than a "conventional" system. The back-drop to this question is the intensity of the farming in the primary sector and whether dairying could aggravate such effects and reduce the soil’s biological function than a more extensive sector like sheep and beef. We set out to test a simple null hypothesis that there are no differences in soil properties between management systems (panels) for all production sectors.

**Intensification measures**

Dairy EROI values (see above report on energy return on investment) were almost an order of magnitude higher than those for sheep/beef and were due to dairy energy outputs being 10-20 times greater than for sheep/beef whilst inputs were only 2-3x higher. However, not all energy input data was available for the dairy farms with inputs restricted to fertiliser, electricity and supplementary feed. Those for sheep/beef were more comprehensive (Barber & Lucock 2006; Barber et al. 2008; Wells 2001) but Wells (2001) compiled such a list for dairy within New Zealand and our estimate is that that dairy inputs are actually about 30-40% higher for most farms on the same basis. This reduces dairy EROI values accordingly but would still mean values at least 5 times greater that sheep/beef. This was used as our main indicator for increased intensity of production between sectors.

Organic producers generally had lower energy inputs and outputs than the other management systems although these were not significantly different within each sector and did not measurably result in greater efficiency. In terms of imported nutrient use, sheep/beef organic was the lowest user, averaging 13 kg/ha (P, K and S) annually compared with 80 and 60 kg/ha (N, P, K and S) for integrated and conventional, respectively. dairy organic averaged ~110 kg/ha annually (N, P, K and S) compared with twice that for conventional.

Schipper et al. (2007) has documented a gradual loss of soil carbon from some New Zealand soils, especially pastures, in the past 20 years. Whether this process is related to increased intensification of land use and whether dairy organic farming will slow or even reverse this process will require longitudinal monitoring.
Soil fertility

Olsen-P, resin-P and sulphate-S values were significantly (P<0.001) lower for sheep/beef than for dairy reflecting the total amounts of imported nutrients applied but some small amount of variance could also be attributed to differences in soil order (Sparling & Schipper 2002). Similarly, within each sector, the differential application rates between managements systems meant the organic panel values were consistently lower than those for conventional and integrated (P<0.01) In sheep/beef, average organic panel values were lower than optimum (P 20-30; S 10-12) for New Zealand pastures (Roberts et al. 1994) whilst, conversely, Olsen-P values for conventional dairy were about 50% higher on average than the top of the recommended optimal range (20-40).

Sheep and beef, as the most extensive of our pastoral sectors, relies on modest fertiliser use, mainly superphosphate, to underpin clover growth and N fixation (Morton et al. 1994). Consequently, soil fertility values for sheep/beef tend to be at the lower end although in this group only organic-S appears to be less than optimal (Morton et al. 1994). Conversely, dairy P and S values are around twice those of sheep/beef and reflect a policy to maximise production from smaller pastoral areas by ensuring major nutrients are adequate. Olsen-P values for dairy conventional are well above the recommended optimal range and these have the capacity to lead to water quality issues from farmland runoff (McDowell et al. 2001; Watson et al. 2002; Wilcock 1986; Wilcock et al. 2006).

Soil pH, cation and total base saturation (BS) values were highest for dairy but not cation exchange capacity (CEC). Although most of the dairy cluster were on allophanic soils with high pH and a moderate-to-strong variable-charge component (Theng 1980), sheep/beef clusters were dominated by twice as many finer textured clay loams as dairy (Figure 29). Consequently, sheep/beef clusters generally had higher CECs despite (slightly) lower pH. Between sectors there were several system interactions with sheep/beef Organic having lower CEC and BS% values than either conventional/integrated but not for dairy. Greater use of nitrogen fertiliser and higher animal stocking rates on dairy conventional farms may explain this difference through greater acidification and cation leaching rates.

![Figure 29](image)

**Figure 29** Mean soil texture classification for A and B horizons for SB and DY sectors; (Key for soil orders: C = clay, CL= clay loam, ZCL= silt clay loam, SCL= sandy clay loam, ZL= silt loam, SL= sandy loam).
Soil organic matter (SOM) values for C and N were greater on average for dairy than sheep/beef but no significant differences were recorded between panels for either sector. Differences between sectors are more likely founded in the soil order and the greater number of dairy clusters on allophanic soils rather than landuse per se (Sparling & Schipper 2002). With dairy organic farms, the younger of the two sectors in their establishment, and 50% of farms still to reach accreditation at the time of sampling, there may be further changes in soil properties still to occur. Schipper et al. (2007) has documented a gradual loss of soil carbon from some New Zealand soils, especially pastures, in the past 20 years. Whether this process is related to increased intensification of land use and whether dairy organic farming will slow or even reverse this process will require longitudinal monitoring.

Although soil C and N values between panels did not differ significantly for any sector, C/N ratios did for both sectors (P<0.001) and panels (P<0.05). The more intensive use of N fertilisers and greater stocking rates in dairy probably explains most of this between sector variation. Higher soil C/N ratios for Organic panels convey that, without applied external N, organic returns will also have higher C/N ratios and therefore, less N is being cycled overall. Potentially (anaerobic) mineralisable-N (AMN) values were greater (P<0.001) for dairy but whilst there was no overall management effect, there was a sector-by-panel interaction for sheep/beef, where organic was lower than conventional (P<0.05). Whilst this may be due to not using any N fertilisers it may also reflect less than optimal P and S for some of these farms and reduced legume vigour (During 1984). When AMN values were expressed on a soil-N basis these trends were still evident if not significant.

Soil biological condition

Earthworm numbers and weights were similar between dairy and sheep/beef and across panels but there was an interaction (P<0.05) in earthworm numbers between sectors with dairy organic having greater worm numbers than conventional but not for sheep/beef where organic and conventional were similar (integrated had the lowest numbers). There was no increase in earthworm weights between dairy and sheep/beef panels that suggests that although worm numbers were about 20% greater under dairy organic they were individually smaller, which might reflect fewer available food sources but lower treading effects from reduced stocking rates.

Soluble-C, basal respiration and metabolic quotient values were higher (P<0.001) for dairy than for sheep/beef but when SMB-C, N and basal respiration were calculated on a soil C or N basis, values were substantially lower than the equivalent sheep/beef values (P<0.01). This is probably due to a large part of the SOM held in allophanic soils being stabilised by the clay minerals allophane and ferrhydrite, which resists degradation by soil micro-organisms (Parfitt et al. 1997). These soils make up the majority of the dairy clusters and consequently, a greater proportion of total soil carbon, as compared with sheep/beef soils, and is not a major contributor to soil biological respiration. Higher soluble-C and metabolic quotient values for dairy probably reflects the higher excreta returns and increased respiration as a result.

Panel differences were restricted to sheep/beef and values for SMB-C (P<0.05) and basal respiration (per unit soil-C; P<0.05). Greater SMB-C for integrated (and N to a lesser extent) over organic/conventional may simply reflect the lower C/N ratios of organic returns. It is questionable to make a firm explanation for the higher respiration rate per unit soil-C for
sheep/beef organic but this may be related to increased microbial stress and higher soil C/N ratios of the organic returns. Further monitoring and investigation is required.

**Soil physical condition**

VSA scores for soil porosity (P<0.05) and aggregation (P<0.05) were ranked highest overall for sheep/beef with most scores ranked “very good-to-excellent”. Physical condition for dairy overall, however, was still ranked “good”. Qualitative measures for porosity and aggregation using VSA scoring have been shown to have a strong relationship with macroporosity and aggregate mean weight diameter measurements, respectively (Shepherd 2003). Just under 20% of dairy, and 4% of sheep/beef porosity scores were ranked “fair” or “bad”, a rating that ranks below the macroporosity value of 10%, the accepted margin for optimal maintenance of pasture production (Drewry et al. 2008). There were no significant differences in porosity or aggregation scoring between panels for either dairy or sheep/beef.

![Proportion of scores](image)

**Figure 30** Soil porosity score distribution for each panel DY and SB sectors. An asterisk denotes a significant difference (P<0.05) in scores at an individual level or cross-sector basis (NS; not significant).

Soil bulk density (SBD) values were greatest for sheep/beef and lowest for dairy (P<0.001), a characteristic largely attributable to soil order (Sparling & Schipper 2002). However, about 30% of variation is still attributable to land use and it expected that treading effects and higher stocking rates for dairy would increase SBD, comparatively, over sheep/beef. Soil moisture content (SMC) at field capacity inversely mirrored SBD with higher moisture contents under dairy than sheep/beef. There were no strong differences between dairy and sheep/beef panels for organic and conventional/integrated but with many of the dairy farms still undergoing transition to organic there may be some further divergence with changes in stocking rates. Current soil physical condition for dairy is, however, good based on current VSA scoring so there may be few further beneficial effects to be gained from organic production.
Conclusions

Our comparison of soil properties between sheep and beef and dairy sectors showed that although there were large differences in energy inputs and EROI values, there were few differences that indicated these increased with an increase in farming intensity. A greater number of differences in soil properties were observed in response to management effects between organic and conventional/integrated systems across both sectors, mainly those related to soil fertility. Most of the overall difference in soil properties found between sectors and panels was due to soil order and land-use characteristics rather than management system effects. With dairy Organic an establishing group, further differences in soil properties between organic and conventional panels may still yet develop.

5 Social

5.1 The social dimensions of sustainable agriculture – six years on:

During the past year, the ARGOS social research team initiated a new round of interviews to examine the historical experience of crisis and change in each of the project’s sectors: sheep/beef, kiwifruit and dairy. While it is too early to report on findings from these interviews (that are only in the initial stages of coding and analysis), we expect them to provide good insight to the capacity for resilience demonstrated by ARGOS participants as well as the pathways that have contributed to or enhanced this capacity. What is evident from our initial reflections on our conversations with all of you, is that your personal experience with ‘crises’ in your farming sector has occurred under very different circumstances. In other words, a period of low lamb prices may be much more difficult for those who are also dealing to crises in their family life and/or facing large debt loads, et cetera. Such information will help us to identify factors that contribute to a more resilient response to adverse conditions, as well as to recommend more appropriate pathways to encourage resilience in the sector as a whole.

The topic and structure of the latest interviews was largely a response to both the achievements and shortcomings of our earlier interactions with ARGOS participants. Our existing social data has an almost exclusive focus on current conditions (and, to some extent, future aspirations) of the farming and orcharding families participating in the project. These data have allowed us to develop a better understanding of existing situations and to draw strong conclusions regarding the sustainability of the management panels in each sector. (These findings are summarised below.) We were, however, not able to provide confident assessments of farmers’ response to crisis that would contribute to attempts to model the impacts of possible changes in the context of agricultural production in the future. The objective of our analysis of the current set of interviews is to develop greater insight to the types of response that occurs as farmers and orchardists are faced with new or more intensive challenges to the viability of their farms and orchards in the future.

5.1.1 What we already understand:

In the process of synthesising our findings across the different social data collected and analysed so far (two interviews, a causal map exercise and three postal surveys), we have identified both that there is great similarity within each of the sectors and that there is a strong basis for differentiating among the management panels as well. The similarities show that the people who chose to practice a particular form of production (sheep/beef, kiwifruit or dairy) have adopted a largely shared form of adaptation to the demands and challenges of that sector. Another way to say this would be that similar types of people are attracted to the
advantages and challenges of a given form of production —most sheep/beef farmers would be less ‘happy’ growing kiwifruit than raising stock, especially given the extent that management practice is audited in the former sector. Thus, there is some basis for using generalities when referring to the types of actions and responses that are common to a given sector.

That said, it is possible to identify slight differences of approach and orientation among sheep/beef farmers (and kiwifruit orchardists and dairy farmers). The differences appear to be relatively small in comparison to the similarities; but they also help to explain the fact that farmers choose to employ distinct management systems, which the ARGOS project refers to as conventional, integrated and organic. We have attributed these differences to five general social dimensions:

- environmental positioning;
- good farming;
- breadth of view;
- response to feedbacks; and
- approaches to risk and innovation.

Our research suggests that these social dimensions influence choice of management system where they show differences between the conventional, integrated and organic panels.

- **Environmental positioning:**
The sheep/beef farmers’ perceptions of and engagement with the environment (their *environmental positioning*) provide a means of differentiating among the panels. Throughout the social data, topics related to the environment provide a principal axis along which the organic panel can be distinguished from the rest. For example, the organic farmers are consistently more proactive in their engagements with the environment (for example, as a group, they plant more woody vegetation to encourage biodiversity or to improve stream health), are more apt to refer to management as *working with* nature and (based on their survey response) are the least convinced of technological fixes for the remediation of human-induced environmental problems. By comparison, the integrated and conventional panels are more similar to each other and were more likely to refer to the need to *control* aspects of the environment (soil fertility, weed growth, etc.) that impeded the growth rate of stock or the condition of the pasture. The existing data does not, however, indicate whether the environmental positioning of the Organic farmers preceded their conversion or emerged thereafter. Therefore, in regard to the ARGOS research questions, the environmental positioning of the sheep/beef farmers indicates that the organic farmers are more likely to defer to environmental rationales in developing their management strategies. This does not imply that only organic farmers show concern for the environment, only that they tend to place greater emphasis on that concern compared to the other farmers. The relevance of this positioning for the sustainability of the agriculture sector will depend on the relative economic, social and environmental benefits and costs that accrue to practices that are perceived to be more or less sustainable.

- **Good farming:**
The concept of *good farming* refers to the shared understandings of what constitutes good practice on farms and how that practice is measured. In other words, farmers frequently evaluate each other based on standards of *good farming* that are evident in visual aspects of the farm, for example the state of the pasture and the health of the stock. Tidiness is often
identified as an element of good farming and it is very evident in the kiwifruit sector. In the qualitative interviews with the sheep/beef farmers, however, none of the panels showed a comparable emphasis on tidiness. That said, tidiness is identified as an important indicator of good management in the most recent survey data by the great majority of respondents, suggesting that it may be a ‘taken for granted’ aspect of pastoral farming. The similarity in the attitudes towards tidiness held by members of each of the panels is reflected in the lack of readily apparent visual distinctions among their farms. This relative uniformity in understandings of good farming likely reflects the enduring traditional approaches to pastoral production.

The subtle distinctions in good farming which do emerge largely involve the greater extent to which the integrated and organic farmers are willing to push and/or adjust their management systems to meet the standards of their respective niche markets. In other words, for these two panels, the production of quality meat includes direct references to the importance of meeting the demands of the market, especially retailers and consumers. By comparison, the emphasis on a high quality product among the conventional farmers emphasises the intrinsic value of the pastoral production and its contribution to New Zealand society and economy—features that become symbolic qualities of their product. Thus, in the case of the former two panels, the symbolic qualities of the product involve more narrowly defined characteristics that result from an alternative method of production (niche markets). The fact that the organic and integrated farmers have directed their production toward a specifically defined market appears to be associated with their greater willingness to comply with auditing structures and to conform to contract stipulations.

The actual management associated with good farming remain, however, relatively uniform among the panels as demonstrated by the fact that audits are described as requiring minimal change in practice beyond the attention to paperwork and documentation. Here again, the organic panel is distinctive as their concept of good farming involves a stronger emphasis on the condition and health of the environment especially in regard to the soil. Two factors likely contribute to the lack of strong differentiation between panels in regard to good farming in the sheep/beef sector: the relative recent introduction of the audit schemes in the sheep/beef; and the limited impact of audit compliance on accepted management practice.

• Breadth of view:
Perhaps among the more noteworthy findings in the ARGOS research is the confirmation of the distinctive character of organic farmers relative to their non-organic counterparts (both traditional and alternative). This difference is very evident in the breadth of view expressed in data from the interviews, causal maps and surveys. Breadth of view refers to the scope of reference used by individuals when discussing the impact of farm management on the environment (the relative focus on ecological relations in the productive area, the drainage basin, or the globe), society (from farm family to local community to global) and the economy (from farm accounts to international trade), respectively. The organic farmers demonstrate the broadest perspective on environment and society, placing themselves and their farms within a larger landscape and less localised community. They also placed the greatest emphasis on off-farm product quality in the causal maps. By comparison, the conventional and integrated panels demonstrated a more narrow focus on the processes and conditions that they recognised within the boundaries of their own farms or their local communities. These characteristics suggest that organic farmers are more likely to incorporate a broader set of concerns within their management decisions, although it is not possible to establish the impact this has on the resilience of farming practices.
• Feedbacks:
The category of feedbacks is somewhat related to breadth of view in that it refers to the range of indicators that influence an individual’s ongoing management practice (for example climate events on decision making). In this case, however, we are interested in the number and type of indicators that provide direct feedback on management practices. Despite the differences in the environmental positioning of the panels, the sheep/beef farmers appear to share relatively similar responses to feedbacks within their production systems. For example, all of the panels refer to the importance of the state of the paddocks and of stock health as indicators of environmental wellbeing, with the organic panel putting greater emphasis on the soil and soil biota.

The indicators of economic wellbeing are also overwhelmingly similar, with an emphasis on returns being the most important gauge. In earlier reports we suggested that this reflected a sense among the farmers that their costs were essentially set and proper management in the context of numerous influences (such as low market prices and variable weather conditions) involves achieving sufficient returns to realise some profit, or at least pay the bills. A slight variation in economic feedbacks is that many integrated farmers also include costs in their assessment. This suggests that the integrated panel have a stronger tendency to employ technologies that involve costs (for example greater expenditure on fertilisers and weed control) in order to more effectively meet the contract stipulations.

Stronger differences between panels are evident in the feedbacks which are used to justify good farming practice. The integrated farmers, for example, assume an elite status among suppliers to a given processing firm as a result of increased interactions with firm representatives. By comparison, the organic panel generally emphasises its lower costs, the symbolic qualities of the organic product and their environmental practices when comparing themselves to non-organic peers. While the conventional panel is more prone to use comparisons of production and returns without reference to costs. These differences reflect the distinctive emphases of their management orientations and suggest that each panel would employ different assessments of innovation or change with varying impacts on the resilience of their farming practice.

• Risk and innovation
As discussed in regard to feedbacks, it is possible to differentiate among the sheep/beef panels according to their response to risk and innovation. For example, in the second qualitative interview, the organic and the integrated farmers overwhelmingly demonstrated a capacity to meet the timing; weight and fat cover stipulations of procurement contracts. This is especially true of the latter group who have often been selected by stock agents as preferred clients based on such history. Because meeting the tighter timing criteria often requires greater management control, these farmers appear more willing to test environmental limitations on production (for example earlier lambing in cooler temperatures) in their efforts to meet contract demands. The conventional farmers, by contrast, tend to emphasise the extent to which they farm within environmental or social constraints and attribute weaknesses in the sector to low international prices, the high exchange rate and in some cases abuses within the industry. These attitudes are similarly reflected in the farmers’ approach to audit schemes attached to the contracts with the organic and integrated panels less likely to perceive the audits to be excessive impositions.

5.1.2 Conclusion:
The differences in these five key social dimensions appear as relatively slight deviations from shared characteristics within sectors. We believe that they are important enough, however,
to help explain the relative attraction of particular aspects of the different management approaches used by the ARGOS panels. While we are able to identify difference, we do not claim that these necessarily indicate better practice or more resilient individuals. On the contrary, it appears that the variation in farmers’ approaches to management is a vital element in the resilience of the sector as a whole. Each panel or type of farmer contributes to the capacity of the sector to provide consistent supply and to continually explore and experiment with alternative practices and technologies. For example,

- Conventional farmers ensure that a continuity of supply to an industry currently focused on export commodity production.
- Integrated farmers enable processing firms to explore the potential of quality assured production contracts, testing the waters with the assistance of those more willing to assume some of the risks and new practices involved.
- Finally, organic farmers provide a real world laboratory in which alternative and less chemically intensive practices can be attempted, tested and perfected as potential future options for the whole of the sector.

The understandings of farmers’ actions and attitudes developed during the first six years of the ARGOS project also help us to assess a variety of pathways to sustainability. We have already discussed the relevance of the findings to the use of audit (quality assurance) schemes to ensure use of a range of practices from animal welfare to environmental protection to social responsibility. While these have not had a large presence in the sheep/beef sector to this point, they are very much a feature of horticultural production in New Zealand and promise to expand their influence in the pastoral sectors as well.

Our findings also offer insight to farmers’ response to the Emissions Trading Scheme (ETS). Of most interest to our analysis is the extent to which the regulation of greenhouse gas emissions is perceived as a political rather than an environmental or moral issue. Due to both the contentious reception of climate change science and the apparent implication of fault (that is, farmers believe that they are punished by the ETS as polluters, rather than acknowledged as environmental stewards and economic drivers), the policy is viewed as a challenge to the societal role of farming. It, thus, directly challenges strongly held perceptions of good farming and a shared understanding of social worth among sheep/beef farmers and overwhelms any differences between panels in regard to environmental positioning, breadth of view or feedbacks. This suggests the need for regulation and incentives that better fit farmers’ desires and aspirations as valued members of New Zealand society and economy.
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ARGOS High Country Environmental Report
No. 1, August 2006 - High Country Environmental Monitoring Report 2005-06

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1. Background to the ARGOS Programme
2. Transdisciplinary Research
3. Cicadas in Kiwfruit Orchards
4. Market Developments for NZ Agricultural Produce
5. Spiders in Kiwfruit orchards
6. Organic Kiwfruit Survey 2003
7. Analysis of ZESPRI's Organic Kiwfruit Databases
8. Types of Kiwfruit Orchardist
9. First Kiwfruit Interview: Individual and Orchard Vision
10. Sketch Map Results : Kiwfruit Sector
11. Sketch Map Results: Sheep/Beef Sector
12. Positive aspects of wellbeing for ARGOS sheep & beef farmers
13. What makes ARGOS sheep & beef farmers stressed?
14. Ways in which ARGOS sheep & beef farmers managed the stress of farming
15. Soil nematodes in kiwfruit orchards
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17. Bird Sampling Methods
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22. Annual monitoring of cicadas and spiders to indicate kiwfruit orchard health
23. Cicada Species in Kiwfruit Orchards
24. Shelterbelts in kiwfruit orchards
25. Biodiversity on Kiwfruit Orchards: the Importance of shelterbelts
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30. Soil Phosphorus and Sulphur levels in Sheep & Beef farms
31. Assessing the sustainability of kiwifruit production: the ARGOS study design
32. Fertiliser use on ARGOS kiwifruit orchards
33. How ARGOS uses Geographical Information Systems (GIS)
34. Food Miles
35. Understanding sheep/beef management using causal maps
36. Earthworms in kiwifruit orchards
37. Four types of sheep/beef farmers across the ARGOS panels
38. Audits and Sheep/Beef Farm Management
39. Quality Assurance Programmes in Kiwifruit Production
40. High Country Woody Weeds
41. The Relevance of Performance Indicators Used for Non-Agribusinesses to Kiwifruit Orchards
42. The Relevance of Performance Indicators Used for Non-Agribusinesses to Sheep and Beef Farms
43. Common elements of pastoral farming systems as shown by causal mapping
44. Differences in soil quality within kiwifruit orchards
45. Differences in soil quality between organic and conventional kiwifruit orchards
46. Strong production focus shown in kiwifruit causal mapping