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AGRICULTURE RESEARCH GROUP ON SUSTAINABILITY

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ECONOMICS OBJECTIVE SYNTHESIS REPORT

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1. Executive Summary

The research undertaken by the ARGOS Economic Research Objective covers a wide range of research areas, many of which do not involve comparison of data from sector panels. The team monitors and reviews market access factors that may affect New Zealand agricultural producers' opportunities to export products to key markets, such as trade policies, market audit systems, and non-technical trade barriers. Ongoing consumer behaviour research is also undertaken to better understand consumer trends and attitudes towards food. Trade modelling to investigate the impacts of changes and potential changes in world markets on New Zealand trade comprises a large component of the Economic Research Objective. .

There are four areas of the Economic Objective research where sector panel data has been collected and analysed, the first of which is the on-going work comparing financial data between the panels that is undertaken in order to assess whether the farm management systems influence financial outcomes. Detailed financial data for the majority of the ARGOS sheep and beef farms over six farming seasons, 2002/03 to 2007/08, have been collated and statistically analysed using and unbalanced Analysis of Variance. Individual year analyses have been carried out for each financial variable for each sector with relative few differences detected. More differences between panels were identified when the data were converted to 2007/2008 real values and analysed as single data set. However, high levels of variability within panels and small sample sizes make the power of the analysis weak and while identification of a number of differences has been possible, in most areas where differences have not been identified it has not been possible to say that differences do not exist.

Organic sheep and beef farms have lower total costs and revenues and it appears that the Economic Farm Surpluses (EFS) generated by Organic Farms are lower than for other farms. Although we have some reservations about the validity of aspects of the estimation of EFS this is a potentially significant finding. There are no significant differences in Cash Farm Surplus amongst panels but the analysis of net farm profit before tax is insufficiently powerful to allow us to conclude that inability to identify differences in this variable means that they do not exist. Differences in individual costs reflected the expected differences resulting from the restrictions imposed by Organic certification schemes on inputs such as fertiliser, animal health products and purchased feed as well as the lower stocking rates on Organic farms.

The income and cost aggregate measures for the kiwifruit orchards showed that orchards growing the Gold variety have higher Gross Orchard Revenues, Orchard Gate Returns, Orchard Working Expenses and Cash Orchard Expenses than orchards growing the Green and Organic varieties, which suggests that the higher per hectare returns achieved by the Gold orchards are being offset by higher production costs. Further analysis is needed to confirm this. This difference is not reflected in the 'bottom line' measures of Cash Orchard Surplus, Net Orchard Profit Before Tax or Economic Orchard Surplus but absence of analytical power invalidates any conclusion that such differences do not exist. Differences in individual cost elements reflect the higher costs associated with higher yields of Gold kiwifruit and the restrictions imposed by Organic certification schemes.

For each sector, analysis of the financial data by grouping the growers by “farmer typology” using a description derived by the Social Objective team, rather than by panel, shows differences in the “bottom-line” economic variables between the two identified types of growers. Those categorised as having a “broader” view of environmental and social factors generated lower Net Farm profits before Tax and Economic Farm Surpluses than others and had higher total costs.

The second area of panel analysis, conducted in 2007, involved investigation of the extent to which the indicators used to assess the performance of Conventional businesses apply to farm businesses. A number of performance indicators were investigated in a face-to-face survey of ARGOS farms and orchardists, and analysed in conjunction with financial data. The results indicated that for most parts the performance indicator measures were not related to the financial data, suggesting that caution should be taken when applying Conventional performance indicators to the agricultural sector. However, there were some differences between the panels. For the sheep and beef sectors, Conventional farmers have more of their supplies purchased locally than farmers using Organic and Integrated management systems. In the kiwifruit sector, Gold orchards have a higher number of paid staff and greater gross revenue per effective hectare than Green and Organic orchards, which is consistent with the results from the financial analysis.

Thirdly the economic team has examined the OECD agri-environmental indicators and attempted to use ARGOS data to calculate these for New Zealand kiwifruit orchards and determine whether they indicate that there are differences in sustainability between Conventional and Organic management systems. However, many of the indicators could not be calculated because the relevant data were not available, and that a number of others did not differ at all amongst orchards or even throughout the New Zealand agricultural sector. Analysis of the indicators that do differ across farms has led to the conclusions that firstly, sustainability may not be a function of farm level practices, but rather may be a function of the industry or national initiatives and secondly, that a different set of AEIs may be necessary to capture farm-level variation in sustainability.

Finally a review of the literature relating to the capital approach to sustainability and an initial evaluation of capital-based sustainability indicators has been undertaken and work in this area is on-going. An initial estimation of some indicators of human-made, social and natural capital from ARGOS kiwifruit sector data found a number of significant differences amongst panels but because it is the changes through time in these measures that affect sustainability, it is too early to be able to understand the implications of these differences.

2. Introduction

The Agriculture Research Group on Sustainability (ARGOS) was established to examine the environmental, social and economic sustainability of New Zealand farming systems, and to develop a better understanding of the environmental effects, and the social and economic consequences of different farming practices.

The Economic Research Objective has the target of monitoring and reviewing the international trends in policy and market access which will, or are likely to, affect New Zealand's market access and returns. Much of the work undertaken by the Economic team to assist in achieving the underlying ARGOS objective does not involve the comparison of data from the sector panels.

Work includes a review of market audit systems and international policy trends and their relevance and application to the New Zealand situation, as well as their importance. From this, six monthly ARGOS reports are produced for the sectors. This also has resulted in co-funded research such as the Food Miles project. In addition a range of presentations, papers and reports have been produced for a variety of end-users including government agencies, sector groups and academics. The Economic team also has ongoing work in consumer behaviour research, both the development of the theory and of applications to assess consumer behaviour and its changes, as well as co-funded projects which have assessed consumer behaviour and its implications for New Zealand agriculture. In addition, a bio-economic model of on-farm weed control has been developed to identify optimum methods of weed control accounting for physical and financial constraints (Kaye-Blake and Dhakal, 2008). A full list of Economics Objective papers related to ARGOS is included as Appendix 4.

Another key objective of the Economics Research Objective is the modelling of impacts of changes and potential changes in world markets on New Zealand's trade, primarily using the Lincoln Trade and Environment Model (LTEM). This is a unique model in that it relates trade through to the production system and to its environmental consequences. The ARGOS project has used the LTEM model in a number of ways:

- A range of policy and market change scenarios has been modelled to assess their impacts on New Zealand agriculture and the results presented through papers and workshops to a range of sector groups and academic forums. This is ongoing work allowing the information collected in the market access part of the project above and changes in trade policy to be assessed. The data collected on-farm as part of ARGOS, including production system and environmental data, are being used on an ongoing basis to update and recalibrate the LTEM. Moreover, it is envisaged that more of the data collected under the Environment Research Objective and, it is hoped, under the Social Research Objective will be included in the model in the future.

- Over the last two years the major developments in the trade modelling area have been:

    1. Inclusion of more countries and commodities in the Trade Model to allow assessment of the impact of biofuel polices internationally on New Zealand's

trade. This work also included evaluating the impacts of other factors such as drought in various countries, and of growth rates in consumption in emerging countries to assess factors causing the rises and instability in world food prices.

2. The expansion of the Trade Model to include energy and emissions associated with energy. As a result energy use from fuel, electricity, fertiliser and concentrates is now measured and included for selected countries.

3. Currently under construction is the expansion of the model to include forestry (funded by MAF). Clearly this is important addition as the model now covers most rural land uses and allows modelling of carbon sequestration.

   Outputs from the model will also contribute to syntheses across all objectives so that farmers and their sector representatives can identify the best pathways to sustainability. This will be achieved by showing how the different dimensions of sustainability are related, and the trade-offs involved when multiple dimensions are considered. Priorities for policy will be identified with input from sector leaders and industry policymakers.

On-going work includes review of the literature on sustainable development, which has led to publication of a number of papers in national and international journals. This literature covers the economic, social, environmental and cultural aspects of sustainability and should contribute to trans-disciplinary analysis under ARGOS.

The production of six monthly market access reports for the export sectors represented in ARGOS is also part of the on-going role of the Economics Objective.

Panel analysis has been undertaken in the farm financial area. Detailed data for six farming seasons, 2002/03 to 2007/08 have been collated for the majority of farms and the statistical analysis, reported in Section 3, has been undertaken to test the null hypothesis of ARGOS that:

H_O: There are no significant differences in the environmental, economic and social characteristics and conditions of the management styles on the participating farms and orchards.

Farm financial data has also been analysed with respect to farmer typology to determine whether factors other than management system may be key determinants of farm financial performance.

A second area of panel analysis involved investigation of the extent to which the information employed to assess the success or performance of Conventional businesses applies to farm businesses. This information is based on models of business success that have become important planning, analytical and policy tools in the broader business community, enabling firms to analyse the structure of a particular sector, plan business ventures, and monitor ongoing performance. These models also enable policy makers to understand the key elements of business activity within a sector and provide tools to facilitate business development and overall socio-economic growth strategies. The

Economic Objective (Zellman, 2007) has examined the degree to which these indictors are related to the financial performance of farms in New Zealand, specifically sheep and beef farms and kiwifruit orchards, using ARGOS farm data. The research also tested the null hypothesis that farms and orchards with different management systems (in different panels) did not differ in the performance indicator measures (see Section 4).

The Economics Objective team has recently completed and presented papers on research into agri-environmental indicators (AEIs) and on an initial examination of capital indicators. Data collected in ARGOS with internationally validated indicators of farm health and performance. For example, we have used findings from the ecologists and soil scientists to investigate the relative AEI performance of ARGOS kiwifruit farm panels, and reported our results in a peer-reviewed article in an international journal (Saunders et al, 2009c). The results of this work are summarised in Section 5.

Work on capital indicators of sustainability is in the very early stages. A review paper has been is in the final stages of preparation on the capital approach to sustainability that summarises the definitions of the five types of capital that are separately identified in the literature on this subject. They include human-made, natural, human, social and cultural capitals and some further divisions within these. The importance of the inclusion of measurement of changes in capital stocks din the on-going discussion of agricultural sustainability is highlighted and current progress in the development of capital-based indicators of sustainability is summarised. In addition an initial attempt to use ARGOS kiwifruit panel data to estimate indicators of human-made, social and natural capital has been undertaken (Saunders et al 2009b) and is reported in Section 6).

3. The Farm Financial Analysis

3.1 ARGOS Panels and Data Availability

Three panels of farms have been defined in each of the Sheep/Beef and Kiwifruit sectors, on the basis of the growers' involvement with market audit and certification schemes. These schemes impose and/or prohibit particular farm management practices and, as such, may be expected to change the relative magnitudes of costs incurred. An objective of the financial analysis is the estimation of the extent to which these effects influence financial profitability and, ultimately, sustainability. The panels are defined as:

- Sheep/Beef sector: Certified Organic; involvement in a quality-assurance audited supply chain (integrated); Conventional, minimally audited
- Kiwifruit sector: Certified Green Organic (Hayward); EurepGAP certified Green (Hayward), EurepGAP certified Gold (Hort 16A)

In 2003 twelve clusters of three farms were selected for each sector. By the end of the 2007/08 season 11 Sheep/Beef farms had withdrawn from the project as a result of farm sales, leases, or conversion to dairy production. Few or no financial data were available on two other properties. Because the Gold cultivar was relatively new at the beginning of the study period it was not possible to locate a "Gold only" property in each cluster and six of the Gold properties also produce green kiwifruit. The availability of financial data for each sector in each year is summarised in Table 1

Table 1
Data availability

	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Sheep/Beef:						
All data available/usable	29 (11O, 10I ,8C)	30 (11O, 10I ,9C)	31 (11O, 10I ,10C)	29 (11O, 8I ,10C)	29 (12O, 7I ,10C)	23 (9O, 6I ,8C)
Data not available	4	4	3	2	1	2
Farm withdrawn[1]	2	2	3	5	5	11
Kiwifruit:	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
All data available/usable	27 (8Gr, 11O ,8Go)	29 (10GR, 10O ,9GO)	29 (8GR, 11O ,10GO)	26 (7GR, 11O ,8GO)	21 (7GR, 9O ,5GO)	19 (7GR, 7O ,5GO)
Operating data only available[2]	1	1	1	1	5	3
Data not available	8	6	6	9	10	14

1 Cumulative totals
2 Not possible to calculate Economic Orchard Surplus, which is based on total farm capital, for these farms

3.2 Data Collection

Annual farm accounts, which are the main source of financial data that are provided by the majority of farmers, have been collected for each of the six farming seasons. However, as these are prepared primarily for taxation purposes, they usually fail to provide a clear and current picture of the operation of the whole farm entity. In particular, the following issues have been addressed as described:

Historical cost reporting of capital items: Most schedules of farming assets are prepared on a "depreciated historical cost" basis, which, although not likely to lead to major value distortions when applied to plant, machinery and other fixed assets on farms and orchards, is not an appropriate approach to ascertaining current capital values. Instead Quotable Values New Zealand Ltd has supplied annual updates of capital values for each ARGOS property, based on the most recent Government valuations and the local knowledge of district valuers. On several of the kiwifruit farms it has not been possible to obtain capital data since the ARGOS orchard is a small part only of a much larger fruit-growing or packing enterprise and no separate data are available.

Ownership structures: Farms in the ARGOS panels are owned and operated under a range of structures including companies, partnerships and trusts. On most Sheep/Beef farms (although this is less prevalent amongst the Kiwifruit orchards), more than one of these structures are involved and a range of between-entity transfers occurs for taxation and succession reasons each year. In order to take a "whole-farm-entity" approach all internal transfers have been excluded and the income, costs and capital streams of all entities involved have been aggregated.

Livestock valuation: In annual farm accounts, accountants may value stock on hand using one of two standardised methods, National Average Market Cost (NAMV)" or National Standard Cost (NSC)" and sometimes use values other than these. In order to analyse all farms on an equal footing all livestock on hand have been valued using NAMV.

Valuing non-cash resources: In comparing business growth and financial outcomes between farms it is necessary to assess the extent to which the final cash result has been achieved at the expense of unpaid family labour or by depletion of other non-cash resources such as feed reserves and soil fertility and to value those resources where possible. To date "Wages of Management" have been calculated using the approach advocated by the Ministry of Agriculture and Fisheries for each of the industries and unpaid labour over and above the management role that has been reported by farmers has been charged at the prevailing average wage for each industry (Baker and Associates pers. comm. from an annual farm remuneration survey, Andrew Woods KGNZI pers. comm.). Data on feed inventories have been incorporated since 2004/05 and valued at the prevailing rate for pasture equivalent dry matter. While it was intended to include values for changes in soil phosphate inventories, insufficient data are available to undertake this for Sheep/Beef panel and anomalous values for some Kiwifruit farms in some years led to the decision not to include these values at this stage.

Other major enterprises: On several properties a major enterprise other than those normally associated with that farm type is carried out (e.g. contracting) and the resources it uses cannot be separated from those devoted to farming. The resource costs and returns from these ventures could not be excluded from the analysis but where possible have been aggregated as “other major enterprise” costs and returns.

Additional data: In most cases the data obtained from farm accounts has been supplemented with information obtained from farmers and accountants in order, for example, to reallocate costs to categories that are more meaningful in a management sense than the accounting categories used. However, the integrity of the “bottom-line’ reported in the accounts has been preserved in all cases.

Atypical years: In two cases, a year of data has been dropped from the analysis for an individual farm because of the complexity of the capital and operating transactions, outside of ARGOS but included in the accounts in that year. In each case transactions associated with farm sale/purchase activities that did not relate to the ARGOS farms could not be separated from those that did and these created major distortions in the financial outcomes for a particular year.

3.3 Panel Differences

Analysis of Variance (unbalanced treatment structure) was conducted using GenStat in order to determine whether there were significant differences between panels in each sector with respect to financial variables. The treatment was the management system while cluster was treated as a blocking variable to account for differences in location. In the case of the Sheep/Beef panels, the proportion of revenue derived from cash cropping was included as a covariate in the analysis as it accounted for a significant proportion of the variation in many of the costs and revenues. In the kiwifruit analysis, whether or not the orchard grew both green and gold fruit was included as a covariate.

A significant (at the five percent or lower level) proportion of variability was accounted for by Cluster in almost every analysis conducted and, while the importance of Season as an explanatory variable differed in the analyses of the financial variables, it was generally significant at least at the 20 percent level. Further analysis of explanatory variables showed that in the Kiwifruit analysis latitude, one of the sub-factors accounted for in Cluster, provided significant explanatory power on its own. In the Sheep/Beef analysis the significance of the Percentage of Cropping as an explanatory variable was high for total costs and revenue variables, for EFS and for a number of individual costs, while the explanatory power of the Combined covariate in the Kiwifruit analysis varied widely amongst the financial variables analysed.

Individual year analyses were carried out for each variable with relatively few differences detected, but when all data were converted to real 2007/08 values using the Consumer Price Index (Statistics New Zealand), and analysed as a single dataset with Season included as a blocking variable, a number of significant differences were detected between panels, particularly with respect to individual cost elements in the Sheep/Beef analysis and income and cost aggregates in the Kiwifruit analysis (Greer and Saunders, 2008, Greer et al, 2009). However, for a number of the main financial aggregate variables the analysis conducted was found to have very low power as a result of the small sample size and high within-panel variability. This will be further discussed throughout Section 3.

For the sheep and beef panels a second ANOVA was carried out to investigate differences in financial performance between Organic and "Not Organic" (i.e. the combined group of Conventional and Integrated farms) farms. This was undertaken for several reasons:

- The only variable that was found to differ significantly between Conventional and Integrated farms was the repairs and maintenance expense.

- The size of the Integrated panel declined to a greater extent than other panels and very large changes in the structure of some farms before, for example, conversion to dairy production, had pronounced impacts on panel means.

- Evaluation of the farm management practices of Conventional and Integrated farmers over the period suggests that overall there is little consistent difference in the management systems employed by farmers in the two panels during the period, particularly in comparison to the differences between individual farmers within panels.

A second analysis of the kiwifruit data was also undertaken comparing Organic and Green orchard performance because it was considered that differences due to cultivar characteristics between Gold and other orchards may mask management system differences.

3.4 The Sheep/Beef Sector

3.4.1 Per hectare income and cost aggregates

The results of the two and three panel analyses showed little difference with respect to the relationships between the main financial aggregates of different panels, although the combined panel approach revealed more differences in individual working expenses.

Organic farms operate on a lower input/lower output level than Conventional and Integrated farms, with mean total cost and revenue estimates between 70 and 80 percent of those estimated for the other panels. However, these differences were not reflected as significant differences in the "bottom-line" profitability indicators Cash Farm Surplus (CFS=CFR - Cash Farm Expenditure, which includes debt servicing) or Net Farm Profit before Tax (NFPBT=CFS + change in value of produce on hand-depreciation) in the main analysis or in the combined panel analysis. In the three panel analysis the difference between the Economic Farm Surpluses (EFS=net return after accounting for cash and non-cash inputs and outputs) generated by Organic and Conventional Farms was found to be approaching significance (F=.10) while in the two panel analysis this difference was significant at the five percent level (F=.04). However, it should be noted that calculation of the EFS relies on valuing farmer estimates of unpaid labour employed on farms that in some cases appeared to be higher than might be expected.

In the case of CFS, subsequent analysis (see Section 3.4.5) that takes into account farmer typology as well as management system has sufficient power to show that the lack of difference amongst the panels, is real but the fact that differences were not found in NFPBT does not establish a lack of difference in this indicator of financial performance. Rather, this may be a reflection of the low power of the analysis as the result of the very high within-panel variation in this parameters relative to the estimated panel means, and as a result of small sample sizes. The power of the analysis is its ability to reject a false null hypothesis, or, how likely it is that a response of a specified size would be detected. In designing experiments, sample sizes are usually set at levels that will result in analytical power of 80 percent. If analysis of this type is to be undertaken of populations that have high levels of variability, very large sample sizes may be required to achieve acceptable power levels.

Figure 1 shows the estimated real ($2007/08) mean values of Cash Farm Revenue (CFR), Gross Farm Revenue (GFR=Cash Farm Revenue plus value of inventory changes); Farm Working Expenses (FWE=cash operating expenses i.e excludes debt servicing); Cash Farm Expenditure (CFE=cash operating expenses including interest and rent), CFS, NFPBT and EFS over the six years from 2002/03 to 2007/08. Tables showing means and 95 percent confidence intervals are presented in Appendix 1.

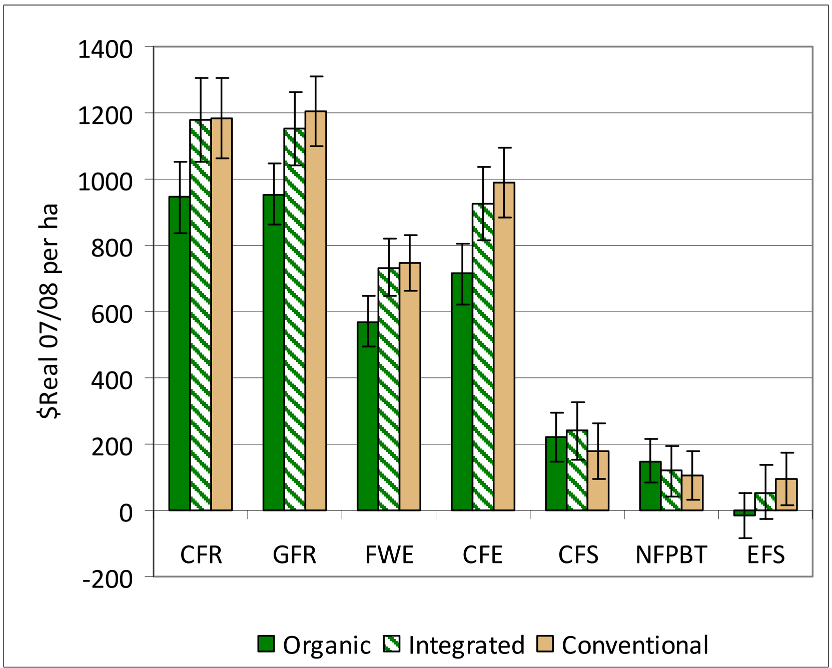

Figure 1

<u>Sheep/Beef panels mean values over six years – major financial aggregates (Real $2007/08 values)</u>

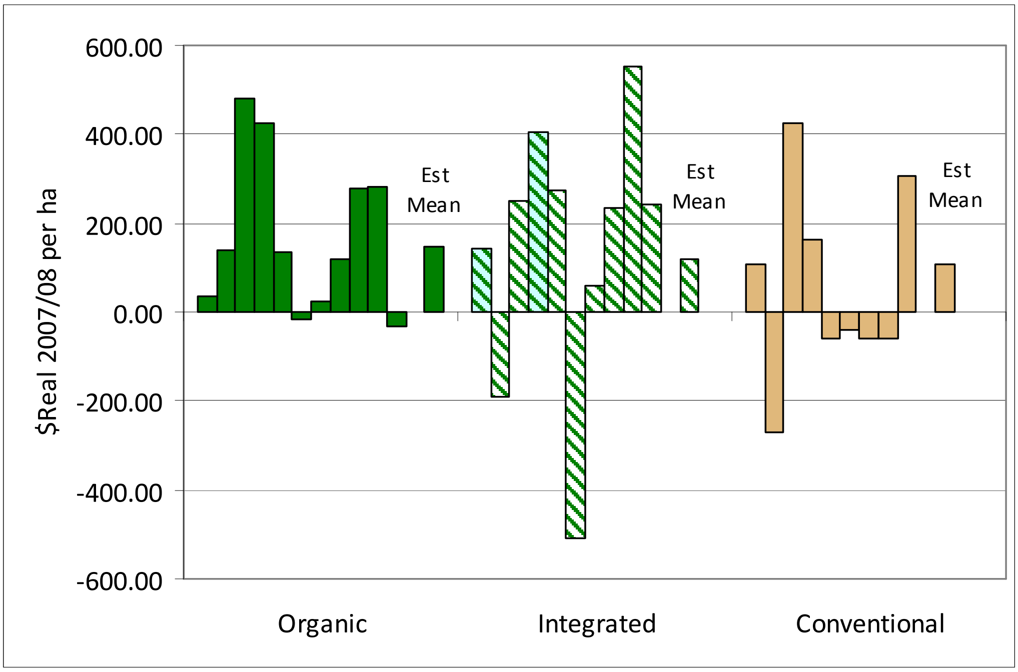

Figure 2
Sheep/beef panels average Net Farm Profits before Tax over six years per hectare Real $2007/08 values

3.4.2 Individual cost elements

Many significant differences were detected in individual cost elements amongst the panels, as Table 2 shows. When the two panel analysis was conducted the same differences emerged but often with higher levels of significance, while the differences in repairs and maintenance and in vehicle expenses, which were approaching significance in the three panel analysis, were of much lower significance when the Conventional and Integrated panels were combined. In each case where Table 2 indicates a lack of significant difference (or of difference approaching significance) between any two panels there was insufficient analytical power for reasonable certainty that the lack of significance reflects a genuine lack of difference. Consequently, while the analysis undertaken has identified a number of cost elements in which there are significant differences amongst the panels, we cannot make any definitive statements about lack of difference in individual costs.

Lower inputs of animal health products and fertiliser on Organic farms have, as expected, led to significantly lower stock and fertiliser costs on Organic farms than on the Conventional or Integrated farms, which has translated into lower pasture renewal costs on Organic properties. Cash and total (i.e. including changes in feed inventory) feed costs per hectare are also lower on Organic farms. Figure 3 shows the mean real values of individual cost elements for each of the panels.

Table 2
Sheep/Beef panel differences in individual working costs

Cost element	Significance	Difference
Cash Labour	NS (F=.518)	
Stock	S (F=<.001)	(O<I,C)
Cash Feed	S (F=.016)	(O<I,C)
Pasture	S (F=<.001)	(O<I,C)
Fertiliser	S (F=<.001)	(O<I,C)
Vehicles	NS (F=.142)	
R &M	NS (F=.102)	
Overheads	NS (F=.268)	
Other working	NS (F=.742)	
Total labour costs	NS (F=.333)	
Total Feed costs	S (F=.042)	(O<I,C)

3.4.3 Other key performance indicators

No significant differences in the ratios of FWE to GFR or CFE to GFR were found amongst panels. Mean values of all panels were above the levels generally regarded as financially sustainable in the long-term which, as MAF Farm monitoring reports show, has been true for many New Zealand sheep and beef farms in recent years. The difference in debt servicing ratio between Conventional and other farm panels was found to be approaching significance (F=.066), suggesting that these farms are more vulnerable in times of low prices, rising costs and interest rates than other farms. The debt servicing ratio is one of the parameters that is taken into account by banks when evaluating new financing proposals and debt servicing costs cannot be reduced in the same way that physical inputs can be reduced in times of low farm incomes. Table 3 shows these financial ratios.

Table 3
Sheep/Beef panel differences in financial ratios

	Organic	Integrated	Conventional
FWE:GFR	66%	64%	65%
CFE:GFR	82%	79%	88%
Debt servicing ratio	16%	12%	23%

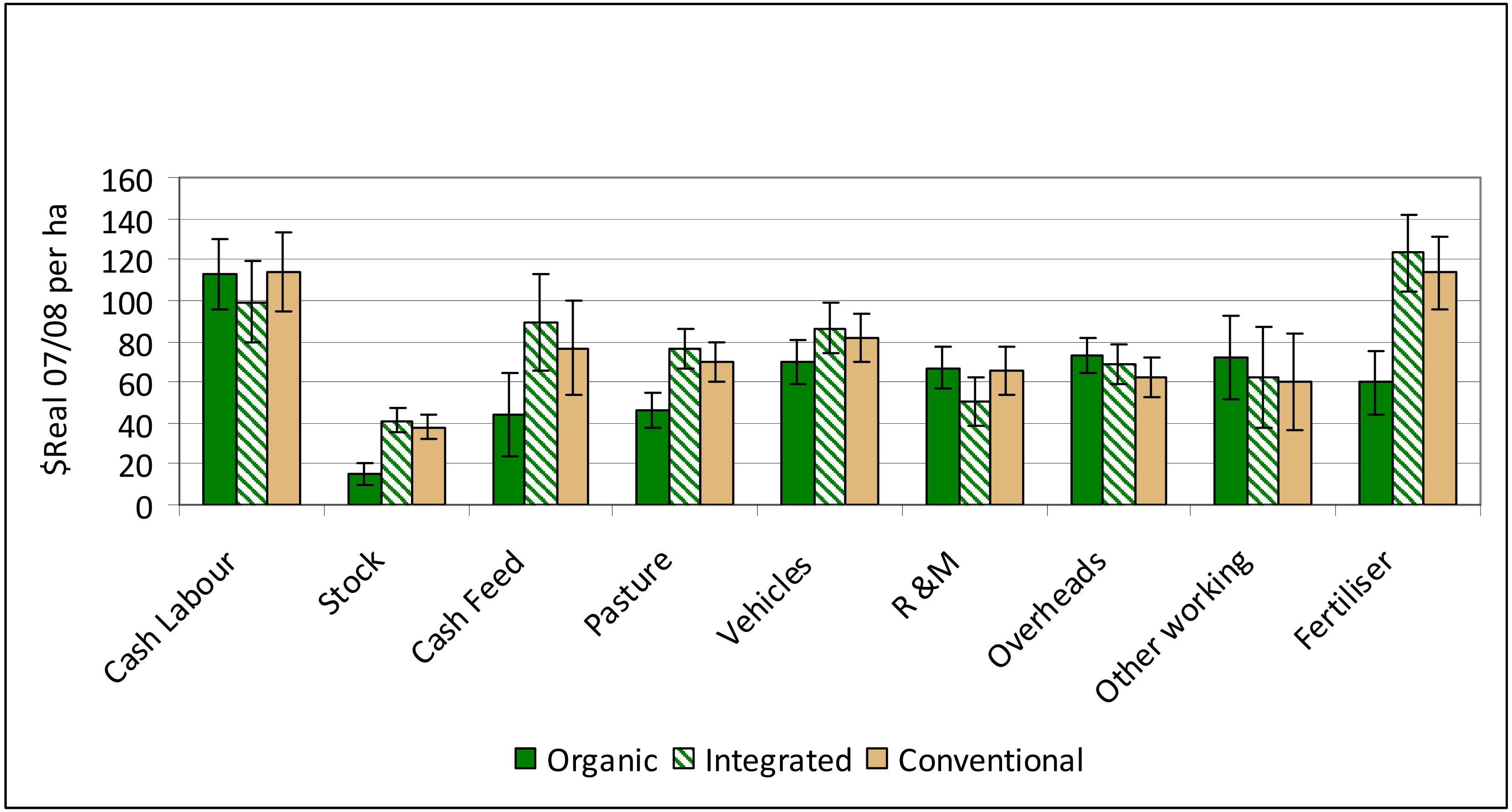

Figure 3

Sheep/Beef panel mean values over six years– individual cost elements (Real $2007/08 values)

3.4.4 Non-Panel Differences

The absence of statistically significant differences between management systems panels has prompted ARGOS researchers to consider other groupings of farmers that may better capture or explain differences in farm performance. Under the social objective of the ARGOS project a type of cognitive mapping was used to show how the Sheep/Beef farmers integrated the economic, social and environmental factors important to their farming systems in the form of a map. (Fairweather et al 2007). Before the causal mapping was undertaken the Q-sort methodology was used to allow farmers to identify the factors they considered to be most important to their farming systems from a list of 41 factors presented to them. Each farmer then prepared a map showing how these factors causally influenced each other. Group maps were constructed for the panels representing the three management systems using averaged data. In addition four different groupings that crossed the management system panels were identified from the Q-sort data and were later simplified to two farmer typologies, Type A and Type B. The maps of Type A farmers had fewer connections and less emphasis on environmental factors while Type B maps had more connections and emphasise satisfaction, external factors, the environment and family. The researchers concluded that these farmers have "a more profound view of their systems and this manifests wherever they focus their attention, whether it be family, environment or production." Of 33 farmers included in the analysis, 9 were characterised as Type A and 20 as Type B with three not fitting any group and one having left the programme before the Q-sort interviews were held. The financial data was regrouped according to these farmer typologies to determine whether differences in typology were reflected in relative farm performance.

Analysis of the differences in the main financial aggregates between farmers classified as Type A and Type B was undertaken using an unbalanced treatment ANOVA methodology over the full six-year dataset transformed into real 2007/08 values, using Cluster and Season as blocking variables. Financial data and a Q-sort index were available for 27 properties. The Type A group comprised two Organic, three Integrated and four Conventional farmers while the Type B group comprised ten Organic, five Integrated and four Conventional farmers. The distribution of Q-sort values and availability of financial data is shown in Table 4.

Table 4
Q-sort distribution of Farmers Included in the financial analysis

	Organic	Integrated	Conventional	Total
Type A	2	3	4	9
Type B	10	5	4	19
None	0	2	2	4
Total	12	10	10	32
Type A	16.7%	30.0%	40.0%	28.1%
Type B	83.3%	50.0%	40.0%	59.4%

The ANOVA approach identified some important differences between these groups. No significant differences in total revenues (CFR or GFR) were detected between the groups but the power of these analyses was low (less than ten percent) so no conclusions can be drawn about relative revenue levels. However, significant differences (F=<.05) in both farm expenditure (CFE and FWE) and highly significant differences (F=<.01) in the "bottom-line" variables CFS, EFS and NFPBT were found. As Figure 4 shows, Type A farmers have lower farm costs and higher net financial outcomes than Group B farmers. What this means in terms of their farming objectives and practices warrants further investigation.

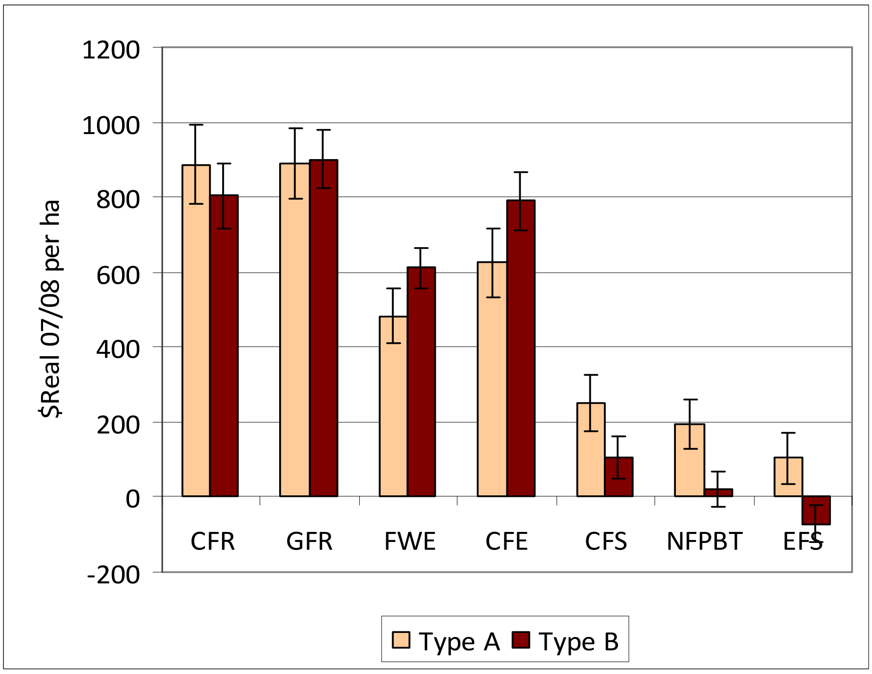

Figure 4

Sheep/Beef Q-sort types mean values over six years – major financial aggregates (Real $2007/08 values)

3.4.5 The interaction between management system and farmer typology

Because such a high proportion of the variation in "bottom-line" profitability indicators was explained by differences in farmer typology, the final stage of the financial analysis was to undertake ANOVA analyses of CFS and NFPBT that included both management system and farmer typology as treatments. No further significant differences were found between panels using this approach but the power of the CFS analysis was increased sufficiently (87 percent) to accept the null hypothesis that there is no difference in CFS between Organic and Non-Organic farms.

3.5 The kiwifruit sector

3.5.1 Per hectare income and cost aggregates

ANOVA (unbalanced treatments) was conducted on the kiwifruit financial data using the management system as the treatment, Cluster and Season as blocking variables and whether the orchard was involved in only one of the management systems as a covariate.

Although the three-panel analyses of the kiwifruit sector had sufficient power to detect that the Gold orchards generated significantly higher (F=.001) total revenues and incurred significantly higher total costs than Green and Organic orchards, the two panel analysis showed that there was insufficient power (power levels ranged from 30 percent to less than ten percent) to detect differences between the Green and Organic panels except with respect to some individual cost elements.

No significant differences could be detected between Gold and other orchards with respect to the "bottom-line" financial variables COS, NOPBT, EOS. In the case of the COS there was sufficient power (81 percent) to be able to accept the null hypothesis on the basis of the analysis, but this was not true of NOPBT or EOS (see Section 3.4.1 for definitions which are the same as the definitions of CFS, NFPBT and EFS). At least in terms of the net cash outcome, the higher returns driven by higher yields, on Gold orchards are being offset by higher costs of production. Estimated mean revenue, cost and "bottom-line" values are shown in Figure 5, while Figure 6 shows the variability in average NOPBT per farm during the period. As was the case amongst the Sheep/Beef panels the differences amongst panel means were small compared with the differences in values within panels.

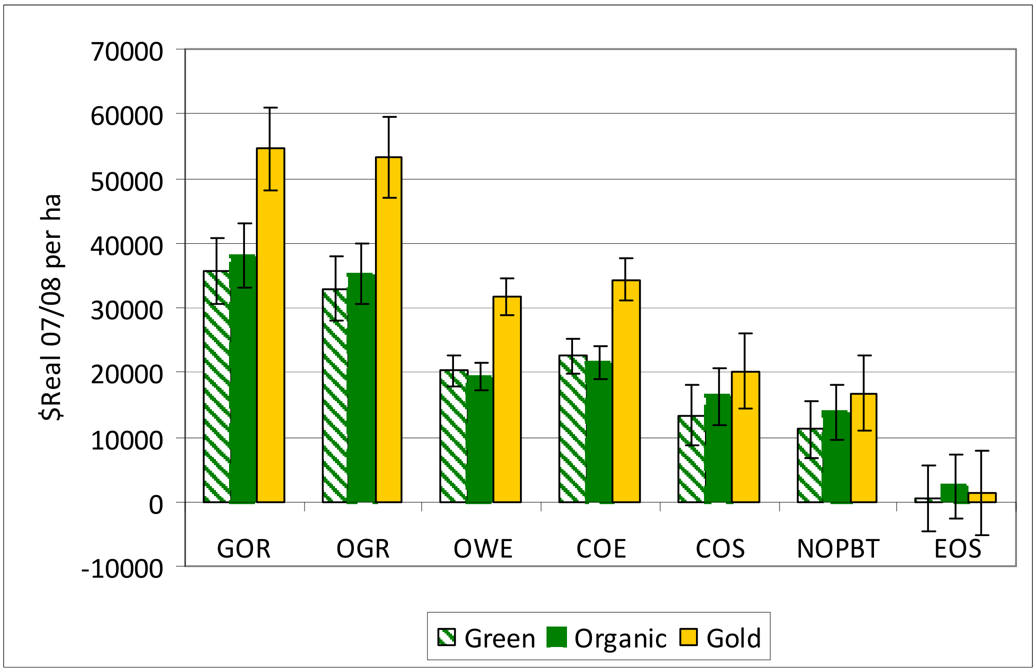

Figure 5
Kiwifruit panels mean values over six years – major financial aggregates (Real $2007/08 values

Analysis of the yields and orchard-gate returns per tray of kiwifruit over the study period showed highly significant differences amongst the three panels (F>.001). The highest yields were achieved on Gold orchards (8,690 trays per hectare) while Organic production was lowest (5,208 trays per hectare). Green kiwifruit produced 7107 trays per hectare on average. It should be noted that the estimated Gold yield is not the mature yield of the Gold cultivar since most Gold vines were not at full production in the early years of the study. Conversely Organic fruit returned the highest average price ($7.18 in 2007/08 dollars); Gold the median price ($6.18) and Green kiwifruit returned $4.19 per tray.

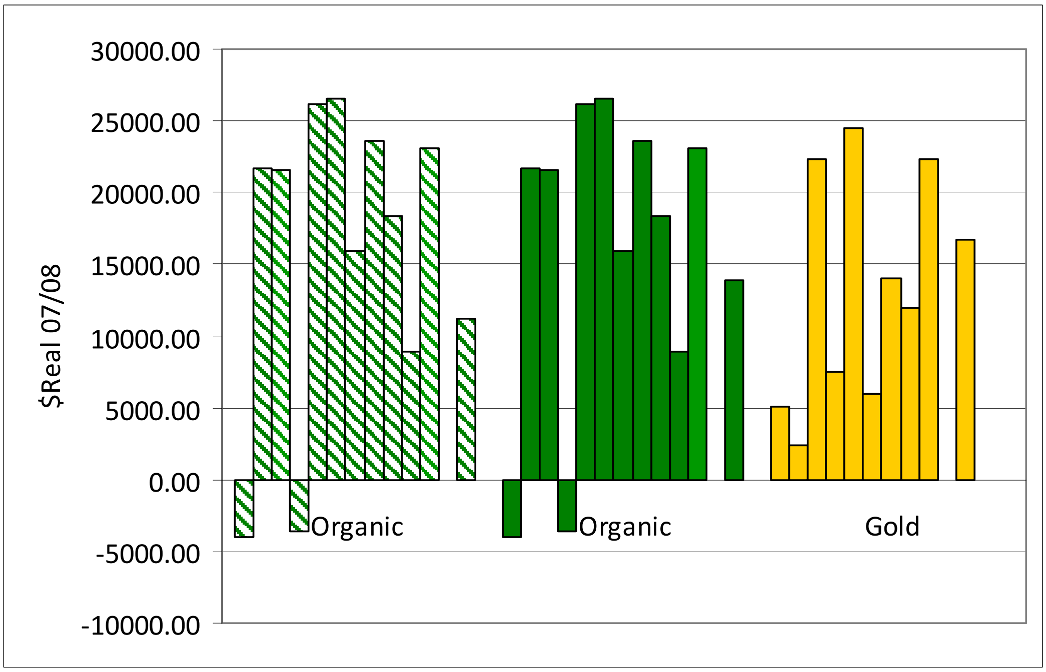

Figure 6
Kiwifruit panels average Net Orchard Profit before Tax over six years per hectare (Real $2007/08 values)

3.5.2 Individual cost elements

Significant differences were detected in the levels of most individual orchard costs amongst the three panels, but as was the case with the total cost variables, most of these differences were between the Gold and other panels and the analysis was insufficiently powerful to detect differences between the Green and Organic panels. In all cases where no significant difference (or difference approaching significance) between any two panels was detected there was insufficient analytical power for reasonable certainty that the lack of significance reflects a genuine lack of difference. As Table 5 shows, labour costs are significantly higher on Gold orchards than on other orchards, reflecting the higher costs of canopy management and picking of the higher-yielding Gold crop. Fertiliser expenses are significantly lower on Green orchards than on higher-yielding Gold orchards and on Organic orchards where composting costs are often high. Overhead expenses are higher on Organic than Green and Gold orchards, which may reflect the costs associated with Organic certification. Average working expenses over the period are shown in Figure 7.

Table 5
Kiwifruit panel differences in individual working costs

	Significance	Difference
Cash labour expenses	S (F=<.001)	Go>(Gr,O)
Total labour expenses	S (F=<.001)	Go>(Gr,O)
Fertiliser expenses	S (F=.01)	(Go,O)>Gr
Pollination expenses	~S (F=.068)	G>(Go,O)
Repairs and maintenance expenses	NS (F=.114)	
Spray and chemical expenses	S (F=<.001)	Go>Gr>O
Overhead expenses	S (F=.025)	O>(Gr,Go)
Other working expenses	~S (F=.08)	Go>Gr>O
Vehicle expenses	NS (F=.157)	

3.5.3 Other key performance indicators

The ratios of OWE and COE to GOR were calculated for the kiwifruit panels but as a large number of farms lacked debt servicing data the debt servicing ratio was not. These analyses had low power and no significant differences were detected.

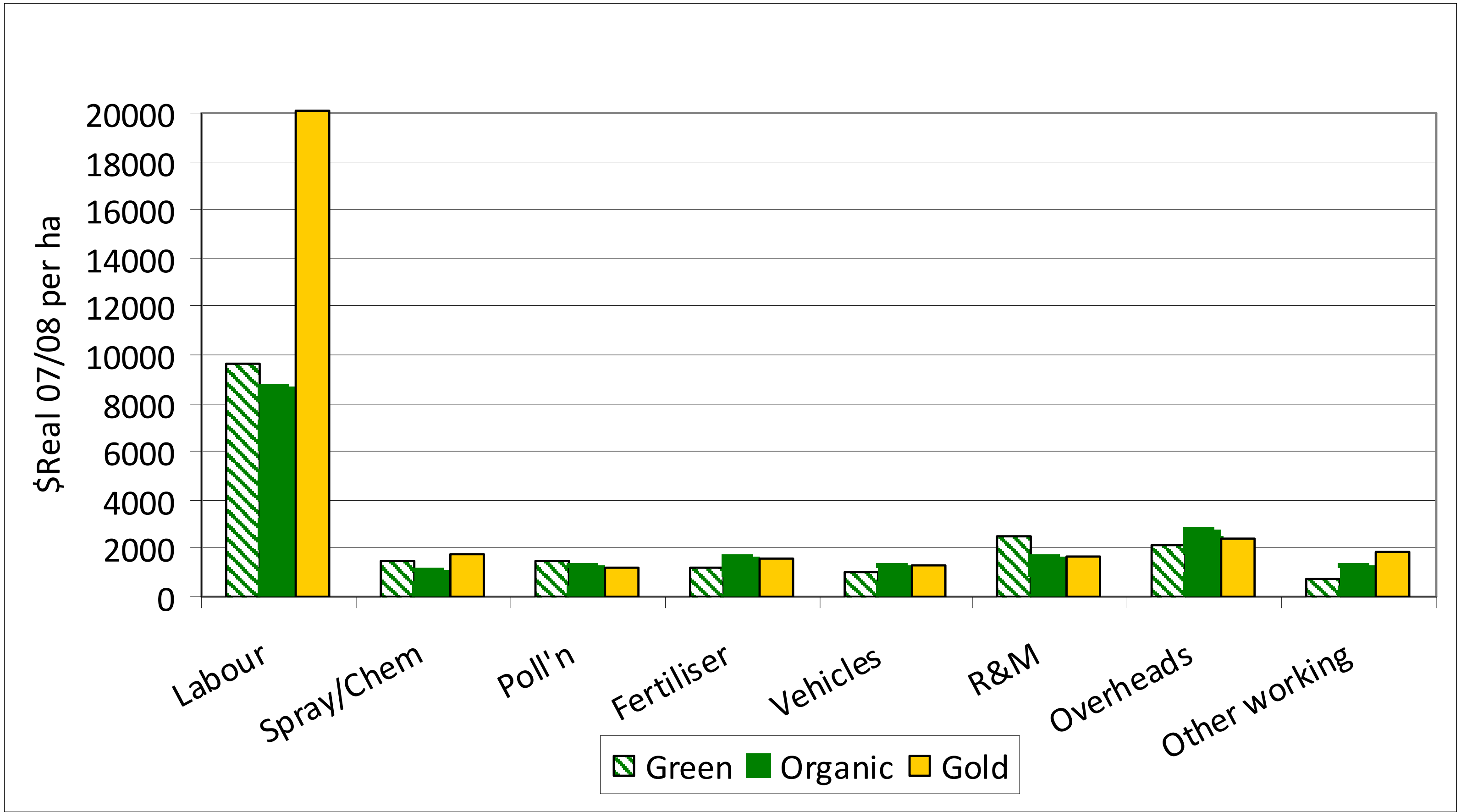

Figure 7

<u>Kiwifruit panel mean values over six years– individual cost elements (Real $2007/08 values)</u>

3.5.4 Non-panel differences

A Q-sort analysis based on the kiwifruit orchardists' causal maps was conducted by the Social Objective team. This identified two farmer typologies; Type 1 (described as the "business" group) who gave more emphasis to post farmgate aspects such as customer satisfaction and requirements and post-harvest quality, and Type 2 (described as the "lifestyle" group) who emphasised family needs, off-orchard activities and the orchard environment as a place to live (Fairweather et al, 2009). Of 31 orchards included in the kiwifruit financial analysis; 24 were assigned a Q-sort value. Table 6 summarizes the Q-sort typologies in relation to management panels in each sector. Investigation of the interaction between management system and farmer typology via an ANOVA that included both of these variables as treatments did not identify any additional significant differences. Nor did it enhance the power of the analysis sufficiently to allow us to accept the null hypothesis that there is no difference between management panels with respect to profitability indicators.

Table 6
Q-sort distribution of farmers included in the kiwifruit financial analysis

	Green	Organic	Gold	Total
Type 1 = Business	5	6	5	16
Type 2 =Lifestyle	2	4	2	8
None	3	1	3	7
Total	10	11	10	31
Group 1 = Business	50.0%	54.5%	50.0%	51.6%
Group 2 =Lifestyle	20.0%	36.4%	20.0%	25.8%

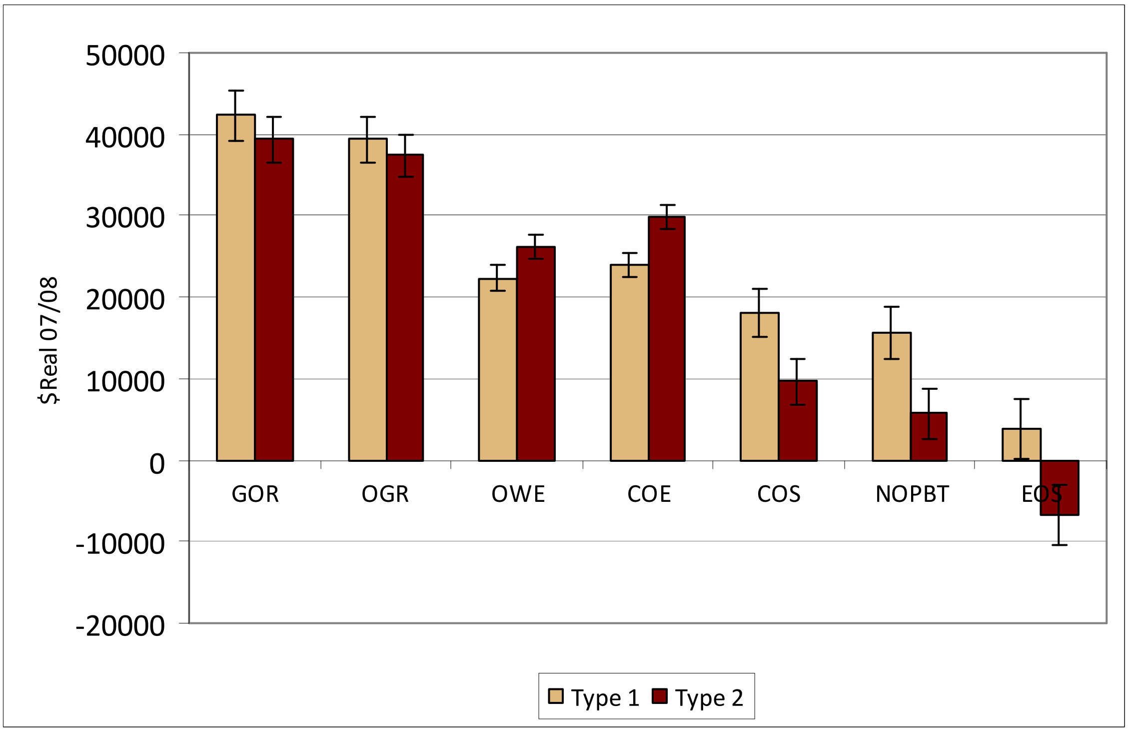

Figure 8
Kiwifruit major financial aggregates by Q-sort type over six years (Real $2007/08 values)

As Figure 8 shows, Type 1 orchardists have lower costs and greater profitability than Type 2 orchardists. However, just as for the Sheep/Beef panels, the ANOVA analysis of the main financial variables using Q-sort as the treatment type was insufficiently powerful to detect significant differences in either Gross Orchard Revenue or the Orchard-gate Return for kiwifruit (power=25 percent). However, the differences detected in total orchard expenditures and in the "bottom-line" variables were all highly significant.

3.6 Summary of differences in the Financial Performance under Differing Management Systems and Farmer Typologies

The analysis of differences in financial performance between Sheep/Beef management systems has confirmed that Organic farms are operated on a lower output/lower input basis than Conventional or Integrated farms. The only significant difference that has been identified in the analysis of "bottom-line" financial performance by management system has been that, when compared with the combined group of "Not Organic" farmers, Organic farms have generated a lower Economic Farm Surplus per hectare (also referred to as Operating Profit), which is a widely-used measure of farm business profitability that is independent of ownership or funding, during the study period. While there are some doubts over the validity of the unpaid labour estimates used in calculating the EFS, this is a significant finding that requires more investigation in future.

The differences in individual cost elements that were found amongst panels were the anticipated reflections of both the limitations imposed on Organic farms by the audit systems under which they operate and their lower per hectare stocking rates. One difference that may have been expected, but that was not found, was that Organic farms would have higher overhead costs because of the annual fees levied by certification agencies. Total overhead costs in this analysis included all administration costs and standing charges with the exception of debt servicing costs, and there is a wide range of costs that individual farmers include in these categories. Farm accounts seldom provide sufficient detail to identify certification costs separately.

With the exception of CFS in which the analysis showed that there are no significant differences between Organic and Not-Organic farms, it was not possible to draw conclusions about variables for which no significant differences were found between management systems because these analyses lacked the levels of power required to accept the null hypothesis with confidence.

Analysis of the Kiwifruit panel financial data with respect to management system showed the Gold orchards to be operating a higher input/higher output system than the Green or Organic orchards but it was not possible to show that this resulted in any difference in net financial outcomes. However, only COS can be said to be not significantly different between panels, since there was insufficient power in the NOPBT and EOS analyses to determine this.

The individual cost differences found between Kiwifruit panels reflected both restrictions imposed by the Organic certification systems and the higher inputs of labour and chemicals required by the heavier yielding Gold crop.

Alignment of farmer typographies determined by the Social Objective team with the financial outcomes on farms/orchards has proved interesting. Separation of farms by the Q-sort scores derived from the causal maps drawn by farmers, rather than by management systems, has created groupings that are significantly different with respect to farm profitability and costs in both sectors. Farmers who have a narrower, more farm/business-oriented focus (Type A/Type 1) achieve greater profitability and have tighter cost control. No significant differences have been found in total revenues, but this may reflect lack of analytical power rather than lack of difference.

Investigation of farm and orchard profitability in relation to management systems using the existing panel approach has had only limited success because of the extreme variability in financial parameters even amongst farms that have many similar characteristics. In order to demonstrate conclusively the extent of the true difference (or lack of difference) in financial performance between different management systems may a radically different research approach may be required, rather than merely increasing the sample size. Estimation of the required sample size in order to conduct ANOVA with a number of effects is an extremely complex task, but estimation of the numbers of observations required to achieve 80 percent power in analysing EOS data from Sheep/Beef farms in even a simple two treatment model suggests that 18,000 observations would be required per panel. This is clearly outside the scope of a time-series study involving intense monitoring on many fronts.

Analysis of the financial data in relation to Q-sort typologies requires much smaller sample sizes and results in much clearer outcomes, because of the lower variability within groups. The limited analysis undertaken certainly appears to support the view that “sticking to one’s knitting” and focusing on a limited number of important factors for the individual farming operation has the best financial outcomes. However we cannot determine what the financial outcome for a particular farmer would be if he/she changed from one of the management systems included in ARGOS to another.

4. Applicability of Performance Indicators to Farms and Orchards

4.1 Framing the performance indicators

Review of the literature on business performance indicators elicited a number of indicators that had potential relevance for the assessment of farm business success. These were investigated by means of a "face-to face" survey of farmers and orchardists. The responses were then analysed in conjunction with financial data for the 2004/2005 financial year in the case of the Kiwifruit orchards and financial data from the 2003/2004 financial year for Sheep/Beef farms. (This analysis was completed before the 05/06 rework of all financial data during which some changes to the data from previous years were made). Gross Farm Revenue and Cash Farm Surplus per effective hectare were used as financial performance indicators. Responses were also analysed in conjunction with other factors derived from the ARGOS database that may potentially affect success. In the case of Kiwifruit orchards, one environmental indicator was included (average number of earthworms between and within rows) and one quality indicator (average fruit dry matter). In the Sheep/Beef analysis the ARGOS database provided one environmental factor (the average number of earthworms). Between panel differences were investigated using analysis of variance for a randomised block design.

The performance indicators investigated included:

a) *Structure of the firm*: (Firm size)	• Number of paid staff • Total number of staff)
b) Business strategy (Business management plan)	• Have a management plan • Number of times refer to management plan • Value of management plan
c) Customer focus (Contact with and feedback from customers)	• Frequency of customer information • Influence of customer information • Percentage sales directly to customers/ end-users
d) Quality (Quality grades of products)	• Dry matter (kiwifruit only)
e) Employee relations (Employee turnover)	• Percentage staff turn over
(Absentee rates/sick leave)	• Work days lost due to sickness and injury
(Performance based pay)	• Number of staff on performance based pay • Value of performance based pay
(Training provision)	• Number of staff participated in training

	• Number of training days
f) Innovation (Use of ICT)	• Importance of ICT usage
(Investment/change in cap.)	• State of current plant and machinery • Planned investments in technology • Changes to management system
g) Social/ environmental factors	
(% of employees from the locality)	• Number of staff members living locally or on-farm
(% of suppliers locally based)	• % of key supplies obtained locally
(Participation in local/ public policy making)	• Participation in local and national election • Participation in community groups
(Contributions to/ donations to/ participation in local groups)	• Donations to community activities • Value of donation
(Environment)	• Average number of earth-worm*s*

4.2 Success of the performance indicators

4.2.1 Structure of the firm

Kiwifruit sector

On kiwifruit orchards positive relationships were found between the size of the business and aspects of financial performance. Both gross orchard revenue per effective hectare (GOR) and cash surplus per effective hectare (COS) were significantly correlated with the number of paid employees and with the number of employees in total. The greater the number of staff working on an orchard, the higher the GOR and COS.

Analysis of variance for a randomised block design test found a significant difference (p=5%) amongst the three different management systems with respect to the "number of paid staff" measure, and descriptive post hoc analysis showed that Gold orchards have more paid employees than Green and Organic orchards. The post hoc analysis also revealed a statistically significant cluster effect for the "number of paid staff" and "total number of staff" measures, so location of orchards is important.

Sheep/Beef sector

Conversely, on Sheep/Beef farms a significant negative correlation was found between both the number of paid staff and the numbers of total staff and CFS per hectare. These results suggest that the more people a Sheep/Beef farm employs, the lower its CFS (but this does not take into account the fact that on many Sheep/Beef there is little or no paid labour as most labour is undertaken by the owner(s). The correlations between the two farm-size measures and GFR were not statistically significant and no management system or cluster effects were found for these indicators.

4.2.2 Business strategy

Kiwifruit sector

Only five of the 30 orchardists stated that they have a written management plan, and those that have management plans and those that do not had similar levels of GOR and COS per hectare. The number of times per year that producers consulted their business plans also appeared to have no correlation with GOR and COS, and there was no statistically significant correlation between the value placed on having a written management plan and GOR and COS per hectare.

The value of a written management plan measure did not differ significantly between management systems, but does differ significantly amongst clusters.

Sheep/Beef sector

Eleven of the 31 Sheep/Beef farmers reported having a written business plan. Cross tabulation results showed that a higher proportion of farms with a business plan had Gross Farm Revenues per effective hectare (GFR) that were above the median (63%) than farms without a business plan (35%). No similar trend was found for Cash Farm Surplus per effective hectare (CFS).

Neither the number of times per year that farmers consulted their business plans nor the value they placed on having a written management plan were found to be significantly related to the financial performance measures tested. No management system effect on the perceived value of having a business plan was found.

4.2.3 Customer focus

Kiwifruit sector

The frequency of customer feedback was not shown to have any impact on GOR or COS but it is important to note that 80 per cent of orchards did receive information about customer requirements at least once a month. The low differentiation amongst orchards on this performance indicator (because all are involved with Zespri) made it difficult to ascertain the importance of customer requirement information in the Kiwifruit sector. There was a significant positive correlation between the extent to which orchardists believe that the information they receive about customer requirements influences the way they operate their orchard and GOR but not COS. None of the orchards made sales directly to consumers, and all marketed their entire crop through ZESPRI.

An analysis of variance for randomised blocked design was conducted for the "frequency of customer feedback" measure to establish any management system effects, but none were detected.

Sheep/Beef sector

Sheep/Beef farmers tended to receive information about customer requirements less often than kiwifruit orchards, and only 61 per cent of farmers received this type of information at least once a month. The Chi-square results showed that that no differences between the groups who receive information at least once a month and those who receive information less frequently in the proportions of group members with above-median GFRs and CFSs. In addition, there was no statistically significant correlation established between the extent to which customer-requirement information influences farming operations and GFR and CFS

Only eight out of the 31 Sheep/Beef farms made sales directly to consumers and there was no significant difference found between the number of farms with above median GFR or CFS between these eight farms and the farms that do not make any sales directly to customers.

Potential management system effects for the frequency of customer feedback indicator were explored, but none were detected.

4.2.4 Quality

Kiwifruit sector

Kiwifruit dry matter was the only quality indicator tested. Orchards were divided into those which have average dry matter above and below the median score for the participating ARGOS orchards. When GOR and COS for these orchards were compared, 63 per cent of orchards with above median dry matter also had above average GOR and COS compared to only 36 percent for orchards with below median dry matter, although the results were not found to be statistically significant because of the high levels of variability in the parameters analysed.

A significant management system effect was found for this variable and the Games-Howell post hoc pairwise comparison test revealed that the Gold orchards produce fruit with significantly more dry matter than Green and Organic orchards, a direct reflection of cultivar characteristics.

4.2.5 Employee relations

Kiwifruit sector

Thirty-three per cent of orchardists who completed in the questionnaire had paid staff (includes paid employees and paid family members working full-time or part-time). The number of staff members per orchard varied from one to eight, with a median value of zero and mean of 1.27. Twenty-eight of the 30 orchards participating in the questionnaire used contract labour for some operations. There was insufficient variability in the responses from orchards on the employee relations measures to conduct a meaningful analysis. Only one of the 30 orchards had had a staff member resign in the last 12 months; only one orchard had lost paid staff workdays in the last 12 months due to sickness or injury at work; and two of the 30 orchards had a staff member on a pay for performance scheme.

Information on participation in training programmes was also collected. There was no statistically significant difference in GOR or COS between orchards that had either the orchardist or a staff member participate in external/formal training in the last 12 months and those that did not, and no significant correlation between number of training days and GOR or COS.

Management system effects were analysed for the number of staff participating in external/formal training and training days measures, but no statistically significant results were identified. On the other hand, significant cluster effects were found for the number of staff participating in external/formal training measure.

Sheep/Beef sector

The Sheep/Beef farms used a difference balance of paid labour and contractors to the kiwifruit sector. Seventy-seven per cent of Sheep/Beef farms that completed the questionnaire had paid staff (paid employees and family members). The number of staff members per farm varied from one to ten, with a median value of two and mean of 2.16. Twenty-six of the 31 Sheep/Beef farms used contractors for labour requirements. Seven of the 31 Sheep/Beef farms had paid employees resign in the last 12 months, but there was no significant correlation between staff turnover and GFR and CFS or between sickness and injury rates and the financial performance measures. Pay-for performance schemes were only used by three of the 31 farmers, so their relationship to financial performance could not be assessed.

No significant relationships were established between employee relationships and financial performance on the Sheep/Beef farms.

4.2.6 Innovation

The questionnaire asked about several specific areas of innovation. Growers were asked to rate their current plant and machinery against commonly available "best technology"; about their plans for future investment in technology, machinery and/or equipment; whether the farm or orchard had undergone management system changes in the last two years with the aim of improving any aspect of the operation; and about the importance that they placed on using information technology and computers for a range of purposes.

Kiwifruit sector

On Kiwifruit orchards no significant relationships were established between financial performance and growers' perceptions of whether their plant and machinery was up-to-date with the best commonly available technology, their expected future investment in technology, machinery and/or equipment or changes in management systems in the last two years.

The importance that the orchardists accorded the use of information technology and computers overall was positively correlated with GOR and COS, although no significant correlations were found between the two financial measures and use of individual computer applications including financial recording, information seeking and e-mail purposes.

Management system effects were explored for two indicators: to what extent plant and machinery is up-to-date with the best commonly available technology, and level of importance that the orchardists placed on using information technology and computers for different purposes. No significant management system effects with respect to the use of most up-to-date plant and machinery and emphasis on using ICT for information seeking were identified.

Sheep/Beef sector

In contrast to orchardists, Sheep/Beef farmers' perceptions of whether their plant and machinery was up-to-date with the best commonly available technology had a significant relationship with GFR but not with CFS. A higher proportion of farmers who perceived their plant and machinery to compare favourably with best commonly available technology had above-median levels of GFR. An analysis of variance with randomised block design test was performed to explore any management system effects for this measurement, but this test did not reveal a significant result.

No significant differences were found in GFR and CFS between those who plan to invest in technology, machinery and/or equipment in future and those who do not, or between those who had made management changes during the last two years and those who had not.

The three innovation questions about the importance farmers place on using information technology and computers for different purposes did not appear to be related to GFR or CFS on Sheep/Beef farms and there were no management system effects for the three information technology measures.

4.2.7 Social/environmental indicators

Kiwifruit sector

A final set of questions covered the producers' support of community activities through sponsorship, monetary donations, or time. The cross tabulation results indicated that a higher proportion of orchardists who engaged in sponsorship or donation activities tend to have above-median GOR and COS (56%) than orchardists who do not engage in sponsorship or donation activities (20%). However, these results were not found to statistically significant. There was no significant correlation found between the value placed on supporting community activities and GOR or COS.

Orchardists were also asked about their participation in community groups. The cross tabulations results suggested that a higher proportion of orchardists who were involved in a community group had above-median GOR and COS (56%) than those that did not participate (20%), but this difference was not found to be statistically significant.

Participation in the local economy has been linked to business success. Consequently, the orchardists were asked where they sourced their chemical, fertiliser, veterinary and seeds supplies. Eighty percent of orchardists obtain all their supplies locally and the variation in the dataset was thus insufficient to analyse statistically.

Participating orchardists were also asked whether their staff lived locally. Twenty-six of the 30 orchards had all their staff (orchardist, family, employees) living either on the orchard or locally. Another indicator of participation in society is the level of participation in national and local elections. All but one orchardist generally participated in national elections and all but three orchardists generally participated in the local elections. There was insufficient variability in the responses to conduct any meaningful analyses of these measures.

Finally, the ARGOS database contained environmental data in the form of number of earth-worms within and between rows of kiwifruit vines. For each orchard, it was established whether the average count of earth-worms was above or below the median count for all ARGOS orchards completing the questionnaire. The chi-square results did not reveal a significant difference in GOR or COS between orchards with above and below median counts of earth-worms between rows or between orchards with above and below median counts of earth-worms within rows.

Management systems effects were explored for the earth worm and local purchasing of supplies indicators, but none were found. Cluster effects were found for the between and within rows earth-worm measure.

Sheep/Beef sector

The Sheep/Beef farmers were also queried about social and environmental indicators. As nearly all farmers reported that they participate in community groups or support community activities through sponsorship, monetary donations, or time, there was insufficient variation to conduct a statistical analysis. As in the Kiwifruit sector, there was no significant correlation between the value placed on supporting community activities and GFR or CFS.

To establish to what extent the farmers participate in the local economy, they were asked about where they sourced their chemical, fertiliser, veterinary and seeds supplies. Farmers reported purchasing 70 per cent of their supplies locally, 27 per cent regionally and three per cent nationally and overseas. There was a significant positive correlation between percentage of supplied purchased locally and GFR but not between local purchasing and CFS. There was also a significant management system effect for this measurement. The descriptive post hoc analysis revealed that Conventional farms purchase a higher percentage of their supplies locally than Organic and Integrated farms, perhaps reflecting lower use of specialised system-related products, but the Games-Howell pairwise post hoc comparisons was not statistically significant.

No significant correlation was found between local residence and the financial performance indicators.

All the farmers who participated in the survey generally participated in national elections and all but one of the farmers generally participated in the local elections. The lack of variability for this performance indicator precluded a meaningful statistical analysis.

Finally, the results for the environmental indicator, measured by the average counts of earth-worms in the soil, showed that there was no significant relationship between farms' gross revenues or cash surplus and the number of earth-worms in their soil.

4.3 Discussion

These results suggest that caution should be used when applying Conventional performance indicators to the agricultural sector since, for the most part, the indicators did not appear to be related to farm/orchard financial performance. There are several potential explanations for this result. First, the farms and orchards in the questionnaire sample did not represent a random selection of businesses (although ARGOS research does suggest they are representative in some dimensions). If they are able to participate in the ARGOS project because they are more financially secure, then any indicator linked to more successful firms may not have sufficient variation within the sample. For example, if community participation and involvement in ARGOS are both indicative of more successful farms, then one would expect to find few ARGOS farms with low rates of community participation.

A second possible explanation is that the sample size is too small. If it were possible to analyse results from a larger sample of farms and orchards, trends in the data might become clearer and more often statistically significant.

The third possible explanation is that these indicators are not particularly useful for identifying successful farms/orchards. It may be the case that the differences between the agricultural sectors and other sectors make these indicators less relevant for agricultural businesses. In particular, farms and orchards are geographically-tied, small in size and frequently family-run. This limits the growth of such businesses. Moreover these farms/orchards are integrated with the physical environment over which there is limited control. Another important factor for many farms and orchards is that their output is part of a larger supply chain and the end product is often exported. The degree of control that a single farm and orchard can have on its product is limited.

Despite these difficulties and reservations, there were suggestions of potentially significant indicators from the questionnaire, but these indicators differ between the Kiwifruit and Sheep/Beef sectors. In the kiwifruit sector, orchard size in terms of number of staff appears to be a relevant indicator as it was positively related to gross orchard revenue and cash orchard surplus per effective hectare. In addition, customer focus may be a relevant indictor of orchard success. Orchardists who change the way they operate their orchard based on information on customer requirements had higher GOR. In the Sheep/Beef sector, on the other hand, the farm size indicator appears to have a different effect on financial performance than in the kiwifruit sector. There was a negative relationship between the numbers of staff working on the farm and COS. Innovation, such as up-to-date plant and machinery, may be an important indicator of financial success in the Sheep/Beef sector.

The results also indicate that farms and orchard with different management systems differed in some of the performance indicator measures. In the kiwifruit sector, have more staff working on the orchard, and have higher gross farm revenue per effective hectare than orchards growing green and Organic kiwifruit. However, whether the Hayward variety was grown Conventionally or Organically had little bearing on most indicators. These results highlight the fact that the properties of the gold variety are inherently different from the Hayward variety, for example, the gold variety is naturally higher in dry matter than green and Organic kiwifruit. Hence, different performance indicators may be relevant for Gold orchards and orchards growing the Hayward variety. In the Sheep/Beef sector, the results revealed differences amongst the different management systems for one of the social indicators. Farmers using a Conventional management system tend to purchase more of their supplies from local businesses than farmers using Organic and integrated management systems. This may reflect the more specialised inputs required in Organic and integrated production systems

The physical location of the farm/orchard also influenced many of the performance indicators, especially in the kiwifruit sector. Hence, the geographical location of agricultural businesses may also influence their success, and may be a much more important success indicator than standard business indicators.

In summary, this study indicates that many of the indicators of success relevant for Conventional businesses may not be applicable to agriculture firms. Consequently, there is a need to identify alternative indicators that are more relevant to agribusinesses. At the same time, it is important to recognise that different agribusiness sectors may require different performance indicators. The differences between kiwifruit orchards and Sheep/Beef farms presented in this study suggest that a broad-brush approach to establishing performance indicators may be misguided.

5. Agricultural Environmental Indicators

5.1 Introduction

The state of the natural environment is important for producers and consumers. For agricultural producers, degraded environments are by definition less able to produce output and are less resilient to negative shocks. Consumers demonstrate concern for the environment, for example, by buying Organically grown food that they believe has been produced with less environmental harm. Furthermore, New Zealand depends on its natural environment for agriculture and tourism, which are key economic sectors.

It is possible to measure the state of the environment, and changes to its state, using environmental indicators that describe the health of the natural environment and the impacts on it of economic activities such as agriculture and tourism. Recent emphasis on the need for a more sustainable agriculture has required that agricultural practices minimise negative effects while maintaining positive output contributions. Consequently, Agri-Environmental Indicators (AEIs) have been developed to detect the risks and benefits resulting from agriculture and to improve the monitoring, evaluation and directing of agricultural programmes (Parris, 1999).

Two issues arise from this development. The first concerns the accuracy of the perceptions of producers and consumers that they are helping the environment. For example, one cornerstone of the Organic foods industry is its perceived lower environmental impact than the Conventional food system. By using a standard set of indicators, it may be possible to determine whether there is empirical evidence to support this perception. The second issue concerns the set of indicators to be used. Several sets have been developed, but their usefulness for describing on-farm or peri-farm environmental impacts is uncertain.

5.2 Review of AEIs

Indicators of the health of agri-environments have been developed in specific countries and internationally that are in various stages of completion. In New Zealand, environmental indicators have been developed by a number of agencies. The Ministry for the Environment, for example, has developed an Environmental Performance Indicators programme that includes national environmental indicators which are broader than AEIs, but relevant to agriculture. Aspects of the environment measured include water quality, biodiversity, greenhouse gas emissions, and soil health, among others. The Growing for Good report (PCE, 2004) proposed a list of indicators that could be used to assess the state of New Zealand's natural environment and thus to evaluate the sustainability of the country's agriculture. Finally, New Zealand also reports on environmental farm plans (Manderson et al. 2007).

Internationally, one important set of AEIs has been developed by the OECD (2008), the basis of which is the OECD Driving Force-State-Response (DSR) Model (Parris, 1999) (OECD, 2008). These have then been used to assess countries' agri-environmental performances against a consistent set of criteria, which allows for international comparisons.

5.3 Applying AEIs to the ARGOS kiwifruit orchards

On the ARGOS kiwifruit orchards many dimensions of farm environmental performance, including energy, soil fertility, biodiversity, water quality, and others have been measured. These data have been transformed into orchard-level indicators matched as closely as possible to the AEIs developed by the OECD (Saunders et al, 2009a). A total of 36 indicators, developed and described by the OECD (2008) and Parris (1999) was investigated. Table 1 describes the specific indicators used, and groups them by the aspect of the environment (water, earth, air) and the characteristic of the aspect they are targeting.

The results can be divided into three groups. The first group contains those indicators for which no data were collected. This analysis has taken environmental data gathered by a dedicated team of environmental scientists and attempted to map them to OECD AEIs. At the outset the ARGOS Environmental Objective team made conscious decisions to target aspects of the environment that were important to New Zealand and for which reliable data could be collected within the constraints of the ARGOS programme. Where no data were collected – such as with water quality and biodiversity indicators – either the data were too difficult to collect reliably or more important aspects of the environment took precedence.

The second group of indicators includes those that showed no variability across the panels. Values for these indicators were generally either 'zero' or 'all' for all orchards in the panel. For example, there were no orchards that converted to other uses and all or nearly all orchards conduct soil testing. For some of the indicators, it is even possible to determine that they show no variability across New Zealand agriculture. For example, production agriculture will show very little variability in cultivated species across the country and methyl bromide use is nil for large parts of agriculture.

The third set of indicators includes those for which there is variability across farms and orchards in New Zealand and for which data was collected within ARGOS. For this set of 11 indicators, data from the Organic and Conventional orchards were analysed using one-way ANOVA to determine whether there were significant differences between the two panels. Of the 11 indicators, only ammonia emissions had significantly different values between the Organic and Conventional orchards (Organic orchards had more ammonia emissions), while pesticide risk approached significance. However, the ARGOS Environment team was uncertain about the appropriate measure for this OECD indicator, so this result may be discounted. The other nine indicators showed no clear relationship between orchard management practice and AEI values.

These 11 indicators were also used as the basis for a cluster analysis of the Conventional and Organic orchards. Two different approaches were used: a two-step cluster analysis and a K-means cluster analysis with number of clusters set to two. Both were undertaken in SPSS 17. As neither approach indicated that the results could be accurately grouped into more than one cluster, the orchards appear to belong to a single group, cluster, or distribution.

Table 6 shows all the indicators examined for inclusion in this analysis while Table 8 includes average values for the indicators for the three panels of orchards and all orchards combined, and comments on the indicators with respect to the nature of the data available to estimate these. The results of the ANOVA analysis on the third set of indicators are summarised in Table 9.

Table 7
Agri-environmental indicators evaluated

Environmental Aspect	Dimension measured	Indicator
Soil	Soil erosion	1. Area of agricultural land affected by water erosion
		2. Area of agricultural land affected by wind erosion
Water	Water use	3. Agricultural water use in total national water utilisation
		4. Agricultural groundwater use in total national groundwater utilisation
		5. Area of irrigated land in total agricultural land area
	Water quality	6. Nitrate and phosphate contamination derived from agriculture in surface water and coastal waters
		7. Monitoring sites that exceed recommended limits for nitrates in surface water and groundwater
		8. Monitoring sites that exceed recommended limits for pesticides
		9. Monitoring sites where one or more pesticides are present
Air	Ammonia emissions	10. Share of agricultural ammonia emissions in national total ammonia (NH3) emissions
	Methyl bromide use	11. Agricultural methyl bromide use in tonnes of ozone depletion potential
	Greenhouse gas emissions	12. Gross total agricultural greenhouse gas (GHG) emissions and their share in total (GHG) emissions
Biodiversity	Genetic diversity	13. Plant varieties registered for marketing for main crop categories
		14. Five dominant crop varieties in total marketed production for selected crops
		15. Area of land under transgenic crops in total agricultural land.
		16. Livestock breeds registered for marketing for the main livestock categories
		17. Three dominant livestock breeds in total livestock numbers for the main livestock categories
		18. Livestock in endangered and critical risk status categories and under conservation programmes.
		19. Status of plant and livestock genetic resources under national conservation programmes.

Table 7 (cont): Agri-environmental Indicators Measured

Environmental Aspect	Dimension measured	Indicator
Biodiversity	Wild species diversity	20. Wild species that use agricultural land as primary habitat
		21. Populations of selected breeding bird species dependent on agricultural land
	Ecosystem diversity	22. Conversion of agricultural land area to (land exits) and from (land entries) other land uses
		23. Area of agricultural semi-natural habitats in the total agricultural land area
		24. Bird habitat areas where agriculture poses serious threat to ecological function
Farm management	Nutrient management	25. Farms under nutrient management plans
		26. Farms using soil nutrient testing
	Pest management	27. Arable and permanent crop area under integrated pest management
	Soil management	28. Arable land area under soil conservation practices
		29. Agricultural land area under vegetative cover all year
	Water management	30. Irrigated land area using different irrigation technology systems
	Biodiversity management	31. Agricultural land area under biodiversity management plans
	Organic management	32. Agricultural land area under certified Organic farm management
Agricultural inputs	Nutrients	33. Gross balance between the quantities of nitrogen (N) inputs and outputs
		34. Gross balance between the quantities of phosphorus (P) inputs and outputs
	Pesticides	35. Pesticide use in terms of tonnes of active ingredients
		36. Risk of damage to terrestrial and aquatic environments, and human health from pesticides

Table 8
Average of indicator results by management system

Dimension	Indicator	Comment	Years	Units	Averages			
					Conventional	Organic	Gold	Overall
Soil erosion	1	All zero	04-08	ha	0.00	0.00	0.00	0.00
	2	All zero	04-08	ha	0.00	0.00	0.00	0.00
Water use	3	For spraying only; other irrigation not quantified	08/09	m^3 / ha	10.92	14.28	11.91	12.37
	4	For spraying only; other irrigation not quantified	08/09	m^3 / ha	9.93	13.95	9.98	11.29
	5	Majority of orchards not irrigated	08/09	ha	0.98	0.63	0.59	0.74
Water quality	6	Not measured	-	-	-	-	-	-
	7	Not measured	-	-	-	-	-	-
	8	Not measured	-	-	-	-	-	-
	9	Not measured	-	-	-	-	-	-
Ammonia emissions	10	Estimated from Overseer	06/07	kg / ha	2.83	5.33	3.67	3.94
Methyl bromide use	11	All zero	All	tonnes	0.00	0.00	0.00	0.00
GHG emissions	12	In progress	04/05	tonnes	-	-	-	-
Genetic diversity	13	Kiwifruit varieties	08	number	1.08	1.00	1.67	1.25
	13	Other crop varieties	08	number	0.25	0.17	0.25	0.22
	14	All zero	04-09	number	0.00	0.00	0.00	0.00
	15	All zero	04-09	number	0.00	0.00	0.00	0.00
	16	All zero	04-09	number	0.00	0.00	0.00	0.00
	17	All zero	02-09	number	0.00	0.00	0.00	0.00
	18	All zero	02-09	number	0.00	0.00	0.00	0.00
	19	None	02-09	-	-	-	-	-

Table 8 (cont): Average of Indicator Results by Management System

Dimension	Indicator	Comment	Years	Units	Averages			
					Conventional	Organic	Gold	Overall
Wild species diversity	20	Mainly birds	04/05 06/07	number	birds	birds	birds	birds
	21	Density of all species	04/05	no. / ha	17.40	12.43	11.60	13.81
	21	Density of all species	06/07	no. / ha	27.62	26.37	28.91	27.63
Ecosystem diversity	22	No conversions to other uses	00-08	ha	0.00	0.00	0.00	0.00
	22	No conversions from other uses	00-08	ha	0.00	0.00	0.00	0.00
	23	No fallow land or woodlands	04-08	ha	0.00	0.00	0.00	0.00
	24	Not measured	-	-	-	-	-	-
Nutrient management	25	Unknown	-	-	-	-	-	-
	26	Nearly all orchards undertake soil testing	04-08	ha	All	All	All	All
Pest management	27	All NZ commercial kiwifruit IPM	04-08	ha	All	All	All	All
Soil management	28	Soil conservation not an issue	04-08	ha	All	All	All	All
	29	All land area covered with sward	04-08	ha	3.60	3.77	2.05	3.14
Water management	30	Definition unclear	04-08	ha	-	-	-	-
Biodiversity management	31	All Organic orchards. Others unknown.	06/07	ha	-	3.77	-	-
Organic management	32	Kiwifruit canopy area in Organic orchards	06/07	ha	-	3.77	-	-
Nutrients	33	N surpluses calculated by Overseer	06/07	kg N / ha	145.75	128.75	141.75	138.75
	34	P surpluses calculated by Overseer	06/07	kg P / ha	18.25	28.17	19.42	21.94
Pesticides	35	Total orchard	08/09	tonnes	0.15	0.27	0.09	0.17
	36	Active ingredient per effective area	08/09	tonnes	0.04	0.07	0.04	0.05

Table 9
Results of one-way ANOVA, Organic and Conventional orchards

Indicator		Sum of Squares	df	Mean Square	F values	Sig.
3. Water use	Between Groups	67.67	1	67.67	1.508	.232
	Within Groups	987.22	22	44.87		
	Total	1054.89	23			
4. Groundwater use	Between Groups	96.80	1	96.80	1.791	.194
	Within Groups	1188.88	22	54.04		
	Total	1285.68	23			
5. Irrigated area	Between Groups	.74	1	.74	.367	.551
	Within Groups	44.06	22	2.00		
	Total	44.80	23			
10. Ammonia emissions	Between Groups	37.50	1	37.50	45.000	.000
	Within Groups	18.33	22	.83		
	Total	55.83	23			
13. Plant varieties	Between Groups	.04	1	.04	1.000	.328
	Within Groups	.92	22	.04		
	Total	.96	23			
21. Bird species	Between Groups	148.16	1	148.16	1.493	.235
	Within Groups	2183.67	22	99.26		
	Total	2331.83	23			
29. Permanent cover	Between Groups	.18	1	.18	.049	.826
	Within Groups	81.80	22	3.72		
	Total	81.98	23			
33. N balance	Between Groups	1734.00	1	1734.00	1.337	.260
	Within Groups	28528.50	22	1296.75		
	Total	30262.50	23			
34. P balance	Between Groups	590.04	1	590.04	.879	.359
	Within Groups	14759.92	22	670.91		
	Total	15349.96	23			
35. Pesticide active ingredient	Between Groups	.08	1	.08	2.608	.121
	Within Groups	.68	22	.03		
	Total	.76	23			
36. Pesticide risk	Between Groups	.00	1	.00	3.428	.078
	Within Groups	.02	22	.00		
	Total	.03	23			

5.4 Discussion

The results of this research have facilitated an assessment of the indicators themselves, as well as an assessment of the sustainability of New Zealand kiwifruit orchards.

The results raise questions about the usefulness of OECD AEIs for investigating the sustainability of New Zealand kiwifruit orchards for two reasons. Firstly several of the indicators are difficult or expensive to collect and are, therefore, unsuitable for on-farm assessment of sustainability, for which ease and accuracy are important considerations. In addition, some indicators are not applicable to New Zealand conditions, which is the reason that they are not interesting to New Zealand's environmental scientists. Secondly, the OECD AEIs are not useful for evaluation of New Zealand kiwifruit orchards because many of them show little variation across orchards. For example, the biodiversity is fairly homogenous across orchards, and the number of domestic species across orchards is fairly constant. Without variation, it is difficult to create ratings or rankings of sustainability.

The results do provide some indication of the sustainability of New Zealand orchards. For two-thirds of the indicators, sustainability appears to relate to the performance of the kiwifruit industry as a whole or to the agricultural sector, not to practices that vary from farm to farm. Thus, sustainability in a general sense as measured by the OECD AEIs may not be a farm-level issue in New Zealand. Sustainability, as measured by these indicators, may have little to do with whether a farm is Conventional or Organic. This division is based on adherence to a market audit scheme that prescribes and proscribes specific inputs and practices. Adherence to the scheme allows an orchardist to claim Organic status and receive a price premium through ZESPRI. For the 11 of the 36 indicators for which practices or values did vary by farm, only one showed a significant relationship to whether an orchard was Organic, while the other indicators, whether farms scored better or worse was unrelated to Organic status. This result suggests that the "Organic" label does not provide an indication of sustainability that is related to the OECD AEIs.

The OECD indicators were designed to compare sustainability internationally. It may, therefore, be unfair to attempt to compare individual farms using them. However, the attempt to use these AEIs in the ARGOS programme has led to the conclusions that firstly, sustainability may not be a function of farm level practices, but rather may be a function of the industry or national initiatives and secondly, that a different set of AEIs may be necessary to capture farm-level variation in sustainability.

6. Capital Based Sustainability Indicators as an Approach to the Measurement of Agricultural Sustainability

6.1 The capital approach to sustainability

Robert Solow's 1974 presidential address to the American Economics Association was devoted to the question of economic and environmental sustainability. Solow, the originator of modern growth theory in economics, defined economic sustainability as "non-declining per-capita human well-being (utility) over time" - a definition that emphasised 'well-being', not 'income'. At about the same time, Hartwick interpreted sustainability as non-declining consumption over time (Hartwick 1977), which is now often referred to as the Hartwick–Solow condition for sustainability. This condition 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 and is created through lifelong experience as well as by 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) while Cultural capital is defined as the set of values, history, traditions and behaviours that link a specific group of people together. Cultural capital can be particularly important where a minority culture exists alongside a dominant majority culture, e.g. Wales in the United Kingdom; Quebec in Canada and Māori in New Zealand. 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, hospitals, the courts, telecommunication networks, and electricity networks. Many of these are either under the direct or indirect influence of local government.

Natural, or environmental, capital in economics is generally classified into three types: extractive resources such as soil, minerals, forests, fish and water; amenity values (direct and indirect) such as landscapes, native bush, recreational fishing; and assimilative capacity or 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 irreplaceability of some forms of natural capital when used. This leads societies to develop "well-being" rules on its use that may include using renewable resources in a way that the harvest rate is not more than the renewal rate and keeping waste flows within the assimilative capacity of the local environment (Pearce, 1988). Such rules are particularly important for stock natural resources that do not renew themselves (e.g. coal, oil). One rule that may be applied to stock resources is that planners and/or policy makers should ensure that reductions in the stock are compensated for by increased investment in renewable resources or other forms of capital (Hartwick, 1977). Of course, this assumes there is substitutability between stock resources and other capital (Solow, 1974) - an assumption that is not universally accepted (see, for example, Daly, 1996, pp. 76-80).

When assessing natural capital (and indeed other forms of capital), an important factor to consider is its multi-functionality and, therefore, whether all the associated benefits are properly assessed. This is important for the stability and/or resilience of the natural system where resilience is 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 take account of the impact on the ecosystem as a whole rather than just on the resources themselves, with care to avoid threatening the stability of the ecosystem (Common and Perrings, 1992).

All these forms of capital, including natural capital, can be enhanced by technological development. Achieving a constant or increasing standard of living, despite a reduced set of natural resources, is assumed to be possible through technical advances and/or greater efficiency, which is why governments pay such attention to fostering innovation in their policies on industry and higher education.

Economists consider it important to view capital as having two aspects with reference to time – stocks and flow, which were described by Fisher (1896, p. 514) as follows:

> *"Stock relates to a point of time, flow to a stretch of time ….The total capital in a community at any particular instant consists of all commodities of whatever sort and condition in existence in that community at that instant [i.e. capital stocks], and is antithetical to the streams of production, consumption and exchange of these very same commodities [i.e. capital flows].*

6.1.1 Human-made capital

Human-made capital "includes fixed assets that are used repeatedly or continuously in production processes for more than one year" (United Nations, 2008, p. 49). Such assets include tangible types "such as machinery, buildings, roads, harbours and airports" and stocks of "raw materials, semi-finished and finished goods held for future sale" and intangible types "such as computer software" and telecommunications (ibid. p. 49). "The value of produced capital is recorded in the balance sheet accounts of the national accounts" (ibid. p. 49) and also in accounts of firms and farms.

6.1.2 Natural capital

In general natural capital is regarded to consist of three key categories: natural resources, land, and ecosystems (United Nations, 2008; United Nations, 2003). All three categories are critical for "the long-term sustainability of development" because of "their provision of "functions" to the economy, as well as to mankind outside the economy and other living beings" (United Nations, 2003, p. 5). These functions may be categorised as follows:

i. Resource functions – resources that are extracted from nature such as "mineral deposits, timber from natural forests, and deep sea fish" for use within economic production systems and are "converted into goods and services for the benefit of" humankind (United Nations, 2003, p. 5).

ii. Sink functions – nature's ability to "absorb the unwanted by-products of production and consumption" through three naturally occurring destinations that are typically referred to as sinks – the atmosphere, water (including the ocean) and land. For instance, "exhaust gases from combustion or chemical processing" are vented into the air, "water used to clean products or people" are released into waterways that end up in the ocean, and "packaging and goods no longer wanted" are "buried in landfill sites" (United Nations, 2003, p. 5).

iii. Service functions – the aspects of nature that make up "the habitat for all living beings including" humankind. These functions may be subdivided into two broad categories: (a) survival functions which comprises aspects of the habitat that are critical for the survival of biological beings such oxygen and water and (b) amenity functions such as beautiful landscapes which do not determine survival but are valued for their function. This can be use value or non-use value.

6.1.3 Human capital

According to the United Nations (2008) the term human capital does not yet have a standard definition. For instance, in one definition, human capital is seen as "the stock of economically productive human capabilities" which stresses the economic worth of these capabilities (Bahrman and Taubman in World Bank, 2006, p.89; cited in United Nations, 2008, p. 51). In an OECD report the term was defined as the "knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being" (OECD, 2001, p.18) – a definition which places a greater emphasis on the well-being aspects of peoples' capabilities (United Nations, 2008). Nevertheless, there is a link between the two areas of emphasis. For instance, a worker who is happy is likely to be more productive and "a healthy worker will be happier as well as more productive" (Ekins, 2000, p. 55). Today, the economic importance of knowledge and skills is widely recognised both within labour economics, growth theory and business economics. At the same time, many see the personal and social well-being effects of learning as being as important as the economic ones" (United Nations, 2008, p. 51).

Within a more confined definition, human capital may be regarded as "the stock of educated and experienced workers in the economy, and labour is the output [or capital flow] of this stock" (Smith et al., 2001, p. 7). A broader definition would describe human capital as the individual's capability to carry out work, which in turn is dependent on his or her education, knowledge, experience, skills, happiness, health status, and motivation to work. For example, workers who contribute to the agricultural sector include field workers (farmers, growers and their employees) and those who contribute somewhat such as agricultural researchers and government officials. Therefore human capital within agriculture may be defined to include the years of field level experience in agriculture, variety and levels of academic qualifications in agriculture, variety and levels of agriculture-related technical skills, the communication and interpersonal skills of farm managers, the status of farm workers' health and their level of motivation.

6.1.4 Social capital

"The notion of social capital is the most recent addition to the capital approach" (United Nations, 2008, p. 52). Human capital is differentiated from social capital. While the former entails features embodied in individuals (as discussed in the sub-section above), the latter descends from the manner in which individuals interact (Ekins 2000). However, despite "a considerable amount of research and attention devoted to social capital in recent years, there remains a lack of agreement around a precise definition of the concept" (United Nations, 2008, p. 53). Since the "social capital" concept originates from sociology, it has largely focused on "identifying the positive elements of society to be conserved and further developed" (United Nations, 2008, p. 52). There has been a broad range of proposed "theoretical approaches for conceptualising social capital" and these approaches often overlap "and range from the distribution of basic goods, to the maintenance of social peace, to social protection and constitutional goals, to networks and associated norms" (ibid., p. 52).

Goodwin (2003, p. 1) described social capital as "the most controversial and the hardest to measure"; nevertheless it may be regarded to consist "of a stock of trust, mutual understanding, shared values and socially held knowledge". Ekins (2000, p. 55) suggested that social capital also has "a direct relationship with welfare". For instance, the states of social structures such as the family "are major determinants of welfare" and the state of welfare of individuals in turn may "affect the performance of social structures" (ibid., p. 55). The OECD (2001, p. 41) adopted the following definition of social capital: "networks together with shared norms, values and understandings that facilitate co-operation within or among groups. Networks relate to the objective behaviour of actors who enter into associative activity. Shared norms, values and understandings relate to the subjective dispositions and attitudes of individuals and groups, as well as sanctions and rules governing behaviour, which are widely shared".

Within the context of sustainability the term social capital suggests that "social bonds and norms" are necessary for sustainability-related endeavours (Pretty, 2003, p. 1912) For instance where there exists a significant stock of social capital within a community or within formalised groups, people are more likely to "have the confidence to invest in collective activities, knowing that others will do so too" (ibid., p. 1912). Within such a community, people "are also less likely to engage in unfettered private actions with negative outcomes, such as resource degradation" (ibid., p. 1913). Four features of social capital that are important for sustainability aims are: "relations of trust; reciprocity and exchanges; common rules, norms, and sanctions; and connectedness in networks and groups" (ibid., p. 1913). "Relations of trust lubricate cooperation, and so reduce transaction costs between people. Instead of having to invest in monitoring others, individuals are able to trust them to act as expected, thus saving money and time. But trust takes time to build and is easily broken. When a society is pervaded by distrust or conflict, cooperative arrangements are unlikely to emerge. Reciprocity increases trust, and refers to simultaneous exchanges of goods and knowledge of roughly equal value, or continuing relations over time. Reciprocity contributes to the development of long-term obligations between people, which helps in achieving positive environmental outcomes" (Pretty, 2003, p. 1913).

At the farm level, the social capital stock of relationships of trust between farmers and institutions (including government agencies) interested in progressing sustainable agriculture appears essential for flow effects such as the exchange of information and the acquirement of knowledge that can facilitate the adoption of sustainability practices at the farm level. Farmers' engagements within their community through memberships of local groups, for instance, may mean the building of the social capital stock of shared values and norms – in cases where these include environmental values and the norms of sustainability related behaviours (e.g. waste reduction, recycling, choosing of environment-friendly products) – it may lead to flow effects that encourage farm-level practices that are in line with such values and norms.

6.1.5 Cultural capital

Cultural capital is a community's embodied cultural skills and values, in all their community-defined forms, inherited from the community's previous generation, undergoing adaptation and extension by current members of the community, and desired by the community to be passed on to its next generation (Dalziel et al, 2009). "The cultural context in which shared attitudes, values and knowledge are transmitted from generation to generation is important in understanding the choices of individuals and groups in relation to co-operation. Shared norms and values enable people to communicate and make sense of common experiences as well as divergences in some norms and values" (ibid., p. 41).

Another potentially problematic area is that although it is widely accepted that "sustainable development requires maintenance of natural capital, the relationship between natural capital and other types of capital remains a matter of debate" (United Nations, et al. 2003, p. 5). While it may be generally agreed that all capital types are essential for the achievement of sustainability, views differ as to whether the various types of capital serve as substitutes for one another or if they are necessary complements to each other (ibid.). One contentious area of debate is "whether natural capital can be replaced by other forms" (ibid., p. 6). Some argue that it is often possible to replace natural capital with human-made and human capital (ibid.). Some such examples include the use of human-made and human capital in the production of synthetic fertiliser, which replaces the natural soil fertility (ibid.). "Even soil itself can be replaced in a limited way through the use of hydroponics" (ibid., p. 6). Such replaces have sometimes been inevitable; for instance, the building of sewage treatment plants as substitutes to natural waterways for waste disposal. "Because sewage production far exceeds that which rivers could accept without suffering a dramatic decrease in functioning, society has been forced to divert financial and human resources away from other purposes into the production and operation of sewage treatment plants. These plants do nothing more than replace the waste assimilation service that the natural capital (the river) cannot provide at current levels of sewage production" (ibid., p. 5). "History is full of similar examples where technological advancement has allowed substitution of scarce resources with those that are more abundant. Many would claim there is every reason to believe that such advancement will continue, even at increased rates, in the future" (ibid., p.6).

Another problem that is likely to be encountered in current attempts applying the capital approach to sustainability is that the five categories of capital are not "equally well understood, either conceptually or empirically" (United Nations, 2008, p. 44). Financial capital is perhaps the best understood, followed by human-made capital, natural capital, human capital and social capital (ibid.). "Social capital, the least well studied of the five, remains a controversial concept for which no single definition is universally accepted" (ibid., p. 44). "Some forms of capital, particularly human and social, cannot be treated in complete analogy with financial or fixed capital. Human capital, it is noted, is what use to be called human potential or human resources, while social capital resembles the notion of social cohesion or social institutions" (ibid., p. 44). Therefore, the differences between the various categories of capital and the current lack of a clear definition and understanding of certain groups of capital is likely to pose a problem to the application of capital-based indicators of sustainability.

6.2 Agricultural sustainability – The need for measurement

Historically, agricultural practices have had a particularly important role to play in the evolution of the concept of sustainability. The consequences of indiscriminate pesticide use in agriculture, as raised in Rachel Carson's "Silent Spring", stirred concerns about sustainability in the 1960s. Agriculture has since been a central concern in sustainability debates for two key reasons – one, its extensive use of natural resources, which means a potential for widespread and extensive environmental effects, and two, the fact that its end product is food which makes it a foundation of human society (Bell and Morse, 2008). This makes agricultural sustainability highly critical, pointing to a need for viable tools for its measurement.

Within an agriculture system, van Calker et al., (2008, p.408) suggest that economic sustainability may be "defined as the ability of the…farmer to continue his farming business (economic viability)". They subdivide social sustainability to include the internal type which concerns "qualitative and quantitative working conditions for the farm operator and employees" and the external type which relates to "societal concern about the impact of agriculture on the well being of people and animals" (ibid, p.408). "Ecological sustainability concerns threats or benefits to flora, fauna, soil, water and climate…" (ibid. p.408).

While there are likely to be varying views about what is required within the various components in ensuring sustainability within a given situation, when this 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 of the types of capital discussed above. As noted by van Loon et al. (2005, p. 48) these include:

i. 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

ii. Human capital – humans who supply labour, not only physical labour but also intellectual input for planning production strategies

iii. Social capital – systems providing labour and marketing support as well as information related to agriculture and health services

iv. Financial capital – markets for purchase and sale of goods, a credit system supplying funds to all levels of agricultural workers

v. Human-made capital – implements needed for agriculture, roads and means of transport, factories for processing of farm produce.

At every level, an agricultural system depends "on the value of services flowing from the total stock of" these five types of capital (Pretty, 2008, p. 451). As an economic sector, agriculture is one that is unique because of its capacity to directly affect "many of the very assets on which it relies for success" (ibid., p. 451). In propagating sustainable agriculture, policy makers are keen "to combine economic performance and a sustainable use of natural resources" (van Passel, 2007, p. 149). There is, therefore, a requirement that the practices of sustainable agriculture take into account each type of capital that it relies on (van Loon et al. 2005). While "the various forms of capital are continuously being used" in food production operations, there is also a need for these operations to be "sensitive to the need to build up" the various types of capital "so that a balance is maintained" (ibid., p. 48). From a capital-based perspective, "terms such as natural, social and human capital are useful in helping to shape concepts around basic questions such as what is agriculture for and what system works best" (Pretty, 2008, p. 452). Moreover, as noted by Statistics New Zealand (2002, p. 89), sustainable development initiatives often take on the capital approach which is "based on the concept of maintaining [the] natural, economic and social base [of human society] over time" in order to provide future generations with "the means and options to pursue their own goals."

Since agricultural systems function in close connection with the natural environment, related assessment indicators would need to move beyond an assessment of their functions as if they were stocks of capital to have a strong sustainability element. Kemp et al., (2001) argue that indicators such as water efficiency, fertiliser inputs, soil chemistry and crop diversity, while useful for estimating and monitoring the production efficiency of a farm, may not necessarily relate to sustainability of the resource base over the long haul. They propose the necessity to perceive an agricultural system as if it were an ecosystem, since essentially agriculture functions within the wider natural ecosystem. This would mean a shift away from likening an agricultural system to a factory system where it would be possible to covert all resources into products. Instead, agriculture needs to be seen as a "purposeful human activity system" that reaps products from the ecosystem. To ensure the efficiency of this activity, it is essential that the wholeness, stability and balance of the ecosystem be preserved. For instance, natural processes such as nutrient cycling and the balance between pest and beneficial organisms need to be maintained for an agricultural system to be sustainable.

Thus, a key challenge for sustainable agriculture and the concept of sustainability in general lies in giving a greater emphasis to considering each type of capital when measuring progress towards sustainability. For these reasons, establishing a clearer understanding of each type of capital within an agricultural system appears critical. The establishment of such an understanding and the use of capital-based indicators in measuring sustainability not only has the potential to be an important measurement device that can prescribe ways for moving forward in making the concept of sustainability a viable goal, but it also has the potential to uplift sustainable agriculture as an appealing approach. For instance, positive correlations between farm level capital-based sustainability indicators and economic performance of farms are likely to be a motivating factor for farmers to adopt and retain the incorporation of indicator-based monitoring in farm practice and management. This acceptance in turn could aid the implementation and evaluation of established agri-environmental policies within a country, improve related decision-making, and facilitate the achievement of agricultural sustainability. Establishing and highlighting such relations would be of importance, considering the concerns over limitations in endurance of farmers' participation in voluntary agri-environmental schemes that Morris and Potter (1995) note and farmers' non-use of professionally established sustainability indicators as Carruthers and Tinning (2003) note. In a survey of farmers in New Zealand, Fairweather and Campbell (2002, p. 297) found that although most farmers were inclined towards "at least a vague version of the agro-ecological approach to farming", their levels of commitment were variable. Although these farmers express an interest in the agro-ecological farming approach, the actual materialisation of related practices were somewhat limited (ibid.). In general, although the adoption of environmentally friendly farm management practices has seen rapid increase in New Zealand over the decades, general adoption rates remain low (OECD, 2008). As Pannell and Glenn (2000, p. 136) assert: "In choosing indicators to recommend to farmers, it has to be recognised that whatever is recommended to them, farmers will make their own, independent choices based solely on their own perceptions about whether indicators are worth monitoring." Therefore, it is essential to highlight that the approach taken in developing and recommending indicators highlights the 'worthiness' of those indicators.

In spite of the differences in the definitions of sustainability and the different approaches to its achievement, as van Passel et al., (2007, p. 149) point out, "there is a clear consensus to move from definition attempts toward developing and using concrete tools for measuring and promoting actual sustainability achievements". This paper argues that capital-based sustainability indicators have the potential to be such a concrete measurement device for measuring agricultural sustainability.

6.3 Current progress in the development of capital-based indicators of sustainability

The New Zealand government's "Linked Indicators Project" led by Statistics New Zealand has identified a set of core sustainable development indicators that encompasses the social, economic, environmental, and cultural elements of human wellbeing (See Statistics New Zealand, Analytical Reports, Linked Indicators http://www.stats.govt.nz/analytical-reports/default.htm). The selected indicators were detailed within four broad categories: (1) Economic indicators which provide measurements of income and socio-economic status which in turn measures people's wellbeing through their capability to buy goods and services, to acquire sufficient food and adequate housing and to take part within the wider community; (2) Social indicators which illustrate a society's attributes or characteristics and in connection to this indicator set, social well-being indicators comprises the aspects of human life that contributes to happiness, life quality and welfare as agreed upon by society in general; (3) Environmental indicators which informs of the built environment as well as aspects of the natural environment such as the quality of air, water, and biodiversity which can directly determine people's quality of life and thus their wellbeing; and (4) Cultural indicators such as "the customs, practices, languages, values and world views that define social groups" which provide a measurement of cultural engagement, cultural identity, and heritage, which in turn provides a measurement of wellbeing since identification with a specific culture generates a feeling of belongingness and security. Cultural capital in particular has been identified to be "an integral part of sustainable development for New Zealand" (Statistics New Zealand, 2002, p. 90) and has been the topic of recent report (Dalziel et al., 2009).

Appendix 3 gives an extensive list of the possible different types of capital relevant for the agricultural sector. These different types of capital have been categorised and defined variably in the literature.

6.4 The ARGOS programme and its use of capital-based sustainability indicators in the evaluation of agricultural systems

Data from the research programmes undertaken by each of the ARGOS objectives has been used to conduct a preliminary examination of the use of the various categories of capital indicators in evaluating the sustainability of farming systems.

Initial research into capital indicators has estimated some of the above indicators from ARGOS data, and examined whether they are useful in characterising different forms of capital. Despite the small number of farms examined, this research enabled us to take a brief look at the feasibility of using such measures, and to identify any differences that exist between the ARGOS kiwifruit panels. Not all the relevant data collected is presented in this section, which reports on a selection of different measures collected for the three of the capital types. The following sections summarise the differences found between the capital indicators for the panels, but this is preliminary research only and conclusions have yet to be drawn about the implications, if any exist, of these differences.

6.4.1 Human-made capital

Four years of data were available for the human capital calculations. An unbalanced ANOVA, with “management system” as the treatment and “season” as a blocking factor was run to determine whether management system had any impact on the value of human-made capital. Two measures were available from the ARGOS database that measured human-made capital, namely “Land & Buildings” (which was information collected from Quotable Value New Zealand (QV)) and “Plant, Machinery & Vehicles” (which was an estimate provided by individual growers). All calculations were carried out with data at a per hectare level.

As Table 10 shows, significant differences amongst panels were found for both measures identified for human-made capital. With respect to Land and Buildings, the capital value of Gold orchards was significantly higher than that of Green orchards, which in turn had significantly higher values than Organic orchards.

The value of plant, machinery and vehicles also differed significantly by management system. However, in this case, Green orchards had plant, machinery and vehicles that are worth significantly more than Organic orchards, while the plant on Organic orchards was worth significantly more than that of Gold orchards.

Table 10
Means and significance of differences between Green, Organic and Gold kiwifruit orchards for selected human-made capital measures

	Land & Buildings	Plant, Machinery & Vehicles
Green	$318,049	$40,019
Organic	$283,564	$19,031
Gold	$382,354	$8,026
Significance of difference	*	*

*P<0.05, **P<0.001, ***P<0.0001

6.4.2 Social capital

Data from only one year were available for estimation of the social capital indicators. While there was a number of different indicators that could have been used to measure social capital, the four indicators chosen for this study were selected because they have been used in other research reported in the literature. The four indicators selected were: 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". The questions were answered using a 7-point Likert scale with one representing "not all involved", and seven representing "heavily involved" (for the first three measures), and one representing "very strongly disagree" and seven representing "very strongly agree" for the final measure. An unbalanced ANOVA was run to determine whether any significant differences existed between management systems.

No significant differences amongst panels were found for any of the measures chosen (see Table 11).

Table 11
Means and significant difference between Green, Organic and Gold kiwifruit orchards for selected social capital measures

	Voting in national elections	Voting in local elections	Providing cash financial support to community activities	Orchard is contributing to the local community
Green	5.9	5.5	3.7	4.7
Organic	5.8	5.3	3.3	5.6
Gold	5.6	5.0	3.2	4.6
Significance of difference	*ns*	*ns*	*ns*	*ns*

However, in drawing conclusions about sustainability from differences in indicators such as these, the changes that occur over time will be of much greater importance than point estimates, since there is there is no right or wrong indicator value. Rather, values should be constant if not improving over time. Further research over a longer period is required to determine whether the indicators estimated in this research are useful, whether their values change over time, and whether these changes vary amongst panels.

6.4.3 Natural capital

Carey et al., (2009) have recently published the results of their measurement of natural capital based on the ARGOS data. To reduce duplication, this section presents selected elements of the data presented by Carey et al to illustrate the measurement of natural capital. Those measures presented here are: Soluble C; Microbial biomass N; Olsen P; pH; and the number of earthworms. An ANOVA was run to determine the differences amongst panels with respect to these variables (for full details of the analysis conducted, see Carey et al., 2009).

Table 12 shows the natural capital measures reported. No significant differences were observed amongst panels for Soluble C while microbial mass N was greater for Organic orchards than for Green or Gold orchards. Higher microbial mass N was measured between rows than within rows. Olsen-P was significantly lower for Organic orchards than Gold orchards, with no difference between Green orchards and others, and Soil pH was significantly higher on Organic orchards than on Green and Gold orchards, although these differences were small. Finally, there were significantly more earthworms in Organic orchards than in Green or Gold orchards, and higher earthworm numbers between rows than within rows.

Table 12
Means and significant difference between Green, Organic and Gold kiwifruit orchards for selected natural capital measures

	Sampling Position	Soluble C *(mg C kg^{-1})*	Microbial biomass – N *(mg N kg^{-1})*	Olsen P *(mg P kg^{-1} soil)*	pH	Earthworms *(No. m^{-2})*
Green	WR[1]	133	53	55.5	6.5	51
	BR[2]	144	76	40.8	6.5	106
Organic	WR	143	88	50.3	6.6	119
	BR	148	99	37.1	6.8	149
Gold	WR	151	64	65.6	6.2	61
	BR	157	86	50.0	6.5	87
Significance of difference		*ns*	***	*	***	*

From: Carey et al., 2009

*P<0.05, **P<0.001, ***P<0.0001

[1] Measurement taken within row
[2] Measurement taken between row

As Table 12 shows there is little consistency in direction of difference amongst the measures of natural capital in which significant differences were found, although Organic orchards were observed to be higher in microbial mass N, pH and number or earthworms.

Although there have been a number of significant differences found amongst panels with respect to the capital indicators identified, it is important to note that many of these measures do not have an established "optimal" level, and that it is the change over time that provides important information about sustainability. For most measures, consistency or increase over time is the desired outcome. For example, we would hope that values of many of the social capital measures, e.g. voting participation, will at least remain constant over time to show that the involvement of people in their communities is not decreasing. There are, however, some measures that should remain constant or decrease, e.g. greenhouse emissions. Many of the natural capital measurements should fall within an "ideal" range to ensure that the natural environment is not deteriorating.

This section includes a brief discussion of some of the potential measures of capital (particularly human-made, social and natural) and, using data available from the ARGOS work currently being undertaken, provides values for a number of indicators. This work provides a platform for further research and paves the way for future studies to be undertaken extending the comparisons across a number of years for these or other indicators in order to investigate changes in capital stocks overtime.

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APPENDIX 1
SHEEP/BEEF PANELS
REAL ($2007/08) FINANCIAL DATA
PER HECTARE INCOME AND COST AGGREGATES

Cash Farm Revenue		F=0.005			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		945	53	839	1051
Integrated		1178	53	1053	1303
Conventional		1183	60	1063	1303
Gross Farm Revenue		F=0.002			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		955	47	861	1049
Integrated		1153	55	1042	1264
Conventional		1204	53	1097	1311
Farm Working Expenses		F=0.004			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		571	37	496	645
Integrated		733	44	645	821
Conventional		748	42	663	833
Cash Farm Expenses		F=<.001			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		714	46	621	807
Integrated		926	54	816	1035
Conventional		988	52	882	1093
Cash Farm Surplus		F=0.585			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		219	292	84	213
Integrated		240	327	44	197
Conventional		179	263	32	179

Net Farm Profit Before Tax		F=0.676			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		149	213	145	292
Integrated		120	197	153	327
Conventional		106	179	96	263

Economic Farm Surplus		F=0.101			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		-17	34	-86	52
Integrated		55	41	-26	137
Conventional		96	39	17	174

THE INDIVIDUAL COST ELEMENTS

Cash Labour Expenses		F=0.518			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		113	8	96	130
Integrated		99	10	79	119
Conventional		114	10	94	133

Stock Expenses		F=<.001			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		15	3	10	20
Integrated		41	3	35	47
Conventional		38	3	32	44

Cash Feed Expenses		F=0.016			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		44	10	24	65
Integrated		89	12	66	113
Conventional		77	11	54	100

Pasture Expenses		F=<.001			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		46	4	37	54
Integrated		76	5	66	86
Conventional		70	5	60	80

Vehicle Expenses		F=0.142			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		70	5	60	81
Integrated		86	6	74	99
Conventional		82	6	70	94

Repairs and Maintenance Expenses			F=0.102		
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		67	5	57	77
Integrated		51	6	39	63
Conventional		66	6	54	77

Overhead Expenses		F=0.268			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		73	4	65	81
Integrated		69	5	59	79
Conventional		63	5	53	72

Other Working Expenses		F=0.742			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		72	10	51	93
Integrated		62	12	38	87
Conventional		60	12	37	84

Fertiliser Expenses		F=<.001			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		59.90	7.81	44.21	75.59
Integrated		123.20	9.22	104.68	141.72
Conventional		113.70	8.88	95.86	131.54

Total Labour Expenses		F=0.333			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		393	17	359	426
Integrated		374	20	334	414
Conventional		354	19	316	392
Total Feed Expenses		F=0.042			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		45	11	23	67
Integrated		86	13	60	111
Conventional		79	12	54	103

THE KEY PERFORMANCE RATIOS

FWE:GFR		F=0.992			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		65.16%	2.66%	59.81%	70.51%
Integrated		64.76%	3.14%	58.45%	71.07%
Conventional		65.30%	3.03%	59.22%	71.38%
CFE:GFR		F=0.269			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		80.9%	3.51%	74.22%	87.64%
Integrated		80.5%	3.88%	72.62%	88.46%
Conventional		88.2%	3.81%	80.57%	95.83%
Debt Servicing Ratio		F=0.066			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	96				
Organic		15.8%	2.20%	11.36%	20.20%
Integrated		15.8%	2.60%	10.56%	21.00%
Conventional		22.9%	2.50%	17.87%	27.93%

APPENDIX 2
KIWIFRUIT PANELS
REAL ($2006/07) FINANCIAL DATA
PER HECTARE INCOME AND COST AGGREGATES

Gross Orchard Revenue		F=<.001			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		35742	2561	30597	40887
Organic		38059	2561	33149	42969
Gold		54556	3215	48097	61015
Orchardgate Revenue		F=<.001			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		32913	2434	28023	37803
Organic		35201	2333	30514	39888
Gold		53205	3085	47007	59403
Orchard Working Expenses		F=<.001			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		20215	1143	17919	22511
Organic		19319	1099	17111	21527
Gold		31720	1428	28851	34589
Cash Orchard Expenses		F=<.001			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		22486	1291	19892	25080
Organic		21543	1241	19050	24036
Gold		34315	1612	31076	37554
Cash Orchard Surplus		F=0.242			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		13328	17945	6789	15577
Organic		16260	20700	9569	18187
Gold		20143	25911	10905	22501

Net Orchard Profit Before Tax			F=0.347		
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		11183	15577	8711	17945
Organic		13878	18187	11820	20700
Gold		16703	22501	14375	25911

Economic Orchard Surplus		F=0.86			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		505	2503	-4524	5534
Organic		2360	2468	-2598	7318
Gold		1435	3232	-5058	7928

INDIVIDUAL COST ELEMENTS

Cash Labour Expenses		F=<.001			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		9663	715	8227	11099
Organic		8750	713	7318	10182
Gold		20092	948	18187	21997

Spray & Chemical Expenses		F=<.001			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		1483	101	1281	1685
Organic		1071	96	878	1264
Gold		1785	126	1531	2039

Pollination Expenses		F=0.068			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		1513	91	1329	1697
Organic		1252	87	1077	1427
Gold		1233	116	1000	1466

Fertiliser Expenses		F=0.01			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		1221	102	1015	1427
Organic		1638	98	1442	1834
Gold		1534	129	1276	1792

Vehicle Expenses		F=0.157			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		1001	121	759	1243
Organic		1267	115	1036	1498
Gold		1335	151	1031	1639
Repairs and Maintenance Expenses			F=0.114		
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		2469	302	1863	3075
Organic		1697	288	1119	2275
Gold		1655	379	895	2415
Overhead Expenses		F=0.025			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		2170	179	1811	2529
Organic		2819	171	2476	3162
Gold		2405	225	1954	2856
Other Working Expenses		F=0.08			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
All years ($07/08)	84				
Green		699	295	107	1291
Organic		1269	287	692	1846
Gold		1809	370	1065	2553
Total Labour Expenses		F=<.001			
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		23033	1050	20924	25142
Organic		22880	1024	20823	24937
Gold		37652	1353	34934	40370

OTHER KEY PERFORMANCE INDICATORS

OWE:GOR	F=0.323				
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		60.7%	3.9%	52.8%	68.6%
Organic		57.0%	3.7%	49.5%	64.4%
Gold		67.4%	5.0%	57.4%	77.4%
COE:GOR	F=0.478				
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		67.5%	4.3%	58.9%	76.1%
Organic		63.4%	4.1%	55.2%	71.5%
Gold		72.2%	5.4%	61.3%	83.1%
Yield (trays per ha)	F=<.001				
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		7107	323	6458	7756
Organic		5208	308	4589	5827
Gold		8690	405	7876	9504
OGR per tray	F=<.001				
Management System	DF	Mean	Std. Err.	95% Confidence Interval	
				Lower Bound	Upper Bound
$07/08	84				
Green		4.91	0.15	4.62	5.20
Organic		7.18	0.14	6.89	7.46
Gold		6.18	0.19	5.81	6.56

APPENDIX 3
CATEGORISATION OF CAPITAL WITHIN THE AGRICULTURE SECTOR

Indicator Terminology and Source	Indicator Categories
erformance Indicators for gribusiness *Saunders et al. (2007)*	***Human Capital*** • Employment (full- time, part-time and unemployed) • Qualifications of employees • Skill level and experience of employees • Attributes of employees
	Human-Made Capital • Buildings by type and age • Water (water races and potable supplies) • Power distribution (network capacity and current delivery) • Telecommunication (access to phone, internet and fax; and data capacity)
	Natural Capital • Land use (by type) • Water quality • Green house gas emissions • Energy use • Water (stockwater, groundwater riparian water usage) • Soil fertility • Climate
	Social Capital • Turnout at elections • Membership of local groups • Donations to local groups • Use of local facilities (eg: Doctor)
	Cultural Capital • Ethnic group • Usage rates of public halls and recreation centres • Length of time in locality
Statistics New Zealand, Analytical Reports, Linked Indicators (*http://www.stats.govt.nz/analytical-reports/default.htm)*	**Environmental Indicators** • Look and feel of the city • Traffic and transport • National environmental air quality standards • Greenhouse gasses • Indigenous vegetation • Native birds • Contaminated sites • Land cover and use • Energy use • National water quality • National water quantity (surface and groundwater)

	Economic Indicators • Tourism – number of guest nights purchased • Building – building consents • Migration flows • Openness to trade • Income • Social deprivation • Share of national economy • Household consumption • Unemployment • Employment • Real capital investment • Infrastructure (quality) • Research and development (financing) • Intangible investment
	Social Indicators • Voting at general elections • Life expectancy • Injury rates • Household size • Number of households • Participation in sport and active leisure • Criminal victimisation • Perceptions of safety • Road causalities • Educational attainment • Early childhood education • Quality of life • Telephone and internet access at home
	Cultural Indicators • Language retention • Maori language speakers • Employment in cultural industry • Local content on New Zealand television • Historic places
Agricultural Capital *(Table 1.1. Strategies for building up various forms of capital required for agricultural food production) (Pretty, 1999 cited in van Loon et al. 2005, p.48)*	**Natural Capital** • Water harvesting, water management • Soil conservation • Biological pest control • Composting, manuring • Diverse systems – many types • Conserving genetic resources

	Social capital • Cooperatives • Extension workers: Government, NGO, private • Farmers self-help and research activities • Social values and systems
	Human capital • Improved nutrition • Education • Health
	Financial capital • Stable markets • Subsidiary activities • Readily available credit • Post-harvest technological opportunities • Value-added activities
	Physical capital • Improved tools, machinery • Precision agriculture methods • Low dose sprays • Improved crop varieties • Roads • Processing plant
Sustainability Indicators *(Bond and Klonsky, 2006)*	**(Input Based Sustainability Indicators)** ***Man-made and Human Capital Indicators*** • Pesticide Use • Fertiliser Use • Labour Use • Machinery Use • Livestock Use
	(Input Based Sustainability Indicators) ***Natural Capital Indicators*** *Soil* • Soil physical, chemical and biological properties • Soil erosion • Fertiliser use • Use of Tillage Practices • Use of hedgerows and walls • Use of alternative cropping systems (rotation, intercropping, etc.) *Land* • Area of deforestation • Categories of land use • Inherent land quality (slope, altitude, etc.) *Water* • Water use • Depth of groundwater table

	• Water storage capacity • Concentrations of pollutants in ground and surface water • Water salinity *Energy* • Categories of energy use
	(Institutional and Economic Sustainability Indicators) ***Social Capital and Institutions*** • Access to land, water, markets, and credits • Quality of life measures • Provision of services (health care, education, etc.) • Land Tenure • Market Characteristics (especially prices)
	(Institutional and Economic Sustainability Indicators) ***Risk*** • Yield variability • Probability of system failure • Use of risk-reducing management practices • Input self-sufficiency • Biodiversity
	(Institutional and Economic Sustainability Indicators) ***Revenues, Costs, and Employment*** • Farm profits (revenues less costs) • NPV of returns • Farm assets • Leverage ratios • Regional / national income • Ag employment • Subsidies / Env. Payments • Credit Availability
	(Output Based Sustainability Indicators) ***Output and Production*** *Goods* • Crop/tree/animal yield • Production per capita • Technology • Output / input ratio • Total factor productivity • Total social factor productivity *Bads (Externalities)* • Air pollution (concentrations and emissions) • Water pollution (concentrations and emissions, leaching and runoff) • Food pollution (related to pesticides) • Land pollution (acidification, etc.) • Soil erosion

	• Nutrient losses / balances • Biodiversity measures / depletion • Habitat destruction • Land Use • Pesticide Use • Fertiliser Use • Other management practices
Sustainability indicators and attributes of agricultural sustainability *(SCARM, 1993)*	***Economic Indicators*** ***Real net farm income*** • Net farm income • Productivity Terms of trade • Area of land used for agriculture
	Off-site environmental impacts • Food chemical contamination level • River turbidity • Dust storm frequency • Length of contact zones ***Land and water quality*** • Water use efficiency • Nutrient balance • Area of native vegetation • Degree of vegetation fragmentation
	Social Indicators Managerial skill of farmers, landowners and land managers in finance, farming practice and environmental stewardship – e.g. decision making about the products grown, physical farm management including operational planning and conservation, financial planning, and the capacity to realize personal and societal goal. 1. Formal knowledge – educational level of those employed in farming compared to that of the rest of the community. (full school education / higher education) 2. Skills base – e.g. literacy, numeracy, driving, welding, machinery operation and computing. (While farming skills are taught in rural education institutions, many farmers have acquired skill through years of experience and there is a danger of undervaluing this.) 3. Attitudes of the land managers – ethics, codes of practice, and organisational membership (e.g. membership within conservation groups or other community or other community land management groups, such as Landcare), public awareness of conservation, the proportion of community attending training course and the degree of promotion of conservation practices by advisory services, the proportion of farmers using multiple sources of

	information such as advisory services and consultant. 4. Planning capacity of farmers – farm planning (e.g. use of physical and financial plans), responses to risk and financial management.
Sustainability Indicators *(Smyth and Dumanski, 1993)*	***Economic Indicators*** • Profitability
	Biophysical Indicators Off-site biophysical indicators. The most frequently cited off-site environmental impacts arising from both historical and present agricultural activities include: • The alteration of landscape hydrology by clearance of deep rooted perennial vegetation; • Rise in ground water through the excessive use of irrigation waters; • Siltation of rivers, dams, and natural water bodies, and atmospheric pollution, through surface soil transportation by water and wind; • Leaching of fertilizers and pesticides into ground waters and streams, and aerial pesticide pollution leading to human health problems, through inappropriate use of agricultural chemicals; and, loss of natural flora and fauna through large-scale clearing of native habitats.
Indicators for Sustainable Development *(Bossel, 1999)*	***Human Capital*** • Human system = social system + individual development + government • Individual potential describes the potential for competent individual action as produced by—and producing—the possibilities for individual development. It is the accumulated result of tradition and culture as well as socio-political and economic conditions. • Social potential denotes something less tangible: the ability to deal constructively with social processes, and to employ them for the benefit of the total system. This has a strong cultural component determining social coherence and relationships. It includes such aspects as honesty, trust, competence and efficiency. • Organizational potential, as manifest in the know-how and performance standards of government, administration, business and management, is vital for effective resource use (natural and human) for the benefit of the total system.
	Structural (built) Capital • Support system = infrastructure + economic system • Infrastructure potential denotes the stock of built structures like cities, roads, water supply systems, schools and universities. It is the essential backbone of all economic and social activity. • Production potential of the economic system includes

	the stock of production, distribution and marketing facilities. It provides the means for all economic activity.
	Natural Capital • Natural system = resources + environment • Natural potential represents the stock of renewable and non-renewable resources of materials, energy and biosystems, including the capacity for waste absorption and regeneration.
Indicators For The Economic And Social Dimensions Of Sustainable Agriculture And Rural Development *(European Commission, 2001)*	**Economic dimension** ***Efficiency indicators*** • Output indicators (Quality and • quantity) • Competitiveness and viability indicators ***Over space*** • Indicators on the viability of rural communities and the maintenance of a balanced pattern of development including the agricultural sector's contribution
	Social dimension ***Efficiency indicators*** • Indicators on employment • Indicators on institutional efficiency ***Over space/sectors*** • Indicators on access to resources/services and opportunities ***Social groups*** • Indicators on equal opportunities ***Ethics*** • Labour conditions • Animal welfare indicators

APPENDIX 4
ARGOS PUBLICATIONS FROM THE ECONPOMICS OBJECTIVE TO OCTOBER 1 2009

AERU Research Reports

Kaye-Blake. W., Greenhaigh, S., Turner, J. Holbek, E. Sinclair, R., Matunga, T. and Saunders, C. (2009). A Review of Research on Economic Impacts of Climate Change. AERU Research Report No. 314, Lincoln University, April.

Kilgour, M., Saunders, C.M., Scrimgeour, F., and Zellman, E. (2008). The Key Elements of Success and Failure in the NZ Kiwifruit Industry. AERU Research Report No. 311, Lincoln University, August 2008.

Saunders, C.M., McDermott, A., Sinclair, S., de Aragao Pereira, M. and Dowling, S. (2008). Meat Sector Literature Review. Report for MAF in Agresearch Farming, Food and Health.First, August 2008.

McDermott, A., Saunders, C.M., Zellman, E., Hope, T. and Fisher, A. (2008). The key elements of success and failure in the NZ sheep meat industry from 1980-2007. AERU Research Report No. 308, Lincoln University, August 2008.

Saunders, C.M. and Barber, A. (2008). Food Miles, Carbon Footprinting and Associated Factors with Potential to affect New Zealand Exports. Report prepared for Ministry of Foreign Affairs and Trade, July 2008.

Saunders, C.M. and Hayes, P. (2007). Air Freight Transport of Fresh Fruit and Vegetables. AERU Research Report No. 299, Lincoln University, October 2007.

Saunders, C., Kaye-Blake, W., Hayes, P. and Shadbolt, N. (2007). Model development and key indicators applicable to agribusiness development. Report for MAF, AERU, Lincoln University, May.

Saunders, C.M., Kaye-Blake, W. and Shadbolt, N. (2006). Agricultural Business Models and Performance Indicators, report to MAF, December 2006.

Saunders, C.M., Kaye-Blake, W., Shadbolt, N. and Shettihewa, S. (2006). Business Models and Performance Indicators for SMEs, report to MAF, November 2006.

Wreford, A. and Saunders, C. Analysis of a Free Trade Agreement between China and New Zealand. Report prepared for Ministry of Foreign Affairs and Trade, NZ (2004).

Saunders, C., Allison, G. and Wreford, A. (2003). Food Market and Trade Risks. Report prepared for the Office of the Parliamentary Commissioner for the Environment, New Zealand (2003).

Conference Papers

Greer, G., Kaye-Blake, W., Campbell, R. (2009). Comparative performance of Organic, Conventional, and integrated producers in New Zealand. Paper presented at the 15th New Zealand Agricultural and Resource Economics Society Conference, 27-28 August, Nelson.

Saunders, C.M, Kaye-Blake, W., Campbell R. and Benge, J. (2009). Agricultural environmental indicators: using OECD agri-environmental indicators to assess New Zealand kiwifruit orchards. Paper presented at the 15th New Zealand Agricultural and Resource Economics Society Conference, 27-28 August, Nelson.

Saunders, C.M., Kaye-Blake, W. and Campbell R. (2009). The capital-based sustainability indicators as a possible way for measuring agricultural sustainability. Paper presented at the 15th New Zealand Agricultural and Resource Economics Society Conference, 27-28 August, Nelson.

Saunders, C. (2009). Feeding the world: the role of New Zealand's food exports. Presented to Dimensions of the Global Food Crisis, University of Otago 44th Foreign Policy School, Dunedin 26-28 June.

Saunders, C. (2009). Food Miles, Carbon footprinting and their potential impact on trade. Presented to NZ Soil Carbon Conference, Napier 23-25 June.

Wreford, A., Cagatay, S. and Saunders, C. (2009). Climate Change and Agriculture: The Economic and Environmental Implications of Extreme Weather Events and Bio-Energy Policy. Paper presented to Joint AESI / AES conference, Dublin, Ireland, 30 March – 1 April.

Saunders, C. (2009). Drivers of Current World Food Prices and the Effects on Food Consumption Expenditures in China and India. Paper presented to Joint AESI / AES conference, Dublin, Ireland, 30 March – 1 April.

Saunders, C., Barber, A. and Sorensen, L. (2009). Food Miles Carbon Footprinting and their potential impact on trade. Paper presented to AARES 53rd Annual Conference, Cairns, North Queensland, Australia, 10-13 February.

Saunders, C. (2008). Market access issues for New Zealand into Europe and issues around collaboration of research. Paper presented to NCRE, in association with EUSA, Asia Pacific Joint International conference entitled "Europe in the Changing World: Challenges, Priorities and Research Collaboration, Christchurch, 25-27 September 2008.

Saunders, C., Kaye-Blake, W., de Aragao Pereira, M., Marshall, L. and Greenhalgh, S. (2008). Impacts of Biofuel Policy in EU and NZ trade. Paper presented to NCRE, in association with EUSA, Asia Pacific Joint International conference entitled "Europe in the Changing World: Challenges, Priorities and Research Collaboration, Christchurch, 25-27 September 2008.

McDermott, A., Saunders, C.M., Zellman, E. and Hope, T. (2008). Sheepmeat Industry Performance in New Zealand: 1980-2007. Paper presented to 13th Annual Conference of the NZARES, Nelson, 28-29 August 2008.

Saunders, C.M., Kaye-Blake, W., Marshall, L, Greenhalgh, S. and de Aragao Pereira, Mariana (2008). Impacts of a United States biofuel policy on New Zealand's agricultural sector. Paper presented to the 13th Conference of the NZARES, Nelson, 28-29 August 2008.

Kilgour, M., Lock, S., Saunders, C.M. and Scrimgeour, F. (2008). Kiwifruit Industry Performance in New Zealand 1980-2007. Paper presented to 13th Annual Conference of the NZARES, Nelson, 28-29 August 2008.

Saunders, C.M. (2008). Carbon Footprints, lifecycle analysis, food miles – Global trade trends and market issues. Presented to South Island Dairy Events (SIDE), Stadium Southland, Invercargill, 23-25 June 2008.

Saunders, C.M. Marshall, L. Kaye Blake, W., Greenhalgh, S. and de Aragao Pereira (2008) Impact of US biofuel polices on international trade in meat and dairy products. Paper presented to Agricultural Economics Society Annual Conference, Cirencester UK, 31 March - 2 April 2008.

Saunders, C.M. (2008). Increased returns from exports through sustainability. Presented to Outlook 2008 conference, Canberra, Australia, 4-5 March 2008

Saunders, C.M., Marshall, L., Kaye-Blake, W., Greenhalgh, S. and de Aragao Pereira, M. (2007). Impacts of U.S. biofuel policies on international trade in meat and dairy products. Paper presented at the Center for North American Studies conference, *Domestic and Trade Impacts of U.S. Farm Policy: Future Directions and Challenges*, Washington, D.C., 15-16 November, http://cnas.tamu.edu/SessIBPaperSaundersKayeBlakeEtAl.doc. Conference programme available at http://cnas.tamu.edu/.

Saunders, C.M. and Zellman, E. (2007). New Zealand Access to the EU Market: Factors Affecting Agricultural Exports. Paper presented to European Union Centres Network Conference 2007, St David's Centre, University of Otago, 12-13 November.

Saunders, C.M. (2007) Carbon footprints, life cycle analysis, food miles – global trade trends and market issues and Implementing a carbon neutral strategy – issues and challenges. Presented at Romeo Bragato 2007 conference, Auckland, 23-24 August 2007

Saunders, C.M. (2007). Food miles and other threats. National Organics Conference, Lincoln University, 17-19 August 2007.

Saunders, C.M. (2007). What lies ahead? Looking at costs and sustainability for the future. SIDE conference, Lincoln University, 18-20 Jun 07.

Saunders, C.M. (2007). Growing export returns from increased sustainable agricultural production, EDANZ National Conference, 20 April – 2 May 2007, Christchurch Convention Centre.

Kogler, K. and Saunders, C.M. (2007). Single Farm Payment in the European Union and its Implications on New Zealand Dairy and Beef Trade, AES 81st Annual Conference, Reading, London, UK, 2-4 April 2007.

Kaye-Blake, W., Saunders, C.M. and Bicknell, K. (2007). Modelling Refusal of Genetically Modified Food, AES 81st Annual Conference, Reading, London, UK, 2-4 April 2007.

Saunders, C., Sun, Y. and Greer, G. (2006). A preliminary analysis of total factor productivity in New Zealand Agriculture 1985-2002. Paper presented to NZARES Conference, Tahuna, Nelson, 24-25 August 2006.

Wreford, A. and Saunders, C.M. (2006). The Implications of Global Trade Policy Reform for Meeting Kyoto Protocol Commitments. AES Conference, Paris, March 2006.

Saunders, C.M., Wreford, A. and Rasin, S. (2005). An analysis of agriculture trade policy reforms and their impact on the Eu, China and New Zealand. Paper presented to 11th Annual Conference of the New Zealand Agricultural and Resource Economics Society (Inc.), Nelson, August 2005.

Saunders, C., Kaye-Blake, W., & Cagatay, S. (2005). How GM Technology Can Benefit Agricultural Producers: a partial equilibrium trade analysis. Paper presented at the 79th Agricultural Economics Society Conference, London.

Saunders, C. and Wreford, A. (2004). Modelling the Effects of Climate Policy on the NZ Livestock sector. Presented at the New Zealand Association of Economists Annual Conference, Wellington, 30 June – 2 July 2004.

Saunders, C., Wreford, A. (2004). Agricultural Trade Liberalisation and Greenhouse Gas Emissions: Modelling the linkages using a partial equilibrium trade model. Presented at the NAREA/CAES trade-environment workshop, June 23, Halifax, Nova Scotia.

Saunders, C.M. and Wreford, A. (2004). Modeling pastoral land use for climate change analysis. Paper presented to the NZ Association of Economists Conference, Wellington, 30 June to 2nd July 2004.

Saunders, C. and A. Wreford (2004). Linking Natural and Social Science to Assess the Impact of Climate Change Policy on International Trade. Paper presented at the Agricultural Economics Society (UK) conference, April 2- 4, London, United Kingdom.

Saunders, C. and Wreford, A. (2004). Modelling the impact of mitigation policies to meet Kyoto requirements: Using the LTEM to assess the impact on trade. Presented at the Australian Association of Resource and Environmental Economists, Melbourne, February 2004. Available on-line at http://come.to/aares

Keynote

Saunders, C. (2009). Carbon Footprints for the Dairy Industry. Paper presented at the Joint meeting of NSW Farmers' and Association Dairy Section and Dairy NSW, 3 June 2009, Sydney, Australia.

Saunders, C.M. (2008). How important is sustainability to "brand NZ" in overseas markets? Presented to Striking a Balance, Association for Women in Sciences (AWIS) conference, Christchurch 2-4 July 2008.

Saunders, C.M. (2008). Food Miles, Carbon Footprinting and New Zealand Trade. Presented to NZIFST annual conference, Rotorua, 24-26 June 2008.

Saunders, C.M. (2008). Carbon Footprinting and factors affecting trade. Presented to Energy Challenges and Choices for Southland conference, SIT, Invercargill, 6 June 2008.

Saunders, C.M. (2008). The Carbon Footprint. Presented to Network for Women in Dairying conference, Hamilton, 14-15 May 2008.

Saunders, C.M. (2008). Sustainable Exporting in a Climate Constrained Environment. Presented to the Department of Primary Industries Spring St Seminar, Canberra, 6 March 2008.

Saunders, C.M. (2008). Carbon footprinting and other factors affecting our trade. Presented to the Joint Federated Farmers Dairy Section/ADF Council meeting, Sudima Hotel, Christchurch, 15-16 February 2008.

Saunders, C.M. (2007). Food miles, carbon footprinting and other factors affecting our trade. Thrive Waikato – invited keynote address, 20 November.

Saunders, C.M. (2007). Food Miles, Carbon Footprinting and NZ Trade. Presented to Climate Research workshop, Christchurch, 14 November 2007.

Saunders, C.M. (2007). Technical, Trade & Consumer Issues: An introduction to carbon footprints, life cycles analysis and food miles Global trade and market trends and issues, Carbon Neutrality & Winegrowing seminar, Napier, 14 May 2007.

Journal Article Refereed

Saunders, C., Kaye-Blake, W., Marshall, L., Greenhalgh, S., and Pereira, M. d. A. (2009). Impacts of a United States' biofuel policy on New Zealand's agricultural sector. *Energy Policy 37* (9), September.

Greer, G., Kaye-Blake, W., Zellman, E., and Parsonson-Ensor, C. (2008). Comparison of the financial performance of Organic and Conventional farms. *Journal of Organic Systems 3*(2), 18-28.

Saunders, C., Kolandai, K., Greer, G., Kaye-Blake, W. and Sorensen, L. (2009). An application of agri-environmental indicators to panels of New Zealand farms. *Aspects of Applied Biology – Integrated Agricultural Systems: Methodologies, Modelling and Measuring*, 93: 139-142.

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