AGRICULTURE RESEARCH GROUP ON SUSTAINABILITY

ARGOS Annual Sector Report

High Country

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Report 1

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Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Preface

This report is an abbreviated version (personal information removed) of the report that ARGOS high country farmers recently received. It includes baseline data collected during the establishment of each High Country property in the ARGOS prgramme and contains the following sections:

- Description and background of the ARGOS programme;
- An overview of key attributes of all high country farms involved in the ARGOS programme.
- Methods and initial results obtained from monitoring of land cover, aquatic and soil variables on your farm
- Upcoming expectations from the social objective

This report will be updated annually and will be complemented with other information gathered by the ARGOS team. This will include information on the social, economic and ecological indicators being measured throughout the course of the research.

Every effort has been made to ensure that all the information is accurate. However, if there are any inaccuracies, please let me know as soon as possible.

Please be assured that this report and its information will remain confidential to the ARGOS team with only aggregated results published that will not identify the results of individual properties.

Please contact me if you have any questions.

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1. ARGOS

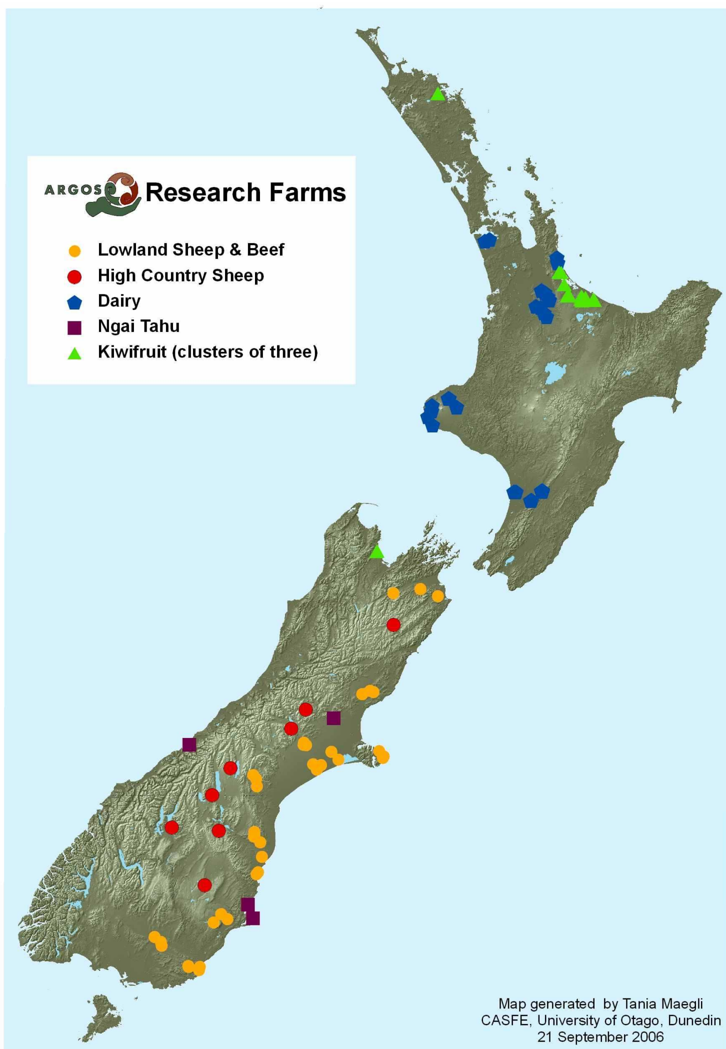
1.1 Description of the ARGOS programme

Background

ARGOS (Agriculture Research Group on Sustainability) was formed to undertake a long term research programme called “Pathways to Sustainability in Primary Production”. The project is a unincorporated joint venture between three parties - the Agribusiness Group, Lincoln University, and the University of Otago.

The key task of the programme is to examine the economic, environmental and social performance of four New Zealand farming sectors:

- Lowland sheep and beef — 36 farms
- Dairy — 24 farms
- Kiwifruit — 36 orchards
- High Country — 8 farms
- Ngai Tahu landowners — 8 case studies



The programme is funded by the government through the Foundation for Research, Science and Technology (FRST) and various industry stakeholders – a meat packing company, Merino New Zealand Inc, Fonterra, Ngai Tahu and Zespri International. This funding has been secured for 6 years as a first step in a 20 to 30 year project.

The goals of the ARGOS research is to facilitate innovation and improved performance in primary production systems and to enhance those systems abilities to meet environmental and quality standards, leading to greater returns for New Zealand farmers and growers.

1.2 High Country ARGOS

The High Country section of ARGOS is focused on the merino sector and involves the monitoring and analysis of eight High Country properties throughout the South Island.

The monitoring and analysis includes financial, management, environmental and social variables.

Motivation and Benefits

The marketing of New Zealand Merino wool has long been supported by a strong reputation and brand image based on the pure and natural landscape that it is produced in and it appears likely that New Zealand Merino growers are producing Merino wool in a very sustainable manner. In today`s markets however there is a need to have objective information to back up these marketing claims. Consequently, there is a need for an integrated, in-depth program of monitoring, recording and analysis across key indicators of sustainability for Merino production.

A major outcome of the ARGOS programme will be to provide information that can be used to enhance the exisiting Zque sustainability assurance programme that allows the industry and individual merino growers to report on the sustainability of the systems in which merino wool is grown. This provides the market and other stakeholders with an assurance that the farming system that New Zealand Merino wool is produced in has a high level of sustainability and environmental integrity. The information from ARGOS will also provide information that can be used to respond to regulatory and market demands for information on the environmental performance and impact of High Country farms.

The project will also assist in identifying management strategies that can be used to lift the environmental and financial performance of any less sustainable farming operations so that they can successfully meet market demands for sustainably produced products.

In addition to industry benefits, through direct involvement in the programme participants can expect additional benefits including:

- Annual collection, analysis and reporting of performance against a broad range of sustainability factors including economic, social and environmental (e.g., soil physical, chemical and biological quality) dimensions.
- Information that may assist to satisfy compliance reporting requirements e.g. Zque Assurance programme.
- Tailored individual support provided through the Field Research Manager.
- Information on new technologies and approaches to management.
- Identification of possible best management practices to enhance the sustainability of their farm.
- Up to date information on the impact that local and central government policies may potentially have on farming systems
- Information on the impact that alternative land use activities will have on farming systems

Involvement in the Research Programme

We have designed the Research Programme to limit the demands on the participant's time. We do, however need to carefully and systematically record data for the duration of the research programme.

We anticipate the following annual interactions:

- Interviews – 2-3 meetings per year on each property to clarify environmental, economic and social data relating to each farm. This will require personal involvement from the farmer (and anyone in their family that may wish to be involved) with each meeting taking 1-3 hours.

- Farm monitoring – monitoring farm physical and environmental issues (undertaken by research teams - will not require input from the farmer). This may involve up to six visits per year.

In addition to the above we will offer the following activities to the participant. Their participation in them is entirely voluntary.

- Discussion Group meetings, workshops and conferences where results, best management practices and other findings will be shared.
- Access to new technologies and management interventions through linkage with associated projects.

2 Farm Management:

2.1 Introduction

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

Initially descriptive data was collected to describe an overview of each property. Additional data will be collected annually to cover the different parts of the system as outlined in figure 1. These factors can be regarded as 'dots in a box', so the next step will be to learn how these factors interrelate.

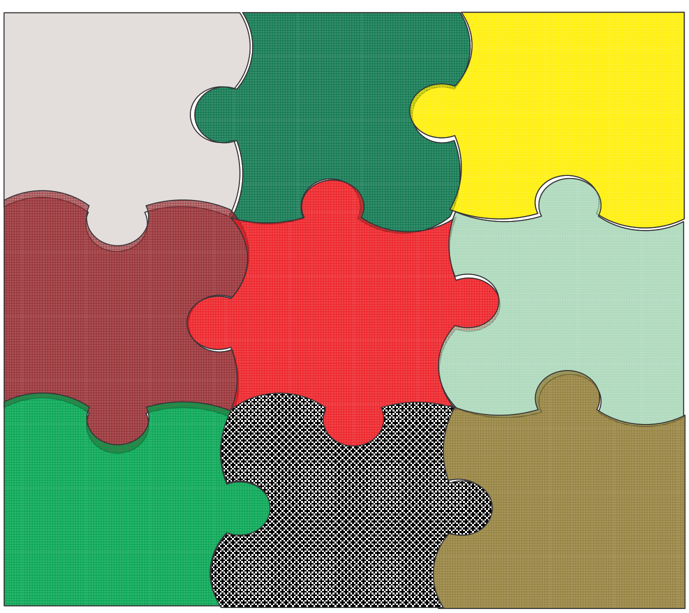


Figure 1 Farm management factors collected in annual surveys

2.2 Financial Summary - 2004/2005

In this section the financial summary is presented on a per hectare and per stock unit basis, and are compared with both Ministry of Agriculture (MAF) and Meat and Wool New Zealand (MWNZ) figures for South Island High Country Properties. Stock units have been estimated using the traditional 'Coop' method where one breeding ewe weighs 55kg bears one lamb and rears it to 3.5 months.

The High Country properties under study by ARGOS range from approximately 4000 hectares to 40000 hectares with stocking rates from 0.7 to 2.0 s.u/ha. Figure 2 shows the cash farm surplus (both per hectare and per stock unit) and carrying capacity (su/ha) range of 6 high country properties, MAF and MWNZ.

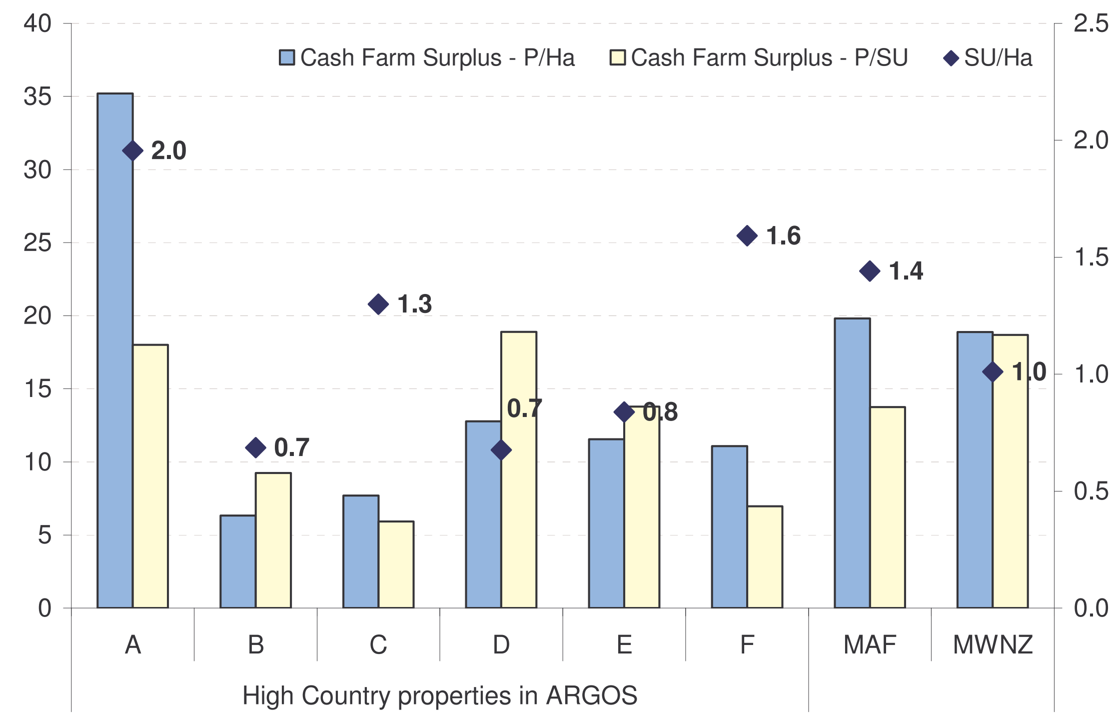


Figure 2 Cash farm surplus/ha (CFS/ha), cash farm surplus/su (CFS/su) and stocking rates (su/ha), for 6 high country properties, MAF and MWNZ.

> **Cash Farm Revenue** is defined as total cash revenue from farming less livestock purchases

Figures 3 and 4 depict the breakdown of main farm expenses in per hectare (fig 3) and per stock unit (figure 4) comparing MAF and MWNZ figures with the range from ARGOS high country properties.

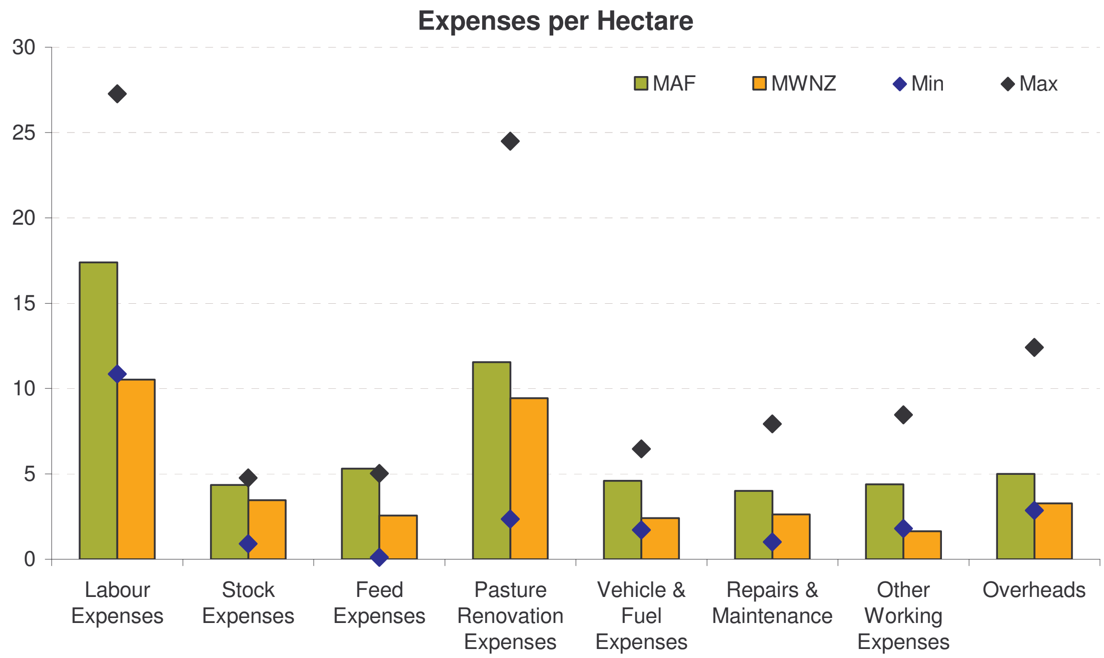


Figure 3 Expenses per ha comparing, MAF, MWNZ, with maximum and minimum range across the high country properties involved in ARGOS

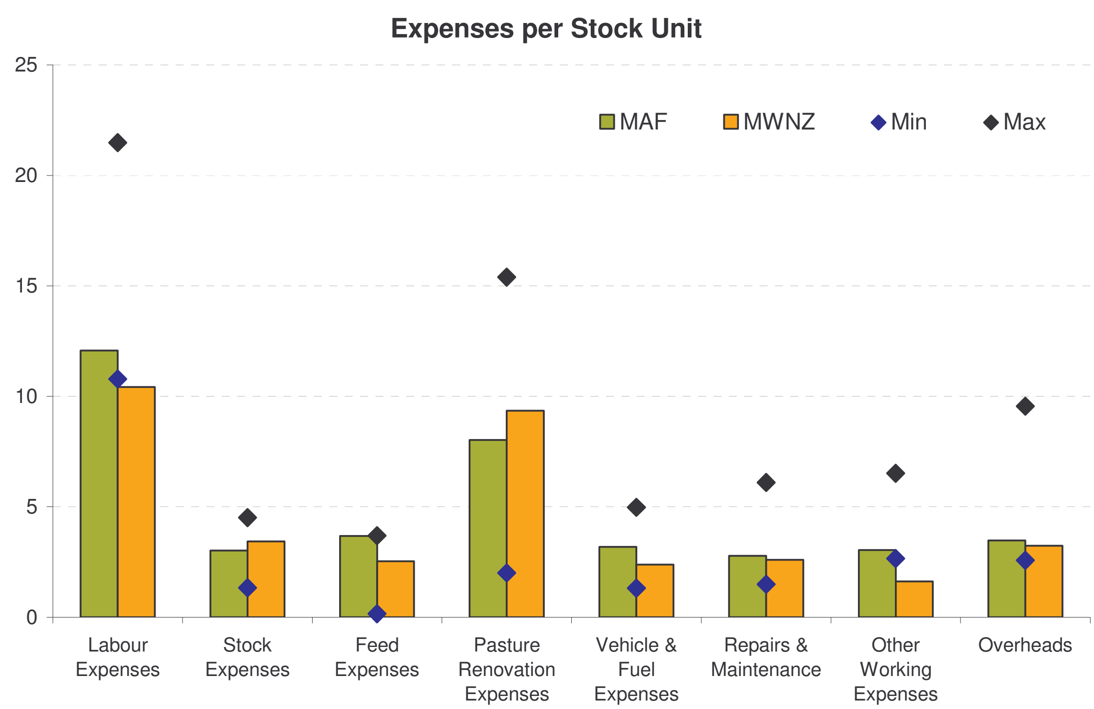


Figure 4 Expenses per su comparing, MAF, MWNZ, with maximum and minimum range across the high country properties involved in ARGOS

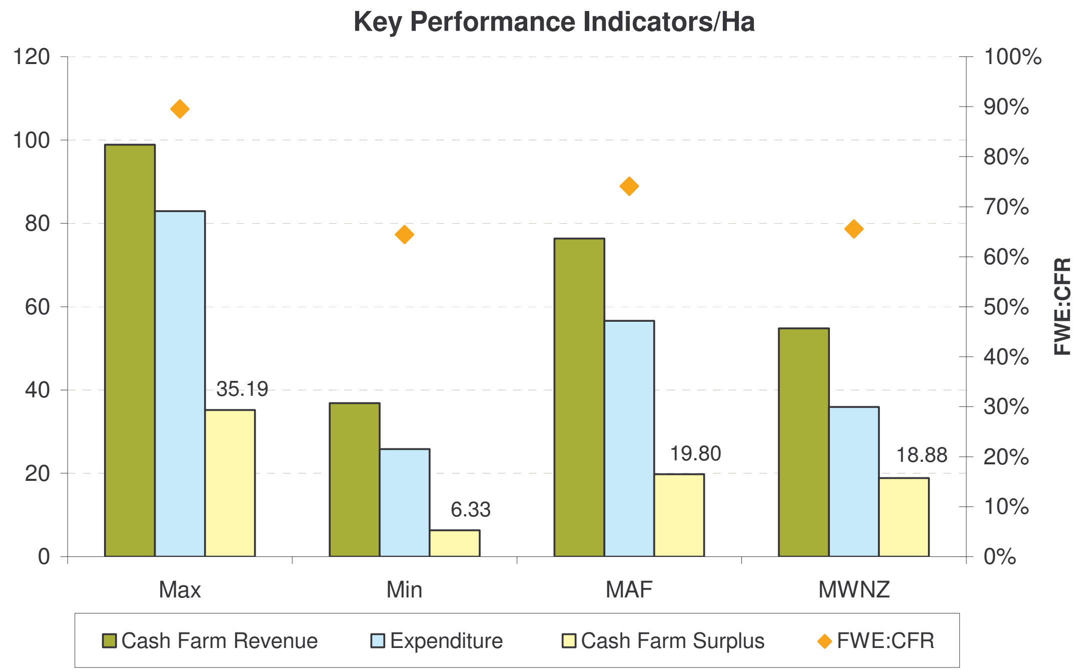


Figure 5 Key performance indicators (per ha) for MAF and MWNZ, in addition to maximum and minimum range across high country properties involved in ARGOS.

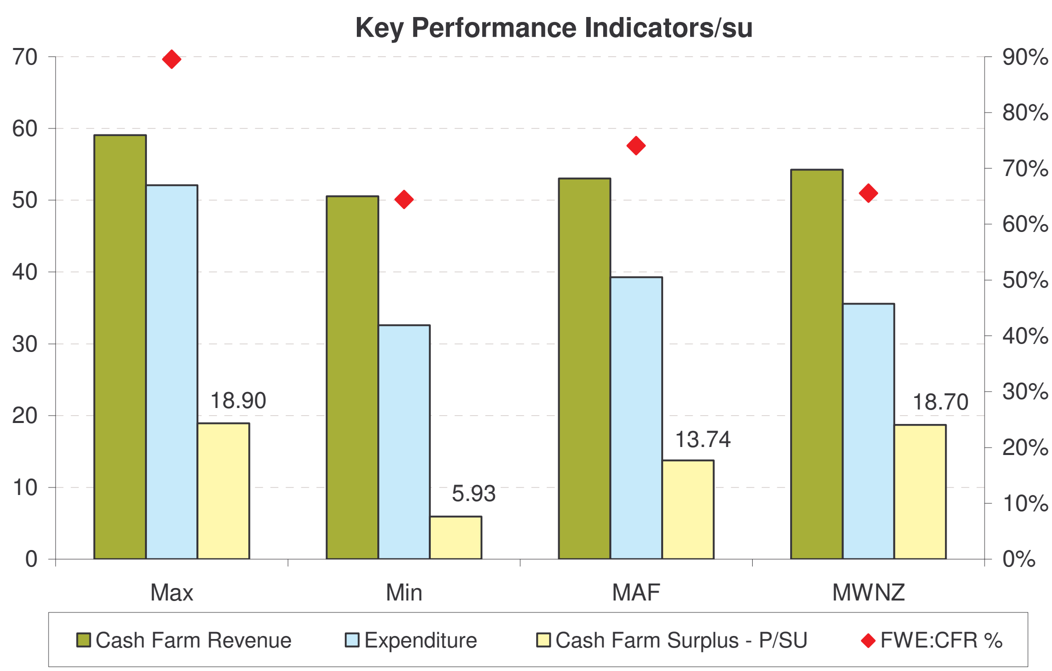


Figure 6 Key performance indicators (per su) for MAF and MWNZ, in addition to maximum and minimum range across high country properties involved in ARGOS.

Table 1 Actual financial summary figures comparing the range of ARGOS with average MAF and MWNZ figures.

Financial Detail 2004/05	All ARGOS Max	All ARGOS Min	MAF SI Merino Average	MWNZ Class 1 Average
Effective Area (Ha)	39,996	3,870	6,500	8,936
Total Stock Units	27,050	5,028	9,363	9025
SU/Ha	2.0	0.7	1.4	1.0
REVENUE - Total	**1,543,382**	**284,732**	**496,492**	**489,686**
Labour Expenses	581,293	74,503	113,050	94,080
Stock Expenses	47,588	15,272	28,300	30,958
Feed Expenses	35,888	4,280	34,500	22,876
Pasture Renovation Expenses	188,732	10,091	75,100	84,313
Vehicle & Fuel Expenses	89,462	18,874	29,800	21,493
Repairs & Maintenance	54,484	11,602	26,000	23,406
Other Working Expenses	71,857	19,086	28,500	14,630
Overheads	114,445	29,229	32,550	29,189
Total Working Expenditures	**1,032,020**	**254,922**	**367,800**	**320,945**
Key Performance Indicies				
Cash Farm Revenue	1,543,382	284,732	496,492	489,686
Expenditure - Gross	1,032,020	254,922	367,800	320,945
Cash Farm Surplus	511,362	29,810	128,692	168,741
FWE:CFR	89.5%	64.4%	74.1%	65.5%
REVENUE - P/Ha	**98.87**	**36.85**	**76.38**	**54.80**
Labour Expenses	27.27	10.86	17.39	10.53
Stock Expenses	4.76	0.90	4.35	3.46
Feed Expenses	5.03	0.11	5.31	2.56
Pasture Renovation Expenses	24.49	2.36	11.55	9.44
Vehicle & Fuel Expenses	6.47	1.72	4.58	2.41
Repairs & Maintenance	7.93	1.01	4.00	2.62
Other Working Expenses	8.46	1.80	4.38	1.64
Overheads	12.41	2.86	5.01	3.27
Total Working Expenditures	**82.90**	**25.80**	**56.58**	**35.92**
Key Performance Indicies				
Cash Farm Revenue	98.87	36.85	76.38	54.80
Expenditure - Gross	82.90	25.80	56.58	35.92
Cash Farm Surplus	35.19	6.33	19.80	18.88
FWE:CFR	89.5%	64.4%	74.1%	65.5%
Cash Farm Revenue P/SU	**59.05**	**50.56**	**53.03**	**54.26**
Labour Expenses	21.49	10.78	12.07	10.42
Stock Expenses	4.50	1.33	3.02	3.43
Feed Expenses	3.69	0.16	3.68	2.53
Pasture Renovation Expenses	15.39	2.01	8.02	9.34
Vehicle & Fuel Expenses	4.98	1.31	3.18	2.38
Repairs & Maintenance	6.10	1.49	2.78	2.59
Other Working Expenses	6.52	2.66	3.04	1.62
Overheads	9.55	2.58	3.48	3.23
Total Working Expenditures	**52.09**	**32.57**	**39.28**	**35.56**
Key Performance Indicies				
Cash Farm Revenue	59.05	50.56	53.03	54.26
Expenditure - Gross	52.09	32.57	39.28	35.56
Cash Farm Surplus - P/SU	18.90	5.93	13.74	18.70
FWE:CFR	89.5%	64.4%	74.1%	65.5%

3 Environment

3.1 Introduction

This section describes the results of the initial land-cover (vegetation), aquatic and soil monitoring established on the eight ARGOS high country study properties during 2005/06 and 2006/07. Because this was the first year of monitoring, only a summary of the data collected is presented here, both for all high country properties and for each individual property. However, as monitoring is repeated in future years, a detailed analysis of trends in the monitored variables for individual properties and across the eight study properties will be produced. Individual monitoring reports have been sent to each high country property with the following summarising generic across-property patterns.

The land-cover, aquatic and soil monitoring protocol for the high country properties was developed and implemented during the 2005/06 and 2006/07 summer. It was developed from the broader environmental monitoring programme that is being undertaken across all ARGOS study farms (Moller et al. 2005), but has been adapted to meet the specific requirements of the high country situation (Norton et al. 2006).

The primary goal of the high country land cover, stream health and soil monitoring is:

- To assess the response of high country ecosystems to (1) management inputs and (2) external perturbations such as climate change or species invasion.

Specifically, the monitoring aims to:

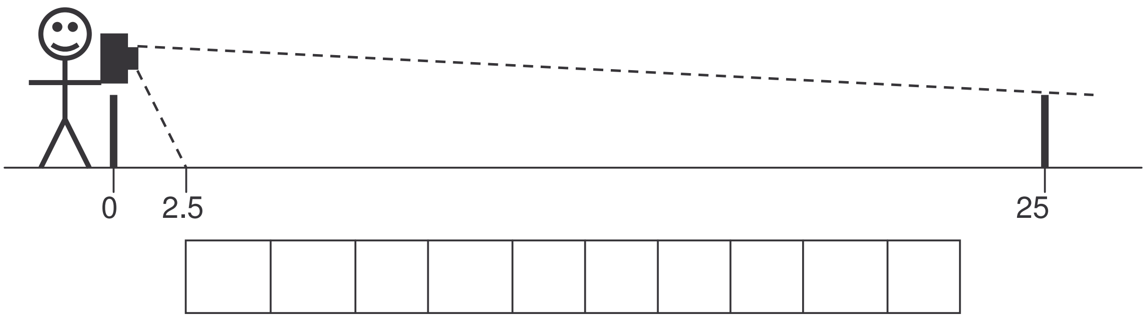
- Provide baseline information on trends in land-cover, stream health and soil conditions through time for a range of permanent sample sites representative of each high country property that the individual farmers can use to directly assess the effects of their farm management practices.
- Provide more detailed information on land-cover, stream health and soil conditions that can be used to test experimental hypotheses generated within the ARGOS project relating to the impacts of management inputs and external perturbations (e.g., climate change) on the resilience of high country ecosystems.

3.2 Land-cover monitoring

Methods

The land-cover monitoring methods are fully described in Norton et al. (2006) and only a summary is included here. Land-cover monitoring was based on 25 m long sampling transects. These were located in a stratified random manner across each property using the broad landform patterns present and farm management units (e.g., over-sown versus undeveloped) as a basis for stratification. An attempt was made to keep the density of monitoring sites proportional to the area of each landform/management unit, although high mountainous areas were usually under-sampled relative to the more accessible and usually more developed lower parts of properties. No permanent vegetation monitoring sites were located within regularly cultivated blocks, as the monitoring layout with permanently fixed metal standards is not compatible with cultivation.

Monitoring points were located randomly and marked by labelled 1.8 m metal standards set 25 m apart (Fig. 7). Land cover measurements were then made within a transect located between the two metal standards and photos taken from each end looking down the transect. The transect involved ten 2x2 m contiguous plots that were centred along the centre-line between the two standards starting at 2.5 m from the first standard and finishing 2.5 m before the second standard.



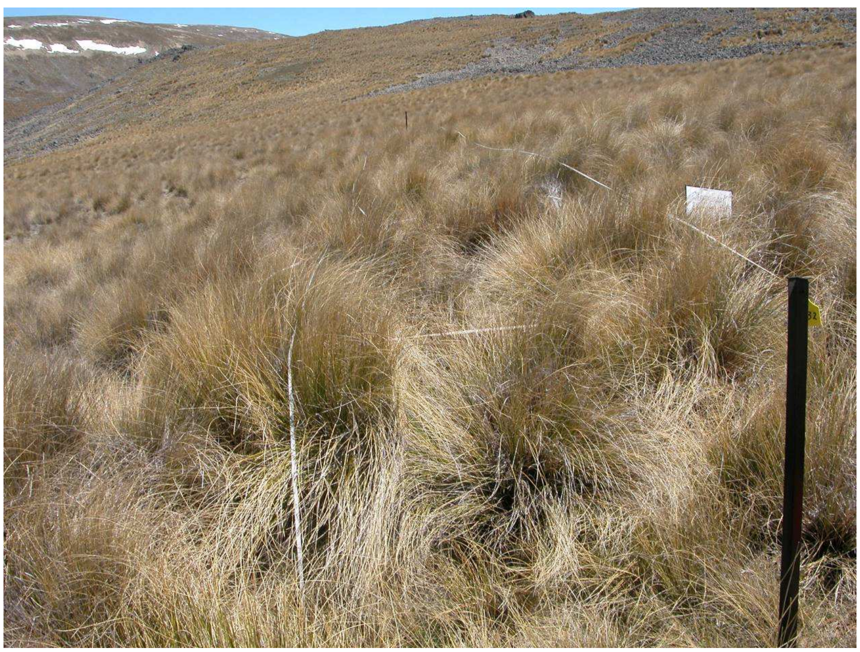


Figure 7 Schematic diagram showing land-cover monitoring site layout and photo of a monitoring site being established on Otematata Station.

The following was recorded for the first two 2x2 m plots at each end of the transect.

- The cover abundance class of the following land cover types:
  - Individual tussock species (hard tussock, silver tussock, snow tussocks)
  - Any woody species (e.g., matagouri or sweet briar)
  - Hawkweed species (mouse-ear hawkweed, king-devil hawkweed, tussock hawkweed)
  - Clovers and exotic grasses (as one combined cover type)
  - Other distinctive plant species (e.g., Poa colensoi, Celmisia lyallii, Raoulia subsericea)
  - Bare ground, litter and rocks

In addition to this the following were also recorded:

- One photo was taken from each end of the plot with the camera held immediately above the metal standard looking down the taped transect with the top of the second stake just visible in the distance. The tapes are left laid out for the photo and a white board with the plot number placed so as to be visible to the side of the transect.

- Cover abundance of tussocks or woody species for the remaining six 2x2 m plots in the middle of the transect.

Land-cover monitoring across the ARGOS high country properties

Across the seven high country properties on which monitoring has been implemented (monitoring will be established on one further property during the 2007/08 summer), 264 permanent land-cover monitoring sites have been established.

While there are some marked similarities among the properties reflecting the dominance of grassland vegetation across all properties, there are also some differences in the cover of particular plant groups (Table 2). For example, while the cover of short tussocks (hard tussock and blue tussock) was similar across the properties (8.6 – 18%), the cover of tall (snow) tussocks and exotic grasses was more variable. Typically, properties with no or little tall tussock had the highest cover of exotic grasses (mainly browntop, sweet vernal, chewing's fescue, and brome). For example, the two properties with lowest tall tussock cover (HC1 and HC2) also had the highest exotic grass cover, while the property with the highest tall tussock cover (HC6) had the lowest exotic grass cover. This pattern largely reflects the relative altitudinal balance of these properties, with some properties having no or very little high altitude areas, while other properties had extensive areas of alpine grassland. Interestingly the cover of clover was not strongly correlated with the average cover of exotic grasses, mainly reflecting the proportion of a property that had been over-sown with a clover-only seed mix.

A real concern from this data is the high average cover of hawkweed species. mouse ear hawkweed (Hieracium pilosella) cover ranged from 8 – 27.7%, but the property with only 8% cover had 16.3% cover abundance of other hawkweed species (in this case mainly tussock hawkweed). Overall hawkweed cover ranged from 22.2 - 30.1%.

Table 2 Summary values (mean ± standard deviation) for the average percent cover of different land-cover types on the seven ARGOS high country properties with established land-cover monitoring.

	Bare ground	**Tall tussocks**	**Short tussocks**	**Exotic grass**	**Clover species**	***Hieracium pilosella***	***Hieracium* species**
HC1	12.6 ± 13.0	0.0 ± 0.0	9.2 ± 7.7	65.1 ± 27.4	5.1 ± 8.0	15.3 ± 11.9	14.8 ± 16.1
HC2	5.1 ± 7.0	3.4 ± 13.9	18.0 ± 14.9	52.4 ± 29.2	2.2 ± 4.4	19.2 ± 19.1	3.0 ± 3.4
HC3	14.1 ± 17.3	5.4 ± 11.1	13.0 ± 12.2	6.9 ± 15.6	22.8 ± 34.2	27.7 ± 28.2	1.5 ± 2.8
HC4	23.0 ± 20.6	10.9 ± 10.3	11.0 ± 9.7	27.7 ± 35.5	5.6 ± 12.5	8.0 ± 12.8	16.3 ± 14.2
HC5	19.8 ± 18.6	15.6 ± 16.1	8.6 ± 11.2	37.8 ± 29.6	10.0 ± 12.4	26.4 ± 29.3	0.8 ± 1.3
HC6	19.5 ± 22.7	23.5 ± 29.4	16.7 ± 16.9	3.6 ± 13.1	19.9 ± 31.7	26.3 ± 27.5	2.8 ± 4.6
HC7	9.2 ± 7.7	7.2 ± 16.6	16.5 ± 9.3	49.3 ± 32.5	13.7 ± 17.8	26.2 ± 26.4	2.6 ± 4.3

An initial analysis of the overall floristic data collected from the monitoring transects shows considerable overlap in floristic composition among the seven properties (Fig. 8). This figure (ordination diagram) is based on a statistical analysis called detrended correspondence analysis which groups together samples (monitoring sites) with similar species composition. Thus on the ordination diagram (Fig. 8), monitoring sites which are close together are similar in terms of their floristic composition, while those that are far apart are different. The relative position of each monitoring site in the ordination diagram was then compared with the broad environmental data that was collected across all monitoring sites (latitude, elevation, slope, aspect). The only environmental variable that was significantly correlated with the ordering of the monitoring sites in the ordination diagram was altitude. Monitoring sites in the lower left of the ordination diagram are typically low altitude sites, while those on the upper right are typically high altitude sites.

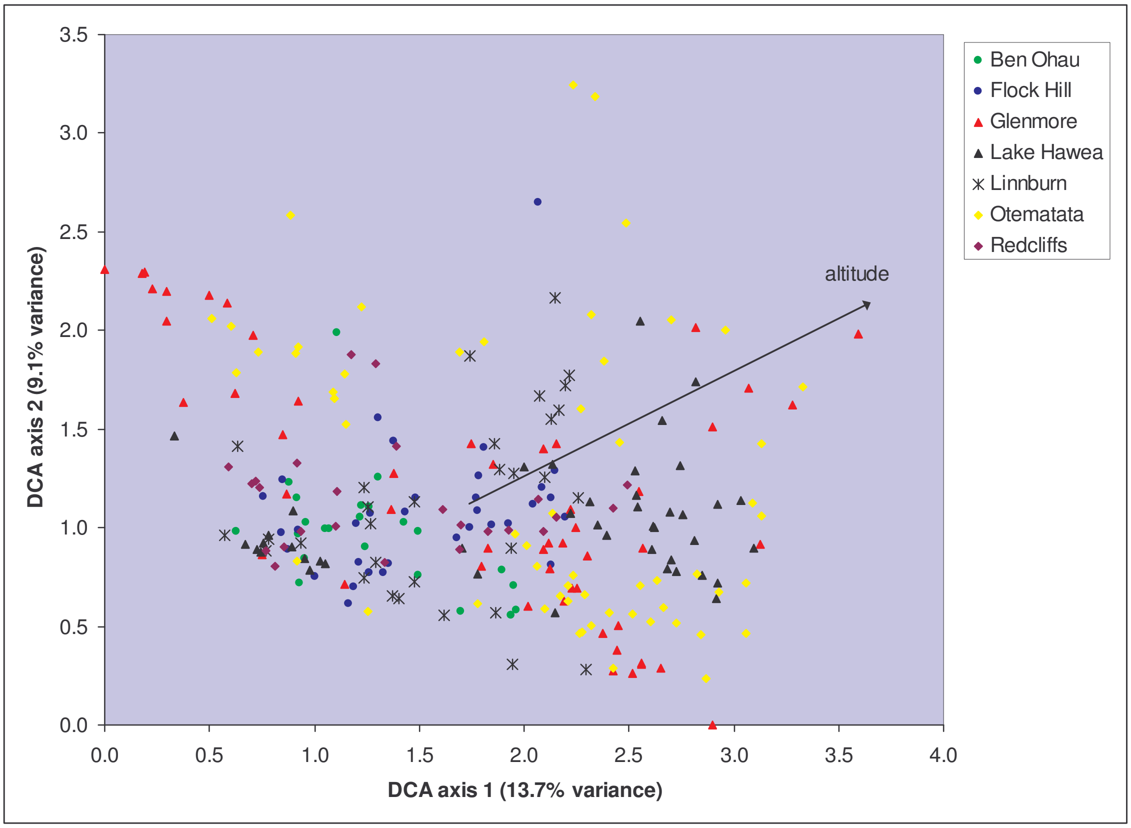


Figure 8 Scatter plot showing the relationships of monitoring sites to each other based on their floristic composition. Sites that occur close together are similar to each other in terms of the plant species present, while those that occur far apart are dissimilar. The main environmental variable correlated with this data is altitude and the direction of the correlation is indicated by the arrow.

3.3 Aquatic monitoring

Methods
Aquatic monitoring was less extensive than land-cover monitoring because aquatic ecosystems are of limited extent on high country properties and because of the considerable resources available to sort and identify the invertebrate taxa collected during monitoring. Aquatic monitoring followed standard protocols (Stark et al. 2001). Lakes and tarns were not sampled during this monitoring.

Aquatic systems were divided based on their size and source, with three main types recognised:

- Large (>5 m) streams/rivers with unstable beds.
- Smaller (<5 m) non-spring fed streams with more stable beds.
- Smaller (<5 m) spring fed streams with stable beds.

In addition, consideration was given to the type of land management occurring within the catchment of individual streams. In some instances aquatic sampling points were located immediately above and immediately below portions of the catchment that had been heavily developed (e.g., cultivated).

Final monitoring sites were randomly chosen, the monitoring being established on the first section of stream immediately upstream from the random point that was relatively uniform for at least 10 m (the sampling reach). The upstream end of this reach was marked by a metal standard, with a second standard located 25 m downstream from this on the opposite bank (Fig. 9). Within each sampling reach the following were recorded:

- Physio-chemical variables (width, depth, velocity, substrate size, stream channel stability (Pfankuch Channel Stability evaluation system), water temperature, pH, conductivity and turbidity)
- Phosphorous and nitrogen levels (samples sent to Hill Laboratories for analysis).
- Quantitative benthic invertebrate fauna using a Surber sampler (Protocol C3, Stark et al. 2001)
- Semi-quantitative benthic invertebrate fauna using a “kick net” (Protocol C1, Stark et al. 2001).

Figure 9 Photo of a monitoring site being established on Linnburn Station

Aquatic monitoring across the ARGOS high country properties

Across the seven high country properties on which monitoring has been established (monitoring will be established on one further property during the 2007/08 summer), 55 permanent aquatic monitoring sites have been established.

In terms of their physio-chemical properties the streams sampled here are all very healthy, with low levels of nitrogen and phosphorus, neutral pH readings and low turbidities, especially in comparison with ARGOS sheep and beef farms and dairy farms (Fig. 10).

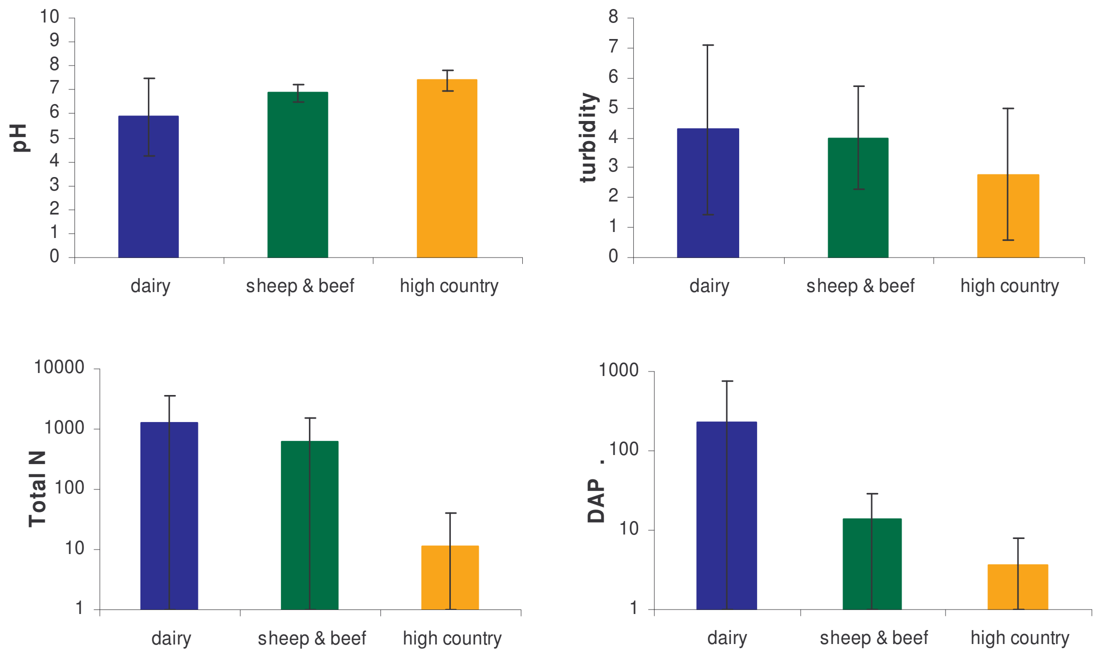


Figure 10 Comparison of pH, turbidity, Total N and DAP between ARGOS high country, sheep & beef and dairy farms (means ± standard deviations – note that the Total N and DAP graphs are on log-scales)

Various indices are used in New Zealand to assess the health of streams based on the species present, the most common being the macro-invertebrate score (MCI). While there has been some debate over the best way to interpret MCI scores, it is suggested that scores of >120 correspond to excellent stream health, scores of 100-119 to good health, 80-99 fair health, and <80 to poor health. The EPT scores measures the number of species of mayflies, stoneflies and caddisflies recorded from the sample. The EPT scores generally give a reasonable indication of the health of a stream. High EPT scores (>10) suggest high water and/or habitat quality, whilst low scores typically indicate low water and/or habitat quality. However, the use of indices like MCI and EPT to assess differences in water quality between sites can be problematic. For example, if one site has a stony bed while the other is silty, then the difference in MCI may reflect these differences as much as it does water quality as biotic indices respond to a complex of factors including water quality, substrate, and disturbance.

Assessment of the invertebrate communities within the high country streams resulted in an average of 20.7 species per sampled stream (with a range from 11-30; Table 3). Average EPT score was 11.5 (3-19) and average MCI score 112 (47-182). For both the EPT and MCI indices, the results presented here suggest that high country streams are typically in good to excellent health with 71 % of streams having EPT scores ≥10 and 68 % having MCI scores ≥100. However, there was considerable diversity in the streams sampled, which ranged from small spring feed streams to medium-sized rivers draining major mountain ranges, in one case with small glaciers, with corresponding differences in stream substrate and disturbance regime. Given this diversity, it may well be that the usefulness of these indices for comparing between streams is limited, but that they will be of value for comparing stream health in the same stream at different times.

Table 3 Summary statistics for stream invertebrates across the ARGOS high country streams sampled.

	No species	EPT score	MCI score
Mean	20.7	11.5	112.0
Standard deviation	4.6	3.7	31.4
Minimum	11	3	47.3
Maximum	30	19	181.8

3.4 Soil monitoring

Methods

The broad approach to soil monitoring is the same across all ARGOS farming sectors (Moller et al. 2005), with only minor variations made to this approach in the high country relating primarily to the way soil monitoring sites were located. Soil monitoring sites (SMSs) are based on management units (MUs), with three individual soil assessments made in each MU. Selection of MUs for soil monitoring at Glenmore were based on the established land-cover monitoring system, with MUs spread between three broad management zones:

1. Cultivated and often irrigated flats (3 MUs)
2. AOSTD (Aerial, Oversown, Top Dressed) lower hill country. (7 MUs)
3. Undeveloped (native) higher hill country (2 MUs)

The stratified areas are further abbreviated to Cultivated (C), AOSTD (A), and Undeveloped (U). Within each of the three management zones, MUs were selected randomly based on the land-cover monitoring sites with the proviso that only one land-cover monitoring sites can be selected within a MU. The selected land-cover monitoring sites were then used as the location for the first SMS.

Within each SMS the following were measured:

- Nutrient analysis and microbial activity – based on a sample of ten soil cores (0-7.5 cm depth) collected from each SMS, with the 10x3 samples collected from each MU combined into a single prior to lab analysis. Individual soil cores were collected randomly from the area around the SMS. Soil nutrient analyses included pH, Olsen-P, Resin - P, calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), P retention (ASC), anaerobic mineralisable-N (AMN), sulphate-S (SS), cation exchange capacity (CEC), % base saturation (%BS), weight/volume (w/v), and soil C and N. In addition soil respiration and soil microbial biomass were determed, and bulk density measured.
- Soil texture, ground cover, thatch build-up, soil porosity, the presence of mottles and gleying and soil aggregation (all assessed in the field) from a single representative soil pit.

3.4.1 Soil monitoring established and some initial results

The soil part of this report describes:

- Plant available nutrients tested.
- Cations and an introduction into how they work.
- Microbia
- Example of tabulated soil test results

<u>Nutrient availability to plants</u>
Soil includes nutrients, commonly refered to as cations and anions. Cations (Calcium, Potassium, Magnesium and Sodium) are used to balance the anions (Phosphate, Sulphate and Nitrogen) to become a stable form. Tests are carried out to quantify nutrients that are available to plants and these are commonly known as "Quick tests".

The following three graphs show average results and the standard deviation of ARGOS high country properties for Phosphorus (Olsen P and Resin P), Sulphur, and Nitrogen (available to plants). A high standard deviation, in relation to the average, reflects wide variation across the test sites

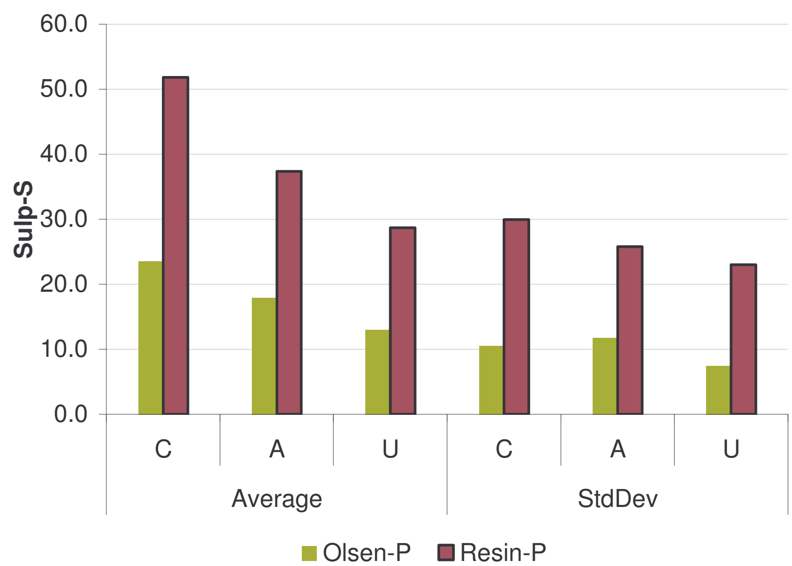


Figure 11 Olsen and Resin P for Cultivated (C), AOSTD (A) and Undeveloped (U).

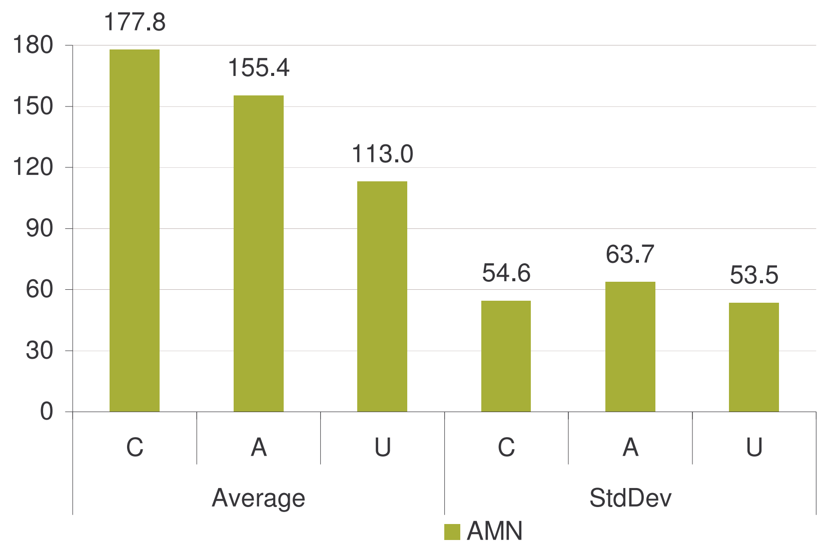


Figure 12 Available Nitrogen kg/ha for Cultivated (C), AOSTD (A) and Undeveloped (U).

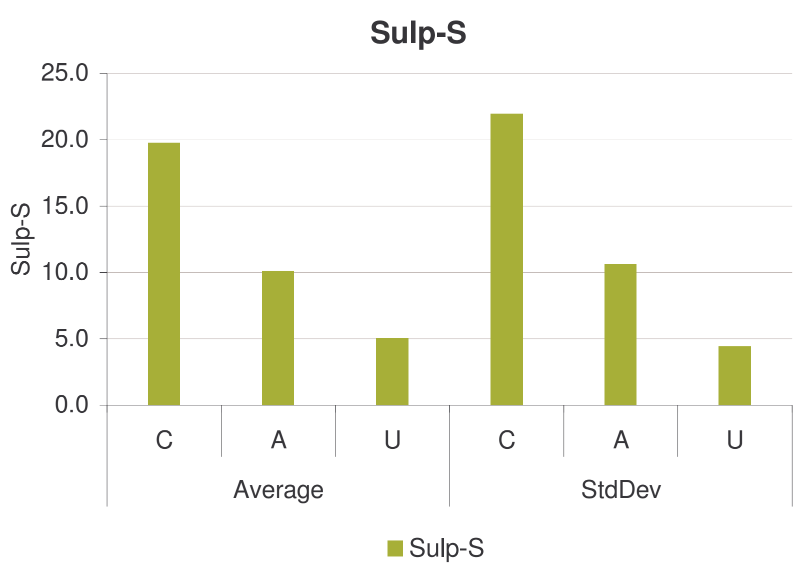
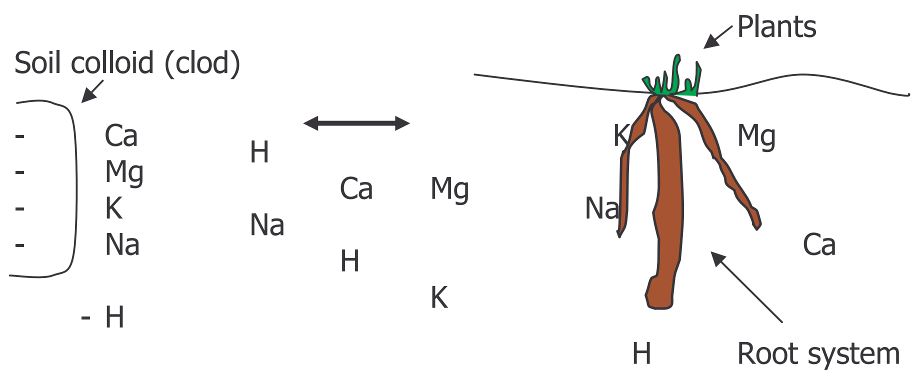


Figure 13 Benchmark of Sulphate for Cultivated (C), AOSTD (A) and Undeveloped (U).

<u>Existing soil nutrients</u>
Macro nutrients are the building blocks for plant growth and cation exchange capacity (CEC) is a measure of the soil's ability to hold exchangeable cations. Exchangeable cations are the cations that are swapped between the plant's root system and the soil (see diagram below)



These exchangeable cations can be categorised in two groups: The basic cations Ca2+, Mg2+, K+ and Na+, and the acidic cations H+ and Al3+. Basic cations, in most non-acidic soils, occupy 80% of the exchange sites, with acidic cations taking up more of these exchange sites as the pH decreases. Figure 14 shows the proportions of major exchangeable cations in soils with a pH less than 5.5 compared with soils of pH 6 - 7.

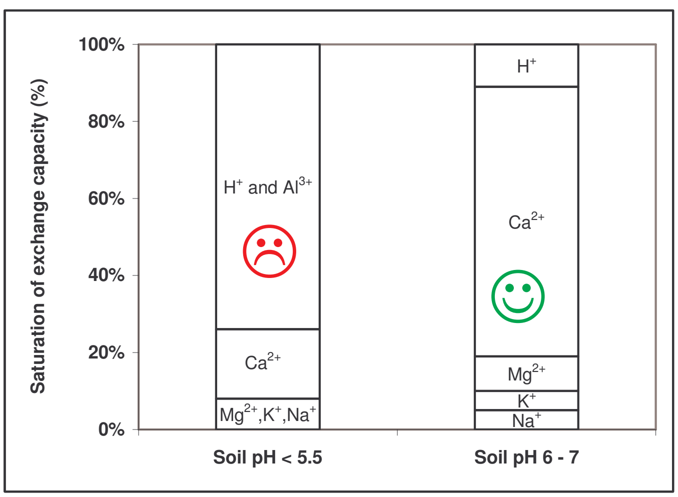


Figure 14 Proportions of major exchangeable cations in Soils (adapted, McClaren & Cameron)

The percentage of base saturation is an assessment of the percentage of the basic exchangeable cations in the soil (the acidic cations are not included). Figure 15 shows average and standard deviation values for the ARGOS high country properties

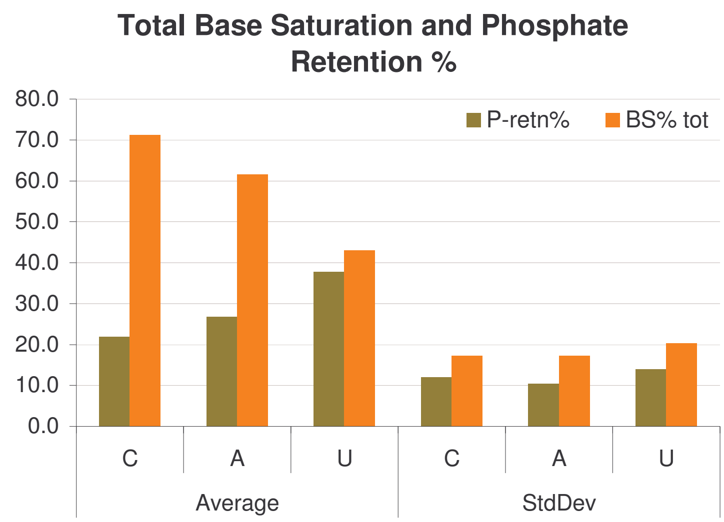


Figure 15 Total base saturation and Phosphate retention percentages

Optimal range for base saturation is 70 - 90%

Table 4 on the following page tabulates the soil test results for each of the soil monitoring sites. This is followed by a map showing each of the sites. L1, 2 and 3 are the cultivated areas. A4 to A10 are the AOSTD areas and U11 and U12 are the undeveloped areas.

Table 4. Soil Tests Results

Soil Tests Results - Trickster Station (2006)

Paddock name	Site	pH	Olsen-soluble P ug/mL	Calcium Quick Test Units	Magnesium Quick Test Units	Potassium Quick Test Units	Sodium Quick Test Units	Sulphate-S ug/g	Ext.Org. Sulphur ug/g	P Retention (ASC) % w/w	soil resin P mg/kg
A	LC1	7.1	37	7	48	10	207	96	8	8	133
B	LC2	7.3	42	21	80	21	32	33	10	7	87
C	LC3	5.7	36	6	26	16	7	26	9	14	72
D	A4	6.1	53	6	45	35	5	8	10	22	106
E	A5	5.5	19	3	21	15	4	8	8	38	34
F	A6	5.7	14	5	34	16	4	9	6	19	26
G	A7	6.1	32	7	29	18	6	26	6	10	73
H	A8	5.8	11	6	39	11	5	11	9	11	22
I	A9	6.1	20	7	23	12	4	6	6	17	48
J	A10	6.0	12	8	45	10	10	6	7	19	30
K	U11	5.1	11	1	10	7	4	5	4	51	16
L	U12	5.5	7	3	26	8	5	3	2	37	12

Paddock name	BD g/mL	CEC me/100 g	Calcium me/100 g	Magnesium me/100g	Potassium me/100g	Sodium me/100g	Base Saturation %				
							Ca	Mg	K	Na	Total
A	0.88	14	6.4	2.37	0.56	4.25	45.6	16.8	4.0	30.1	96.5
B	0.78	28	21.1	4.37	1.31	0.73	75.3	15.6	4.7	2.6	98.2
C	0.76	11	5.9	1.49	0.99	0.16	53.4	13.5	9.0	1.4	77.3
D	0.61	19	7.7	3.22	2.74	0.16	39.9	16.7	14.2	0.8	71.6
E	0.63	14	3.3	1.44	1.11	0.12	23.5	10.3	7.9	0.8	42.6
F	0.67	13	6.3	2.17	1.15	0.10	47.5	16.5	8.7	0.8	73.5
G	0.78	11	6.6	1.58	1.13	0.13	60.2	14.5	10.3	1.2	86.2
H	0.70	13	6.7	2.38	0.76	0.14	53.7	19.1	6.1	1.1	80.0
I	0.72	11	7.9	1.37	0.83	0.11	70.5	12.3	7.4	0.9	91.1
J	0.68	16	9.4	2.86	0.74	0.27	57.8	17.6	4.6	1.6	81.5
K	0.56	14	1.8	0.80	0.57	0.13	13.0	5.8	4.1	1.0	23.8
L	0.65	13	3.1	1.73	0.56	0.14	23.9	13.2	4.3	1.1	42.5

The normal range of base saturation for the

· Calcium	60 - 70 % of CEC
· Magnesium	10 - 15 % of CEC
· Potassium	3 - 7 % of CEC
· Sodium	> 1 % of CEC
· Total	70 – 90 %

Soil Test Ranges to Achieve Near Maximum Pasture

Soil Test	***Soil Parent Material***			
	Sedimentary	Ash	Pumice	Peat
Olsen P	20 - 25	20 - 30	35 - 45	35 - 45
Sulphate-S	10 - 12	10 - 12	10 - 12	10 - 12
Organic-S	15 - 20	15 - 20	15 - 20	15 - 20
Quick Test Ca	6 - 12	6 - 12	6 - 12	6 - 12
Quick Test K	6 - 8	7 - 10	7 - 10	5 - 7
Quick Test Mg^2	8 - 10	8 - 10	8 - 10	8 - 10
Reserve K (TBK)	>1	N/A	N/A	N/A
Soil pH	5.8 - 6.0	5.8 - 6.0	5.8 - 6.0	5.0 - 5.5
				(0 - 7.5 cm)

Biological activity

- **Soluble carbon (SolC-C)**
  - measure of labile (forever changing) organic matter and serves as an index of available substrate (framework) for microbial respiration as well as aggregate (soil) stability.
- **Metabolic quotient**
  - indicator of the metabolic efficiency of the microbial population. High MetQ values can reflect microbial populations under stress as they respire more to overcome stresses within their environment ie moisture, salinity. Low pH. Microbia prefer to be fat and lazy.
- **Carbon Nitrogen ratio**
  - measure of carbon relative to nitrogen in the soil. There is less nitrogen available for plant growth when the ratio is high (refer to the following table for low, medium, high and optimal values).

Table 5 Relevance of C:N ratios for pastoral farming systems

C/N Ratios	Low	Medium	High	Very high	Optimal
	<10	10 - 12	12 - 16	16 - 24	>24

An active microbial population is necessary to recycle essential nutrients when they decompose dead plant and animal material. Optimal soluble carbon levels and carbon nitrogen ratios are crucial to support this. Figure 16 shows average and standard deviation baseline values assessed from 3 stratified areas (Cultivated, AOSTD and Undeveloped), and compares this with the average and standard deviation of ARGOS sheep/beef farms.

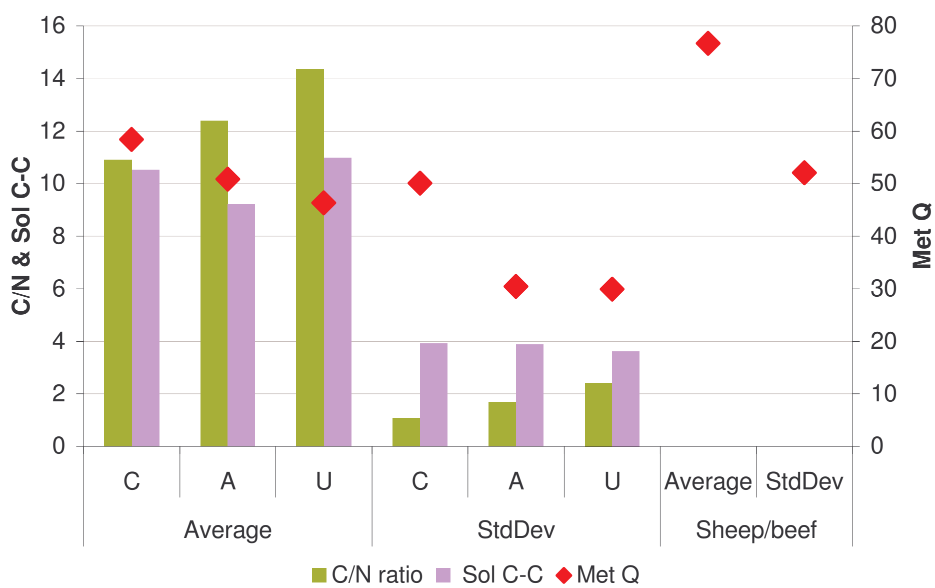


Figure 16 Soluble carbon, metabolic quotient and carbon nitrogen ratio

4 Social

Improving the sustainability of farming involves social, as well as economic and environmental, dimensions. For example, while it is possible to assess the relative viability of farm incomes, the earning potential of a given farm household may reflect issues of succession, retirement objectives, ethical decisions or pressures exerted by family or society more generally. Similarly, whereas the promotion of more bio-diverse farmscapes may appear to involve relatively straight forward decisions regarding resource management, the influence of shared ideas of appropriate farm management or the availability of sufficient skills and labour may limit the feasibility of such decisions. The social research component of the ARGOS project is designed to examine a range of social features, including those identified above, that have been shown to impact the ways in which farmers approach farm management and engage with issues of sustainability.

During the coming year we will initiate our data gathering programme in the High Country sector employing a variety of social research methods. This will involve two face-to-face meetings with each participant (preferably including all members of the household who contribute to the overall management of the property). In the first meeting you will be asked to complete a 'causal map' with the assistance of Dave Lucock, the High Country field manager. The second meeting will be a qualitative interview conducted by a member of the social research objective and will focus on a variety of social aspects of farm life and farm management. This range of information will contribute to a comprehensive understanding of the social dimensions of agricultural production in the High Country context. In turn, this knowledge will enhance our assessment of sustainable farm management in New Zealand. The following two sections provide a short introduction to the causal maps and qualitative interviews.

Causal maps

The causal maps are a method of obtaining information on how participants think about managing their farm. The method is described by practitioners as "multi-step, fuzzy cognitive mapping" in which the resulting maps "are qualitative models of a system, consisting of variables and causal relations between variables" (Ozesmi and Ozesmi 2004). It involves an activity in which the farmer is asked to reflect on factors that are important to farm management and to, then, indicate any sort of relationship between a given set of variables– for example, the influence of fertiliser applications on paddock health. Each relationship identified is further assigned a direction (*which factor will exert an influence on the other?*) and a weight (*what is the extent of the influence exerted?*). The primary value of the maps is derived from the potential to convert them into models. It is, for example, possible to combine the maps of individuals and compare the impact of policy or changes on the management system for different groups. To date, the method has shown promising results with participants from the kiwifruit, sheep/beef and dairy sectors.

Qualitative interviews

The qualitative interview examines a wide range of information from farm households on identity; visions and constraints; environmental, economic and social wellbeing; and managing well. Such data contribute to our understanding of the type of people who are farmers and their understandings of what makes farming a desirable profession. We will also ask each household to discuss factors such as climate, labour or audit systems that can limit the flexibility of their management practice. As social researchers, we refer to these as structural constraints because they are strongly determined by established rules and norms that govern social interactions. The interviews are expected to last approximately 90 minutes. Analysis of the resulting data involves identifying themes in the discussion of the interview topics. The extent to which these themes represent individual perspectives or are shared within a given geographic cluster, management panel, or industry sector provides an indication of the influence of various social factors on management at the farm level.

5 Acknowledgements and References

5.1 Acknowlegements

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- Jon Harding for assistance with invertebrate identifications.
- The owners/managers of the eight ARGOS high country properties for facilitating the field work.

5.2 References

Social

Understanding Approaches to Sheep/Beef Production in New Zealand: Report on First Qualitative Interviews of ARGOS Sheep/Beef Participants (2006), by Lesley Hunt, Chris Rosin, Marion Read, John Fairweather, Hugh Campbell

New Zealand Farmer and Grower Attitude and Opinion Survey: Sustainability in Primary Production (2006), by John Fairweather, Lesley Hunt, Andrew Cook, Chris Rosin, Hugh Campbell

The Representativeness of ARGOS Panels and Between Panel Comparisons (2006), by John Fairweather, Lesley Hunt, Andrew Cook, Chris Rosin, Hugh Campbell

Environment

Cleaner streams and improved stream health on North Island dairy and South Island sheep/beef farms (2006), by Grant Blackwell, Mark Haggerty, Suzanne Burns, Louise Davidson, Gaia Gnanalingam and Henrik Moller

A Survey of Herbaceous Plant Management on South Island Sheep and Beef Farms (2006) Henrik Moller, Richard Hill, and Dave Lucock

Herbaceous plants on ARGOS sheep and beef farms (2006), by Martin Emanuelsson and Dave Lucock

PUBLIC REPORTS

The following are publicly available on the ARGOS website (www.argos.org.nz). Please contact ARGOS if you would like a copy.

Research Reports

05/01 Understanding Approaches to Kiwifruit Production in New Zealand : Report on First Qualitative Interviews of ARGOS Kiwifruit Participants, by Lesley Hunt, Chris Rosin, Carmen McLeod, Marion Read, John Fairweather and Hugh Campbell, June 2005

05/02 Soil quality on ARGOS kiwifruit orchards, 2004-2005, by Andrea Pearson, Jeff Reid , Jayson Benge and Henrik Moller, June 2005

05/03 Soil quality on ARGOS sheep & beef farms, 2004-2005, by Andrea Pearson, Jeff Reid, and Dave Lucock, June 2005

05/04 Food Markets, Trade Risks and Trends, by Caroline Saunders, Gareth Allison, Anita Wrexford and Martin Emanuelsson, May 2005

05/05 ARGOS biodiversity surveys on Kiwifruit Orchards and Sheep & beef farms in summer 2004-2005: rationale, focal taxa and methodology, by Grant Blackwell, Stephen Rate and Henrik Moller, June 2005

05/06 Bird community composition and relative abundance in production and natural habitats of New Zealand, by Grant Blackwell, Erin O'Neill, Francesca Buzzi, Dean Clarke, Tracey Dearlove, Marcia Green, Henrik Moller, Stephen Rate and Joanna Wright, June 2005

05/07 Interspecific interaction and habitat use by Australian magpies (Gymnorhina tibicen) on sheep and beef farms, South Island, New Zealand, by Marcia Green, Erin O'Neill, Joanna Wright, Grant Blackwell and Henrik Moller, July 2005

05/08 to be published

05/09 to be published

05/10 Sketch Maps: Features and Issues Important for the Management of ARGOS Orchards and Farms, by Marion Read, Lesley Hunt and John Fairweather, July 2005

06/01 Understanding Approaches to Sheep/Beef Production in New Zealand: Report on First Qualitative Interviews of ARGOS Sheep/Beef Participants, by Lesley Hunt, Chris Rosin, Marion Read, John Fairweather, Hugh Campbell, February 2006

06/02 Weed survey to be published, Henrik Moller et al

06/03 Cleaner streams and improved stream health on North Island dairy and South Island sheep/beef farms, by Grant Blackwell, Mark Haggerty, Suzanne Burns, Louise Davidson, Gaia Gnanalingam and Henrik Moller, June 2006

06/04 to be published

06/05 Prevalence and diversity of non-forage herbaceous plants on sheep/beef pastures in the South Island, by Grant Blackwell, Dave Lucock, Henrik Moller, Richard Hill, Jon Manhire and Martin Emanuelsson

06/06 to be published

06/07 Total Energy Indicators: Benchmarking Organic, Integrated and Conventional Sheep and Beef Farms, by Andrew Barber and Dave Lucock, September 2006

06/08 Kiwifruit energy budgets to be published, Andrew Barber and Jayson Benge

06/09 Understanding kiwifruit management using causal mapping, by John Fairweather, Lesley Hunt, Chris Rosin, Hugh Campbell, Jayson Benge and Mike Watts, September 2006

06/10 New Zealand Farmers and Wetlands, by Carmen McLeod, Lesley Hunt, Chris Rosin, John Fairweather, Andrew Cook, Hugh Campbell, November 2006

07/01 Soil Properties on ARGOS Dairy and Sheep & Beef Farms 2005-6, by Peter Carey, Dave Lucock and Amanda Phillips, May 2007

07/02 Understanding sheep/beef farm management using causal mapping: development and application of a two-stage approach, by John Fairweather, Lesley Hunt, Chris Rosin, Hugh Campbell and Dave Lucock

07/03 The Representativeness of ARGOS Panels and Between Panel Comparisons, John Fairweather, Lesley Hunt, Andrew Cook, Chris Rosin, Hugh Campbell

ARGOS High Country Environmental Report

No. 1, August 2006 - High Country Environmental Monitoring Report 2005-06

Working Papers

Working Paper 1: Social Dimensions of Sustainable Agriculture: a Rationale for Social Research in ARGOS by Hugh Campbell, John Fairweather, Lesley Hunt, Carmen McLeod and Chris Rosin

Working Paper 2: Social Research Compendium: Key Questions on Social Dimensions of Agricultural Sustainability (The Corpse) by Hugh Campbell, John Fairweather, Lesley Hunt, Carmen McLeod and Chris Rosin

Working Paper 3: Economics Rationale for ARGOS by Caroline Saunders and Martin Emanuelsson

Working Paper 4: He Whenua Whakatipu Rationale for ARGOS by John Reid

Working Paper 5: Scoping Report for monitoring and evaluation processes within ARGOS by Esther Water (Members only)

Working Paper 6: Environmental Monitoring and Research for Improved Resilience on ARGOS Farms by Henrik Moller, Alex Wearing, Andrea Pearson, Chris Perley, David Steven, Grant Blackwell, Jeff Reid and Marion Johnson (Appendix 3: Visual Soil Assessment)

Research Notes (short research summaries)

1. Background to the ARGOS Programme
2. Transdisciplinary Research
3. Cicadas in Kiwifruit Orchards
4. Market Developments for NZ Agricultural Produce
5. Spiders in Kiwifruit orchards
6. Organic Kiwifruit Survey 2003
7. Analysis of ZESPRI's Organic Kiwifruit Databases
8. Types of Kiwifruit Orchardist
9. First Kiwifruit Interview: Individual and Orchard Vision
10. Sketch Map Results: Kiwifruit Sector
11. Sketch Map Results: Sheep/Beef Sector
12. Wellbeing 1: Sheep/Beef Sector
13. Wellbeing 2: Sheep/Beef Sector
14. Wellbeing 3: Sheep/Beef Sector
15. Soil nematodes in kiwifruit orchards
16. Understanding kiwifruit management using causal maps
17. Bird Sampling Methods
18. Birds on sheep/beef farms
19. Birds on kiwifruit orchards
20. Management of Data in ARGOS
21. Evaluation of the bait-lamina test for assessing biological activity in soils on kiwifruit orchards
22. Annual monitoring of cicadas and spiders to indicate kiwifruit orchard health
23. Cicada Species in Kiwifruit Orchards
24. Shelterbelts in kiwifruit orchards
25. Biodiversity on Kiwifruit Orchards: the Importance of shelterbelts
26. Kiwifruit orchard floor vegetation
27. Monitoring stream health on farms
28. Stream management: it really matters what you do on your own farm!
29. Soil Phosphorus and Sulphur levels in Dairy farms
30. Soil Phosphorus and Sulphur levels in Sheep & Beef farms
31. Assessing the sustainability of kiwifruit production: the ARGOS study design
32. Fertiliser use on ARGOS kiwifruit orchards
33. How ARGOS uses Geographical Information Systems (GIS)
34. Food Miles
35. Understanding sheep/beef management using causal maps
36. Earthworms in kiwifruit orchards
37. Four types of sheep/beef farmers across the ARGOS panels