On farm

Final Animal Production and Nutrients Theme

Project number SGS.114
Final Report prepared for MLA by:

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Sustainable Grazing Systems

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1. HIGHLIGHTS

- A minimum protocol was developed which obtained a useful and common set of data across sites and was not too demanding on site resources

- Results from the National Sites highlighted how the more intensive grazing systems based on pasture improvement, higher fertility and higher stocking rates have few environmental problems on some parts of the landscape, but not on others. In many cases the most financially rewarding pasture system also had similar or fewer environmental problems (recharge to groundwater, acidification, erosion risk, loss of nutrients to waterways). There were, however, notable exceptions such as on gradational soils and steep hills.

- Quantities of P and N in runoff waters from sheep pastures were much lower than anticipated at the start of the SGS program, and amount to less than 50c/ha.year of P fertiliser equivalent

- In some environments a high proportion of surface runoff exceeded the healthy stream standard of 0.05 mg P/litre; how much of this reaches the stream is unclear.

- Pasture improvement and fertiliser can in some cases reduce P runoff into waterways (NW Slopes), have little effect (NE Vic sites) or increase the problem (Wagga, Vasey). Reductions in P runoff at the NW Slopes site were associated with increased ground cover causing less erosion. Increases in P runoff occurred where there was already good cover on the low-P control treatment. Why the NE Vic sites behaved differently from Wagga and Vasey has not yet been fully resolved.

- New research leads have been found for how to capture the benefit of fertiliser application while minimising P loss in waterways. This is by intensifying production on areas less likely to contribute to surface runoff.

- N losses on high, medium and low intensity systems were similar, and thus high input systems are no less environmentally acceptable than lower input ones.

- Very little N is lost in surface runoff but substantial concentrations (over the WHO drinking water level of 10 mg N/litre, and well over the stream health figure of 0.5 mg N/litre) can be lost in subsurface flow and deep drainage. Whether this ends up in waterways is unclear but it raises serious political issues about current agricultural systems, particularly those based on annual pastures.

- Nitrogen application has been found to benefit a kikuyu-subclover pasture, but was of little benefit to a phalaris-subclover pasture

- Data sets on plant and soil nutrients have been assembled which will yield a rich wealth of scientific papers and findings during the Harvest Year

2. BACKGROUND TO THE THEME AND KEY QUESTIONS

The theme was initially set up to develop a minimum protocol for nutrient sampling and analysis. As SGS developed, the theme's plans addressed the following issues:

For a range of the major climatic regions of the High Rainfall Zone where temperate perennial pastures are an important land use, to quantify the positive and negative effects of N and applied P both on and off site on:

(a) pasture and animal productivity;
(b) soil acidification; and
(c) P and N concentrations in runoff waters

3. OVERVIEW OF PROGRESS AGAINST THE CONTRACT OBJECTIVES

The theme has provided leadership and co-ordination of:

- the role of intensive pasture systems
- forage mineral nutrient analyses
- soil analyses for a standard fertility description of two treatments at each site (low and high fertility
- soil analyses for pH buffering capacity

In addition, the theme has provided a focus for issues of intensive vs extensive pastures. The theme leader is also involved in the Triple P research program, funded by Wool Innovations Limited and the NRE Wool Program, and a Dairy Nitrogen project funded by DRDC, ARC and the NRE Dairy Program. His co-involvement has enabled substantial synergies that have allowed the SGS program rapid access to the latest findings from these other programs.

4. FINDINGS HUNCHES AND UNCERTAINTIES

4.1 Summary of site findings

Environmental aspects

Loss of P in water can be as great from unfertilised pastures as from improved high fertility pastures, because of greater bare ground on the unfertilised pasture leading to greater erosion **(NW Slopes)**.

Low-P native pastures generate greater quantities of runoff and more consistently than high-P phalaris-subclover pastures, and the water has lower P and N concentrations **(Wagga)**.

At a site producing large quantities of runoff (>100mm/year), only 20% of samples exceeded the healthy stream standard of 0.05 mg P/litre, and there was little relationship between P application rate and P concentration in runoff **(Maindample)**.

At a site producing lower quantities of runoff (20 mm/year), nearly all samples exceeded the healthy stream standard even where low rates of P had been applied **(Vasey)**. Since both Maindample and Vasey have similar soil P values (Table 2), P in waterways appears to be more of a problem where runoff rates are lower and streamflow more erratic.

P losses in runoff from sheep-grazed pasture represent only a small financial cost to production (about 50c/ha.year of fertilizer equivalent) **(Maindample, Vasey)**

The higher the P fertility of an area, the greater the amount of P loss into waterways when runoff occurs. It is therefore important that the parts of the landscape developed as high-fertility pastures are those less likely to produce surface runoff, such as areas well away from stream frontages. **(Vasey)**

A high proportion of surface runoff is generated from small areas that are often wet for extended periods after rain. These springs, soaks and stream frontage areas should be fenced off and run as low-phosphorus systems to improve water quality. **(Vasey)**

N losses of up to 10 kg N/ha year have been recorded from the NE Vic sites. Whether this is acceptable depends on whether the N ends up in streams or groundwater **(Ruffy and Maindample)**.

There have been no measured differences in N losses between high, medium and low input systems (**Maindample, Ruffy).**

[At the SGS **Carcoar** site, runoff quantity has been recorded but not its nutrient concentration. During the Harvest Year, the runoff plots will be continued and nutrient concentrations determined by Paul Milhem as part of a project with internal NSW Agriculture funding.]

Production aspects
Superphosphate and subterranean clover can economically lift stocking rates, provided pastures are not overgrazed in summer and wool micron is maintained below 20 μm. There is also a substantial ecological benefit of providing high quality litter in late spring to increase soil microbial activity **(NW Slopes)**.

The response of phalaris to additional N has been found to be erratic and not economic. N applied in winter caused no additional growth in winter, but caused extra growth in November if soil water was sufficient **(Vasey)**.

A phalaris-subclover pasture has been found to respond to either N or K. Of these, K is the more economic to apply because of its better residual value **(Vasey)**.

In a Mediterranean environment where kikuyu grass is active in summer/autumn, the application of nitrogenous fertilisers to kikuyu pastures in later spring or preceding summer rain can provide feed of sufficient quality and quantity to grow livestock outside the growing season **(Esperance)**.

4.2 Intensive vs extensive pasture systems

Nearly every site of the SGS National Experiment includes a comparison of intensive vs extensive pasture systems. At the SGS National Forum at Armidale in March 2000, a question posed to theme team members from each site was whether the more intensive treatments were more sustainable from economic and environmental criteria. In many cases there was a win:win, where the improved system gave both a higher gross margin and fewer environmental problems. There were, however, notable exceptions such as on gradational soils and steep hills. Our working hypothesis is that the more intensive animal production systems are appropriate on some parts of the landscape, but not to others.

The team's initial draft summary for each of the National Sites is shown in Table 1. This will be developed further into a scientific paper during the Harvest Year.

Table 1: Where are higher-input systems more sustainable from economic criteria (better gross margins) and from environmental criteria (less erosion or less recharge) ?

Site	Question	Economic criteria	Environmental criteria	Comment
NW Slopes, NSW	Is naturalised pasture + subclover + fertiliser better than naturalised pasture without fertiliser?	Yes	Yes	Better cover with subclover and fertiliser reduces erosion.
NW Slopes, NSW	Is phalaris + resting better than continuously stocked phalaris?	Yes	Yes	Higher phalaris persistence gave better cover, reducing erosion.
Carcoar, NSW	Is sown pasture (cocksfoot, fescue, phalaris) better than naturalised pasture?	Yes	Unsure	Significantly less runoff measured on sown pasture
Carcoar, NSW	Is chicory better than naturalised pasture?	Yes	Unsure	Chicory pasture using more water at depth but lower cover in establishing chicory pasture may increase erosion.
Wagga Wagga, NSW	Is fertilised phalaris better than unfertilised native pasture?	Unsure	No	Higher P concentration in runoff from fertilised phalaris. Possible increased recharge from the phalaris treatment needs further investigation
Maindample, Victoria	Is a well-fertilised phalaris/ subclover pasture better than a low-fertility naturalised pasture?	Yes	Yes	N losses from sown and unsown pasture need to be investigated further
Ruffy, Victoria	Is a well-fertilised cocksfoot-based/subclover pasture better than a low-fertility naturalised pasture?	Yes	No	High recharge on shallow soils. All grazing systems had economic losses, but cocksfoot + P had lower losses
Vasey, Victoria	Is moderate fertility phalaris better than naturalised pasture?	Yes	Yes	However, higher salinity in groundwater under phalaris because of reduced recharge
Vasey, Victoria	Is phalaris + P + rotation better than set-stocked moderate fertility phalaris?	Yes	Unsure	No evidence yet that the rotation uses more water (because of dry seasons?)
Esperance, WA	Is kikuyu better than annual or phalaris Pasture?	Yes	Yes	Recharge and soil erosion significantly reduced. Stocking rate increased due to green feed in summer/ autumn.
Albany, WA	Are bluegum belts (greater than 100m apart) combined with kikuyu better than annual pasture?	Yes	Yes	Recharge and soil erosion significantly reduced. Stocking rate same or higher.

4.3 Forage mineral nutrients

As part of the minimum protocol for the Pasture Theme, forage quality samples collected from all sites of the National Experiment at various times of the year and painstakingly sorted into green and dead, then analysed by NIR (Near Infrared Spectroscopy) for digestibility and crude protein. As the SGS model was developed to include nutrients, there was no reality check on P, S and K uptake. It was then considered to be excellent value for the nutrient theme to undertake mineral analysis of these samples. We are unaware of comparable data sets that can be used in developing a model such as the SGS model. Samples were generally collected from both high and low fertility treatments at each site. Results are summarised in Appendix 1, and show that across all minerals analysed Vasey had the highest nutrient concentrations, followed by Ruffy, Albany, Maindample, Carcoar, Esperance, Fullbrooks, Forrests and Wicks. Other mineral nutrient analyses were obtained at virtually no extra cost, and will be valuable in estimating intake of these mineral nutrients by livestock, and the potential for transfer of these nutrients to sheep camps.

Responsibility for analysing, modelling and writing up this unique dataset will be with the postdoctoral fellow, with guidance from the Nutrient Theme leader Dr. Malcolm McCaskill and model developer Dr. Ian Johnson. For his PhD, Dr. McCaskill developed a model of S, P and N cycling in grazed pastures, and many of the concepts in this model have been reprogrammed into the SGS model.

4.4 Cross-site soil analyses

Different methods of extracting plant-available phosphorus have become accepted in the various States of Australia. The Colwell P test has become accepted in most cropping regions, while Olsen P has become accepted in Victoria and Bray P in NSW for pastures. A suggestion early in SGS was that a low and high fertility treatment at each site be tested for all three common P extraction methods at the start and end of SGS. Soil samples (0-10 cm) were collected during the spring of 1998 and in 2000. Results for Olsen P (Table 2) show that P fertility changed little during the course of the experiment at Vasey and at the NW Slopes sites (Forrests, Wicks and Fullbrooks), increased at Albany and Wagga, and fell at Maindample and Ruffy. Similar changes were observed for Colwell and Bray P. Data are not available from Esperance, because the site was terminated prior to 2000, and results from Carcoar are not yet available. These changes in soil fertility need to be taken into account when conducting financial analyses of the treatments, in order to separate the fertiliser cost for fertility improvement from that for maintenance.

There were strong relationships between the various soil tests (Figure 1). This means it is possible to convert data into whatever units are appropriate for the audience.

Other data from the cross-site soil samples include pH, total C, total N, available S and K, slaking and dispersion. These data will be analysed and written up during the Harvest Year by the research fellow servicing the water and nutrients themes.

Table 2: Olsen P (mg P/kg) at the National Sites in spring 1998 and spring 2000.

		Fertility treatment		
Site	**Year**	**High**	**Medium**	**Low**
Forrests	1998	10		14
	2000	11		11

Site	Year	High	Fertility treatment Medium	Low
Fullbrooks	1998	11		
	2000	11		
Maindample	1998	18	13	11
	2000	15	8	7
Ruffy	1998	22	12	9
	2000	15	13	7
Vasey	1998	19		9
	2000	18		7
Wagga	1998	13		3
	2000	20		5
Wicks	1998	35		30
	2000	32		26
Albany	1998	22		8
	2000	27		10
Esperence	1998		12	6
Carcoar	1998		8	6

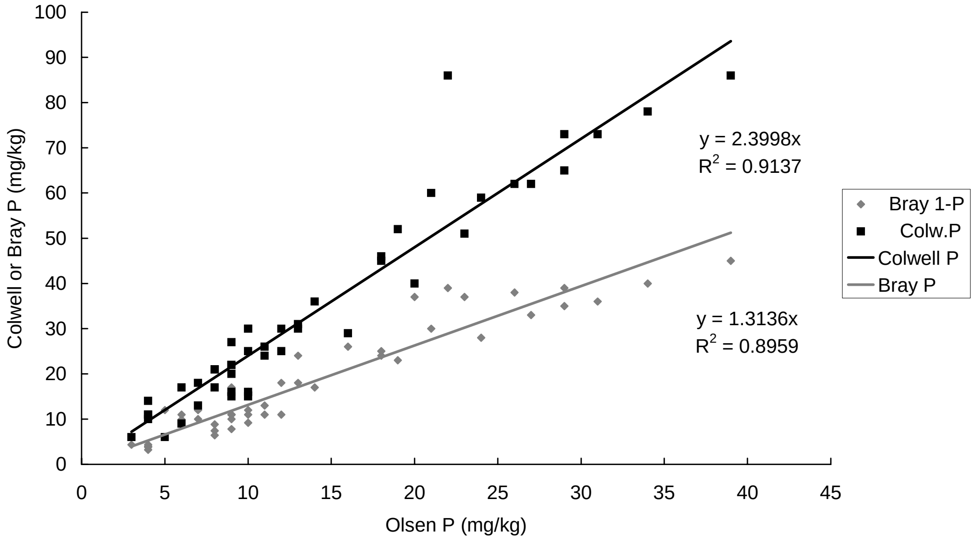

Figure 1: Comparison of Olsen, Colwell and Bray soil tests at the National Experiment sites.

4.5 pH buffering capacity

At the SGS modelling meeting in August 2000, it was suggested that samples be collected from the National Sites to determine pH buffering capacity. This is to estimate the likely changes in pH as alkalinity is exported through product removal and leaching of nitrate. The nutrient theme provided coordination and the Soils theme funds for soil analysis. Samples were collected from 0-10 cm and 10-20 cm depths in spring 2000 and analysed at CSIRO Townsville, where these analyses are conducted regularly as part of another MLA-funded project led by Dr. Andrew Noble.

Soils with a low pH buffering capacity would exhibit more rapid changes in pH per unit of alkali exported than soils with a high buffering capacity. Alkali export occurs primarily through nitrate leaching and secondly through the removal of animal product. Alkali import occurs when lime is applied. Soils with low pH buffering capacity show a much greater pH change per unit of lime addition than soils with a high buffering capacity. Fifty kg/ha of lime is sufficient to neutralise 1 cmol H^+/ha.

There was a range in pH buffering capacity of the top 20 cm from 0.97 cmol H^+/kg soil at the Adams site in WA to 5.48 cmol H^+/kg soil at Ruffy (Table 3). There was a high correlation between buffering capacity at 0-10 cm with that at 10-20 cm (R^2=0.991). These results were obtained with the addition of acid (ie. to test the effect of acidification). A subset of samples was tested for buffering capacity using addition of alkali, and results were similar.

Table 3: pH buffering capacity (cmol H+/kg soil) at the SGS National Sites, grouped into low, medium and high pH buffering capacity categories.

Site	Location	P buff 0-20 cm	Group*
Adams	Albany, WA	0.97	Low
Carr	Albany, WA	1.23	Low
Wicks	NW Slopes, NSW	1.51	Low
Forrests red	NW Slopes, NSW	1.67	Low
Forrest Brown	NW Slopes, NSW	2.07	Low
Fullbrooks top	NW Slopes, NSW	2.11	Med
Fullbrooks bottom	NW Slopes, NSW	2.15	Med
Ireland Farm	Esperence, WA	2.45	Med
Vasey	W Vic	2.59	Med
Wagga Research Centre	NSW	2.69	Med
Carcoar	Central Slopes, NSW	3.03	Med
Long-term Phosphate Expt	Hamilton, Vic	3.21	Med
Terang	Western Victoria	3.31	Med
MaindampleLow	NE Vic	3.41	Med
MaindampleMedium	NE Vic	3.70	High
MaindampleHigh	NE Vic	3.94	High
RuffyLow	NE Vic	4.24	High
RuffyMedium	NE Vic	4.83	High
RuffyHigh	NE Vic	5.48	High

"Low" is below the lower quartile of the sites listed, and "High" is above the upper quartile

4.6 Unanswered questions

Inadequate P on "high-input" treatments

What could have been produced if soil P had been adequate? Some sites have relatively low soil P even on the improved treatments. At Carcoar, for example, the best treatment could carry only 16.4 DSE in an 800 mm rainfall environment, whereas at Vasey, 25 DSE could be carried with 600 mm rainfall. Olsen P at Carcoar was only 8 mg P/kg, compared with 18 mg P/kg at Vasey. Data from the Long-term Phosphate Experiment at Hamilton indicate that the pasture-animal system is responsive to additional P up to an Olsen P value of 14 mg P/kg.

Concentrating improvement on the best part of the landscape

If we concentrate on improving the better areas and leave stony ridges and fragile riparian zones as areas for trees, shrubs and biodiversity, what is the productivity of the remaining intensified areas? At some National Sites, carrying capacity data include these less productive areas. Perhaps some estimates of this could be made by the Water and Nutrients Research Fellow while travelling to the various National sites.

Low-P systems on wet spots

At the western Victorian site, a study by PhD candidate Alice Melland, showed that a high proportion of surface runoff was generated from a small proportion of the total area. These areas are seasonal springs and riparian zones, and have led to a recommendation that they should be managed as low phosphorus systems to improve stream quality. These "best management guesses" need further testing in a range of environments.

Acidification processes

Acidification through nitrate leaching was only examined at the NE Victorian sites, and estimates are needed for a wider range of environments. This could be done during the Harvest Year using deep drainage estimates from the water theme, and assuming a nitrate concentration.

P buildup vs maintenance

Recommendations for P application need to be refined into capital and maintenance components. The "capital" component is a pasture development cost, and in a financial analysis is usually spread over a 10 year period. We need better methods to determine how much P is needed to lift soil test values into a target range for a range of soils. The "maintenance" component is a variable cost, and has rules of thumb such as "1 kg of P/year per DSE". This maintenance component was recently refined by John Cayley at Hamilton, Victoria, into a value which varies according to rainfall, soil type, slope and grazing method. Wool Innovation Ltd is interested in funding further development in this area. Carrying capacity data from the National Experiment collated by the SGS Animal theme would be useful in defining the maintenance P component across a range of environments in the perennial pasture zone.

5. DATABASE AND MODEL

The Nutrient Theme has been unique in that samples rather than data have been sent from site teams to the coordinator. Data are generally sent direct from the laboratory to the coordinator and are available for immediate statistical analysis and interpretation without being entered onto the database. All data are, however, forwarded to site teams to be entered into their site database.

The model has only recently begun addressing nutrient questions. The first priority in model development was to get water fluxes simulated correctly, because without this nutrient fluxes could not be simulated reliably. The model is, however, now ready for detailed simulations using the nutrient routines. This will be one of the tasks for the research fellow.

6. PUBLICATIONS

The only "publication" produced by the theme has been a special issue of "Prograzier". Publications planned for production during the Harvest Year are

- Cross-site relationships from SGS National Sites. This paper, to be written by a postdoctoral fellow as lead author, will examine cross-site relationships of soil P, labile carbon, pH buffering capacity and forage mineral nutrient concentration.

- Where are intensive pasture systems appropriate in southern Australia ? This paper will be written by Dr. McCaskill as lead author, and other members of the nutrient theme such as Anna Ridley as co-authors. The paper will use the National Experiment to test the hypothesis that where intensive pasture systems are appropriate from financial criteria, they are generally also appropriate from environmental criteria. This implies that there are relatively few situations where private good and public good clash. The P decision support framework recently developed by John Cayley will be tested on the National Experiment and used to estimate productive capacity under intensive systems on a variety of land classes. It is likely that modifications will be necessary in areas of more variable rainfall or greater summer rainfall than western Victoria. The social dimension of intensive systems will be explored using recent findings from Jason Trompf and others, addressing the question of what qualities need to be possessed by farm managers to be successful in applying productive pasture technology. Input from the Regional Producer Network will be sought for confirmation of findings from formal studies, and to cover areas not addressed in these studies, such as the hobby farm belts that now cover large areas around our major cities.

- Modelling of nutrient fluxes in the SGS National Experiment. This paper will be developed by the postdoctoral fellow and use the SGS model to estimate nutrient fluxes at National Experiment sites. Deep sampling of available nutrients, planned as an on-ground activity of the Nutrient Theme for the Harvest Year, will be critical in establishing reliable starting conditions for the model. The paper will present estimates of nitrate leaching at sites of the National Experiment (from the SGS model), transfer of nutrient away from the site in product (from the SGS database), and net accumulation in camps (from forage mineral nutrient data). Likely soil acidification rates will be estimated using these nutrient transfer rates.

7. CHALLENGES AND OPPORTUNITIES FOR THE THEME

The main challenge is that Nutrients is a supporting theme rather than a major thrust of SGS. Whereas nearly every site is planning to produce a site paper on water and pastures, only 3 site papers are planned for nutrients (N responses by kikuyu in WA, and nutrient movement in NE Vic, carbon cycling and carbon indices on the NW Slopes sites).

Strengths for the nutrient theme are:

- that no single site has enough data to report site fertility changes or labile carbon data in special-purpose site papers,

- the wealth of cross-site data on soil characteristics and forage mineral nutrient concentrations;

- integration of intensive and extensive pasture systems;

- its ability to work in with other projects which have a greater emphasis on nutrients;
- that detailed water balances will be produced by the water theme, which can be used to calculate nutrient fluxes down the profile;
- the SGS model is set up to simulate nutrient fluxes

Weaknesses are:

- there has been insufficient scientific time to interrogate the wonderful data set collected through SGS;
- apart from its environmental aspects, the nutrient field is perceived to be relatively well researched.

8. ACKNOWLEDGMENTS

Theme efforts would not have been possible without financial support from MLA, Land and Water, NSW Agriculture, the Victorian Department of Natural Resources and Environment, and Agriculture Western Australia. We have appreciated the assistance of the State Chemistry Laboratory of Victoria, the WA Chemistry Centre and Andrew Noble of CSIRO Townsville for chemical analyses. Martin Andrew has provided stimulating thoughts and comments on proposals.

9. TEAM MEMBERSHIP

Team membership consists of Malcolm McCaskill (coordinator), Paul Sanford, Anna Ridley, Brendon Christy, Bob White, Bill Johnstone, David Michalk, and Greg Lodge.

10. FINANCIAL STATEMENT

Nutrient theme income 2000/2001	$7,500
Carryover funds from1999/2000	$7,500
Subtotal - income	$15,000
Mineral nutrient analyses WA Chem Centre	$9,161
Casual labour for dispatch from Feedtest and integration of Feedtest results with mineral data	$1,255
Subtotal - expenditure	$10,416
Income	$15,000
Less expenditure	$10,416
Carryover funds to Harvest Year (income less expenditure)	$4,584

The nutrient theme also reports on Soils Theme funds, which are managed by Dr. Greg Lodge at the SGS NW Slopes site.

Soils theme income 2000/2001	$7,500
Carryover funds from1999/2000	$7,500
Subtotal - income	$15,000
Analysis of cross-site samples (SCL – Victoria)	$5,386
Analysis for pH buffering capacity (CSIRO Townsville)	$2,750
Subtotal - expenditure	$8,136
Income	$15,000
Less expenditure	$8,136
Balance used for analyses at the NW Slopes site	$6,864

11. THEME PLANS FOR 2001/02

11.1 Aims

1. Finish the collection of data necessary to complete the Site descriptions.

2. To complete the analyses of the SGS Site data to answer the Nutrient Theme questions concerning the soil-pasture-animal grazing systems monitored during the National Experiment.

3. To use the SGS model to examine the nutrient profiles under the control vs perturbed treatments in the National Sites.

4. To examine the loss of soil nitrate and associated acidification processes occurring under the various treatments across the National Experiment.

5. Contribute to finalising the SGS model, and determining the utility and value of the SGS model and SGS database for assisting with cross-site analyses.

6. To provide information from the Nutrient Theme results as input to the WIN Harvest Team to develop guidelines and tools for sustainable grazing systems.

7. To produce a series of publications for refereed journals reporting on the results and conclusions from the Nutrient Theme of the National Experiment.

8. To contribute to planning for the new program by identifying topics for further research, development and demonstration.

11.2 Background

The SGS nutrient theme has imposed minimal demands on site teams, but has been able to assemble some unique multi-site data sets, including:

- comparisons of the 3 main extractants used for soil phosphorus testing in Australia - Olsen, Colwell and Bray P;
- pH buffering capacity for 18 sites;
- analyses of 12 minerals in pasture components (green vs dead, grass vs legume) at various times during the growing season

Through relationships with other projects, the theme has been able to cover philosophical issues of intensive vs extensive pasture systems, and is well placed to prepare a paper on "Where are intensive pastures appropriate ?", using the National Experiment to determine where intensification is appropriate from financial, environmental and social criteria.

At the modelling workshop in March 2001, it was proposed that the theme resource the collection of soil samples to depth as a reality check on the model. It was proposed that low and high fertility treatments at each site be tested for available nutrients (especially S, nitrate and ammonium). This will give insight into the longer term processes operating at each site, and how our treatments have influenced the distribution of plant-available nutrients.

It is proposed that in order to interpret and publish the theme datasets, the time of theme leaders be supplemented by dedicated postdoctoral fellows based at the University of Melbourne. This action plan includes a postdoctoral fellow to be shared with the water theme.

Action	**Main person responsible**	**By when**
Collect soil cores to depth from high and low fertility treatments of the National Experiment	MM for protocol Site nutrient theme members for implementation	Oct 2001
Conduct a meeting of the Nutrient Theme re publications and analyses	MM, RW, postdoctoral fellow	Nov 2001
Nutrient theme paper on cross-site relationships completed to draft stage	Postdoctoral fellow	Dec 2001
Action	**Main person responsible**	**By when**
Nutrient theme paper "Where are intensive pasture systems appropriate" completed to final draft stage	MM	Jun 2002
Nutrient theme paper reporting model simulations for nutrients in the National Experiment completed to final draft stage	Postdoctoral fellow	Jun 2002

11.3 Budget

	Costs covered in other contracts	**Additional cost to nutrient theme**
Theme meeting (currently covered under WVic site budget)	$10,000	
Postdoctoral fellow (covered by Melb Uni contract with water theme)	$80,000	
Analytical costs		$15,000
Costs of collecting samples[1]		$10,000
Total		$25,000

Notes: Technical time and resources will be substantially reduced or unavailable during the Harvest Year at Albany, Esperance and Vasey, so the theme will need to pay for extra activities. Samples have already been collected at NE Vic and Carcoar, and collection will be covered from the site budget at NW Slopes (and done simultaneously with root sampling)

11.4 Draft Protocol for Site Coring

Hypotheses:

1. That long-term equilibria have resulted in the available nutrient profiles observed on control treatments, and the SGS model can mimic that these from soil, plant and climate data.

2. That treatments have caused statistically significant changes in available nutrients in the profile, particularly in the upper horizons.

Protocol:

1. Soil cores are to be taken to a depth of 80 cm in plots representing extreme treatments at each site.

2. Plots and positions are to be based on those used for the cross-site samples (NB There is a total of 47 plots used for cross-site analyses in the National Experiment).

3. Layers to be sampled are 0-10 cm, 10-20 cm, 20-40 cm, 40-60 cm, 60-80, 80-100, 100-120 cm. Where these layer boundaries do not coincide with horizon boundaries, the sampling layer boundaries are to be modified to fit into horizon boundaries on a hole-by-hole basis (NB needs discussion – where there are wavy horizon boundaries, this can lead to data which is very difficult to interpret).

4. Each sample is to be a composite from least 3 holes (except at Albany where only one hole will be used below the laterite).

5. At sites where an initial audit was conducted when the site was set up, the sampling protocol should be as close as possible to that used previously.

6. Samples are to be dried at 40C then sent to a central laboratory and analysed for pH, EC, available S, available K, nitrate-N, and ammonium-N. A subset of samples are to be analysed for total N, total P, total S and total cations. (NB if samples are dried immediately after collection, conversion of organic matter to nitrate and ammonium forms is minimised).

7. Where these data were not obtained from samples taken at the initial audit, the nutrient theme will pay for the additional analyses.

8. At sites where data on bulk density or gravel content are inadequate, these data should also be obtained from the samples.

9. Samples may be obtained either by a powered corer or by hand auger.

10. Where deep sampling is not already part of the site protocol, site teams to be paid about $3,000 from the Nutrient Theme for sample collection and dispatch. Laboratory costs to be paid by the Nutrient Theme.

11. Data interpretation, modelling and writing up are to be the primary responsibility of a research fellow servicing the Water and Nutrients themes, who would be senior author of a paper on this topic, with site nutrient theme members as co-authors

Milestone 25, “Final Animal Production and Nutrients Theme reports incorporating the theme conclusions from across the National experiment. The report to include details of use of the Theme budget”

Due 30 November 2001 in the original contract, but brought forward to 30 June to facilitate the SGS Harvest Year

Prepared by Dr. Malcolm McCaskill, Agriculture Victoria, Hamilton, with input from members of the SGS Nutrient Theme - Anna Ridley, Brendon Christy, Bob White, Paul Sanford, Bill Johnstone, David Michalk, and Greg Lodge.

APPENDIX 1: MINERAL NUTRIENT CONCENTRATIONS OF FORAGE SAMPLES COLLECTED FROM NATIONAL EXPERIMENT SITES

		Albany	**Esperence**	***VASEY***	**Ruffy**	**Maindample**	**Carcoar**	**Fullbrooks**	**Forrests**	**Wicks**
Green	Crude protein (%)	24.98	16.22	30.07	15.37	18.67	16.60	14.74	6.69	4.83
	N (%)	4.00	2.60	4.81	2.46	2.99	2.66	2.36	1.07	0.77
	P (%)	0.37	0.31	0.32	0.31	0.34	0.26	0.27	0.28	0.30
	K (%)	2.25	1.94	2.16	3.79	2.60	2.54	2.73	1.23	1.19
	Na (%)	0.43	0.36	0.96	0.62	0.57	0.15	0.30	0.02	0.01
	Ca (%)	0.93	0.59	0.71	0.86	0.72	0.63	0.45	0.32	0.41
	Mg (%)	0.32	0.26	0.26	0.39	0.22	0.19	0.24	0.11	0.09
	S (%)	0.26	0.22	0.28	0.19	0.25	0.21	0.32	0.08	0.07
	B (mg/kg)	18.62	12.58	13.34	24.33	14.00	13.10	7.33	4.14	4.64
	Cu (mg/kg)	6.62	5.56	7.27	8.30	8.93	7.56	7.18	5.16	4.64
	Fe (mg/kg)	213.17	107.58	390.39	183.33	213.33	207.31	67.00	90.38	88.89
	Mn (mg/kg)	37.76	50.63	96.30	306.67	250.00	183.88	114.73	55.31	69.75
	Zn (mg/kg)	60.21	29.33	61.70	72.67	123.33	53.36	31.20	34.55	31.36
Dead	Crude protein (%)	14.82	12.49	12.13	10.89	9.25	8.23	5.01	2.89	1.45
	N (%)	2.37	2.00	1.94	1.74	1.48	1.32	0.80	0.46	0.23
	P (%)	0.20	0.20	0.19	0.20	0.16	0.10	0.10	0.10	0.09
	K (%)	1.38	1.45	1.10	1.33	0.93	0.43	0.51	0.31	0.20
	Na (%)	0.53	0.21	0.81	0.25	0.31	0.05	0.09	0.01	0.01
	Ca (%)	1.16	0.44	1.24	1.31	0.82	0.70	0.39	0.39	0.44
	Mg (%)	0.27	0.23	0.32	0.35	0.19	0.12	0.15	0.06	0.05
	S (%)	0.19	0.17	0.24	0.16	0.16	0.11	0.13	0.05	0.04
	B (mg/kg)	27.17	8.83	23.66	22.40	10.50	11.33	5.71	2.86	2.74
	Cu (mg/kg)	4.90	4.03	7.89	7.35	6.66	5.25	3.79	3.58	2.64
	Fe (mg/kg)	880.00	110.25	962.89	387.33	335.60	568.48	141.36	248.14	266.72
	Mn (mg/kg)	31.17	42.58	168.76	445.33	334.00	247.50	138.79	54.17	87.72
	Zn (mg/kg)	40.50	23.17	163.68	147.53	119.60	53.66	21.43	28.76	26.83
Overall	Rank	3	6	1	2	4	5	7	8	9