Nutrient Budgeting in Extensive Grazing Systems
Final Report

Produced by:
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Project Details

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Introduction

Maintaining soil fertility in extensive grazing pastures is an important factor in ensuring that pastures reach their potential in terms of yield and quality. It is currently perceived that many soils under extensive grazing pastures are either deficient in critical nutrients or have nutrient levels above optimum for pasture production. The potential of soil acidification in improved extensive grazing pastures with legume components is also an issue. Furthermore, it is thought that many graziers fail to conduct soil tests prior to applying fertiliser. Observations pertaining to excessively high soil nutrient values are supported by research from the dairy industry, where levels of P, K and S are often above the optimum levels for pasture growth (Burkitt and Coad 2006; Gourley et al. 2010). Nutrient levels have been studied less intensively in pastures used for extensive sheep and beef grazing.

This study sought to evaluate the nutrient soil condition of a range of pasture types on extensive grazing properties in the Northern Midlands. The project aims to reduce fertiliser applications where they are not needed to reduce the risk of nutrient runoff into waterways and save money. It aims to provide a tool for farmers to better target their fertiliser applications to the requirements of individual paddocks or groups of paddocks, rather than a blanket approach.

On each property we have endeavoured to only take soil tests from pastures, but in some instances we have included lucerne and lupins as part of the sampling as they were used for grazing and there were not enough grass based pastures. We sampled ten pastures on each of the properties across a range of pasture types from newly renovated pastures, degraded pastures, to native run country. Soil pH and electrical conductivity as well as macronutrients including phosphorus, potassium and sulphur were all measured as part of the study. These results have allowed a comparison to be made with the optimum levels for pasture production. Nutrient maps have been drawn up to display variability in nutrients across the property. Recent soil tests from other companies have also been included to provide more coverage in the soil maps given only ten samples could be taken as part of the project on each farm.

Using the farm data provided by the farmer/landowner we have been able to construct a nutrient budget for the property. The complexity of farms in this region has required us to include cropping as part of the budget given that many fodder crops and crop residuals are included in the grazing rotations. Important information collected for the nutrient budget is; the sales of livestock and livestock products such as wool; the import and export of crops and fodder; and the import and application of fertilisers.

We hope that you find the information collected and presented in this report is most useful in planning the applications of fertiliser into the future. It aims to highlight the usefulness of regular soil testing and mapping of nutrients by either landowners or agronomists to better target fertiliser applications. Constructing a nutrient budget can be an helpful way of keeping track of nutrient flow onto and off the property and highlight any imbalances that may happen before the occur.
Methods

Obtaining participants

The project was initially advertised in the SheepConnect newsletter calling for interested farmers to be involved. After little response, targeted phone calls were made to farmers identified by TIA as likely participants, with Impact Fertilisers also providing the names of likely participants. Appointments to meet in person were made where the Project Officer gave an overview of the project, outlining major activities and intended outcomes. Fertiliser information, farm maps and suggestions of other potential participants were also obtained. Dates were set for soil sampling to occur, however on most occasions they were conducted on the day. A map of the participating properties is presented in Figure 1.

Figure 1: Map of the participating properties within two designated districts; Longford/Cressy and Campbell Town.
Soil Sampling

Ten paddocks on each farm were chosen for soil sampling. These were chosen by the farmer in conjunction with the Project Officer. An attempt was made to choose a range of pasture types (improved, semi-improved and native bush runs) and so that the paddocks were spread out across the farm. Paddocks were generally larger than 5 ha and up to 80 ha in size. Pastures did not have fertiliser applied within the 5-6 weeks prior to sampling. Paddocks were sampled with a corer to 7.5 cm depth. 30 cores were collected from each paddock, making up one composite sample, collected in a plastic sample bag and labelled. Cores were not collected from urine or dung patches, in gateways, on fence lines, areas of high traffic or in the bottom of drains.

Cores were taken in a straight line transect across each paddock (e.g. to diagonally opposite corners in rectangular paddocks) (Figure 2). Samples were stored in eskies out of direct sunlight while out in the field. Samples were transferred to aluminium trays for drying in ovens at 40°C for at least 48 hours before grinding and sieving to pass through a 2 mm sieve (Figure 12). Samples were sent to CSBP Soil and Plant Analysis Laboratory in Western Australia for analysis of pH (water), electrical conductivity, Olsen P, Colwell potassium (K) and KCL sulphur (S).

Figure 2: Soil sampling a lucerne pasture.
Farm survey

A farm survey (Appendix 1) was conducted to collect the information required by the NutriMatch nutrient budgeting calculator. A minimum-risk human ethics approval was granted from the University of Tasmania to collect the farm information, human ethics reference number H0012253. Information collected included livestock, crops and fodder bought and sold. The amount and formulation of fertiliser imported onto the property was recorded. In addition, farmers were asked a few questions regarding their perceptions of the nutrient status of the pastures on the property as well as the use of soil testing and advice on fertiliser application.

Nutrient mapping

Farm maps were obtained from farmers where possible. If participants did not have a map of their property, farm maps were drawn from Google Earth images of the property. Microsoft Word was used to construct the nutrient maps. Separate maps for phosphorous, potassium, sulphur and pH were created. Paddocks were colour coded based on optimal, above optimal and below optimal ranges, as per recommendations (Cotching 2012) developed by Dr Bill Cotching (Senior Research Fellow, TIA) and with reference to ‘Making better fertiliser decisions for grazed pastures in Australia’ (Gourley et al. 2007).

Nutrient budgeting

We used the NutriMatch spreadsheet to calculate nutrient budgets for each farm. As NutriMatch has been developed for dairy, some modifications were required to incorporate the extra activity on grazing/cropping properties. We used soil factors from the NutriMatch guidelines. Nutrient content of livestock products was taken from Appendix 6 of the National Land and Water Resources Audit (National Land and Water Resources Audit. 2001). Nutrient content of fodder, crops and crop products was also taken from Appendix 6 of the National Land and Water Resources Audit and from ‘Managing Soil Fertility on Cropping Farms’ (Nicholls et al. 2009). Analysis of some specific products such as poppy meal or screened cow manure was provided by the farmer and used in the budget.

Productivity assessment

A general judgement was made on each of the pastures using a 3 scale assessment scheme; high; medium; and low. This was based on species present, irrigation, and the potential DM production of the paddock. This was used for comparing soil pH and nutrient levels with productivity. It was not possible to collect pasture production data so this subjective alternative method was used. Thus care should be taken in the interpretation of these results, as it was a ‘gut feel’ type of classification.
Results

Soil pH

Mean soil pH for the ten farms was 5.7, within the optimum range for pasture production. Most farms had a mean soil pH within the optimum range for pasture production (Figure 3). Only farms D and E were below the optimum range. When split into two farming districts, Campbell Town and Longford/Cressy, soil pH was significantly (P<0.05) higher in the Longford/Cressy district (5.76) than the Campbell Town district (5.52) (Figure 4). Farmers were generally good at predicting soil pH, with six of the ten farmers successfully predicting the soil pH levels in soil samples from their pastures (Figure 5).

Figure 3: Mean soil pH (H₂O) levels for each of the ten farms surveyed in the Northern Midlands region of Tasmania. Error bars represent standard errors of the mean.
Figure 4: Mean soil pH ($H_2O$) levels for each of the ten farms surveyed split into the farming districts of Campbell Town and Longford/Cressy in the Northern Midlands region of Tasmania. Error bars represent standard errors of the mean.

Figure 5: The soil pH prediction of the farmer vs. what was measured by soil sampling.
**Phosphorus**

There was a range of phosphorus levels both between farms and within farms. The average phosphorus level for 6 of the farms was within or above the optimum range for pasture production (Figure 6). Only one farm was below the very low level of phosphorus. When analysed by farming district there was no significant (P>0.05) difference between the mean phosphorus level on farms in the Campbell Town (15.1 mg/kg) and Longford/Cressy districts (23.3 mg/kg) (Figure 7). Four of the ten farmers successfully predicted the level of phosphorus in soil samples from their pastures. There was no trend in the incorrect predictions, some underestimated and some overestimated their phosphorus levels (Figure 8).

![Figure 6: Mean phosphorus (Olsen, mg/kg) levels for each of the ten farms surveyed in the Northern Midlands region of Tasmania. Error bars represent standard errors of the mean.](image-url)
Figure 7: Mean phosphorus (Olsen, mg/kg) levels for each of the ten farms surveyed split into the farming districts of Campbell Town and Longford/Cressy in the Northern Midlands region of Tasmania. Error bars represent standard errors of the mean.

Figure 8: The phosphorus level prediction of the farmer vs. what was measured by soil sampling.
Potassium

The optimum range of potassium for pasture production is somewhere between 120 and 250 mg/kg depending on soil type. All farms were within or above this optimum range (Figure 9). There was no significant (P>0.05) difference between farming districts with Campbell Town (270.8 mg/kg) and Longford/Cressy (292.4 mg/kg) recording similar mean sulphur levels, both could be considered as high (Figure 10). Only one of the ten farmers successfully predicted the level of potassium in soil samples from their pastures. Generally, there was a trend for farmers to underestimate the level of potassium by one or two categories. For example, four farmers predicted a low potassium level, but the level was actually high (Figure 11).

Figure 9: Mean potassium (Colwell, mg/kg) levels for each of the ten farms surveyed in the Northern Midlands region of Tasmania. Error bars represent standard errors of the mean.
Figure 10: Mean potassium (Colwell, mg/kg) levels for each of the ten farms surveyed split into the farming districts of Campbell Town and Longford/Cressy in the Northern Midlands region of Tasmania. Error bars represent standard errors of the mean.

Figure 11: The potassium level prediction of the farmer vs. what was measured by soil sampling.
Sulphur

Sulphur levels were also quite variable between and within farms. However, the levels on all farms were within or above the optimum range for pasture production (Figure 12). Mean sulphur levels were significantly (P<0.05) higher in the Longford/Cressy (20.3 mg/kg) district than the Campbell Town district (12.8 mg/kg) (Figure 13). Similar to potassium, only one of the ten farmers successfully predicted the level of sulphur in soil samples from their pastures. Generally, there was a trend for farmers to underestimate the level of sulphur by one or two categories. For example, three farmers predicted a low sulphur level, but the level was actually optimum (Figure 14).

Figure 12: Mean sulphur (KCl-40, mg/kg) levels for each of the ten farms surveyed in the Northern Midlands region of Tasmania. Error bars represent standard errors of the mean.
Figure 13: Mean sulphur (KCl-40, mg/kg) levels for each of the ten farms surveyed split into the farming districts of Campbell Town and Longford/Cressy in the Northern Midlands region of Tasmania. Error bars represent standard errors of the mean.

Figure 14: The sulphur level prediction of the farmer vs. what was measured by soil sampling.
Productivity

In general, soil pH and nutrients declined with declining productivity (Figure 15). There were significant differences in soil pH between the productivity of paddocks. Mean soil pH was 5.9 in high, 5.7 in medium, and 5.5 in low productivity paddocks. Olsen phosphorus was significantly higher in high productivity paddocks at 31.8 mg/kg, than medium (18.7 mg/kg) and low (12.2 mg/kg) productivity paddocks. Although potassium levels were highest in high productivity paddocks at 303.3 mg/kg, they were not significantly higher than the medium and low productivity paddocks. Finally, sulphur levels were significantly higher in the high (18.3 mg/kg) and medium (17.8 mg/kg), than the low (11.9 mg/kg) productivity paddocks.

Figure 15: Soil pH and nutrient levels in high, medium and low productivity paddocks sampled in the trial. Error bars represent standard errors of the mean.
Nutrient budgeting

Mean deficits were recorded for all nutrients in both the Longford/Cressy district and the Campbell Town district. In the Longford/Cressy district the mean deficits were: P = -2.4 kg/ha; K = -17.3 kg/ha; and S = -4.0 kg/ha. While in the Campbell Town district the deficits were slightly higher: P = -8.3 kg/ha; K = -20.8 kg/ha; and S = -6.7 kg/ha. Deficits were consistent across all properties.

Other results

Nine out of the ten farmers said that they sought the advice of agronomists or fertiliser sales reps prior to applying fertiliser. On average, farmers’ soil tested pastures every 3.3 years.

Burlington Road Results

There were no significant (P>0.05) differences in soil pH or nutrients between the pasture cultivars at Burlington. Generally all values sit within the optimum range for pasture production (Figure 16).

![Soil pH and nutrient levels across the four replicates of three pasture cultivars at the Burlington Road Grazing Trial Site. Error bars represent standard errors of the mean.](image-url)
Nutrient Budgeting in Extensive Grazing Systems

Discussion

Soil pH

The optimum range of soil pH for pasture production is between 5.6 and 7.0 (Cotching 2012). Tasmanian pastures are naturally acidic due to high rainfall and organic matter content, with some soils being as low at 4.5 (Cotching 2009). Soil pH affects the availability of nutrients to plants and at low pH some nutrients such as aluminium can become toxic to plants (Cotching 2009). Analysis of the paddocks tested within this study showed that most farms were in the optimum range for pasture production. Farms D and E had below optimum soil pH, and number of the paddocks sampled on these farms contained bush run type pastures with little history of lime applications. Where the pH is considerably lower than the optimum range, applications of lime can be used to increase soil pH. Little benefit is recorded in production by applying lime when the pH is above 6.5 (Cotching 2009). Before liming a pasture, farmers must consider whether the production gained by the increased soil pH will outweigh the cost of the lime. In some instances the pasture may not contain sufficiently higher enough levels of improved plant species to take advantage of an increase in soil pH.

Phosphorus

The optimum range for Olsen phosphorus for pasture growth is between 20 and 30 mg/kg. There was considerable variation in the phosphorus levels within farms and between farms. Although there was a much higher mean in the Longford/Cressy district, the variability between farms and the low phosphorus level on farm G meant that there was no significant difference between districts. Although not recorded, the grazing intensity is higher in the Longford/Cressy district and the nutrient levels reflect that with four of the five farms in the optimum phosphorus range, and only one from the Campbell Town district. High levels of phosphorus can lead to high productivity, but other factors such as soil type, rainfall and grazing management are also crucial. In this case, phosphorus levels were significantly higher in the high productivity pastures.

Generally, the Campbell Town farms had more pastures sampled that were bush run type pastures (used for wool production mainly), which typically have low fertiliser inputs, thus it was not surprising that the phosphorus levels in many of these pastures is lower. Simply raising the phosphorus levels in these bush run type pastures may not see a dramatic increase in production and may actually result in a decline in some native species. Concentrating on raising the phosphorus levels in the improved pastures with a good content of improved pasture species may provide the greatest benefit in terms of increased production.

Many of the pastures in the Longford/Cressy district only require maintenance applications of phosphorus, and a few could handle a reduction in the application of phosphorus for a short period without any production penalty. This would either save the farmer money, or allows phosphorus to be more effectively distributed to other paddocks on the property. This would
reduce the risk of phosphorus leaching from the soil and make pasture production more sustainable.

**Potassium**

Generally, the potassium levels on all farms were within the optimum range for pasture production. This means that in most cases potassium is not limiting pasture production. There was no significant difference in potassium levels between districts, indicating that management may be more important than environment. Farmers tended to underestimate potassium levels and thus it is important to soil test to determine if potassium application are actually required.

Most pastures only require maintenance applications of potassium. Potassium applications could be reduced in a number of pastures without a production penalty. In a small number of cases, potassium levels were extremely high and may result in animal health issues such as staggers or grass tetany (hypomagnesaemia) if not managed correctly.

Potassium is one of the most transportable nutrients. Potassium is taken up by grass in large amounts. This means that if hay is cut and sold off farm, there is a net export of potassium from the farm. In addition, if hay is cut and fed out in another paddock on the farm, there will be a net export of potassium in the paddock in which it was cut and a net gain in the paddock where it is fed out. This means that potassium levels can be altered relatively easily on farm without applying fertiliser.

Although there appeared to be a decreasing trend, there was no significant difference in potassium levels across the productivity levels.

**Sulphur**

Sulphur is generally not limiting pasture production on these farms, as all were within the optimum range. A small number of paddocks were just below the optimum range and could easily be adjusted. Most other paddocks only require maintenance applications. Sulphur is commonly applied with phosphorus in superphosphate. Like potassium, farmers tended to under estimate their sulphur levels, so soil testing could again show potential to reduce application rates in some instances.

Sulphur was significantly higher in the Longford/Cressy district and may reflect a general trend of more fertiliser being applied in this district than in Campbell Town. With most sulphur levels in the Longford/Cressy district being above optimum, reductions in application rates could be implemented to save money, or better target the sulphur applications within farms.

Sulphur levels were significantly lower in the low productivity pastures. The low inputs on bush run type pastures and a tendency for nutrients to be nutrients to be concentrated around
sheep camps in these pastures is a probable reason for lower sulphur levels. Even though levels were lower, they were still within the optimum range for pasture production and as such should not be of concern.

**Nutrient mapping**

The general consensus from farmers was that the colour coded nutrient distribution mapping provided a great visual representation of the nutrient levels across the paddocks sampled on the property. It makes it easier to identify other paddocks that might have similar management and therefore similar nutrient levels, which could be aggregated for targeted fertiliser applications (Figure 17). Further soil testing over the next couple of years could be added to the maps to provide greater coverage of the property. As part of the results delivery visit, one farmer asked for the nutrient mapping file so that they could update the map as they collected further test results over the coming years. We obliged and we are happy to provide them to the other farms. We think that the mapping will encourage further soil testing and promote regular assessments of nutrient statuses.

**Figure 17 – Example of a nutrient map for phosphorus**
Nutrient budgeting

In general, most nutrients on most properties were running at a deficit. That is, the amount of nutrient being exported from the property in animal products or crops was higher than the amount being imported in fertiliser applications or other products. This is despite many instances where an above maintenance level of applications of nutrients had been maintained.

We believe that the soil factors within the NutriMatch calculator may not be well adapted to the lower rainfall/lower leaching conditions of the Northern Midlands region. NutriMatch was developed for high rainfall dairy enterprises, where considerable amounts of nutrients are lost through leaching and run off. The soil factors represent the amount of nutrients are lost through leaching and fixation within the soil. They are dependent on soil type, and may vary due to rainfall, although rainfall is not taken into account in the NutriMatch calculator.

As such, caution should be taken in interpreting the results of the nutrient budgets.

The farms do contrast with dairy properties on the north-west coast of Tasmania where many properties had nutrient levels above the optimum range for pasture production. As such, many of these properties were running at a nutrient surplus. This was not the case in the extensive grazing/cropping properties of the Northern Midlands.

Burlington Road

The results from Burlington road showed that there was little difference in soil pH and soil nutrients between pasture cultivars. This shows that there is little difference in the way these nutrients are being taken up by the different species and that the current maintenance applications, which are consistent across each of the species, of these nutrients is keeping them within the optimum range for pasture production.
Caution on fertilising native pastures

Care must be taken when applying fertiliser to native pastures. Some native pastures are now protected by law and farmers should familiarise themselves with the restrictions on them. Applying fertiliser to native pastures can lead to changes in botanical composition, loss of native species, which are generally sensitive to nutrient additions and an increase in the cover of clover (where clover has been sown!) is one recorded response (Mokany et al. 2006). In general, applying fertiliser will decrease the diversity of native species (Mokany et al. 2006; Dorrough et al. 2008). Increased stocking rates and careful grazing management is required if productivity is increased on native pastures by fertilising. Farmers may find that they get a greater production increase by fertilising improved pastures than native pastures. The technical guide ‘Managing Tasmanian Native Pastures’ (Mokany et al. 2006), in particular chapter 5 ‘Managing fertiliser on native pastures’ is a helpful reference for graziers thinking of fertilising native pastures and provides Tasmanian examples. Other information including a number of fact sheets and reports on managing Tasmanian native pastures are also available from the Land, Water & Wool website: http://australia.gov.au/directories/australia/lwa

Also see:


Figure 18: Example of a tussock grass (Poa spp.) pasture useful for lambing.
Conclusion

The mean soil pH and levels of major nutrient phosphorus, potassium and sulphur are generally in the optimum range for pasture production in the Northern Midlands. Some pastures require the soil pH to be lifted or phosphorus levels to be increased into the optimum range. Consideration of the effects this may have on native species is important in bush run type pastures. Potassium and sulphur levels are generally in the optimum range. However, there were a few instances of very high levels. Very high levels of potassium can cause animal health issues and thus it is important to monitor grazing of these paddocks. Most farms could benefit from reallocation of nutrients; that is more targeted applications that suit the individual paddock or group of paddocks specific needs. The inaccurate farmer predictions of nutrient levels indicate that soil testing is a worthwhile. Soil sampling can save money and can allow more targeted applications. The introduction of more cropping and irrigation onto these properties will have impacts on soil nutrients and these needs to be considered. The use of nutrient maps and nutrient budgeting can have great benefits for farmers planning fertiliser applications. Further work is required to assess the applicability of the NutriMatch calculator to extensive grazing systems of the North Midlands of Tasmania.
References


Cotching, B. (2012) 'Soil test guidelines for optimum dairy pasture production in Tasmania: 0-7.5cm depth soil samples.' (Tasmanian Institute of Agriculture)


## Appendix 1: Farm survey

Information required for nutrient budget 2010-2011 season

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<td>Email contact</td>
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**Farm enterprises: Livestock (type and numbers) crops, forestry**

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**Livestock sold**

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**Fertiliser applied in last 12 months**

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1. Please rate between 1 and 5 how often you take soil samples to base your fertiliser application decision on:

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2. Do you seek advice from agronomists, sales reps, etc on applying fertiliser?

YES  No

3. Please rate between 1 and 5 what you think your soil nutrient levels are (cross appropriate box):

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**pH**

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Please send to: Rowan.Smith@utas.edu.au

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