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Analysis Of The Economics Of Aerially Applying Lime On A Typical High Country Merino Property

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Executive Summary

This study looks at the financial viability of a typical high country merino property aerially applying lime on steeper oversown and topdressed land that is declining in pH. The decline in pH is causing aluminium (Al) levels to rise and as a result will in future exponentially reduce pasture production.

The results show that liming is viable on land that has potential carrying capacities over 3 SU/ha. This viability depends on soil pH being able to be raised by 0.1 with an application of 500kg of lime per ha. The key driver of these financial results is the cost of applying lime.

Background

In March 2005 the Merino Monitoring Group had a workshop on a member's farm (the study farm) where the value of liming was considered. Farming causes the slow acidification of soils because it increases the productivity of plants and the removal of positively charged nutrients (i.e. calcium). These are replaced by hydrogen ions which cause a decrease in soil pH. The normal practice is to substitute with calcium through adding carbonate in the form of lime.

At this workshop the group were shown a large area of oversown and topdressed Blackstone Hills Soils that had an average pH of 5. We would expect shifting this to a pH of 5.5 would only result in a 5% increase in pasture production and perhaps some improvement in pasture quality. This may require 3-5 tonnes of lime per hectare which, on this landscape would need aerial spreading. Given this and the extensive nature of this land, the economics have never favoured it as a viable option.

However, Edmeades *et al* (1983) showed that at some point the decline in pH is accompanied by a rapid (exponential) rise in aluminium levels. Al is shown to limit nodulation of clover thereby reducing its productivity and the contribution it makes to the nitrogen that fuels a grassland. Typically a pasture will become browntop or scrub dominant with a corresponding drop in overall productivity and palatability.

Edmeades showed that Al levels could be measured and correlated to pasture productivity using a calcium chloride ($CaCL_2$) extraction method. In glasshouse trials Edmeades showed levels above 3-5 became increasingly restrictive to clover productivity. Normally these levels occurred at pH levels of 4.8 and below (see Figure 1). However, the point at which Al starts to rise is dependent on a range of soil factors, including natural Al levels. The important factor is the shape of the response curve – Al levels rise exponentially after a threshold level is reached.

These levels have already been met by the study farm. Using the relationship derived by Edmeades it is reasonable to assume that overall productivity has already declined by 25%.

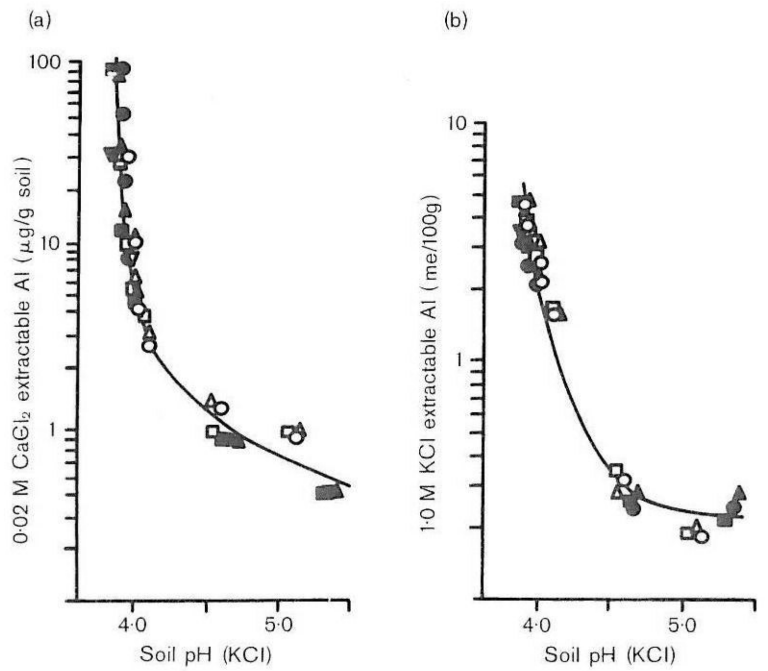

Fig. 1 The effects of pH, applied P, (●, ○ no P; ▲, △ 50 kg P/ha; ■, □ 150 kg P/ha), and sulphuric acid (▼, ▽) on 0.02M $CaCl_2$ (a) and 1.0M KCl (b) extractable aluminium, on the Marua soil (closed symbols) and Waitakere soil (open symbols).

Figure 1. The increase in Aluminium levels as soil pH declines. Source: Edmeades D.C.; Smart C.E.; and Wheeler D.M. 1983: Aluminium toxicity in New Zealand soils: preliminary results on the development of diagnostic criteria. *NZ Journal of Agricultural Research Vol 26*: **493-501**

If liming was carried out to increase pH and improve pasture production, it is reasonable to assume that pasture quality would also improve.

The question asked by farmers at the workshop was "Is it really an economic option to fly lime onto this country?" The elements important to answering this question are:

- The amount of lime needed to get back below the threshold

- The overall productivity of the land
- The improvement in pasture quality
- The cost of applying the lime

It is not known how much lime is required to shift pH on the study farm, however the usual rule of thumb is 1 t/ha per 0.1 pH. The study farm is running a comprehensive trial to determine what rate is needed to get back below the Al threshold (shifting 0.2 pH). Rates being trialled are 0, 125, 250, 500, 1000, 2000, and 4000 kg/ha.

Data compiled by the Merino Monitoring Group, and analysed by Ogle (2000), show that this type of land varies from 1.8 to 3.2 SU/ha with the average achieving 2.4 SU/ha.

No relevant studies have been done to show conclusively what improvement in quality could be expected from liming. This is made difficult in a farm system because it depends on a number of other factors such as the pasture control achieved through the year. This in turn is influenced by the block aspect and slope, the degree of fencing, the ratio of breeding cows to sheep, and mob sizes. Disregarding changes in management, the main reason quality might improve with liming is a change in pasture species. Browntop is dominant at low pH but at higher pH it is possible for and clover (red and white), sweet vernal, and cocksfoot to have a greater presence.

The winter feeding group[1] carried out extensive laboratory tests on pastures during the 2004 and 2005 winters. These tests show there is a difference of at least 3 mega joules of metabolisable energy per kg of pasture dry matter (ME/kgDM) between farms at the same time of the year. Part of this is likely to be the result of pasture species composition. I have therefore included in this analysis the assumption that pasture quality might improve on average over the whole year by 2.5 ME/kgDM if pH was improved from a pH of 4.3 to 5.3.

The cost of buying and applying lime can be easily obtained from the merchants and contractors involved and ranges from $110 to $140/tonne.

[1] The winter feeding group is a study group looking at factors important for efficiently wintering livestock in the High Country. It is sponsored by Merino Inc.

Method

A full financial budget was prepared for the study farm based on current and historical expenditure, debt servicing and personal drawings. Wool prices are in a low point in the commodity cycle so were based on the past 15 years' average. Sheep prices have improved considerably in the past 10 years but are expected to remain at the current level given the increasing demand for lamb. Prices were therefore based on the past three years.

In calculating the changes to the current productivity from either liming or not liming we assumed that stock carrying capacity had declined by 25% already and that the farmer would raise pH by 0.2; a point just before the threshold where the rapidly increasing effect of Al toxicity starts to occur. Increasing pH any further only has a minor effect on increasing pasture production and the economic benefit of this is already known to be poor.

The benefits of increasing soil pH below the Al threshold were calculated on a range of potential carrying capacities for this land type; 1.8, 2.2, 2.4, 2.6, 2.8, 3.0 and 3.2 SU/ha. By altering these carrying capacities the analysis provides results that are applicable to a wider spectrum of high country land types.

The outcomes of the lime trial on the study farm are not yet available, however we looked at different scenarios of lime required from 0.5 to 1.25 t/ha to move pH by 0.1. The farm budget was run for 10 years with every combination of potential stocking rate and lime requirement (per 0.1 movement in pH).

The Overseer 5 program was run to ascertain the need for maintenance lime on these soils at the assumed stocking rates. This was determined at 50kg of carbonate per year at an overall cost of $7,600.

Each 10-year cashflow combination was then compared with the option of "doing nothing". The option of doing nothing was calculated by assuming that further reductions would occur at a rate of 0.005 pH each year if lime was not applied. The corresponding impact on stocking rates for the Blackstone Hill Soils is shown in Figure 2. These reductions were calculated based on the potential carrying capacity for that option, thus reductions at 3.2 SU/ha were greater that at 2.0 SU/ha.

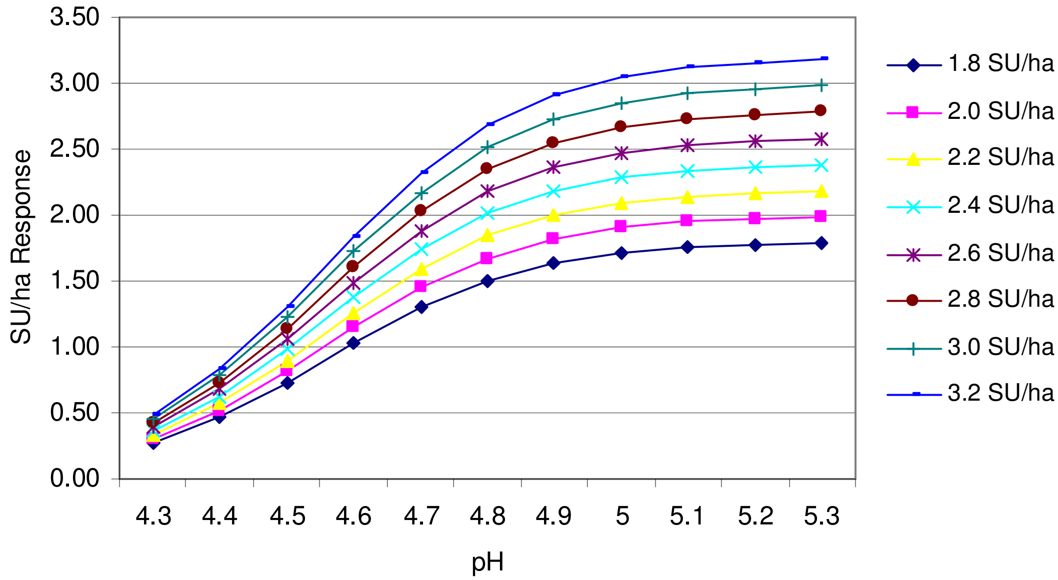

Figure 2. Impact of pH decline of stocking rate at 8 potential stocking rates.

Finally the farm profit (before tax) for the liming option was removed from the "do nothing option" to provide the net gain from liming. This provided a 10-year cashflow which was used, along with the capital invested initially in lime, to calculate an Internal rate of return (IRR).

The farm budget is shown in Appendix 1. The key parts of this budget are shown both as a total and per stock unit in Table 1. Expenditure has been divided into variable and non variable. As stock numbers alter over time with the different combinations (lime required X potential stocking rate) the revenue and variable expenditure vary in proportion to the number of stock units involved.

This means that the results would have a scale effect. A scale effect means that as stock numbers decrease each unit left behind must carry a greater overall proportion of the non variable farm working expenses, standing charges and personal drawings. Likewise increasing stock numbers mean the farm achieves better scale by diluting non variable expenditure.

Farm Revenue	Total	Per Stock Unit[2]
Sheep		
Sales - Purchases	285000	32.76
Wool	342500	39.37
Total Sheep	627500	72.13
Beef		
Sales - Purchases	13100	21.40
Total Beef	13100	21.40
Gross Farm Revenue	640600	64.71
Farm Expenditure		
Total Variable Costs	273680	27.64
Non -variable	190750	19.27
Total Farm Working Expenses	464430	46.91
Total Standing Charges	30000	3.03
Total Farm Expenditure	494430	49.94
Farm Profit (before tax)	146170	14.76
Personal drawings	60000	6.06
Farm Cash Surplus	86170	8.70

Table 1. Summary of the typical merino farm budget based on long run wool prices and current sheep sale prices.

Results and Discussion

If lime is not applied and pH drops by 0.005 each year, stocking rates will fall having an impact on farm profitability. Figure 3 shows the rates of decline for each stocking rate. Clearly, if we assume that the Blackstone Hill Soil is carrying a high stocking rate, as in the 3.2 SU/ha scenario, then the decline in profitability will be high (a reduction of $11,000 or 13%). In the 1.8 SU/ha scenario this area is less significant in the total feed supply and therefore has less impact (a reduction of $6,000 or 7%).

The increasing divergence between the lines from year 1 to year 10 shows the impact the higher reduction in stock numbers has at the higher potential stocking rates. There may also be a scale effect with these declining stock numbers. This means that at higher stocking rates the potential profit from investing in lime is higher.

[2] Sheep revenue expressed as sheep stock units, cattle revenue expressed as cattle stock units. All other figures expressed as total stock units.

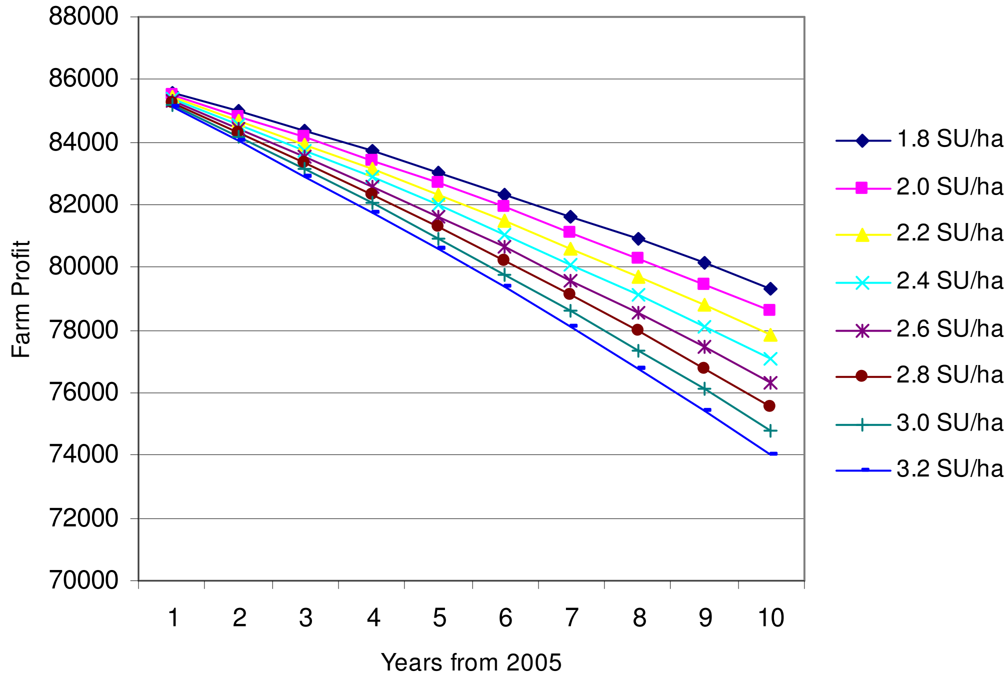

Figure 3. The effect of decreasing pH on farm profit over 10 years for 8 stocking rates.

What is important in predicting whether farmers will go ahead and invest in adding lime is whether they will improve their wealth prospects from doing so – perhaps it is best to just let stocking rates decline? One measure of this is the IRR. This tells us what interest rate a farmer could afford to borrow if he undertook the investment. Figure 4 presents the IRR for all 32 combinations of stocking rates X rates of lime. It is a surface graph which is a method of displaying the relative effects of the two factors (in this case stocking rates and rate of lime). It therefore has two bottom (X) axes.

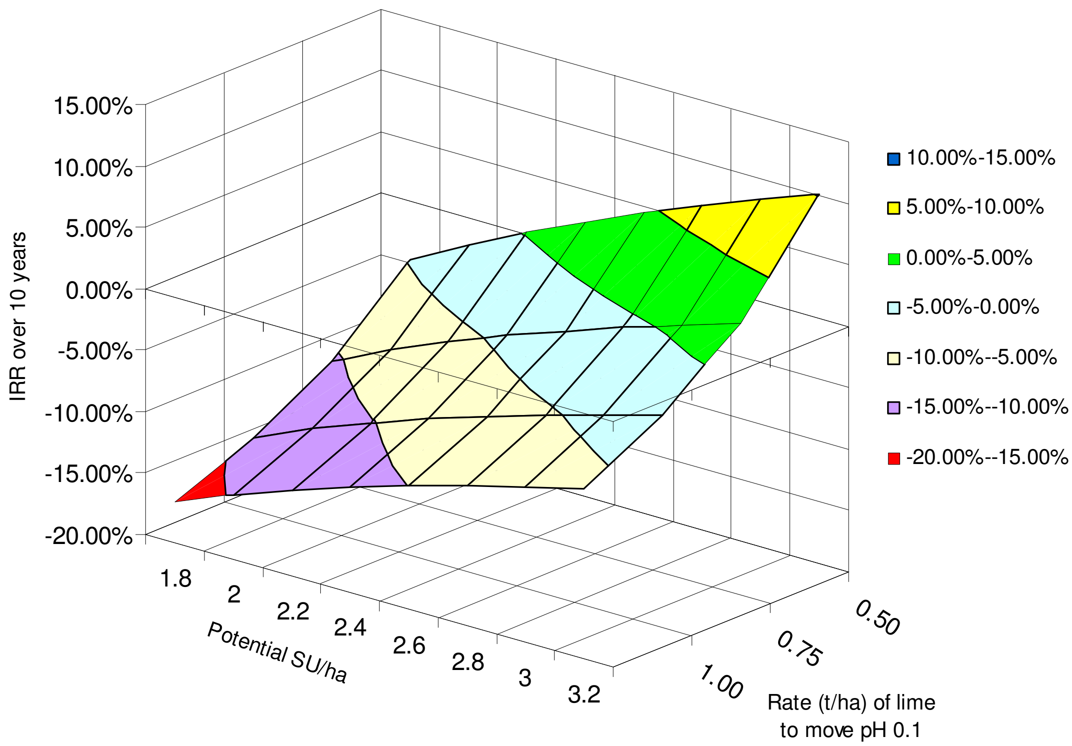

Figure 4. The Internal rate of return from investing in lime over a ten year period to increase soil pH by 0.2 assuming the land carrying capacity is 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0, 3.2 SU/ha and the rate of lime to achieve the 0.1 pH shift is 0.5, 0.75, 1.00, or 1.25 tonnes/ha calculated.

The data shows that while stocking rate is important, the steeper slope along the rate of lime axis confirms that it is the cost of lime that is the most important driver.

No combination provided a positive IRR if it took 1 tonne of lime/ha or more to raise pH by 0.1. At 0.75 tonnes of lime/ha the only positive IRR was on land capable of running 3 SU/ha. To achieve an IRR near the current rate of borrowing funds (8% - 8.5%), land would need the capacity to run 3 SU/ha or more and the shift in pH would need to be achieved by adding no more than 0.5 tonnes of lime/ha/0.1 pH.

Conclusions

- The best IRR was 10.1% for the combination of 0.5 tonnes of lime needed to shift pH 0.1 on land capable of running 3.2 SU/ha. This is above the current cost of borrowing (in 2005). However, it is at the edge of what we can reasonably expect for stocking rates on high country oversown and topdressed land. It is also reasonably optimistic to hope that 0.5 tonnes of lime will raise soil pH by 0.1.

- This study confirms it is the cost of liming that is the key determinant of whether liming will have a reasonable return. The cost of liming is made up of the application cost of transporting and flying it on (87% of total cost) and the cost of the lime itself (13%). The application cost is therefore the most important factor.

  It is therefore doubtful that if the study farm had simply applied lime at maintenance rates through out the last 20 years it would achieve a better IRR than doing nothing – the cost would just have been annualised.

- An opportunity might be on Yellow-Grey Earths and Yellow Grey/Brown Grey intergrade soil types where the main limitation to plant growth is sulphur. Finely ground elemental sulphur is usually applied with superphosphate as a carrier, as it can be explosive on its own. However, most of these soils would benefit more from lime than from phosphate, and if sufficient quantities of lime (instead of superphosphate) could be applied with the sulphur, application costs would be substituted for the superphosphate which is already being applied.

- A number of highly processed lime products that react more rapidly than agricultural lime are available. However, the speed of the reaction is not the issue, it is the total amount of calcium carbonate that must be applied to increase soil pH. Given that these more reactive forms are more expensive per unit of calcium carbonate they may simply make the economics worse.

- The implications for the productivity of those properties which cannot economically apply lime are serious. If lower cartage costs cannot be achieved, clover productivity may decline to the point where the lack of nitrogen means stocking rates become as low as 15% of potential (Figure 2).

Clearly, the results from the lime trial being conducted on the study farm will be important.

References

Edmeades D.C.; Smart C.E.; and Wheeler D.M. 1983: Aluminium toxicity in New Zealand soils: preliminary results on the development of diagnostic criteria. *NZ Journal of Agricultural Research Vol 26*: **493-501**

Ogle G.I. 2000 Stocking rates on different land types in the Merino Monitoring Group as measured through the computerised recording program Endeavour2. *Technical Report.*

Appendix 1. Assumptions and parameters used

Land type	
Dryland	160
Lucerne	120
Downs	250
Shady OSTD	1710
Sunny OSTD	2000
Total ha	1993

Table 2. Land areas on the study farm

Wool weights	**kg**
-Ewes	2.9
-Hoggets	2.0
Wool Price	**$**
-Ewes (18.1 micron)	13.50
-Hoggets (17.0 micron)	18.70
Livestock prices	**$**
-Cull ewes	45.00
-Wether hoggets (18.7kg @$4.2/kg carcass wgt)	78.00
-Cull Ewe hoggets	65.00
-Merino cull lambs	38.00
-Merino cull wether lambs	45.00
-Black face lambs (store)	52.00
Lambing %	**90**

Table 3. General price parameters used in the farm budget

	Farm Revenue	2005
Sheep	Sales - Purchases	285000
	Wool	342500
	Total Sheep	627500
Beef	Sales - Purchases	13100
	Total Beef	13100
	Gross Farm Revenue	640600
	Farm Expenditure	
Working Expenses	Wages	55000
	Shearing	63658
	Hay and silage	59400
	Animal Health	50722
	Breeding	1000
	Forage crops	43900
	Total Variable Costs	273680
	Weed and Pest	45000
	Fertiliser	60000
	Lime	5000
	Nitrogen	5000
	Electricity	6000
	R & M	10000
	Freight	6000
	Administration	15000
	Irrigation energy	
	Contract	
	Vehicles	14000
	Interest	29750
	Total Farm Working Expenses	469430
Standing Charges	Insurance	6000
	Rates	12000
	Rent	
	Sundry	12000
	Total Standing Charges	30000
	Total Farm Expenditure	499430
	Farm Profit (before tax)	141170
	Personal drawings	60000
	Farm Cash Surplus	81170

Table 4. The study farm financial budget.

	Numbers
Ewes	6600
Hoggets	3000
Cows	102

Table 5. Stock numbers wintered on the study farm.

		$
Assets	Land and improvements	4950000
	Stock value	
	-Sheep	624000
	-Beef	71400
	-Deer	
	Total Stock Value	695400
	Supplements	
	Current Account	43492
	Total Assets	5688892
Liabilities	Existing Borrowings	350000
	New Borrowings	0
	Current Account	
	Total Liabilities	350000
	Net worth	5338892

Table 6. Farm asset and liability structure