THE DECISION TO INVEST IN LIME FOR ACID SOILS

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1. INTRODUCTION

This study is about how to make long-term farm management decisions effectively when the amount of information available is extremely limited. Long-term decisions rely on judgements of input responses and outcomes which are uncertain or unknown. This is the reality of farm management decision-making. Complex decisions have to be based, in part, on some very 'soft' data. Therefore, good decision-making relies on good judgement. Judgement derives from lessons from experience (old information), and from the assimilation of new information generated by analysis of all the available information.

In this study, information about liming acid soils in north-eastern Victoria is used, along with farm management information, to generate further information, and thus facilitate the making of some judgements about the economic merit of investing in lime on a particular farm. Soil acidity is a physical phenomenon which has the potential to lower agricultural production and reduce farm profitability. The potential of soil acidity to lower agricultural production has led to it being described as a serious problem for agricultural activities in south-eastern Australia (Coventry 1985; Coventry et. al. 1987a; Cregan 1980; Ellington 1984b; Evans 1991; Helyar et. al. 1990; Reeves and Ellington 1985; and Williams 1980).

Making long-term farm management decisions with the limited information which is available requires finding a way to analyse and assimilate the available and new information, and then presenting it in such a way that sound judgements can be made about the likelihood of the possible outcomes actually eventuating. In this study, the standard farm management investment technique discounted cash flow analysis is used. To facilitate making sound judgements about the likelihood of outcomes, a break-even method is developed and applied to the major unknown parameter. The break-even level of the critical factor in the investment provides the decision-maker, who is looking ahead in a world of very uncertain input responses and outcomes, with something concrete on which to focus. Judgements can be formed about the likelihood of this critical level of the critical variable being achieved.

The analysis of liming as an investment provides information on the yields required for an investment in lime on the case study farm to break-even, that is, to cover all costs, including the opportunity cost of capital. The judgement made as to whether such yields are achievable will determine whether liming is a worthwhile investment on the case study farm and, implicitly, whether soil acidity is a problem requiring action by the case study farmer at this stage.

2. LIMING AS AN INVESTMENT

The application of lime can be looked at in two ways. Firstly, it can be viewed as just another input in the production process that enhances yield, albeit an input of a relatively long-term nature; or, as is more commonly the case, as a means of preventing or ameliorating the degradation of soil production potential which is caused by soil acidification. In either view, lime is another fertilizer which enriches the nutrient status of the soil and increases plant growth, or an input which prevents a decrease in plant growth and yield which might have occurred if it was not used.

Agronomists can determine the increase in plant growth and yield which might result from the application of lime in a specific set of circumstances. However, the dilemma facing the farm manager is not whether the application of lime increases plant growth and yield or not, but whether it increases it sufficiently to justify expenditure on lime. That is, is the application of lime a profitable investment?

For liming to be a profitable investment, the benefits provided by its use must be greater than the cost of using it. The costs of using lime include material, transport, spreading and incorporation, and the opportunity cost of the capital invested, while the benefits accrue from increased crop and livestock products or prevention of losses which would otherwise have occurred.

If the agronomic research has been done and the most likely response function of the particular crop or pasture to lime on a particular area of land is known, then the profitability of a range of different liming strategies can be determined through the use of partial budgeting. Where the response function is not known, the expected profitability of a specific liming strategy cannot be determined with the same precision. In either case, the return on investment in lime depends on unknown future prices and yields, and on unknown rates of future deterioration in production without liming.

The complexities of the physical environment in which agriculture operates means that most often case study analyses are based on relatively 'soft' data, including judgements about the levels of the key parameters in the future. Although response functions may have been determined from agronomic research, they are usually 'for the average farm' (which does not exist), or apply to broad soil groupings or, more precisely, are site specific. In addition, when you consider the specific nature of each farm manager's financial situation and skill level, it becomes apparent why such response functions, even if calculated, do not apply with precision to any particular farm area or farm.

To overcome this difficulty of lack of response data, it is necessary to turn the question around. Instead of attempting to answer, 'Is the response adequate to make the application of lime profitable?' when there is inadequate information, an attempt can be made to answer the question, 'What response is required for liming to be profitable?' That is, the break-even response required from added lime for the investment to be profitable can be determined.

The break-even lime response is the increased return from increased production which will equal the extra costs of liming. This information informs the farmer that this is the minimum response required to make a particular liming strategy profitable, with some allowance made for all the uncertainties involved. The decision-maker can then assess the best information available to determine whether such a response is achievable before deciding to proceed with the investment.

If the best information available shows that the calculated break-even response is beyond reach with reasonable assumptions about the applicability of whatever relevant research information is available, then the investment is not worth proceeding with. If it appears that the required response is achievable, then it is well worth further considering the investment. Finance availability, the level of risk involved and personal goals will help determine the farm manager's best strategy.

3. THE CASE STUDY FARM

A mixed cropping-livestock farm in north-eastern Victoria was selected as the case study for this analysis. Farm data was collected from the farm manager to allow the farm investment analysis to be carried out using real data in a realistic situation. Whilst the use of a case study farm means the results of this study apply only to this farm, it is the method described and the approach taken that are just as important as the results. That is, the case study farm is used to demonstrate how this approach could be used and how the results could be interpreted in one situation, and can thus be used in other case studies.

The case study farm is located in the Lake Rowan district, approximately thirty kilometres north of Benalla in north-eastern Victoria. This is a traditional mixed farming area, with cereal and woolgrowing the major enterprises. Research scientists from the nearby Rutherglen Research Institute have identified increasing soil acidity problems in the district (Coventry et. al. 1989; Coventry and Slattery 1991; and Ridley and Coventry 1992). However, local agronomists report that farmers in the district generally rely on acid-tolerant varieties of crops rather than liming (J.C. Avery pers. comm.).

This district was selected as an appropriate area to study as many of the farmers are currently facing the decision of whether or not to invest in lime. The case study farm provided an excellent example of a farm where the farm manager is facing just that decision. It also encompassed a range of activities, from the traditional rotation involving a clover ley phase to continuous cropping and permanent pasture. This, together with its proximity to lime research sites, enabled the analysis to be applied to a number of different activities and some insight to be gathered about the efficacy of an investment in lime in the local district.

There are two main rotations followed on the farm with a number of variations applied as appropriate. They are the continuous cropping rotation of wheat/wheat/lupins (WWL) and the more traditional rotation of wheat/oats/four years of pasture (WOPPPP). Other cereal crops, such as triticale, oats or barley, can be substituted for the second cereal crop in each rotation. This choice is dependent on grain prices and feed availability in any one season. The balance of the farm is under permanent pasture (PP). This area of pasture, plus the ley phase of the WOPPPP rotation and supplementary feeding from stubbles and grain, supports a self-replacing merino ewe flock.

Gross margins for each of the cropping enterprises within the rotations and the livestock enterprise were developed and then used to calculate the total gross margin of the farm and of each individual rotation. This provided information on the current profitability of each rotation, now and in the future, and provided the base case to which all other investment scenarios could be compared, that is, the do-nothing scenario. The cost of various lime investments were added to each of the rotation gross margins and the break-even crop response needed to justify the investment was calculated for comparison with this base case. The discrete liming strategies chosen for analysis are shown in appendix 1.

4. THE BREAK-EVEN METHOD

In this case study, Discounted Cash Flow analysis is used in conjunction with the break-even budgeting technique to determine the level of crop response required for a given investment in lime in order to break-even. Break-even budgeting is a form of partial budgeting. With partial budgets, the analyst looks at the extra costs and incomes from a change, relative to the costs and the income of the status quo: the aim is to see if the proposed change is worth doing. The break-even approach uses partial budgets but varies a key parameter to find out at what level costs break-even with returns or, the level of this parameter at which the proposed change is equally profitable with the status quo. This is an extremely useful technique for the farm decision-maker, as it identifies the yields and prices at which the change is profitable and unprofitable.

The break-even response to liming is the extra amount of crop and/or livestock product required to be produced to make the extra benefits resulting from liming equal to the extra costs due to liming. The response required to break-even can be calculated as follows:

$$\text{Marginal Benefit} = \text{Marginal Cost}$$

or,

$$\text{Marginal Product} \times \text{Product Price} = \text{Marginal Input} \times \text{Input Price}$$

therefore,

$$\text{Marginal Product} = \frac{\text{Marginal Input} \times \text{Input Price}}{\text{Product Price}}$$

OR

$$\text{Yield Response} = \frac{\text{Rate of Lime} \times \text{Price of Lime}}{(\text{Grain Price} - \text{Harvesting Costs})}$$

for a cropping enterprise

AND

$$\text{Stocking Rate Response} = \frac{\text{Rate of Lime} \times \text{Price of Lime}}{\text{Gross Margin}^{\prime}/\text{DSE}}$$

for a livestock enterprise

The marginal product calculated using the above formulae is the response required to break-even on an investment in lime in any one year. That is, if the desired response is achieved, the lime will be paid for in the year of its application. If this was the norm, then lime could be treated as a variable cost.

However, the response to lime application will occur over a number of years, depending on the amount applied, how it was applied and the initial soil conditions. The normal practice of liming is to apply large quantities infrequently, thus substantially increasing the soil pH in one application and then allowing it to rundown until liming again. Thus, farm financial analysis should treat the application of lime as an investment of marginal capital rather than a variable cost.

Although all of the costs of liming can occur in the year of application, the benefits occur over time. Thus, discounting needs to be applied to the stream of benefits so that they are comparable with the costs in terms of the present value or today's dollars. The marginal product calculated from the formulae above is the total response required to break-even over the life of the investment when discounting is not applied.

The response required to break-even on an investment of marginal capital over any time period is calculated as follows:

$$\text{Present Value} = S_n/(1+i)^n$$

where, S_n = the value being discounted
n = the number of years (in this case 1)
i = the discount rate

Thus,

$$\text{PV(Marginal Product)} = \frac{\text{Marginal Input} \times \text{Input Price}}{\text{Product Price} \times (1+i)^1}$$

The PV(Marginal Product) gives the total response required over the life of the investment. For the purposes of providing useful information to the farm manager, the 'average' annual response was calculated. When the time-value of increases in yield is considered, the equivalent of an increase in average gain is the amortized value or annuity. An annuity is the equivalent annual sum which, if received in each year of the project, would have a present value equal to that of the actual stream of values received. Thus, the average annual response required to break-even on an investment of marginal capital is calculated as follows:

$$\text{Present Value} = S_n/(1+i)^t$$

AND

$$\text{Amortized Value} = \frac{PV[i(1+i)^n]}{[(1+i)^n-1]}$$

where, S_n = the value being discounted;
PV = present value;
n = the number of years; and
i = the discount rate.

Therefore, where the PV is not known:

$$\text{Amortized Value} = \frac{S_n[i(1+i)^{n-1}]}{[(1+i)^n - 1]}$$

OR

$$\text{A(Marginal Product)} = \frac{\text{Marginal Input} \times \text{Input Price} \times [i(1+i)^{n-1}]}{\text{Product Price} \times [(1+i)^n - 1]}$$

The majority of paddocks of the case study farm are used to produce a range of crop and livestock products. This is true of nearly all broadacre farms in which the application of lime might be considered an option. On those farms on which cropping is undertaken, a wide range of crops may be grown in a certain sequence to take advantage of the complementary effects of the different crops. Such a sequence, or rotation, may or may not include pasture.

Therefore, the farm manager needs to know what the expected response of each enterprise in the sequence will be to calculate the profitability of an investment in lime. This is an inherently complex issue, as the responsiveness of each crop and the placement of it in the sequence will effect the resulting benefits. Whilst some agronomic research has been done on the responsiveness of different crops to lime (for example, Bartram 1986), none has been done on the combination of sequence placement and crop responsiveness.

Therefore, calculating the response required to break-even on the investment remains the most viable option to appraise the viability of liming acid soils. Using the formulae derived requires allowance to be made for a range of different crops being produced throughout the life of the investment. In order to do this, the expected gross margins of each enterprise involved in the rotation have been used to calculate an expected rotation gross margin. This provides an average rotation grain price and harvesting cost that can be used in the calculation of the break-even yield response.

5. THE RESPONSE REQUIRED

Lime can be used to increase production from acidified soils or to prevent a decrease in production from soil acidification which would have occurred in the future if lime was not used. The response of crops and pastures to lime and the rate at which the soil degrades due to increases in soil acidity will vary from soil type to soil type, from farm to farm, from paddock to paddock and even within paddocks. Thus, the relationship between the amount of lime applied to an area of land and the production response that can be achieved, or the rate of degradation that can be prevented, is a relationship unique to each particular area of land, and is a relationship which is rarely known for any particular area of land.

The results from this analysis, for a strategy of liming every six years when the discount rate is equal to fifteen per cent, are presented in table 1 and figure 1 for the two different crop rotations grown on the farm and the area under permanent pasture. A summary of the results for all liming strategies, discount rates and rotations analysed is presented in appendix 2. The application of lime must achieve an average annual yield response equal to the figures presented, if it is to be a profitable investment on the case study farm. Average annual yield response is defined in terms of percentage change in crop yield per year or stocking rate per year for the livestock enterprise.

Table 1

Average annual yield response required (%) for the three case study rotations (lime every 6 years/discount rate = 15%)

Rate of Lime	WWL	WOPPPP	PermPast
0.5	3.11	9.07	13.66
1.0	5.83	16.96	25.62
1.5	8.55	24.92	37.57
2.0	11.27	32.81	49.52
2.5	14.00	40.70	61.48

The main factors affecting these results are the cost of the lime (see figure1), the discount rate used (see figure 2) and the price of the output (see figures 3 and 4). The greater the cost of lime or the lower the output price, the greater the response that must be achieved to break-even on the investment. Low costs and/or high output prices mean that the reverse is true. The discount rate has a similar effect, with greater responses required at high discount rates. It also effects the relative ranking of different liming strategies, with high discount rates favouring shorter term investments.

Figure 1

Crop yield response vs price of lime (lime @ 1.0 t/ha every 6 years)

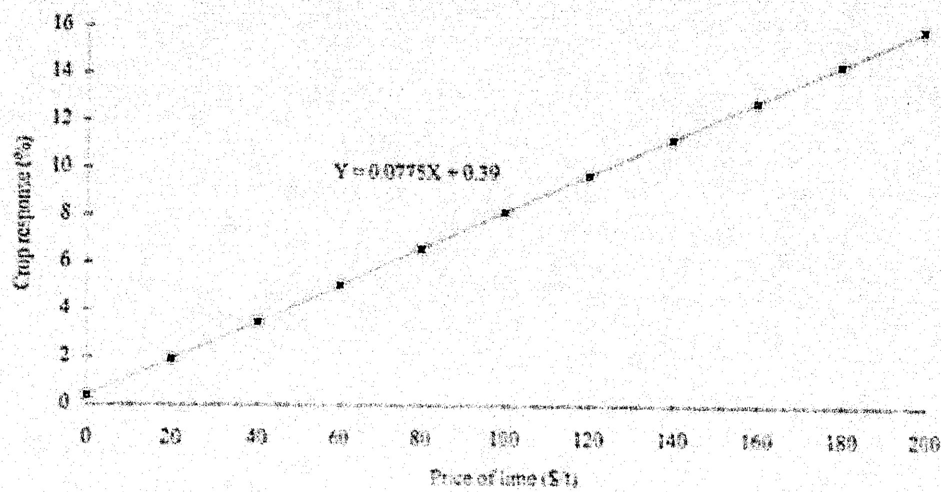


Figure 2

Crop yield response vs rate of lime for different discount rates
(lime every 6 years)

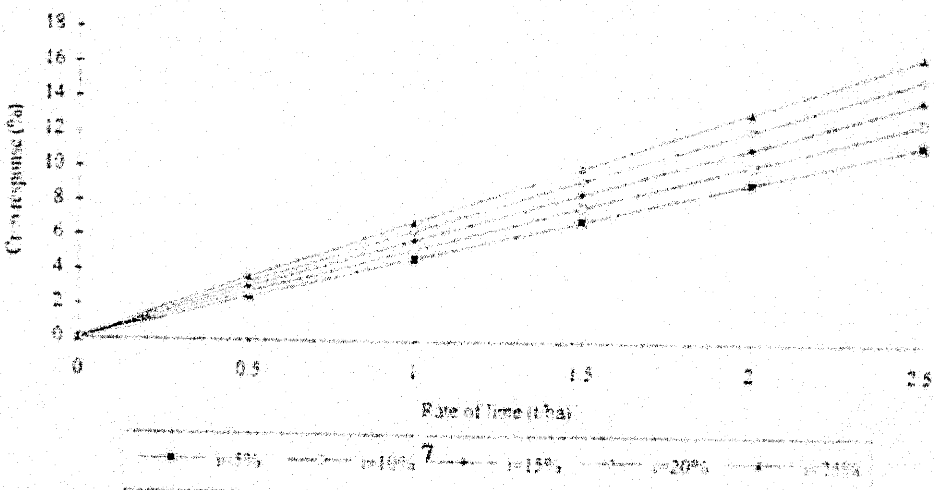


Figure 3

Stocking rate response vs wool price
(lime PP @ 1.0 t/ha every 6 years)

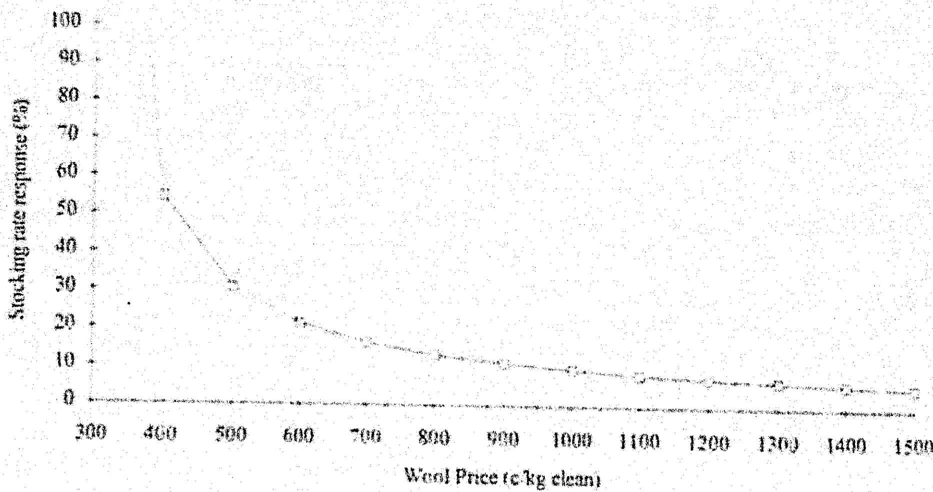
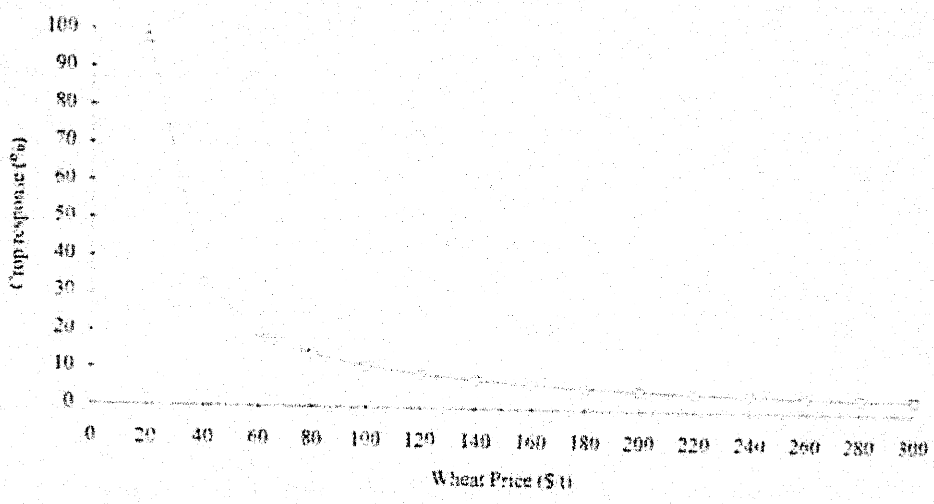


Figure 4

Crop yield response vs wheat price
(lime WWL @ 1.0 t/ha every 6 years)



6. TO LIME OR NOT TO LIME ON THE CASE STUDY FARM?

The crop response required by the case study farm manager to break-even on an investment in various liming strategies has been calculated for each of the case study farm's rotations under a range of discount rates, prices and varying input parameters. The farm manager must now weigh up all of this information against the agronomic research data available for the local district and make a judgement on the worth of an investment in lime compared with investing elsewhere.

The results presented provide the farm manager with information about the level of response in crop yield which is needed to break-even on an investment in lime. However, there is no indication of whether such a response is achievable. To make this decision the farm manager must turn to whatever relevant technical knowledge is available on production responses to lime in their district or on the relevant soil type and make a judgement about this information in the context of the soil type of the area in question.

Soils in the area of the case study farm have acidified to the point where lime responses have been obtained in aluminium-sensitive wheat cultivars (Coventry et. al. 1989). More recent investigations have shown that cropping rotations containing lupins are known to have a significant acidifying effect (Coventry and Slattery 1991). This information is supported by local knowledge that farmers in the district rely on acid-tolerant crop cultivars to maintain yields, but lime is generally not used (J.C. Avery pers. comm.).

The most extensive work on crop response to lime application in north-east Victoria was carried out at Lilliput (Coventry et. al. 1987), seven kilometres south of the Victorian Department of Agriculture's Rutherglen Research Institute, and about fifty kilometres east of the case study farm at Lake Rowan. Wheat grain yields were measured in a field experiment over five seasons from 1981 to 1985. The average annual rainfall at Lilliput is 590 mm and the soil is a sandy clay loam (Dy 2.33) with a pH of 4.31 in the top 10 cm and a pH of 4.22 at a depth of ten to twenty centimetres. Coventry et. al. (1987) described this site as strongly acid with a dense hardpan. They found that:

> Grain yields were increased each year by both lime and deep ripping, but the application of lime was necessary to obtain benefit from deep ripping.

Analysis of their results shows that the average annual crop response to lime achieved over a five year period was far in excess of what was required to break-even for all four application rates investigated (see table 2). If such responses could be duplicated on the case study farm, then the application of lime to the WWL rotation would be an extremely profitable investment, even at the fifteen per cent real discount rate.

However, the critical question is 'How relevant are the results achieved at Lilliput to the case study farm at Lake Rowan?' The soil at Lake Rowan is a loam (Db 2.32) with a pH in the surface ten centimetres of 4.3, and a pH of 5.0 at a depth of ten to twenty centimetres, whilst the rainfall is somewhat lower than that at Lilliput, being an average of 520 mm per annum (Coventry et. al. 1989). Thus, the site at Lilliput is far more acid than is likely to be the situation on the case study farm at Lake Rowan.

Table 2

Average annual crop response (%) achieved at Lilliput compared with the response required to break-even on the case study farm (lime every 6 yrs / i=15%).

Rate of Lime (t/ha)	Lilliput Response (%)	Break-even Response (%)
0.5	24.99	3.11
1.0	55.76	5.83
2.5	54.20	11.27
5.0	61.81	14.00

Similar liming experiments to those described above have subsequently been carried out at thirteen sites across north-eastern Victoria (Coventry et. al. 1989). Importantly, for this study one of the sites chosen was at Lake Rowan. Both an acid-tolerant cultivar of wheat (cv. Matong) and a sensitive cultivar (cv. Oxley) were trialed at Lake Rowan. However, only two years of results have been reported and only two application rates of lime (1.0 and 2.5 t/ha) have been investigated.

The average annual crop responses reported in table 3 are based on analysis of these results. Liming of soils growing the acid sensitive wheat cultivar, Oxley, at both Lake Rowan and Lilliput is a profitable investment. Large returns would be possible if this response was maintained for up to six years, as happened in the earlier experiment (Coventry et. al. 1987). However, even if the response was only maintained for three years, the investment would still break-even (see appendix 2 for the break-even response required when lime is applied every three years).

Table 3

Average annual crop response (%) achieved in trials by Coventry et. al. (1989).

Rate of Lime	Lake Rowan		Lilliput
(t/ha)	cv. Oxley	cv. Matong	cv. Oxley
1.0	16.28	5.72	37.49
2.5	23.94	11.88	58.35

The yield of the unlimed acid-tolerant cultivar, Matong, was similar to that achieved by liming cv. Oxley at both rates of lime application (see table 4). Thus, the benefits of using acid-tolerant wheat cultivars in the Lake Rowan district are confirmed.

However, the application of lime to cv. Matong at Lake Rowan is a questionable investment. The crop response achieved would need to be maintained for in excess of six years for an application of 1.0 t/ha and in excess of nine years for 2.5 t/ha if the farm manager was to break-even on the investment at a discount rate of 15%. Even though Coventry et. al. (1987) have demonstrated that responses can be maintained for five years at Lilliput, this was on a much more acidified soil than at the Lake Rowan case study farm. The lack of data on the longevity of the crop response to lime at Lake Rowan increases the risk associated with making a decision based on this limited, but the only available, data. It is obvious from the results that the farm manager should be growing acid-tolerant cultivars. However, the net benefits of liming these tolerant varieties under these conditions is doubtful. Under the circumstances, it would appear that the farm manager should most likely defer the decision to lime the WWL rotation until more information is known on the longevity of its effect, or until the soil becomes acidic enough to generate the level of response currently achieved by liming at Lilliput.

Table 4

Experimental wheat yields (t/ha) at Lake Rowan
(Coventry et. al. 1989).

Wheat Cultivar:	cv. Oxley		Cv. Matong
Rate of Lime	1.0 t/ha	2.5 t/ha	Nil
Year 1	2.48	2 60	2.92
Year 2	2.12	2 30	2.12

The yield responses of three mixed grass-clover pastures at Beechworth and Lake Rowan has been investigated by Ridley and Coventry (1992), who found:

> At Lake Rowan, no growth responses to lime were seen in any pasture treatment ...

Thus, the application of lime to pasture is an investment probably not worth further consideration by the case study farm manager at present.

If the soil continues to acidify, then the farm manager would need to reconsider their options, as an analysis of the results from the Beechworth site (pH = 4.2) indicate that an application of 0.5 t/ha of lime may be profitable at a discount rate of 15%, if the yield response reported can be maintained for at least six years (see table 5).

Table 5

Average annual pasture response (%) achieved in trials
by Ridley and Coventry at Beechworth (1992).

Rate of Lime (t/ha)	Break-even Response (%)	Pasture Response (%)		
		Phalaris	Cocksfoot	Annual
0.5	13.66	14.14	16.60	4.69
1.5	37.57	19 59	7.02	9.85
5.5	61.48+	31.28	15.57	13.28

Such longevity of response has recently been reported at three sites in southern New South Wales (Scott and Cullis 1992). However, responses of the order of only 10-12% were achieved from a lime application of 2.0 t/ha in the New South Wales work. Such a response would only be profitable on the case study farm if the wool price were to rise to in excess of 1000 cents per kilogram and remain at this level for the period of the investment (see figure 3).

Thus, the best available technical information indicates that the production responses required to make liming a worthwhile investment on the case study farm are not achievable with pastures and are, at best, a risky possibility for the cropping rotation at present. Therefore, at the likely level of responses at the current level of soil acidity, use of acid-tolerant crops and cultivars would seem to be the most appropriate action the case study farm manager should take to combat soil acidity.

Some researchers in the scientific community believe that:

> ... there is a risk that reliance on crop choice alone, and not liming to correct acidity, will ultimately result in productivity losses as the soil acidifies (Scott and Fisher 1989)

It is true that this risk exists, and ultimately losses in productivity could occur. However, this may or may not be a major problem, as from a farm management economics perspective, the most appropriate action to take always depends on the profitability of alternative ways of achieving particular ends.

In this case, the alternatives are to continue to allow the soil to acidify and simply use acid-tolerant species, or to correct the acidity with lime. Quite clearly the first alternative is the most profitable at present. While the soil itself may be degrading (that is, becoming more acid), it has yet to degrade far enough to make liming at this stage more profitable than not liming at this stage. When this occurs, the farm manager should take action.

7. CONCLUSION

The results of the analysis on the case study farm indicated that the response required to break-even on an investment in lime, using current prices and a discount rate of fifteen per cent, were significantly higher than those achieved in agronomic trials in the local district. The greater the cost of lime or the lower the price of wool or grain, the greater the response required to break-even on the investment in lime. The discount rate used in the analysis was also critical. At high discount rates, the loss of future returns from soil acidity was substantially lower and liming was even less of a preferred investment. At low discount rates the losses of returns in the future from soil acidity are relatively higher than with higher discount rates and the more likely it is that liming will be a worthwhile investment on the case study farm. This information led to the judgement that it would be best if the farm manager did not invest in lime at present.

Thus, the problem facing the decision-maker is not soil acidity itself, but judging whether the degree of degradation from soil acidity is sufficient for investment in lime to reduce soil acidity to be the best investment available. The break-even method developed in this study provides an approach which the farm decision-maker confronted with a paucity of information, can use to assist in making this judgement.

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APPENDIX 1
LIMING STRATEGIES USED IN THE ANALYSIS

Rotations:	1.	wheat / wheat / lupins	WWL
	2.	wheat / oats /pasture /pasture / pasture / pasture	WOPPPP
	3.	permanent pasture	PP

Discount Rates: 5%; 10%; 15%; 20%; 25%

Liming Rates: 0.5 t/ha; 1.0 t/ha; 1.5 t/ha; 2.0 t/ha; 2.5 t/ha

Liming Strategies:	WWL	WOPPPP	PP
	1. every year	1. every year	1. every year
	2. every 3 years	2. every 6 years	2. every 5 years
	3. every 6 years	3. every 12 years	3. every 10 years
	4. every 9 years	4. years 1 & 3	4. every 15 years

Total Strategies for each rotation:

5 discount rates x 5 liming rates x 4 strategies = 100

Note:

1. Some extra strategies were run through the spreadsheet to provide consistent data for the tables in the results chapter. These were one-off strategies to assist with presentation only.

2. A summary of the results achieved for each of these three hundred strategies is provided in appendix 2.

APPENDIX 2

SUMMARY OF RESULTS FOR ALL LIMING STRATEGIES, DISCOUNT RATES AND ROTATIONS ANALYSED

CROP YIELDS (t/ha) REQUIRED TO BREAKEVEN ON DIFFERENT LIMING STRATEGIES

Liming Strategy		D.R. = 5%			D.R. = 10%			D.R. = 15%			D.R. = 20%			D.R. = 25%		
		W1	W2	L	W1	W2	L	W1	W2	L	W1	W2	L	W1	W2	L
0 t/ha		3.13	2.08	1.67	-	-	-	-	-	-	-	-	-	-	-	-
	1	3.44	2.39	1.88	-	-	-	-	-	-	-	-	-	-	-	-
0.50	2	3.28	2.18	1.75	3.28	2.18	1.75	3.29	2.19	1.76	[illegible]	2.19	1.76	3.30	2.20	1.76
(t/ha)	3	3.21	2.13	1.71	3.22	2.14	1.72	3.23	2.14	1.72	3.24	2.15	1.73	3.24	2.16	1.73
	4	3.19	2.12	1.70	3.20	2.12	1.71	3.21	2.13	1.71	3.22	2.14	1.72	3.23	2.15	1.72
	5	3.18	2.11	1.69	3.19	2.12	1.70	3.20	2.13	1.71	3.21	2.13	1.71	3.22	2.14	1.72
	6	3.71	2.56	2.25	-	-	-	-	-	-	-	-	-	-	-	-
1.00	7	3.41	2.26	1.82	3.42	2.27	1.82	3.43	2.28	1.83	3.44	2.29	1.84	3.48	2.30	1.84
(t/ha)	8	3.28	2.18	1.75	3.30	2.19	1.76	3.31	2.20	1.77	3.33	2.21	1.78	3.35	2.22	1.78
	9	3.24	2.15	1.73	3.26	2.16	1.74	3.27	2.18	1.75	3.29	2.19	1.76	3.31	2.20	1.77
	10	3.22	2.14	1.72	3.24	2.15	1.73	3.26	2.16	1.74	3.28	2.18	1.75	3.30	2.19	1.76
	11	3.98	2.93	2.53	-	-	-	-	-	-	-	-	-	-	-	-
1.50	12	3.54	2.35	1.89	3.55	2.36	1.90	3.57	2.37	1.91	3.59	2.39	1.92	3.61	2.40	1.92
(t/ha)	13	3.35	2.23	1.79	3.37	2.24	1.80	3.40	2.26	1.81	3.42	2.27	1.83	3.45	2.29	1.84
	14	3.29	2.18	1.75	3.31	2.20	1.77	3.34	2.22	1.78	3.37	2.24	1.80	3.40	2.26	1.81
	15	3.25	2.16	1.74	3.29	2.18	1.75	3.32	2.20	1.77	3.35	2.23	1.79	3.38	2.25	1.80
	16	4.25	3.20	2.80	-	-	-	-	-	-	-	-	-	-	-	-
2.00	17	3.67	2.44	1.96	3.69	2.45	1.97	3.71	2.47	1.98	3.74	2.48	1.99	3.76	2.50	2.01
(t/ha)	18	3.42	2.27	1.82	3.45	2.29	1.84	3.48	2.31	1.85	3.51	2.34	1.88	3.55	2.36	1.89
	19	3.34	2.22	1.78	3.37	2.24	1.80	3.41	2.27	1.82	3.45	2.29	1.84	3.48	2.32	1.86
	20	3.30	2.19	1.76	3.33	2.22	1.78	3.38	2.24	1.80	3.42	2.27	1.82	3.46	2.30	1.85
	21	4.53	3.48	3.07	-	-	-	-	-	-	-	-	-	-	-	-
2.50	22	3.80	2.52	2.03	3.83	2.54	2.04	3.86	2.56	2.06	3.88	2.58	2.07	3.91	2.60	2.09
(t/ha)	23	3.49	2.32	1.86	3.53	2.34	1.88	3.57	2.37	1.90	3.61	2.40	1.92	3.65	2.42	1.95
	24	3.39	2.25	1.81	3.43	2.28	1.83	3.48	2.31	1.86	3.52	2.34	1.88	3.57	2.37	1.90
	25	3.33	2.22	1.78	3.38	2.25	1.81	3.44	2.28	1.83	3.49	2.32	1.86	3.54	2.35	1.89

Notes:

W1 = Wheat1dd
W2 = Wheat2dd
L = Lupinsdd
D.R. = Discount Rate

1,6,11,16,21 = Lime every year at rate listed
2,7,12,17,22 = Lime every 3 years at rate listed
3,8,13,18,23 = Lime every 6 years at rate listed
4,9,14,19,24 = Lime every 9 years at rate listed
5,10,15,20,25 = Lime every 12 years at rate listed

CROP YIELDS (t/ha) AND STOCKING RATES (DSE/ha) REQUIRED TO BREAKEVEN ON DIFFERENT LIMING STRATEGIES

Liming Strategy		D.R. = 5% W	D.R. = 5% O	D.R. = 5% P4	D.R. = 10% W	D.R. = 10% O	D.R. = 10% P4	D.R. = 15% W	D.R. = 15% O	D.R. = 15% P4	D.R. = 20% W	D.R. = 20% O	D.R. = 20% P4	D.R. = 25% W	D.R. = 25% O	D.R. = 25% P4
0 t/ha		3.13	2.80	7.81	*	*	*	*	*	*	*	*	*	*	*	*
	1	3.44	3.29	12.46	*	*	*	*	*	*	*	*	*	*	*	*
0.50 (t/ha)	2	3.20	2.87	8.68	3.21	2.87	8.78	3.22	2.88	8.88	3.23	2.89	8.99	3.24	2.90	9.07
	3	3.17	2.84	8.31	3.18	2.85	8.43	3.19	2.86	8.56	3.20	2.87	8.68	3.22	2.88	8.81
	4	3.33	2.98	9.06	3.34	2.99	9.14	3.34	2.99	9.23	3.35	2.99	9.31	3.35	3.00	9.39
	5	3.72	3.72	16.52	*	*	*	*	*	*	*	*	*	*	*	*
1.00 (t/ha)	6	3.[illegible]7	2.93	9.45	3.29	[illegible]	9.63	3.30	2.95	9.81	3.32	2.97	9.99	3.33	2.98	10.17
	7	3.[illegible]	2.87	8.79	3.23	2.89	8.97	3.25	2.91	9.21	3.27	2.93	9.45	3.29	2.94	9.6[illegible]
	8	3.[illegible]	3.14	10.15	3.52	3.1[illegible]	10.31	3.53	3.16	10.47	3.54	3.16	10.62	3.54	3.17	10.76
	9	3.9	4.15	20.99	*	*	*	*	*	*	*	*	*	*	*	*
1.50 (t/ha)	10	3.3[illegible]	2.99	10.21	3.36	3.00	10.48	3.38	3.02	10.75	3.40	3.05	11.01	3.43	3.07	11.27
	11	3.2[illegible]	2.91	9.19	3.28	2.93	9.52	3.31	2.96	9.88	3.34	2.98	10.21	3.36	3.01	10.56
	12	3.66	3.30	11.24	3.70	3.31	11.48	3.72	3.32	11.70	3.73	3.33	11.92	3.74	3.34	12.14
	13	4.26	4.57	24.65	*	*	*	*	*	*	*	*	*	*	*	*
2.00 (t/ha)	14	3.40	3.04	10.97	3.43	3.07	11.33	3.46	3.10	11.68	3.49	3.12	12.03	3.52	3.15	12.38
	15	3.29	2.94	9.62	3.32	2.97	10.06	3.36	3.01	10.51	3.40	3.04	10.97	3.44	3.08	11.43
	16	3.87	3.46	12.33	3.89	3.48	12.64	3.90	3.49	12.94	3.92	3.50	13.23	3.93	3.52	13.52
	17	4.54	5.03	28.72	*	*	*	*	*	*	*	*	*	*	*	*
2.50 (t/ha)	18	3.47	3.10	11.73	3.50	3.13	12.18	3.54	3.17	12.62	3.58	3.20	13.05	3.62	3.23	13.48
	19	3.32	2.97	10.06	3.37	3.01	10.60	3.42	3.06	11.17	3.47	3.10	11.74	3.51	3.14	12.30
	20	4.05	3.62	13.43	4.07	3.64	13.81	4.09	3.66	14.18	4.11	3.67	14.54	4.12	3.69	14.89

Notes

W = Wheattec
O = Oatsus
P4 = Four years of pasture
D.R. = Discount Rate

1,5,9,13,17 = Lime every year at the rate listed
2,6,10,14,18 = Lime every 6 years at the rate listed
3,7,11,15,19 = Lime every 12 years at the rate listed
4,8,12,16,20 = Lime W and P1 at the rate listed

Liming Strategy		STOCKING RATES (DSE/ha) REQUIRED TO BREAKEVEN ON DIFFERENT LIMING STRATEGIES AT VARYING DISCOUNT RATES				
		5%	10%	15%	20%	25%
0 t/ha		7.81	-	-	-	-
	1	12.46	-	-	-	-
0.50	2	8.83	8.93	9.02	9.11	9.19
(t/ha)	3	8.39	8.50	8.62	8.74	8.85
	4	8.24	8.37	8.50	8.64	8.78
	5	15.52	-	-	-	-
1.00	6	9.73	9.90	10.07	10.24	10.40
(t/ha)	7	8.89	9.10	9.32	9.54	9.76
	8	8.61	8.85	9.11	9.36	9.62
	9	20.59	-	-	-	-
1.50	10	10.62	10.88	11.13	11.37	11.61
(t/ha)	11	9.39	9.70	10.03	10.35	10.67
	12	8.98	9.34	9.71	10.09	10.46
	13	24.65	-	-	-	-
2.00	14	11.52	11.85	12.18	12.50	12.82
(t/ha)	15	9.89	10.30	10.73	11.16	11.59
	16	9.36	9.83	10.32	10.81	11.30
	17	28.72	-	-	-	-
2.50	18	12.41	12.83	13.23	13.64	14.03
(t/ha)	19	10.39	10.91	11.43	11.97	12.50
	20	9.73	10.31	10.92	11.54	12.15

Notes:

1,5,9,13,17	Lime every year at the rate listed
2,6,10,14,18	Lime every 5 years " " " "
3,7,11,15,19	Lime every 10 years " " " "
4,8,12,16,20	Lime every 15 years " " " "