Long-term effects of fertiliser on the productivity and persistence of perennial native grasses

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Abstract: *the pasture persistence, productivity and economics of three fertiliser regimes was measured for 13 years in an unreplicated study on a 42 ha wallaby grass (Austrodanthonia spp.) dominant, 'modified native pasture' at Newbridge on the central tablelands of New South Wales. The soil at the site was a highly acidic, slate/shale based gravelly loam with >20% aluminium throughout the profile. The paddocks had been cleared, cropped once and sown to a mixed introduced perennial pasture containing subterranean clover (Trifolium subterraneum) in the 1960s, but reverted to native species over the years with a low phosphate status as fertiliser use declined. The results showed that the native grasses present [wallaby grass, weeping grass (Microlaena stipoides) and common wheat grass (Elymus scaber)], were persistent and more productive and profitable when fertiliser was applied to overcome deficiencies. The livestock enterprise we used was late July lambing Border Leicester x Merino ewes joined to Poll Dorset rams with the aim of weaning 38 kg lambs before Christmas for the domestic prime lamb market. Despite some dry years and consequent heavy grazing at times, there appears to be no long-term loss of native grasses, even in paddocks where very high fertiliser applications were made. This was attributed to adjustment of stocking rate to utilise the increased pasture growth, preventing smothering of wallaby grass in particular, by annual species stimulated by the increasing fertility. The normal district practice of applying 125 kg/ha single superphosphate to these modified native pastures, only once every third year was uneconomic.*

Key words: prime lamb production, landscape management, land capability, reactive phosphate rock.

Introduction

Large areas of the tablelands of New South Wales (NSW) were semi-improved with legumes and superphosphate in the 1950s and 1960s. In some cases the resident native pastures present tend to be a reasonably stable mix of fertility responsive native grasses with introduced legumes i.e. subterranean or white clover (Garden *et al.* 2001). Such pastures are classified as 'modified native pasture' (Langford *et al.* 2004). As district agronomists we encountered many landholders who thought all native pastures were inferior for livestock production compared with introduced pastures and that it was not economic to fertilise them. In some instances however, we observed that modified native pastures were both productive and persistent, with moderately high levels of fertiliser input and stocking. This appeared to conflict with the results of (Garden *et al.* 2003) that showed native grasses in set stocked pastures decreased with moderately heavy rates of fertiliser, but the reasons for this were not clear. Was it the fertiliser, the legume growth, competition from annual grasses or something else? Does this apply to all native grasses? We suspected the excessive growth of annual species in spring adversely affects native grass persistence if it was only leniently grazed.

There is another factor to consider in regard to native pastures – there is no establishment cost. Currently the cost of establishing introduced pastures is ~$300/ha ($480/ha if 2.5 t/ha of lime is required). To cover this cost, stocking rates must increase by at least 4 dry sheep equivalents (DSE)/ha and the newly sown pasture must remain productive and persistent for 15 or more years (Scott F, 2008, unpublished data). In some soils and landscapes, this is not easy to achieve and we often observed situations where native grasses were better suited to acidic soils and the environment than the introduced species previously sown. At our site, fertility responsive native grasses invaded and became dominant over time, as introduced grasses failed to persist.

Our study site was part of the Prime Pasture (grazing management) Program to examine the effects of fertiliser on a wallaby grass (*Austrodanthonia* spp.) dominant 'modified native pasture'. We compared two fertilisers, single superphosphate (SSP) and the 'organic' fertiliser, reactive phosphate rock (RPR), at two different rates using spring lambing ewes as the livestock enterprise. The aim of the study was to document long-term effects of fertiliser on pasture composition and stability using an enterprise with fluctuating stocking rates (rather than set stocked wethers). This paper addresses questions related to the growth, composition and persistence of native perennial grass-based pastures and the profitability of fertilising such pastures. We also examined the effects of the two fertiliser types on soil P levels to demonstrate that RPR is an effective fertiliser in the high rainfall zone on highly acidic soils (Sale *et al.* 1997).

Methods

The 42 ha study site was located at Newbridge (33° 37' S; 149° 23' E) on the central tablelands of NSW and data was collected from 1994 to 2007. To overcome problems associated with using livestock data from small numbers of animals, the paddocks we used were reasonably large. Attempting to provide realistic data, meet the needs of the Prime Pasture Program to investigate the role that soil fertility and the grazing of a spring lambing enterprise had on native perennial grass persistence, precluded the use of replication. However, the data collected and observations made over a 13-year period indicated substantial trends in species persistence and the economic analyses provide valuable insights.

The long-term mean rainfall at this site was 795 mm, the altitude 1000 m and while green feed remains until late December in most years, there is a pronounced winter feed trough. Pastures were dominated by wallaby grass, with weeping grass (*Microlaena stipoides*), wheat grass (*Elymus scaber*), perennial ryegrass (*Lolium perenne*), subterranean clover, silver grass (*Vulpia* spp.) and soft brome (*Bromus mollis*). Soils were shale derived, relatively shallow, gravelly and acidic (pH_{Ca} 4.2, with 18% aluminium (0–10 cm), >25% (10–20 cm) and a cation exchange capacity 6.2 $cmol^+/kg$. Phosphorus (P) at14 mg/kg Colwell and sulfur (S) at 2 mg/kg KCl-40 were very low.

Pasture data collected included pasture growth rates (using exclusion cages cut and moved monthly; data collected from 1998 onwards), pasture composition and annual pasture persistence. The rod point method (Little and Frensham 1993) was used to record pasture composition, generally in spring. A 1 m^2 grid (10 by 10 cm mesh) was used to measure basal presence at 10 m intervals along a 100 m permanent transect in every paddock, over a period of 13 years. Soil samples were also taken annually along fixed transects, fertiliser was applied in March, except in 1995 when it was spread in November 1994 and all fertiliser costs were recorded. Numbers of ewes joined, lambs marked, lamb weights at weaning, skin value at sale and wool production from ewes were recorded to enable the profitability of each paddock to be compared. Property owner Howard Sinclair carried out day-to-day management and kept excellent records of all overhead costs together with daily rainfall, selling costs, any supplementary feed costs and he recorded all livestock numbers and movements (including occasional cattle grazing).

After weaning in mid December, paddocks were de-stocked and the ewes (tagged to identify which paddock they were from) were run as a single mob until joining in their paddocks in late February–early March. Over summer, paddocks were either rested to allow feed to bulk up for joining, or if excess pasture growth needed to be grazed, cattle were used. Stocking rates for each treatment were set at joining time depending on the fertility of the paddock, how it had performed last year and the current season. Rams were removed after six weeks. The aim was to commence lambing on 1200-1500 kg/ha green pasture dry matter (DM). Grain supplements were needed in dry years in late pregnancy and in extreme cases the paddocks had to be spelled for three to four weeks. From lambing to weaning all paddocks were set stocked at a rate determined at joining. The study was planned to end in December 2006, but severe drought over winter and spring that year meant all paddocks had to be de-stocked to enable the five mobs to be combined and grain fed in a sacrifice paddock. Livestock data was not recorded then, so data for the last year is from 2007.

Fertiliser Treatments: Three strategies ('High Input', 'Annual' and 'Control') were compared, but RPR products became unavailable and so were only used until 2002. Thus the two RPR paddocks were in a fertility run-down phase from 2003–07. The 'High Input' strategy was applied to two paddocks, with a capital dressing in the first year of 420 kg/ha of SSP in one and 300 kg/ha RPR + 300 kg/ha gypsum in the other. This provided equal amounts of the two most limiting nutrients, P and S to each paddock. In the following two years, the SSP paddock received 280 kg/ha SSP each year and the RPR paddock 200 kg/ha RPR + 200 kg/ha gypsum each year. Over the first three years, these paddocks received in total 980 kg/ha SSP (or equivalent RPR), which was sufficient to raise the soil P and S levels to non-deficient levels. From 1998, these paddocks received either 180 kg/ha SSP or 186 kg/ha RPR Supreme (a blend of RPR and elemental S that supplied the same amount of P and S as 180 kg/ha of SSP). These latter rates supplied 2 kg P/ewe (1 kg P/DSE) as is recommended to ensure sufficient pasture growth to enable rapid growth of prime lambs and to balance export of nutrients *via* the sale of these lambs (Clements *et al.* 2010). In the 'Annual' fertiliser strategy, two paddocks received annual applications of either 140 kg/ha SSP or 100 kg/ha RPR. This rate was above normal maintenance levels, but chosen because initial soil sampling revealed both P and S levels were critically low and needed to be raised, not just maintained (Clements *et al.* 2010). For the 'Control' strategy, one paddock received 125 kg/ha SSP initially and similar to common district practice for native pastures this was subsequently re-applied only one-year in three (1998, 2001 and 2004).

Results

There was considerable variation in rainfall between and within years and rainfall had large effects on pasture production, pasture composition and the ability of lambs to gain weight. In wet springs, when the pasture grew tall and was under-utilised, the persistence of wallaby grass and the growth of lambs were reduced. In dry years, wallaby grass began to recover, but lamb growth was restricted; while in years with adequate rain both wallaby grass and lambs grew well. The driest months were March and April and in five of the 13 years the total rain for those two months was <25% of their combined monthly averages. Dry autumns made it difficult to build up sufficient feed in the paddocks for lambing without spelling or supplementary feeding. In six of the 13 years, August was dry, which was good for lambing, but in 2006 and 2007 this, combined with a dry September and October resulted in a 3-month total that was also <25% of their combined monthly averages. For ewes and lambs, the worst years had dry springs – 2002 when a dry winter was followed by a dry spring and 2006 when a dry autumn was followed by a dry spring.

Pasture growth

While our measurements indicate fertility, temperature and day length affected pasture growth, rainfall had an over-riding effect. Table 1 compares the variation in pasture DM production (kg/ha/day) in the critical months August, September and October in two years with poor autumn and only average June–July rain. Warm conditions in August 2006 produced much better growth than August 2005 but by September, 2006 moisture was the main limitation, reducing 2006 growth in October by 100- fold.

Pasture growth data from the 'Control', 'Annual' SSP and two 'High Input' paddocks are shown

Table 1. Variation in monthly DM (kg/ha/day) from two years with dry autumns, but variable spring rain.

Year	August	September	October
2005	1–2	30–40	85–100
2006	3–4	5–6	0–1

in Figures 1 and 2. The curved dotted lines represent annual rainfall each year (Fig. 1) and average monthly rainfall (Fig. 2) over the ten years 1998–07. Figure 1 shows that during this time the 'Control' paddock produced only 79% of the pasture produced per year by the other fertility regimes. A large percentage of the production from the three regularly fertilised paddocks was produced by annuals including subterranean clover, which raised feed quality to achieve good weight gain from the prime lambs. The better quality and increased quantity of pasture produced, enabled the regularly fertilised paddocks to carry 46% more DSEs.

The bars in Figure 2 represent the average daily pasture growth rate in each month over 10 years. Unlike many introduced tableland pastures where up to 80% of pasture production occurs in the three spring months, this native pasture growth data was more evenly spread and showed only 54% in the three spring months (65% for the four months including December), with 21% in summer, 15% in autumn and 10% in winter. In addition, utilising the spring growth flush was more easily achieved on these native pastures with the natural increase in stocking rate following lambing, combined with the increasing spring feed requirement of growing lambs.

Pasture composition

There was only a 5–10% variation in the number of species recorded from different paddocks in 1995 and the 'Control' had the least. Similar variations occurred over the years, but by spring 2007 all four fertilised paddocks recorded 10% more species present than the 'Control'. Figure 3 shows the variations in five main groups (sown perennials, native perennials, legumes, miscellaneous species (Yorkshire Fog (*Holcus lanatus*), rushes (*Juncus spp.*), annual grasses, broad leaf weeds) and bare ground and/or litter). Variations in the three fertiliser strategies were broadly similar and mostly due to season and rainfall. In 1995, before the fertility had increased in any paddock, the main annual grass was silver grass, but thereafter soft brome became the dominant annual grass, except in the 'Control'. Barley grass (*Hordeum vulgare*), which was previously not present on this highly

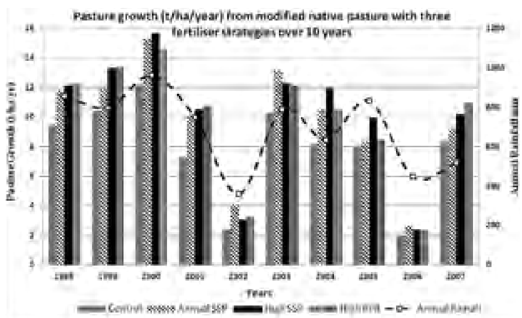

Figure 1. Total annual pasture production over 10 years from four of the five paddocks.

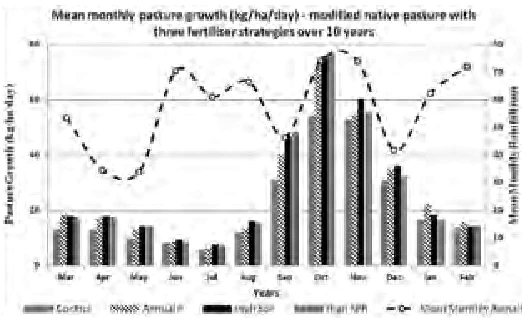

Figure 2. Average monthly pasture production from three fertility strategies over 10 years.

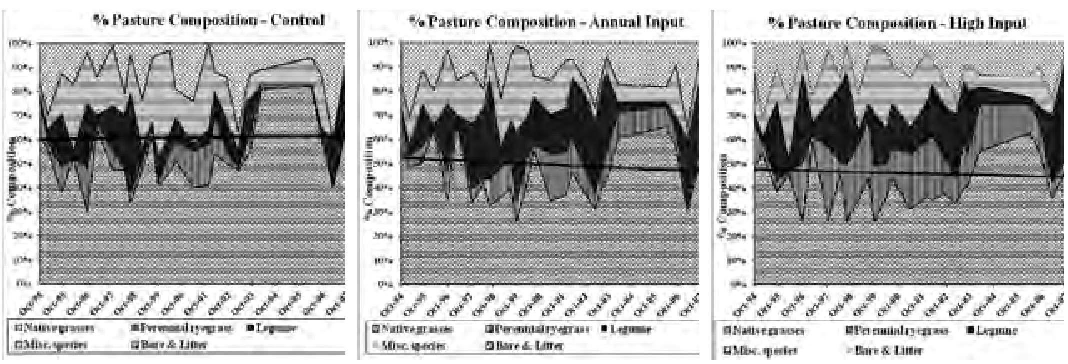

Figure 3. Fluctuations in pasture composition over 12 years in five categories for three fertiliser strategies.

acidic soil, became established on sheep camps where soil pH became sufficiently high to permit barley grass to survive. The line between the left and right margins at the top of the wallaby grass area shows the trend for wallaby grass over the years for each strategy. Fertility appeared to have an effect, especially on the legume and perennial ryegrass and over the years the increase in these two species was marked in the 'Annual' and 'High Input' paddocks. While wallaby grass appeared more stable in the 'Control', by 2007 there was little ryegrass and lower clover levels than in the regularly fertilised paddocks.

Changes were noticeable after good seasons. In spring 1994, native grasses comprised 60% of the 'Control' and about 50% of all other paddocks. However, by spring 2001, after several good years, levels had declined considerably. There was a 33% reduction in native grasses in the 'Control' and 'Annual' paddocks compared with spring 1994, while in the two 'High Input' paddocks reductions were 27%. By this time perennial ryegrass had risen by only 5% in the 'Control' paddock (to 17%), but by 25% (from 15 to 20%) in the four regularly fertilised paddocks. Legumes had increased three-fold in all paddocks; from 2 to 6% in the 'Control' and from 6 to 17% in all 'Annual' or 'High Input' paddocks. In the 'Control' paddock, there was also a seven-fold increase in miscellaneous species, particularly silver grass, with all increases being at the expense of bare ground and litter which reduced from 16% to zero. Bare ground and litter reduced markedly from 15 to 5% in the four regularly fertilised paddocks, while miscellaneous species (principally annual grasses) rose three-fold in the 'Annual' paddocks, but only by 25% in the 'High Input' paddocks. In dry years, these changes tended to be reversed. For example, between the dry springs 2002, 2006 and 2007, when average annual rainfall was only 82% of the long-term mean, wallaby grass levels in 2002 had not fully recovered to 1994 levels, but by spring 2006 levels in all paddocks were equal to or slightly better than the 1994 levels, while due to the dry conditions, legume levels were very low in all paddocks and perennial ryegrass was low and only 1% in the 'Control'.

Pasture persistence

Fluctuations in the basal presence of three native grasses (wallaby grass, weeping grass and wheat grass) and as perennial ryegrass which had persisted since it was sown in the mid 1960s are shown in Figure 4. The 'Control' paddock initially had the highest level of wallaby grass and with a favourable aspect, the highest initial counts of perennial ryegrass, while the two 'Annual' paddocks had the lowest counts for all recorded species. Perennial ryegrass counts peaked in 2001 in all paddocks. A similar interaction as occurred in the pasture composition data, in this case between perennial ryegrass, wallaby grass and rainfall, appears to have occurred, especially in the 'Annual' and 'High Input' paddocks. By 2001, after several years of higher rainfall, ryegrass had increased and wallaby grass presence began to decline. However, after a very dry 2002, these trends began to reverse and it is interesting to note that in the 'Control' paddock where soil nutrients were always deficient, perennial ryegrass never recovered. In the below average rainfall years 2004–06, ryegrass declined in all paddocks whereas wallaby grass recovered to the extent

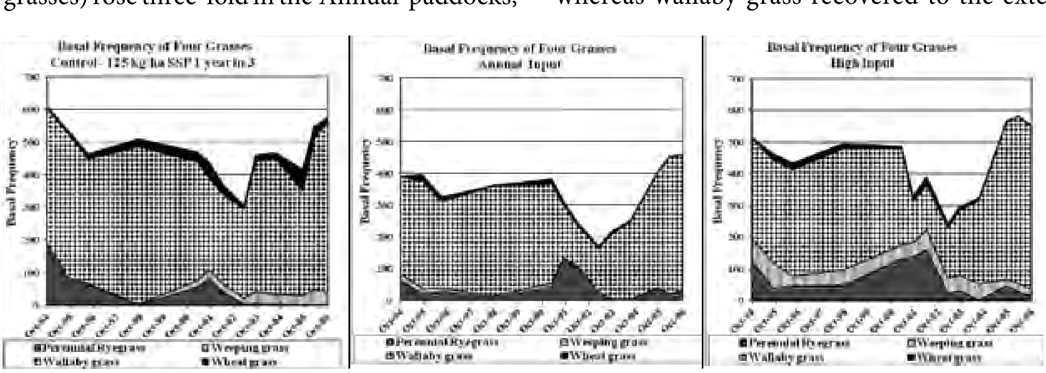

Figure 4. Changes in basal presence of four grasses over 13 years for three contrasting fertiliser strategies.

that by 2006 counts were close to or better than the initial ones taken in 1994. This suggested that wallaby grass was quite resilient with drought and grazing tolerance and it may even be positively influenced by increasing soil fertility.

Soil fertility

Initial soil test results in October 1994 revealed both P and S were critically low with an average of 14 mg/kg Colwell P and only 2 mg/kg KCl-40 S. Figure 5 shows fluctuations in Colwell P levels over the years. The bars at the bottom represent the rainfall in the 12 months prior to the date of soil sampling. There was considerable fluctuation in P levels over the years, but the two 'High Input' paddocks as anticipated, rose rapidly in the first three years. After two years, the SSP paddock (with the more soluble P) rose above the critical value necessary for 90% of maximum legume growth (Simpson *et al*. 2009) and required for high quality pasture production. Phosphorus levels in both paddocks continued to rise while fertiliser was applied. The two 'Annual' paddocks rose more slowly, but after eight years had reached the critical value. The 'Control' paddock rose and fell in response to the intermittent fertiliser application, but after 12 years the soil was still deficient in both P and S. Other noticeable features were low values in 2000, 2001 following three years of above average rain and high production, whereas following the drought years 2002 and 2006, substantially higher P values occurred. Also, the high RPR paddock, where P test values

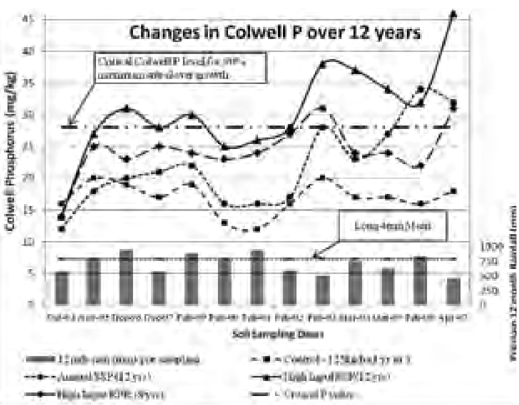

Figure 5. Changes in Colwell P values over 12 years under four fertiliser regimes.

rose more slowly than the high SSP paddock, maintained quite high readings during the last four years, despite being in a run-down phase. This is probably because P in RPR products was less soluble (and less prone to loss by leaching) becoming available over time as it was dissolved by the acidic soil.

Livestock data and economics

This data is reported in two sections – the first eight years when the two phosphate products were able to be compared and the entire 12-year period where the three fertility strategies were examined.

1. RPR versus SSP: this comparison was for eight years and during that time economic results were essentially equal for both products at either annual or high input application rates. While the cost of RPR at the time was cheaper than SSP (for equivalent amounts of P), a narrower spreading width, the need to also spread gypsum to supply S and the difficulty of applying molybdenum, nullified most cost benefits. The other possible advantage of RPR is that it is considered an organic fertiliser. The pasture and livestock production from the two RPR paddocks in 1997 deserves comment. It was quite dry that year, with only 544 mm of rain, yet production was similar to the companion paddocks receiving SSP in that year. This was somewhat unexpected considering the less soluble nature of RPR, but was possibly due to the considerable release of citrate soluble phosphate from the RPR applied in the two wet years immediately before. Table 2 summarises the financial returns from all five paddocks for the first eight years.

2. Comparison of three fertiliser strategies: better returns were consistently achieved from the 'Annual' and 'High Input' paddocks due to the fact that the pastures had a higher nutritive value, could support higher stocking rates and also had a higher proportion of lambs at saleable weight at weaning. Over the 12 years stocking rates averaged 4.7 ewes/ha in the district practice 'Control' paddock and 6.6 and 7.2 ewes/ha respectively, in the 'Annual' and 'High Input' paddocks. It was two years before the stocking rates were increased in the two 'Annual' paddocks (in hindsight this should have occurred after one-year) and a further two years before the maximum stocking rate of 6.75 ewes/ha could be achieved in these paddocks. The 'High Input' paddocks were stocked at 6 ewes/ha from the start of the study and this was increased to 7.5 ewes after two years, peaking at 8 ewes/ha after four years.

Stock numbers were set each year taking account of the seasonal conditions, based on the experience of the land owner and that of the authors with the aim of utilising the extra feed from the winter-growing annuals, ensuring the persistence of the native grasses and to get good prime lamb production. Table 3 compares the financial results over 12 years from the three paddocks that received SSP. The most important difference at this site was that all regularly fertilised paddocks were able to achieve higher lamb growth rates, so that more lambs reached the 38 kg/head liveweight target for immediate sale at weaning at a premium price. Results from 1995 to 2002, before fertiliser prices rose sharply, suggested that when soil P levels were very low, high (capital) applications could be financially worthwhile. However, since 2003, the 'Annual' strategy has produced a better return for dollars invested and so would be a better option. It should be noted that simply reducing costs (as occurred in the 'Control') did not increase profits, particularly as the cost being reduced was the one that addressed the most limiting factor – in this case deficiencies in P and S. After deducting overhead costs, the average net return from the 'Control' paddock over the 12 years was $37.54/ha, and was not economically sustainable in the long-term.

Discussion

The low soil pH combined with an average annual rainfall of nearly 800 mm, meant this site fitted the guidelines for successful use of RPR as a P fertiliser. At this site there has been a substantial shift in soil P and S values over the years in the four regularly fertilised paddocks, yet this did not appear to have had an adverse effect on the native grasses in the long-term. It is important to realise that native grasses cannot be treated as an entity; they are extremely variable. Winter versus summer growing; frost tolerant versus sensitive, tall habit versus more prostrate, fertility responsive

Table 2. Returns SSP versus RPR over eight years.

	'Control'	'Annual' RPR	'High Input' RPR	'Annual' SSP	'High Input' SPP
Gross return/$ha – lambs	126.81	190.23	241.78	188.29	237.81
Gross return/$ha – wool	59.29	76.34	92.70	73.96	94.34
Variable costs/$ha	61.95	6.87	93.91	77.96	95.91
Fertiliser costs/$ha	11.80	35.88	51.41	32.47	49.80
'Profit'/ha #	7.35	48.83	84.17	46.83	81.44

'Profit – is net return/ha less an overhead cost of $105/ha.

Table 3. Average returns from three fertiliser strategies over 12 years.

	'Control'	'Annual' SSP	'High Input' SSP
Gross return/$ha – lambs	147.69	243.69	286.68
Gross return/$ha – wool	57.50	70.61	87.35
Variable costs/$ha	51.27	65.38	79.90
Fertiliser costs/$ha	11.38	37.19	56.18
Total variable costs $ha/annum	62.65	102.56	136.08
Net return $ha/annum	142.54	211.74	237.96
Return on extra $s spent versus 'Control' (%) #		173	130
Net return less overheads ($105/ha)	37.54	106.74	132.96

Spent $39.91 ('Annual') and $69.20 ('High Input') to make $73.44 and $95.42, respectively more than those costs.

versus unresponsive, grazing tolerant versus grazing intolerant, long-lived versus short-lived perennials, seed that germinates on the soil surface versus seed that only germinates in the dark below the soil surface etc (Chivers and Raulings 2009). Many native grass pastures will respond positively to applied fertiliser, provided they contain a responsive legume although kangaroo grass (*Themeda australis*) grasslands are disadvantaged by the application of fertiliser (Waters *et al*, 2000). It is vital to know what species are present in your pastures and their requirements so that appropriate management is used.

Garden *et al.* (2003), using Merino wethers, found that annual grasses increased and wallaby grass decreased when higher rates of fertiliser were used. Our work also demonstrated that when fertiliser is applied to 'modified native pastures' the production of annuals (both grasses and legumes) increases dramatically. Low growing species such as wallaby grass were adversely affected by this competition from annual species in spring, as it is sensitive to shading. In our experience, this also applies to redgrass (*Bothriochloa macra*) which is dormant in winter and does not begin to grow until mid spring. The seed of these two grasses is very small and germinates from the soil surface only when moisture, temperature and light are adequate and seedling recruitment will not occur under a mass of live (or senesced) annuals. The problem of insufficient grazing pressure especially in early spring, which if left unchecked allows annuals to shade and smother the shade sensitive species was overcome by using an enterprise which had a large increase in pasture consumption from late winter onwards. In the experience of the authors, resting (or even lenient grazing) of fertilised, native pastures containing wallaby grass (or red grass) in early to mid spring should be avoided as these species will decline if subjected to shading and competition by insufficient grazing at this time.

An increased stocking rate is also essential to cover the cost of investment in fertiliser. In this study, stocking rates were increased in the 'Annual' and 'High Input' paddocks. The use of a late winter lambing, second cross prime lamb enterprise producing a relatively high value product, combined with the higher stocking rates, achieved high monetary returns. The enterprise also provided a good match with the pasture growth curve to achieve the necessary control of annuals in spring, as ewes and lambs required more and increasing feed from late winter onwards. The enterprise was well suited to the site, but this production strategy is likely be inappropriate in very large paddocks or where shallow, rocky soils, steep topography, westerly aspect or low rainfall, limit pasture responses and the use of appropriate grazing management over the whole area. In such situations, preserving the native perennial grasses to prevent land degradation, must be the primary aim.

Conclusions

It is important to know the native species present in your pastures and their requirements and to be aware that factors such as soil depth, aspect and topography can modify these requirements. Good management involves matching these pasture requirements with the requirements of both your livestock and your soils to produce sustainable and profitable outcomes. Fertiliser was used at this site to correct P and S deficiencies and thus enabled more stock to be run and more lambs finished. The work indicated the native species present were not adversely affected, nor was the biodiversity reduced in the paddocks where higher rates of fertiliser were used. Therefore this long-term study does not support claims that fertiliser will cause the native grasses to die out and that native pastures if fertilised, should only receive low rates, intermittently. We have demonstrated over 13 years that 'modified native pastures' with wallaby grass, weeping grass and wheat grass can persist and be highly productive, even with high fertiliser rates, provided they are grazed correctly. These species have shown good tolerance of both grazing and drought, but for the wallaby grass it was critical that grazing pressure was adjusted, commencing in late winter, to utilise the extra feed grown, mostly from annual grasses and legumes, in response to the fertiliser. Increasing the grazing pressure in mid spring is often too late, with rapid growth compounded by the fact the grasses are maturing, less palatable and avoided by most livestock. While both the 'Annual' and 'High Input' strategies were more expensive to implement, more stock were run, net returns far higher and the return on the extra capital invested was quite good. This study supports the regular use of fertiliser, even at the current high prices, to increase productivity of 'modified native pastures'. The normal district practice of applying 125 kg/ha SSP one-year in every three, while it did not adversely affect the native pasture, was unable to produce a sustainable income.

Acknowledgments

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