Economic analysis of improved perennial pasture systems

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Abstract. New perennial pasture grazing systems have been developed for livestock production in the high rainfall zone of southern Australia. These systems provide producers in south west Victoria with the opportunity to increase stocking rate per hectare compared to current practice. A partial discounted cash flow budget with a whole farm perspective was used to analyse the economic performance, and risk implications, of a 100 hectare investment in the new perennial pasture systems over time for a representative farm at a range of stocking rates. The effect of seasonal variability was investigated and the impact of establishment failure was examined. Based on the assumptions about pasture performance used in the analysis, the new perennial pasture systems were more profitable than current practice at all stocking rates tested with successful establishment. If establishment was successful, an increase in stocking rate was not required to achieve a positive return on investment as a result of reduced supplementary feeding requirements. Risk and return increased concurrently with increasing stocking rate. Increasing stocking rate up to 30 DSE/ha reduced the time taken for the pasture investment to return to positive net cash flow.

Keywords: representative farm analysis, pasture improvement, EverGraze

Introduction

The national initiative EverGraze® was established to develop and test new livestock grazing systems based on perennials across the high rainfall zone of southern Australia (Friend et al. 2007). One of six proof sites for the national EverGraze project was established at the Department of Primary Industries in Hamilton, Victoria. The pasture systems tested at the site were grazed rotationally and were designed to match different perennial pastures to soils and landscape. Investment in pasture improvement was analysed for 10% (100ha) of a 1000ha representative farm. The main benefit of the EverGraze systems identified in the experimental results increased stocking rates per hectare compared to current common practice. Stocking rate increases derived from changes in feed supply, which also made possible tactical feed-use opportunities for livestock production.

Investment in pasture improvement, and subsequently increasing stocking rates, has long been known to increase both the returns and risks to the farm business (Gruen 1959; Pearse 1963; Chisholm 1965; Cacho et al. 1999; Behrendt et al. 2006). Further, intensification of grazing systems increases demands on farmer skills as well as the capacity of the farmer and the business to cope with the increased volatility that accompanies the higher mean income (Malcolm et al. 2005). These later aspects of intensification, when combined with concerns regarding the associated investment costs and returns, and the risk of pasture establishment failure, are often viewed as barriers to adoption of higher stocking rate systems (Scott et al. 2000; Trapnell et al. 2006). The aim in this paper is to report findings about profit and risk from intensification of grazing systems in south west Victoria through investment in novel perennial pasture systems.

Analysing investment in improving pastures

Research questions

- What is the potential profitability associated with investing in the EverGraze pasture systems if the production benefits in the trials were achieved in a commercial farming system?
- What is the relationship between risk and return as a result of intensifying the grazing system through perennial pasture improvement?
- What is the effect of failure of pasture establishment on the potential profitability and risk?

Pasture investment options

In this analysis the EverGraze 'Best Practice Perennial Ryegrass' and 'Triple' improved pasture systems were investigated for a representative farm. These two systems were analysed as alternatives compared to continuing current practice of pasture management of the 'Base Case' pasture system over time.

Experimental data for 2007, 2008 and 2009 enabled the economic and financial merit and the risk profile of the improved perennial pasture systems under seasonal variability to be tested. Full descriptions of the rainfall pattern for each year can be found in Table 1.

Representative farm over time

The representative farm approach to answering farming questions is well documented. Representative farms can be powerful, highly useful tools for analytical purposes, as long as the development of a representative farm is tied closely with the purpose of the specific research question, and typifies the farms and farmers under consideration (Elliott 1928; Becker 1963; Carter 1963; Malcolm 2004). Becker (1963) argues that whilst the exact outcomes from a representative farm will never be duplicated on individual farms, the relative effects of alternatives are demonstrated realistically and reliably. Carter (1963) pointed out that a potential short-coming of representative farm analysis is that they were usually static in nature, encompassing a single time period. Single year analyses of farm systems can represent 'before' and 'after' situations. However, the interesting part with major implications for management – the process of implementing changes to farm systems – is assumed away. Risk, too, is often overlooked. The limitations on the usefulness of farm analyses of ignoring development processes and the effects of time and risk can be profound. These limitations are avoided in this research by modelling the performance of a representative farm system over time, and through incorporating sequential change such as initial and subsequent capital investment, increases in carrying capacity, and allowing for intermittent good and poor seasons. This approach enables an element of real world dynamism to be introduced. The process of adopting the changed farm system is represented, and the operation of the farm can be changed in response to different circumstances over the whole of the relevant planning period. The information that results from this type of analysis enables decision makers and researchers to form well-informed, sound judgements about the technological change and the results of it for similar farm resources, systems and situations.

The representative farm of this analysis is a typical farm size for the south west region of Victoria, and has an effective grazing area of 1000 ha (Tocker et al. 2009; Tocker and Berrisford 2010; Tocker et al. 2010). All major characteristics of the representative farm were validated by the Hamilton EverGraze Regional Advisory Group consisting of local farmers and industry representatives as a 'real world' test of the assumptions used in the model. The farm was located in the high rainfall zone with average annual rainfall exceeding 650mm. Soils across the farm were assumed to have medium level fertility. The topography of the representative farm was assumed equivalent to that of the EverGraze experimental site at the Department of Primary Industries, Hamilton, with equal proportions of hill crest, slope and valley floors. Investments in pasture improvement was analysed for 100ha (10%) of the 1000ha representative farm.

A schematic of the model is shown in Figure 1. Information inputs (grey fill) are used to calculate enterprise feed gaps, gross margins and the partial budget discounted cash flow (dashed lines). Economic, financial and risk measures of each pasture investment option (solid line) are calculated.

Animal enterprise and management information The livestock enterprises of the representative farm are summarised in Table 2 and Table 3. The type and composition of each enterprise was designed to reflect current common practice in the 650mm-plus rainfall zone of the south west region of Victoria (Berrisford and Tocker 2009; Tocker 2010; Tocker and Berrisford 2010) Further details of each livestock enterprise are available in Lewis (2011).

Set stocking is still a common practice in the region, with recent data suggesting less than 40% of producers in south western Victoria implement any form of consistent grazing practices (Karunaratne and Barr 2001; Sargeant and Saul 2009).

The representative farm was set stocked at 16.2 dry sheep equivalents (DSE) per hectare consistent with benchmarked average stocking rate for the region ((Berrisford and Tocker 2009; Tocker and Berrisford 2010; Tocker et al. 2009). The DSE measure standardises livestock classes according to their energy requirements, based on the maintenance requirements for metabolisable energy of a mature 50kg Merino wether (Russell 2009).

Livestock feed demand was estimated in megajoules of metabolisable energy per head per day (MJ ME/head/day) and energy needs were calculated using the 'ME Required' program for the midpoint of each month (CSIRO Plant Industry 2006). Changes in animal condition across the year were captured. Maintenance and growth requirements were calculated for all livestock classes, including allowance for the growth required for young stock to meet saleable weight by the date specified. Full details of the 'ME Required' inputs for this analysis are available in Lewis (2011). Total pasture demand in terms of kg DM/ha month was calculated from the MJ ME/head/day results.

A feed gap was defined as when total pasture demand exceeded total pasture supply (Moore et al. 2009). When the ME required in terms of total pasture supply demanded exceed the ME available from the pasture, supplementary feed was supplied to meet the remaining animal energy requirements. There was no option to destock during the analysis period to counter the effects of a feed gap/shortage. Implicit in this is the notion that destocking and subsequent restocking would incur a capital loss similar to and approximated by the cost of retaining animals and buying extra supplementary feed during the poor seasons.

In the analysis, livestock were agisted off the 100 ha during the initial year of pasture improvement to allow for spraying and pasture establishment. In practice it is likely producers would graze stock intermittently during this period to improve pasture persistence (Sargeant 2009).The timing and length of these grazing periods will depend on seasonal conditions and preferences of management, so grazing benefits from this tactic were not accounted for in this analysis.

For the first year post-successful pasture establishment, the improved pastures systems were initially stocked at half way between the original stocking level on the Base Case pasture system (16.2 DSE/ha), and the new increased stocking level. This followed the approach taken by Scott et al. (2000). After this initial 12 month period, stocking rate was increased to the full production, steady state level and maintained for the remainder of the 12 year investment period for the 100ha.

Pasture growth, nutritive value and management information The description and source of the growth and quality information for each pasture system is outlined in Table 4. Further information on botanical composition of the sward and seasonal DM production over the experimental period is in Clark et al. (2012) and Ward et al. (2012).

Pasture growth is described as kilograms of dry matter per hectare per month (kg DM /ha month). The nutritive value of pasture is described as metabolizable energy (ME) concentration, and is expressed as megajoules per kg of DM (MJ/kg DM). Metabolizable energy is the amount of energy available in a feed for an animal to use for maintenance, growth or reproduction. The 'Base Case' pasture system (Table 4) that was analysed was not a component of the EverGraze experiment. Biophysical modelling using GrassGro (Makki et al. 2001; Moore et al. 1997) was used to construct the expected growth of pasture and metabolisable energy figures for the 'Base Case' system over the three years for which EverGraze experimental data was available.

Total pasture availability in dry matter (DM) kg/ha month was calculated for the three pasture systems by combining the new growth in each month plus two thirds of excess pasture carryover from the previous month, as detailed in Moore and Zurcher (2005). A minimum pasture mass of one tonne dry matter per hectare was assumed to be present on all pasture before stock were introduced. This was unavailable to livestock, and was maintained in the analysis for the lifetime of the pasture systems.

For the 'Base Case' pasture system, all associated pasture maintenance practices as carried out in the Hamilton district were included in the analysis. This included annual fertiliser application of 14kg P/hectare, and periodic over-sowing via direct drilling of 10% of the farm per annum to maintain stocking rates (Reeve et al. 2000; EverGraze Regional Advisory Group 2009). It was assumed that stock continued to graze the system during all pasture maintenance activities on the 'Base Case' system.

Best practice for the district was applied to maintain the soil fertility of the improved EverGraze perennial pasture systems (Cayley and Quigley 2005). The improved perennial pasture systems had 0.9 kg P/DSE applied annually, with the total application per hectare depending on the stocking rate being tested.

The status of the improved pastures was maintained over the 12-year investment period with a renovation investment in year six. The different perennial species in the EverGraze systems were expected to persist to different degrees. For example, perennial ryegrass is sensitive to seasonal conditions and soil fertility and its persistence over the medium term can be problematic, whereas well managed summer-active Tall Fescue is expected to persist well (Clark et al. 2012). The perennial ryegrass portions of the improved perennial pastures systems were assumed to be oversown by direct drilling seed. Livestock were removed from the lucerne for 26 weeks to assist with successful renovation. The Tall Fescue was assumed to persist for the 12 year period, without renovation.

The 'Triple' system required winter cleaning of the Lucerne portion every three years. Winter cleaning involves spraying the lucerne stand with low rates of selective herbicide to remove annual grasses and reduce the soil weed seed bank (Naji 2006).

Enterprise costs and prices information The variable costs and prices of each enterprise were combined with information about animal enterprise management, pasture growth, nutritive value and management information, to calculate enterprise gross margins for each combination of season and stocking rate tested. A composite animal activity gross margin for each pasture system was calculated according to the proportion of each activity in the farm system. These composite animal activity gross margins were used in the partial budget discounted cash flow analysis.

Farm variable costs from the 2009/2010 south west Victoria Livestock Farm Monitor results were assumed to apply for each enterprise (Table 5) (Tocker and Berrisford 2010) with the exception of the annual pasture maintenance and supplementary feed costs which were calculated in the model.

Supplementary feed costs were calculated independently for each livestock enterprise on each pasture system because of differences in matching pasture supply and demand, and were varied with stocking rate and seasonal conditions. A separate ration was calculated for growing and mature stock for each livestock enterprise. See Table 6 for the price assumptions about each ration component.

Total annual pasture maintenance costs for the 'Base Case' pasture system was $4.50 per DSE/year ($73/ha) with single super phosphate. Annual fertiliser application on the improved perennial systems equated to approximately $6.45 per DSE/year using super potash 3:1. Winter cleaning of the lucerne every third year cost $70/hectare for the 'Triple' system.

Prices used for the analysis (Table 7) were assumed to be the most likely values expected for the medium term, after consultation from the EverGraze Regional Advisory Group (EverGraze Regional Advisory Group 2009).

Establishment costs Capital costs to establish rotational grazing included fencing, gates and water troughs amounting to approximately $12,000 for the 100 hectare development for each of the improved perennial systems.

Pasture establishment cost was approximately $350 and $380 per hectare for the 'Best Practice Perennial Ryegrass' and the 'Triple' respectively. These cost estimates included seed, herbicide, insecticide, fuel and fertiliser.

It was assumed existing farm labour and machinery was used to establish the pasture systems. The cost of agistment during the pasture establishment phase was included in the analysis.

When establishment failed, pasture was resown in year two. Lime was not reapplied, and the system was grazed for half of year two at the original stocking rate of 16.2 DSE/ha to align with common practice (G Saul pers comm.). It was assumed that stock were agisted for 26 weeks during the re-establishment. Extra livestock required to raise stocking rates on the improved EverGraze systems were purchased and included as part of the total extra capital invested.

Investment analysis

The investment comparison was between the performances over time of the common practice 'Base Case'. The measures of performances were annual and cumulative profit, cashflows and risk profiles of the farm system with investment in the alternative improved perennial pasture options as outlined in Lewis (2011).

In 1959 Gruen noted that shortages of finance or labour, combined with the need to remove stock from the grazing system during establishment to protect newly sown pastures, limited the area for pasture improvement that can be considered in any year. These factors remain true. Producers incrementally improve farm pastures. It was assumed in this analysis that 10% of the area of the representative farm, or 100 hectares, was being considered as a first step in pasture improvement for the representative farm. The 100 hectares consisted of equal areas of crests, slopes and flats.

The pasture investment involves adding capital to existing land, stock and other farm capital. A partial development budget was constructed, with a whole farm perspective (Malcolm et al. 2005). This approach includes all the extra benefits of the improved perennial systems, minus all the extra costs. The expected return on extra capital invested over the life of the project was estimated using discounted cash flow analysis (DCF). Nominal cumulative net cash flows are calculated to assess financial implications of the investment. The difference in expected persistence of the pasture species utilised in the EverGraze systems was incorporated in the analysis by running the analysis over 12 years.

Nominal internal rate of return (IRR) and net present value (NPV) at 8% nominal discount rate after tax were estimated for the improved perennial pasture investments over the 12-year period[1]. With much of the risk of the investment included in the budgeted numbers, and not the discount rate, this 8% nominal required rate of return per annum is similar to medium-term nominal borrowing rates or earnings in the share market. It is higher than less risky, medium term urban real estate or returns from risk free Commonwealth bonds (Malcolm et al. 2005). The criteria is that if the IRR exceeds the opportunity cost, and if the NPV is positive at the required rate of return, then the investment is more rewarding in economic terms than other alternatives that are available in the economy, and would likely be considered.

As well, cumulative nominal net cash flows (CNNCF) were calculated to identify the financial feasibility of the investment. The CNNCF was calculated after tax of 15% of the approximate annual taxable income with 3% per annum inflation and 8% per annum interest rate. The CNNCF shows the size and timing of peak debt, and time taken to return to positive net cash flow. In practice this information is interpreted in the context of the existing debt to equity state of the farm balance sheet, the debt servicing ability of the investment as 'stand-alone', the sources of additional debt servicing ability from other cash flow and the amount of equity that may be required to be invested.

In practice, information such as the measured potential economic and financial performance results is weighed up by decision-makers in the context of the operation of the whole farm system. This includes the range of goals and practical considerations and constraints that are not accounted for explicitly in the quantitative analysis.

Risk analysis

A key concern of producers when considering pasture improvement, particularly when less familiar grazing species are involved, is the possibility of establishment failure and the flow-on financial implications. The economic performance and financial feasibility of each improvement option was calculated for a range of seasonal conditions and for when pasture establishment was successful in year one, and for when establishment failed. The likelihood of pasture failing and the implications for the economic and financial returns from the investment is information for the decision-maker to evaluate.

Mean-standard deviation efficiency analysis, as detailed by Hardaker et al. (2004), was used in this analysis to assess the risk and net income associated with season type when investing in the improved perennial systems compared to the current 'Base Case' pasture system. Using results from a run of three actual and diverse seasonal scenarios, and projecting these into the future is one way of incorporating an estimate of the potential risk from seasonal variability. This reveals the effect of variability on the extra annual net cash flows for the improved perennial pastures investment. The expected value, in this case mean total annual gross margins from each pasture system, is plotted against the standard deviation of the annual total gross margins for each alternative. The information provides decision makers with a risk profile of each production system as a 100 hectare investment (Lewis 2011).

Scenarios investigated

The assumption in the analysis was that the performance of the pastures in the trials under the diverse seasonal conditions that occurred in 2007, 2008 and 2009 were reasonable representations of the likely range of all seasons that could occur in the future planning period. When the 1963 to 2011 Hamilton DPI rainfall data was considered,

[1] The IRR indicates the return on capital invested over the life of each pasture investment, also termed the economic efficiency of the investment. The NPV represents the addition to investor's wealth above what they would gain if they invested the capital involved in an alternative that earned at the rate of 8% nominal per annum.

total annual rainfall for the 2007, 2008 and 2009 seasons represent the 35th, 45th and 78th percentiles respectively as shown in Table 1. The rainfall total from April to December represented the 41st, 63rd and 69th percentiles. Note that no extreme rainfall scenarios, such as the 2006 year with an annual rainfall total representing the 6th percentile, were included in the analysis.

Firstly the 2007, 2008, 2009 season series was considered for the profitability analysis. For the mean-standard deviation analysis all scenarios outline in Table 8 were used.

The livestock enterprises and enterprise mix on the representative farm was the same for the three pasture systems (Table 2 and Table 3). Increases in stocking rate were on the improved perennial pastures. In practice it is likely that producers would run their most productive livestock on the improved area to maximise the potential of the new pastures, with this likely to be a short term tactical management decision influenced by market and seasonal conditions. Whilst the benefits of tactical management decisions are important, they were not the focus of this research.

A change in the nature of the feed supply can also lead to changes in individual animal performance (Marottie et al. 2002). The impact of this will depend partially on genetic merit, on animal response, and the environmental conditions experienced on the farm. It is difficult to determine the extent to which the livestock run on the EverGraze experiment may have been superior to the other livestock in the region. Given this it was assumed that production quantity and quality per head remained constant across all pasture options and stocking levels.

The stocking rate likely to be sustainable with the EverGraze systems at Hamilton across a range of seasonal conditions was estimated to be approximately 30 DSE/ha. It is well documented that the production levels reported in research experiments are unlikely to be achieved in a commercial environment (Davidson and Martin 1965), rarely exceeding 60-70% of experimental results. Through their own experience, producers involved in the EverGraze Regional Advisory Group indicated that the stocking rates managed by the experiment were achievable in the local commercial grazing environment with improved perennial pasture systems.

For this analysis, it was assumed that the management ability of these producers is well above the 'typical' operator for the region. Six stocking rates on the improved perennial pasture systems were tested as shown in Table 9 to account for variation in management ability and other factors that cause commercial farm results to differ from results seen under research conditions. These stocking rates were assumed to be run only on the 100ha of improved perennial pastures, not over the farm as a whole.

Results

A positive return on investment was seen for improved pasture systems at all stocking rates for the 100 hectare investment considered in this analysis when establishment was successful (Figure 2). A stocking rate greater than 16.2 DSE/ha was required to earn greater than the nominal opportunity cost of capital of 8% used in this analysis, if establishment failed in year one.

The improved EverGraze 'Best Practice Perennial Ryegrass' and 'Triple' systems returned a positive NPV at the 16.2 DSE/ha stocking rate of the 'Base Case' with successful establishment. The impact of establishment failure was greater at lower stocking rates, reducing potential NPV by up to 75% at 21 DSE/ha compared to 41% to 43% at the higher stocking rates of 30 and 36 DSE/ha, respectively.

Investment in the improved perennial pasture systems earned approximately 10 to 27% nominal return on extra capital invested over the 12-year period with successful establishment for the 100 hectares. This is above the opportunity cost of capital of 8% nominal return. The IRR results indicate a 'tipping point' for stocking rate in both systems between 30 and 36 DSE/ha with successful establishment. Increasing stocking rate beyond this point is likely to have a negative impact on the potential return from investment in the perennial pasture systems. Under the establishment failure scenario, the lowest stocking rate of 16.2 DSE/ha failed to return the opportunity cost of capital of 8%. The difference in the rate of return was negligible between the 30 and 36 DSE/ha stocking rates.

The improvement of pasture was able to service the debt incurred, if all capital invested was borrowed, as a 'stand-alone' investment if initial pasture establishment was successful. On average, enough extra annual cash flow was generated to meet the annual repayments of a 12-year loan at 8% interest if all funds required for the 100 ha pasture improvement were borrowed and pasture establishment succeeded. If establishment failed in year one, a stocking rate greater than 16.2 DSE/ha was required to fully service the debt required to fund the total pasture improvement including re-establishment costs in year two.

The net present value of the investment in new pastures increased with stocking rate in all scenarios (Table 10). The difference in NPV between the extremely high 30 and 36 DSE/ha stocking rates was negligible with added benefit of $13 to $37/ha with successful establishment. This was because the extra benefits of increased stock per hectare in the 36 DSE/ha system was negated by the rapid increase in supplementary feeding requirements per DSE at the higher stocking (Figure 3). The higher supplementary feed costs reduced the net benefits of the additional livestock capital invested. This is compared with the difference in NPV between the 16.2 and 21 DSE/ha of approximately $510 to $625/ha with successful establishment where no supplementary feeding was required at either stocking rate on the perennial systems.

The mean-standard deviation analysis was expanded to include six potential stocking rates. The average results of the two EverGraze systems were used for this analysis. Risk and return increased as the grazing system intensified. The single '2007, 2008, 2009' seasonal series results illustrated in Figure 4 shows that as stocking rate increased and the system intensified, the mean annual NCF increased. Concurrently, the standard deviation of steady state annual NCF increased.

A similar trend was seen when the mean-standard deviation analysis was conducted for the multiple seasonal scenarios, described in Table 8, at the six stocking rates as shown in Table 11. The spread of the mean-standard deviation results at the lowest stocking rate of 16.2 DSE/ha for the EverGraze system showed that investing in the improved pasture system has the potential to increase annual NCF whilst reducing the variability of this NCF when compared to the 'Base Case' scenario. This is without the need for extra livestock capital purchases.

As stocking rate was increased on the EverGraze system, the mean annual net cash flow increased concurrently with the volatility of annual net cash flow. For example, approximately 68% of annual net cash flows fell within $4,124 (one standard deviation) of the mean of $48,242 at a stocking rate of 21 DSE/ha, compared to the 30 DSE/ha stocking rate where approximately 68% of annual net cash flows fell within $9,837 of the mean of $57,458.

Discussion

Investment in either of the EverGraze 'Best Practice Perennial Ryegrass' or 'Triple' perennial pasture systems was profitable at all stocking rates tested with successful establishment for the 100 hectares analysed. The economic indicators of NPV and IRR showed that either system has the potential to return greater than the opportunity cost of capital of 8%, assuming that the production levels tested were achieved in a commercial environment. Returns increased with stocking rate because of greater extra net benefits per hectare, up to 30 DSE/ha for the case study analysed. These results are supported by previous pasture investment research which state that increasing stocking rates on improved pastures increases the profitability of the grazing system (Scott et al. 2000; Trapnell et al. 2006). Increasing stocking rate simultaneously with perennial pasture improvement was a profitable exercise for the two EverGraze systems analysed as 100 ha investments assuming successful establishment.

At the highest stocking rate, the decline in IRR results, and stabilisation of NPV, indicated a 'tipping point' in profitability between 30 DSE and 36 DSE/ha, based on the assumptions used for this representative farm analysis when establishment was successful. At this level of stocking, the additional supplementary feed costs negated the increase in extra income per hectare from the additional livestock capital invested. The result, shown in Figure 3, that supplementary feed costs increased at an accelerating rate for successively higher stocking rates is supported by Chisholm (1965) and Warn et al. (2006), both of whom identified similar trends. These results highlight the importance of maximising profitability, and managing risk, rather than maximising production per hectare when considering appropriate stocking rates for newly sown pastures.

Establishment failure had the greatest impact on potential profitability at lower stocking rates. For the scenarios analysed, if stocking rate was not increased beyond the 16.2 DSE/ha stocking rate (same as the 'Base Case') and establishment failure occurred in year one, both EverGraze systems failed to return a positive cash flow within the 12-year period analysed, assuming 'most likely' prices. These results are of particular importance given the use of perennial species in the EverGraze systems, as it has been previously noted that difficulties establishing lucerne was one of the main two barriers to adopting the species in the Glenelg region of western Victoria (Amirtharajah and Kearney 1996). The risk of failure to establish will be affected by the skills and resources of the each manager.

Income (average annual net cash flow) and income risk (standard deviation of net cash flow) increased at a diminishing rate as stocking rate increased on the 100 ha when tested under multiple seasonal scenarios (Table 11). These results agree with previous studies which demonstrate the economic phenomenon of increasing risk and return associated with increasing stocking rates (Chisholm 1965; Hardaker et al. 2004; Behrendt et al. 2006). For a risk-averse producer attempting to maximise utility, rather than profit, an increase in variability of climate will decrease the optimal stocking rate (McArthur and Dillon 1971). When choosing stocking rate, the extent to which higher average annual income is sacrificed to reduce variation in average annual income will ultimately depend on the risk profile of the individual producer (Chisholm 1965). Whilst the higher stocking rates were the most profitable over time and generated the greatest average annual NCF for this analysis, the parallel increase in the riskiness of income highlighted the inherent variability associated with intensifying livestock systems under seasonal variability.

Intensification of the grazing system by increasing stocking rate was not necessary for the perennial pastures to be profitable if establishment was successful under the conditions analysed, and maintaining the 'Base Case' stocking rate post pasture improvement reduced income risk. The change in the feed supply curve as a result of perennial pasture investment reduced the supplementary feeding requirements compared to the 'Base Case' pasture system. This resulted in the 'EverGraze' investments returning greater than the opportunity cost of capital, with the additional annual net cash flow generated able to service the debt of pasture establishment as a stand alone investment over the 100 ha. These results are supported by Moore et al. (2009) who state that management practices that can reduce the impact of feed gaps can greatly improve the profitability of a livestock enterprise by reducing supplementary feeding. Contrary to the previous findings of Trapnell et al. (2006) and current industry recommendations, these results indicated that investment in perennial pastures can be profitable without the need for increased stocking rates when a range of seasons are considered. However, it took 8 to 10 years for NCF to return to positive when the system remained stocked at 16.2 DSE/ha post establishment compared to 6 years when stocking rate was increased to 21 DSE/ha. No additional livestock capital expenditure post establishment was required for the 100 ha perennial pasture investment to be profitable if establishment was successful in year one. However, the time taken to return to positive NCF may limit the attractiveness of low stocking rates based on the representative farm scenarios analysed.

The assumption around renovation of the pasture systems in year six of the analysis was included to account for the phenomenon that sown pastures may not remain in their most productive state over the medium to long-term. The EverGraze reference group believed this assumption was conservative. In their experience, the group believed that the EverGraze systems could persist and maintain stocking levels for at least the 12-year analysis period without the need for renovation with appropriate management. This would increase the profitability of the systems and improve the time taken to return to positive NCF.

Conclusion

This analysis provided information regarding the benefits of changing the pasture base of a grazing systems in south west Victoria. The results suggest that the EverGraze pastures can be more profitable and less risky than the Base Case pasture at the pre-existing stocking rate of 16.2 DSE/ha because the need for supplementary feeding was reduced generally. It is anticipated that once the EverGraze pastures are established, the perennial pasture systems are likely to open up opportunities to further improve economic and financial performance compared to current common practice. More highly productive livestock enterprises can be adopted. For example, tactical management options such as fattening prime lambs prior to sale on summer active perennials such as lucerne.

Interpreting the results of this analysis requires caution. The complexity of higher stocking rate systems and the flexibility to respond to change within such systems are critical determinants of farm management success over the medium term. The potential risk and return reported here by adding new pasture systems and increasing stocking rate on 10% of the whole farm land area and pasture supply will be different from the situation where a larger proportion of the whole farm system is transformed. So too will the implications for complexity and flexibility be different as intensification proceeds. Whether the financial buffer provided by the higher stocking rates outweighs the difficulties of managing more animals is a question that must be weighed up by the individual producer. Complexity of systems does not usually increase in a linear manner; neither do changes in flexibility in systems. For example, an increase in stocking rate on a small proportion of the farm sums to a marginal increase in stocking rate of the total farm. This has different implications for the whole farm system when compared to the same increase in stocking rate per hectare across most of the farm area, as the total increase in stock on the whole farm carried is much greater.

Transforming farm systems in major ways, such as large increases in total stock carried, involves some costs and benefits that can be measured and some which cannot. Costs associated with whole system complexity and inflexibility are not easily included in budget analyses (e.g., learning and the higher management skills required can be accommodated by a higher owner-operator allowance) but this is only part of the complexity story. The likelihood of major drought effects increase in proportion to total stock carried. Type of stock carried also matters. Major changes have greater implications for the balance sheet, especially gearing and exposure to debt servicing obligations, than minor changes. For each change and scale of change, the expected future balance sheet situation and associated cash flows and returns to extra capital invested, have to be calculated carefully.

The conclusion reached above, that these new perennial pasture systems can be an attractive investment, applies to the situation analysed - as a marginal change to a whole farm system. Further work will investigate the economic, financial and risk implications for a whole farm system when a more substantial proportion of the farm is transformed to utilize the EverGraze perennial pasture systems analysed in this research.

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References

Amirtharajah M and Kearney G 1996, *Glenelg salinity implementation survey: a survey of landholder attitudes, practices and intentions for salinity control in the Glenelg region*, Department of Natural Resources and Environment, Hamilton, Victoria.

Becker MH 1963, 'Discussion: Representative farms - guides for decision making?', *Journal of Farm Economics*, 45(5): 1455-1457.

Behrendt K, Cacho O, Scott JM and Jones R 2006, 'Methodology for assessing optimal rates of pasture improvement in the high rainfall temperate pasture zone', *Australian Journal of Experimental Agriculture*, 46(6-7): 845-849.

Berrisford T and Tocker J 2009, *Sheep farm monitor project 2008/2009*, Department of Primary Industries, Ballarat, Victoria.

Cacho OJ, Bywater AC and Dillon JL 1999, 'Assessment of production risk in grazing models', *Agricultural Systems*, 60(2): 87-98.

Carter HO 1963, 'Representative farms - guides for decision making?', *Journal of Farm Economics*, 45(5): 1448-1455.

Cayley J and Quigley PE 2005, *Phosphorus for sheep and beef pastures*, Department of Primary Industries, Hamilton, Victoria.

Chisholm AH 1965, 'Towards the determination of optimum stocking rates in the high rainfall zone', *Review of marketing and agricultural economics*, 33(1): 5-31.

Clark S, Ward G, Kearney G, Lawson A, McCaskill M, O'Brien B, Raeside M and Behrendt R 2012, *Summer-active perennial species improve pasture system nutritive value and sward stability*, Department of Primary Industries, Hamilton, Victoria.

Clark SG, Ward GN, Kearney GA, Lawson AR, McCaskill MR, O'Brien BO, Raeside MC and Behrendt R 2012, Summer-active perennial species improve pasture system nutritive value and sward stability, Unpublished manuscript, Department of Primary Industries, Hamilton, Victoria.

CSIRO Plant Industry 2006, *ME Required*, CSIRO Plant Industry, Black Mountain, Australian Capital Territory.

CSIRO Plant Industry 2007, *GrassGro™: Matching management goals with land capability*, CSIRO Plant Industry, Black Mountain, ACT.

Davidson B and Martin B 1965, 'The relationship between yields on farms and in experiments', *Australian Journal of Agricultural Economics*, 9(2): 129-40.

Elliott FF 1928, 'The "representative firm" idea applied to research and extension in agricultural economics', *Journal of Farm Economics*, 10(4): 483-98.

EverGraze Regional Advisory Group 2009, *EverGraze Regional Advisory Group meeting*, November 2009, unpub., Hamilton.

Friend M, Robertson S, Masters D and Avery A 2007, 'EverGraze: A project to achieve profit and environmental outcomes in the Australian grazing industries', *Journal of Animal and Feed Sciences*, 16(Supp. 2): 70-5.

Gruen FH 1959, 'Pasture improvement - the farmers' economic choice', *Australian Journal of Agricultural Economics*, 3(2): 19-44.

Hardaker B, Huirne R, Anderson J and Lien G 2004, *Coping with risk in agriculture,* Second, CABI Publishing, Oxfordshire, UK.

Karunaratne K and Barr N 2001, *A baseline of adoption of pasture management practices: Glenelg Region,* Department of Natural Resources and Environment, Bendigo, Victoria.

Lewis C 2011, *Profitability and risk evaluation of novel perennial pasture systems for livestock producers in the high rainfall zone*, Thesis, Masters of Agriculture, Melbourne School of Land and Environment, University of Melbourne, Parkville, Vic.

Makki D, Somwaru A and Harwood J 2001, 'Biotechnology in agriculture: implications for farm-level risk management', *Journal of Agribusiness*, 19(1): 51-67.

Malcolm B, Makeham J and Wright V 2005, *The farming game: agricultural management and marketing.,* 2nd, Cambridge University Press, Port Melbourne, Vic.

Malcolm L 2004, 'Farm management analysis: a core discipline, simple sums, sophisticated thinking', *AFBM Journal*, 1(1): 45-56.

Marottie D, Chapman D, Cosgrove G, Parsons A and Egan A 2002, 'New opportunities to improve forage based production systems', in S Peterson (ed.), *Proceedings of the New Zealand Society of Animal Production, 2002*, New Zealand Society of Animal Production, 273-7.

McArthur ID and Dillon JL 1971, 'Risk, utility and stocking rate'; *Australian Journal of Agricultural Economics*, 15(1): 20-35.

Moore AD and Zurcher EJ 2005, *User interface for a Feed Demand Calculator: Report to Meat & Livestock Australia CSIRO Plant Industry*, Black Mountain, Australian Capital Territory.

Moore AD, Donnelly JR and Freer M 1997, 'GRAZPLAN: Decision support systems for Australian grazing enterprises. III. Pasture growth and soil moisture submodels, and the GrassGro DSS', *Agricultural Systems*, 55(4): 535-82.

Moore AD, Bell LW and Revell DK 2009, 'Feed gaps in mixed-farming systems: insights from the Grain & Graze program', *Animal Production Science*, 49(9-10): 736-48.

Naji R 2006, *Weed Manipulation For Productive Lucerne Stands,* Department of Primary Industries, Horsham, Victoria.

Pearse R 1963, 'Financial returns and capital requirements for optimum pasture improvement plans', *Review of marketing and agricultural economics*, 31(4): 117-208.

Reeve IJ, Kaine G, Lees JW and Barclay E 2000, 'Producer perceptions of pasture decline and grazing management', *Australian Journal of Experimental Agriculture*, 40(2): 331-41.

Russell A 2009, How to use Dry Sheep Equivalents (DSEs) to compare sheep enterprises, Department of Primary Industries, Orange, New South Wales.

Sargeant K 2009, *A simple guide to perennial pasture establishment*, Department of Primary Industries, Seymour,Victoria.

Sargeant K and Saul GR 2009, Practices and attitudes to grazing management of beef and sheep producers in southern Australia – results and recommendations for the EverGraze research and extension strategy, Unpublished manuscript, Department of Primary Industries, Seymour, Victoria.

Scott JF, Lodge GM and McCormick LH 2000, 'Economics of increasing the persistence of sown pastures: costs, stocking rate and cash flow', *Australian Journal of Experimental Agriculture*, 40(313-23.

Shakya S, Wilson W and Dahl B 2012, *Valuing new random GM traits: the case of drought tolerant wheat*, Fargo, USA.

Tocker J 2010, South west farm monitor project 2008/2009: Supplementary feed summary, Unpublished manuscript, Department of Primary Industries, Ballarat, Victoria.

Tocker J and Berrisford T 2010, *Livestock farm monitor project 2009/2010: Summary of results*, Department of Primary Industries, Melbourne, Victoria.

Tocker J, Swann C and Berrisford T 2009, *South west farm monitor project 2007/08: Summary of results*, Department of Primary Industries, Melbourne, Victoria.

Tocker J, Berrisford T and Gilmour D 2010, *South west farm monitor project 2008/09: Summary of results*, Department of Primary Industries, Melbourne, Victoria.

Trapnell LN, Ridley AM, Christy BP and White RE 2006, 'Sustainable grazing systems: economic and financial implications of adopting different grazing systems in north-eastern Victoria', *Australian Journal of Experimental Agriculture*, 46(8): 981-92.

Ward GN, Clark SG, Kearney GA, McCaskill MR, Raeside MC, Lawson AR and Behrendt R 2012, Summer-active perennials in pasture systems improve seasonal pasture distribution without compromising winter-spring production, Unpublished manuscript, Department of Primary Industries, Hamilton, Victoria.

Warn L, Webb Ware J, Salmon L, Donnelly J and Alcock D 2006, *Analysis of the profitability of sheep wool and meat enterprises in southern*

Australia, Australian Sheep Industry CRC, Armidale, Australia.

Appendix

Table 1 Description of the rainfall conditions for each year considered in the analysis

Year	Description	Rainfall Percentile (1963-2001)[1]
2007	The total annual rainfall for the Hamilton region for 2007 was 800mm, well above the long term average of 683mm. The year was characterised by record rainfalls in January and November, and low October rainfall, with average conditions throughout the rest of the year. These late spring/early summer high rainfall events came at times when pasture growth was severely restricted. Lucerne, in particular, was able to respond after these rainfall events increasing pasture growth and production in summer and autumn (Makki et al. 2001).	Annual total: 78th Apr-Dec: 69th
2008	In 2008, the total annual rainfall of 628mm was below the long term average of 683mm. Dry conditions were recorded for most of the year with particularly low rainfall recorded in October. This is with the exception of above average rainfall in July and December (Makki et al. 2001).	Annual total: 35th Apr-Dec: 41st
2009	2009 had an annual total rainfall of 659mm, similar to the long term average of 683mm. The year began with record high temperatures and minimal rain, followed by a wet winter and poor October rains (Makki et al. 2001).	Annual total: 45th Apr-Dec: 63rd

[1]Rainfall percentiles calculated on data from the DPI Hamilton weather station from 1963 to 2011 (S. Clark, pers. comm.)

Table 2 Summary of representative farm sheep enterprise (adapted from Lewis 2011)

	Farm Area Grazed	Lambing Time	Percentage of Sheep Enterprise (%)	Main Product
Self-replacing Merino	800 ha equal to 80% of farm area	September	70	3.4 clean kg/head of 18.4 micron wool
Merino x Terminal		July	30	41-45 kg live weight trade lambs at six months of age

Table 3 Summary of representative farm cattle enterprise (adapted from Lewis 2011)

	Farm Area Grazed	**Calving Time**	**Main Product**
Cow-calf Angus	200 ha equal to 20% of farm area	April	400-420 kg live weight steers at 16 months and cull heifers sold at 19 months at 350 kg live weight.

Table 4 Description and source of data used in the representative farm model for the 'Base Case' and two improved perennial pasture systems

	Pasture Description	**Pasture Growth (kg DM/ha day) and Quality (MJ ME /kg DM)**
Base Case	Perennial ryegrass/Subterranean clover with capeweed pasture base in the Hamilton region.	The simulation model GrassGro was run for the 2007, 2008 and 2009 seasons (Moore et al. 1997; Makki et al. 2001; CSIRO Plant Industry 2007;).
Triple[1]	SARDI 7 Lucerne on the crest, Avalon Perennial Ryegrass on the slope and Quantum Tall Fescue on the valley floor (Makki et al. 2001; Shakya et al. 2012).	2007, 2008 and 2009 EverGraze experimental trial pasture supply fresh growth data (Makki et al. 2001; Shakya et al. 2012). The results reflected the theoretical on-farm potential performance of the pasture technology when managed as recommended including adoption of rotational grazing.
Best Practice Perennial Ryegrass[1]	Fitzroy Perennial Ryegrass on the crest, Avalon Perennial Ryegrass on the slope and Banquet Perennial Ryegrass on the valley floor (Makki et al. 2001; Shakya et al. 2012).	

[1]All pastures were sown with Leura and Gosse subterranean clover as part of the pasture mix with the main sown species/cultivar.

Table 5 Variable costs ($/DSE) assumptions used in analysis for the sheep and cattle enterprises based on the 2009/2010 South West Farm Monitor results.

Variable Cost	Sheep ($/DSE)	Cattle ($/DSE)
Animal health	1.82	1.05, 2.611[1]
Supplementary feed	Calculated[2]	Calculated
Pasture maintenance	Calculated	Calculated
Shearing supplies	0.19	-
Selling costs	2.45	1.57
Freight / Cartage	0.47	0.55
Repairs and maintenance	0.13	0.12
Contract services	3.94	0.09
Casual labour	0.02	0.24
Other	0.41	0.71

1For 'animal health' costs in the cattle enterprise, the improved perennial systems attract an extra cost compared to the 'Base Case' pasture of bloat capsules. For this parameter, the first value represents the animal health variable cost used in the model for the 'Base Case' pasture followed by the cost including bloat capsules used for the improved perennial pasture systems.

2'Calculated' indicates that this cost per DSE varied with changes in stocking rate and/or changes in seasonal conditions, with the value ($/DSE) calculated in the model depending in the individual scenario being analysed.

Table 6 Supplementary feed cost assumptions for barley, lupins and pasture hay. Considered to be the most likely price levels for the medium term

Feed	Units	Cost (AU$)
Feed barley	(AU$/tonne fed)	180
Lupins	(AU$/tonne fed)	200
Pasture hay	(AU$/tonne baled on farm)	81

Table 7 Commodity prices assumptions used in analysis for wool and livestock sales. Considered to be the most likely price levels for the medium term.

Commodity	Unit	Price
Wool		
18 micron fleece	(AU$/kg clean)	12
Livestock		
Trade lambs	(AU$/kg carcass weight)	4.40
Mature sheep	(AU$/head)	60
Cast for age ewes	(AU$/head)	55
Yearling steers	(AU$/kg carcass weight)	2.00
Yearling heifers	(AU$/kg carcass weight)	1.95
Mature cows	(AU$/head)	600
Cast for age cows	(AU$/head)	500

Table 8 Seasonal series used in the analysis. Each seasonal series was assumed to repeat four times across the 12-year analysis period.

Seasonal Series	Description
2007, 2008, 2009	This run of seasons was chosen as it is representative of true seasonal variability as seen by the EverGraze trial at Hamilton.
2009, 2008, 2007	Reverse order of actual seasonal variability of the EverGraze trial at Hamilton.
2009, 2009, 2008	2009 season was considered to be closest to a typical season for the district of the three years in terms of average annual rainfall, with 2008 included to represent poor conditions every three years.
2009, 2009, 2007	2009 season was considered to be closest to a typical season for the district of the three years in terms of average annual rainfall, with 2007 included to represent good conditions every three years.

Table 9 Stocking rates tested on the improved perennial pastures

Stocking Rate (DSE/hectare)	
16.2	Equivalent to 'Base Case' pasture system rate and regional average[1]
21	70% of experimental rate
24	80% of experimental rate
27	90% of experimental rate
30	Equivalent to experimental rate
36	20% above experimental rate

[1] (Berrisford and Tocker 2009; Tocker and Berrisford 2010; Tocker et al. 2009)

Table 10 NPV at 8% nominal discount rate ($), nominal peak debt ($), year of return to positive CNCF and debt servicing ability ($) results of the improved pasture systems analysis

	EverGraze Triple				EverGraze Perennial Ryegrass			
Stocking rate (DSE/ha)	16.2	21	30	36	16.2	21	30	36
Establishment success								
Net present value @ 8% after tax ($)	6 424	61 386	123 811	125 165	15 327	69 943	121 899	125 584
Nominal peak debt with 8% interest after tax ($)	64 302	64 302	82 794	107 552	59 705	59 705	78 582	103 075
Year of return to positive cumulative NCF (Year)	10	6	6	7	8	6	6	7
Establishment failure								
Net present value @ 8% after tax ($)	-32 110	15 297	70 703	74 213	-23 600	23 822	69 845	74 057
Nominal peak debt with 8% interest after tax ($)	101 333	103 696	123 696	135 723	95 372	98 846	117 062	132 684
Year of return to positive cumulative NCF (Year)	>12	10	8	8	>12	9	8	8
Debt servicing								
Average annual extra nominal net cash flow after tax ($)	8 970	18 579	21 565	32 324	9 185	18 557	28 291	30 060
Annuity required for 12-year loan of peak debt @ 8% interest ($)								
Establishment success	8 533	8 533	10 986	14 272	7 923	7 923	10 427	13 678
Establishment failure	13 446	13 760	16 414	18 010	12 655	13 116	15 534	17 607

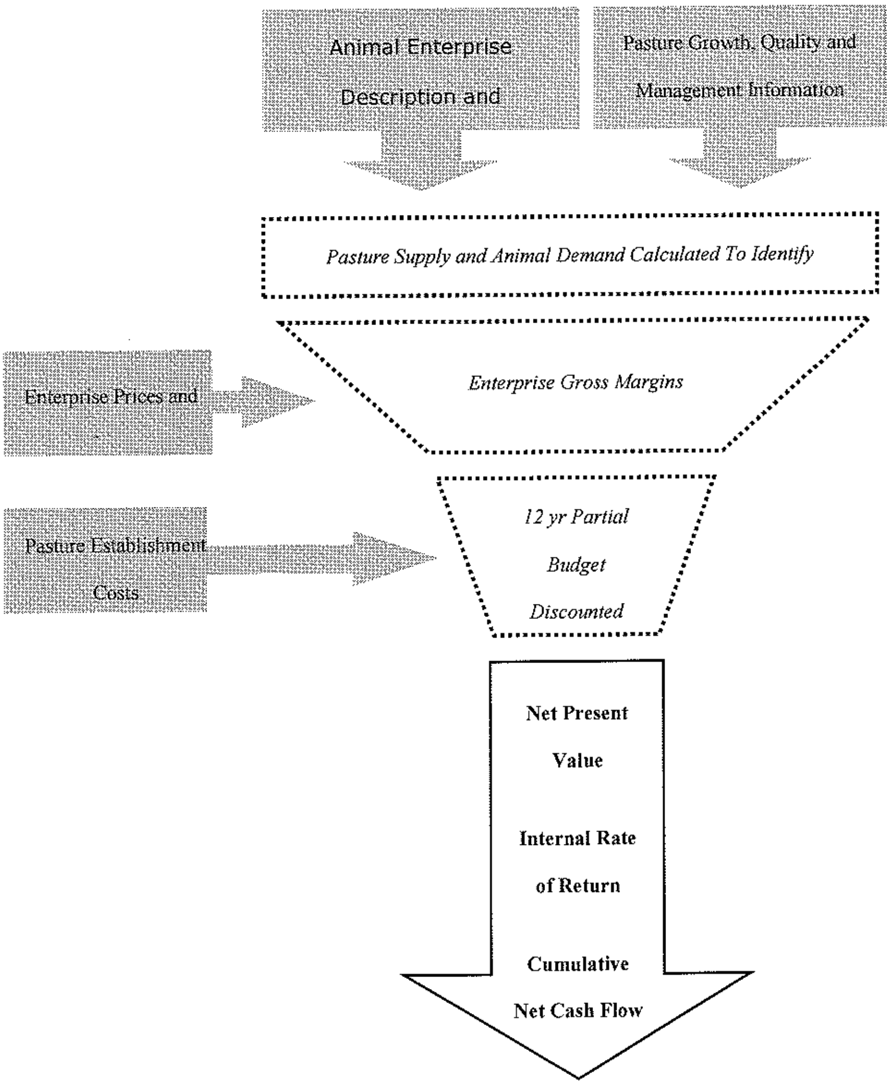
Results calculated for 100 hectares over a 12-year period at four stocking rates with establishment success and with establishment failure. The seasonal series of 2007, 2008, 2009 was assumed to be repeated four times across the 12-year period. Most likely medium term prices and costs assumed.

Table 11 Multiple seasonal series mean – standard deviation analysis of steady state mean annual net cash flow ($) over the 100 ha investment before tax and inflation. Results are the average of the two EverGraze systems at each stocking rate.

System and stocking rate (DSE/ha)	Mean annual NCF of multiple seasonal series ($)[a]	Mean standard deviation of NCF of mult[a]
Base Case 16.2	29184	2,301
EverGraze 16.2	39235	1,419
EverGraze 21	48242	4,124
EverGraze 24	52183	6,828
EverGraze 27	55356	8,490
EverGraze 30	57458	9,837
EverGraze 36	59028	10,931

[a] See Table 8 for description of seasonal series used.

Figure 1 Stylized depiction of the representative farm model[2]



[2] The representative farm model used in this analysis is described in detail in Lewis (2011).

Figure 2 IRR (%) results of the improved pasture systems analysis. Results calculated for 100 hectares over a 12 year period at four stocking rates with establishment success and with establishment failure. The seasonal series of 2007, 2008, 2009 was assumed to be repeated four times across the 12 year period. Most likely medium term prices and costs assumed.

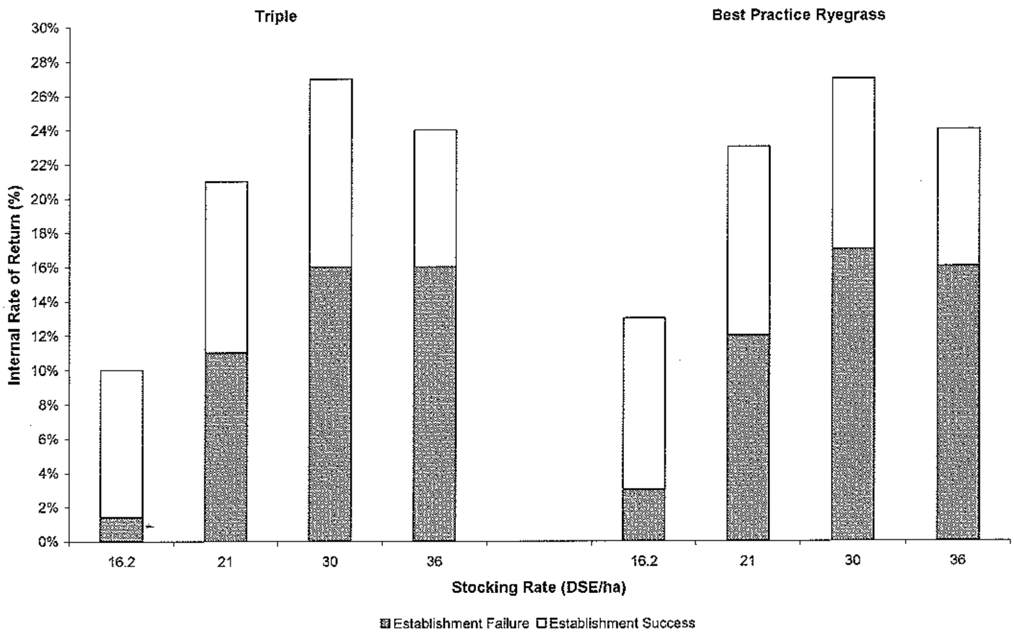


Figure 3 Average annual supplementary feed cost per DSE for the EverGraze systems across the 2007, 2008, 2009 seasonal run at the various stocking rates tested.

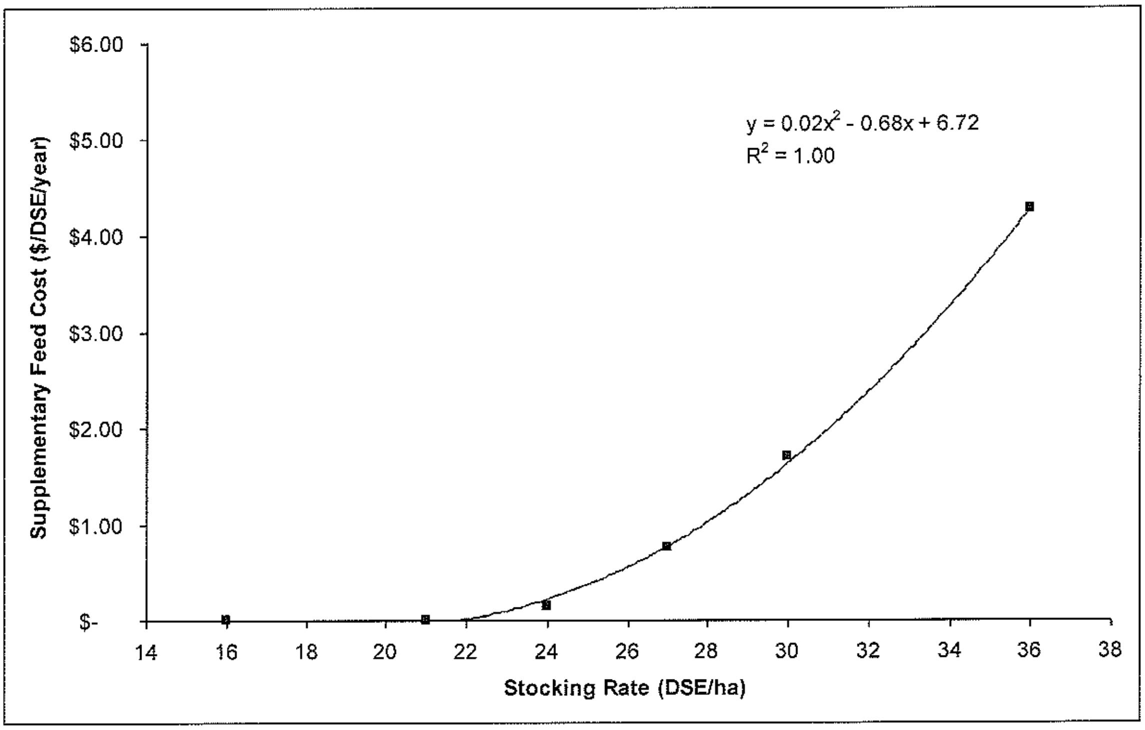


Figure 4 '2007,2008,2009' seasonal series mean – standard deviation analysis of steady state mean annual net cash flow ($) over the 100 ha investment before tax and inflation. Results are the average of the two EverGraze systems at each stocking rate.