Benefit Analysis: Literature Review and Modelling Outcomes

Prepared for the New Zealand Pasture Renewal Charitable Trust

Literature review on effects of pasture renewal in New Zealand and simulation modelling of those effects on whole farm profitability

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Background

A group of agribusinesses has joined forces to identify farm-level barriers to accelerating the rate of pasture renewal in New Zealand.

The programme will have 3 discrete phases:

- Benefit analysis: collation of available data on the financial benefits of regular pasture renewal;
- Market research: establishment of current renewal practice, awareness of benefits and barriers to adoption;
- Information campaign: a sustained programme to inform farmers when and how to benefit from pasture renewal.

This document addresses the first phase i.e. collation of available information.

This review of the effects of pasture renewal on sheep, beef and dairy farming in New Zealand has two parts

The first is a review of the knowledge of pasture renewal. This encompasses the formal published information in journals and conference proceedings, as well as the informal information of unpublished data and anecdotal or farmer collected information.

We are reviewing the impacts of pasture renewal compared with no pasture renewal, rather than the impacts of pasture cultivars or species.

The second is to model the information we gather to indicate the economic impacts of pasture renewal on four sheep/beef and five model dairy farms (9 altogether).

Literature Review

Introduction

Improved pasture is the basis of New Zealand's farming systems and therefore the impact of renewal practices is critical to both performance and productivity. The purpose of this review is to document current knowledge of the effects of pasture renewal. The focus is the impact of pasture renewal compared with no pasture renewal, rather than any impact of either pasture species or cultivar.

The pastures of New Zealand have gradually moved from a primary establishment phase, during the development of pasture from native lands, to pasture renewal, where farmers are replacing pastures. Establishing new pastures in New Zealand has been part of farming practice since the land was cleared from native vegetation during the 19^{th} and 20^{th} centuries. Originally pastures were established where bush had been removed using imported seed. Development of the native tussock grasslands also involved replacing the native grasses with imported and more productive pasture species such as dogstail, browntop, ryegrass and white clover.

The research of people such as Suckling (White 1973) showed that improved management practices and cultivars bred in New Zealand during the 1960's could produce a significant step forward in production. This created the first major drive for pasture renewal.

Plant breeding shifted the emphasis during the 1970's and 80's away from a single cultivar for all of NZ. The development of regional and management specific cultivars during and since the 1980's has created a range of specific options for farmers. Each time these changes have been made, farmers re-examine the question – 'does renewing my pasture pay?'

The research and practices relating to pasture renewal have built up around the steps forward in research into management, fertiliser and plant breeding, rather than pasture renewal as a practice. Typically this research has focussed on the components that make up successful pasture renewal. These include establishment techniques, seeding rates, pasture cultivar comparisons, fertility requirements and pest control. Many of the benefits or impacts of the overall renewal process are then either inferred or modelled.

Specific research on the measurable benefits or otherwise, at a paddock or farm scale, has been limited to relatively few trials and only in some regions of New Zealand. This may have been linked to marketing of new cultivars or the introduction of new species or cultivars with significant differences.

Cocks & Brown (2006) state that changes in the recent sheep, beef and dairy industries have precipitated a need for further efficiencies of production to be explored in the face of rising costs and reduced returns. An example of the goals set for the farming industry comes from Dairy Insight (2005). "The dairy industry will increase dairy farmer profitability and create wealth for the New Zealand economy through achieving, by 2015, a 50% total productivity increase (4% p.a.) and a 35% growth in milk solids (3% p.a.)."

Pasture renewal has been assumed to be an important part of achieving these goals. Previous reviews and summaries of pasture renewal have shown that economic benefits are achieved in almost all cases.

Green (2005) outlined the progress in productivity on farm that has been made – lambing percentage increasing 26%, lamb carcase weight increasing by 20% since the 1990's and milksolids per cow increasing 44% since 1975.

Caradus (2006) in reviewing 75 years of technological advances in pastoral agriculture, stated that the rates of pasture resowing have not changed markedly since the 1930's. The question then remains: if pasture renewal does lead to greater net wealth to the farm, shouldn't we be doing more of it?

This review will outline the process of renewal and reasons why farmers renovate and then summarise available data on the impacts of pasture renewal.

The process of pasture renewal

Baker *et al.* (1996) differentiates between pasture renewal and pasture renovation. They define *pasture renovation* as where it is neither desirable nor necessary to kill the entire existing sward. In contrast, *pasture renewal* is when the existing sward is killed (sprayed) and resown.

It is important to note that researchers, consultants and seed reps tend to use both terms interchangeably. For the purpose of this review we have assumed it is any method of establishing a new pasture when adding new seed.

Pasture renewal is best described as a decision making and implementation process based on the farmer having a need to change or improve the paddock resulting from dissatisfaction with that paddock. Pasture renewal can be either a paddock by paddock or a whole farm decision.

The Concise Oxford Dictionary defines the word 'renew' as: to restore to original state, make (as good as) new, revive, regenerate. A slightly different interpretation from www.Dictionary.com is - to make effective for an additional period; to re-establish.

Following this definition we can consider the pasture renewal process as follows. The farmer makes some assessment as to whether a paddock is 'as good as new'. The benchmark for this may be the best paddocks on his farm or the neighbours. Farmers expect the outcome from pasture renewal to be a new pasture.

The pasture renewal process is a complex one made up of many integrated components. These include:

- Farmers reasons for renewal
- Objectives – what the pasture is for
- Traditional techniques used in renewal
  - Seed bed preparation and seeding
    - Cultivation
    - direct or spray-drilling
    - undersowing
    - oversowing and topdressing (plus variations)
  - Soil fertility
  - Pests and weed control
  - Irrigation and drainage
- Renewal without the inclusion of seed - chemical topping, strategic N use, soil fertility, irrigation, weed and pest control
- Outcome – a renewed pasture that can meet the objectives of the farmer

Farmers commonly believe that pasture renewal will increase productivity but carries some associated risk. The potential productivity gain may come from more than a single feature associated with pasture renewal and therefore requires a systematic approach to evaluate all the factors that impact on its success.

Pasture renewal is one of the many investment options available to the farmer. It is important to establish the objectives and prioritise investment options before undertaking renewal.

The methods of pasture renewal have been covered extensively elsewhere (e.g. Pasture Renovation Manual; (Pottinger 1993)) and are not part of this review.

Reasons why farmers renew

It is important to outline the many reasons farmers renew pastures before discussing the impact of pasture renewal.

Very little research has been done to identify why farmers renovate hence many reasons are ‘anecdotal’. Some work has been done on where farmers get their information and some on how farmers identify a ‘poor’ paddock and a persistent paddock.

Why might farmers renew a paddock?

Run out pastures

Bell *et al.* (2006) described the reasons for pasture decline (run out) as direct pest damage, weed ingress or the combination of pest damage weakening pasture growth and hence pasture cover allowing weed ingress.

Daly *et al.* (1999) documented four specific reasons for a pasture to be deemed ‘run out’ as a result of as farmer survey. These were poor pasture species (51% of farmers), poor pasture production (26%), poor animal performance (12%) and pasture age (11%).

Crop rotation

On farm productivity is often limited by either annual or seasonal feed production (Clark *et al.* 1997) and therefore farmers use summer or winter crops to provide supplementary feed. Pasture renewal is therefore an outcome rather than the primary reason for the crop. Crop rotation can also be used in the renovation cycle to control weed and pests (Bell *et al.* 2006).

Farm development

Pasture renewal can be a result of changing land use, for example the conversion from sheep to dairy. It can also be part of the process of bringing in ‘new’ land, e.g., from oversown tussock to cultivated pasture, or in the rejuvenation of a farm when ownership changes.

Physical paddock issues

Farmers may renew pastures because of physical changes to the paddock. This includes when drainage is upgraded, irrigation borders reshaped or surface roughness removed.

The presence of weeds may also be a reason for pasture renewal. Farmers may cultivate to remove weeds or use the renewal process to apply chemicals to control thistles or other weeds e.g. summer grass infestation in the Waikato.

The removal of desirable pasture species by attacks of pests such as black beetle, porina or grass grub may also be the cause of pasture renewal.

Environmental damage

Pasture renewal may be needed due to drought, flooding or stock damage after a wet winter.

These factors outlined above are directly related to the physical components and outcomes from a specific paddock. They are all about restoring the pasture to ‘as good as new’.

Farmers may use a strategic approach when they are considering renewal as a tool to meet specific farm systems requirements or long term productivity improvement goals. In this case farmers want something better than, or different from, before.

Farmers may also use the following strategies when deciding to renew pastures either in conjunction with any of the above or as a stand alone strategy.

Production

In this instance farmers have improved their pastures in the past. Recent gains in animal performance and stocking rates are now utilising most of the current potential of pasture production. Farmers may now consider pasture renewal with the most advanced plant genetics to enable further production increases.

Fine tuning management

Plant breeding has resulted in cultivars that have a much greater range of attributes. Farmers can now take the opportunity to integrate attributes such as flowering dates, seasonal production differences and specialist feed quality parameters to fine tune their management systems. These individual and sometimes minor changes may result in decreased cost, better feed supply and demand profiles and higher animal performance.

Changing systems

Recent changes from sheep to dairy farming or sheep to bull beef have highlighted fundamental differences in the pasture types needed for each enterprise. Therefore a change in production system may be a key factor in a farmer's strategic decision to renew pastures.

Animal health

Farmers use pasture renewal as one tool in modifying the impacts of disease on animal production. The most common animal health issues that include pasture renewal in decision making are endophyte and facial eczema. The provision of parasite free pasture may also be considered.

This list may not be complete. A full examination of why farmers renew is required. The application of pasture renewal as a technique to aid strategic outcomes can be extended when we have a more complete understanding of the reasons why farmers renew pastures.

Impacts of new pasture

A major feature of pasture renewal is changing the pasture species or cultivar. In turn this can change potential total dry matter production, seasonality of production, feed quality, and animal health and ultimately determine animal productivity potential from the new pasture.

As a result of the decision to renew, the factors that led to the decline of the pasture are usually rectified. Often changes are made to soil fertility, the soil physical structure, and the pest and disease cycles.

The final outcome of pasture renewal is when the pasture is utilised. The type of utilisation will range from grazing by a range of stock types and classes to hay and silage making. Each of these options has a unique set of outcomes that impact directly on the size of any productive and economic effect and the longevity of that effect.

Pasture species

Pasture species selection is the major decision to be made after deciding to renew pastures. The choice made will affect the resulting life span of the pasture and its productivity.

The introduction of the Plant Variety Rights Act in 1987 led to a significant expansion in the seed industry, not only in breeding new cultivars but also importing and multiplying overseas cultivars (Rolston *et al.* 2006). The wide range of pasture species and cultivars available (Charlton & Belgrave 1992) has led to farmer confusion and is likely to be one of the reasons renovation rates have remained constant.

Some cultivars are bred for specific purposes and as such are not expected to last as long in pasture compared to perennial species e.g. chicory and red clover. Within the ryegrass spectrum there is also a range from annual to perennial. The 'ryegrass continuum' is used by many consultants and seed companies as an effective tool to help explain to farmers how to choose cultivars that best meet their objectives for the new pasture.

Ryegrass continuum

Annual	**Italian or Short rotation (Hybrid)**			**Long rotation and perennial**		
	Short term	*Medium term*	*Long term*	*Large leaved*	*Medium leaved*	*Fine leaved*
← **Winter growth increasing**						
← **Feed Quality increasing**						
→ **Persistence increasing**						

Once farmers understand the relationships between cultivar types, best use and expected longevity they can choose cultivars that best fit their expectations.

Plant improvement/genetic gain

Few studies have evaluated the gain in productivity that has been added with the release of new cultivars. The original plant breeding efforts created 'certified' varieties such as 'Grasslands Huia' and 'Grasslands Ruanui' in 1930 (Rolston *et al.* 2006). Up until the early 1980's the release of other varieties and species concentrated on providing a range of pasture plants that were uniform, consistent and adapted to New Zealand grazing systems. These were better than anything else in the market, but were often single releases.

Ryegrass cultivars dominate the market (70-80%; Pyke *et al.* 2004) and are included in the majority of new sowings therefore the impact of genetic gain is important. Italian ryegrass improvement has been estimated at between 1.18% p.a. (Woodfield 1999) and 1.5% p.a. (Easton *et al.* 2002) and perennial ryegrass gains at between 0.25 and 0.73% p.a. (Woodfield 1999) and 0.4% (Easton *et al.* 2002) with higher gains being estimated in recent times.

Genetic gain of seasonal yield in annual ryegrass (Woodfield 1999) and perennial ryegrass (Easton *et al.* 2002) has also been estimated. This is an important feature of annual ryegrass, contributing significantly to reasons farmers use this species. Interestingly the greatest gains have been made in the summer and second autumn yields (2.67 and 3.62% respectively). This reflects farmer expectations of maximising the benefits of this species through increasing the longevity. Gains in summer-autumn yield in perennial ryegrass are estimated to be 0.7% (Easton *et al.* 2002), which is greater than the annual total improvement.

The genetic gain in white clover has been estimated to have increased forage yield in international populations of 0.4 (Caradus 1993) to 0.6% p.a. (Woodfield & Caradus 1994) over 60 years. However, recent estimates of gain are much greater than this, especially when testing New Zealand cultivars under New Zealand grazing conditions (Woodfield 1999). These gains were 1.49% and 1.21% p.a. under sheep and cattle grazing respectively. Gains since the introduction of Plant Variety Rights have been even greater with estimates as high as 2.5 to 4.4 % per annum (Woodfield 1999).

Other species have also shown genetic gain through plant breeding (Woodfield 1999), though fewer cultivars have been released into the market and therefore estimates are less reliable. Often the comparisons are between two cultivars and so progress over time is less relevant.

Animal performance and health gains have also been shown (Woodfield 1999). Again these comparisons are often restricted in the number of cultivar entries due to the high cost of the research. However, in several species, the gain (measured in lamb live weight gain) has been between 0.3 and 1.4% p.a., averaging 1.37 and 0.38% for ryegrass and white clover respectively.

By comparison, farmer expectations of genetic improvement in livestock drive the selection of new sires each year. This expectation has not shifted into pasture renewal with adoption of new cultivars being slow (Belgrave et al. 1991). The recent analysis of genetic gain in pasture species shows that significant gains have been made. These gains are in line with those made in the livestock industries.

Gains that can be made by the farmer by selecting the latest cultivars can be interpreted in terms of the pasture renewal cycle. Current estimates of the annual rate of pasture renewal are approximately 5% and 2.5% of dairy and sheep and beef farm area respectively. The genetic gains in the last 20 years equate to cultivars that may have 15 and 50% more annual dry matter yield from ryegrass and clover respectively than the pasture previously sown.

Evidence to support this increase in dry matter production comes from the New Zealand Plant Breeders Association trial results for ryegrass from 1991 to 2005 (NZPBRA 2006). The two most recently released ryegrass cultivars at that time had mean yields of 14.05 t DM/ha. This compared with the 12.55 t DM/ha from the control, which entered final testing in the mid 1980's. A gain of 15% would equate to a yield in the new cultivars of 14.4 t DM/ha.

Total potential gains per hectare can be estimated. Average genetic gain in both pasture and animal performance can be applied, weighted for potential ryegrass and white clover production in sowings 20 years ago (12.55 t and 2.5 t DM/ha respectively). Total production would increase to 14.4 t and 5 t DM/ha for ryegrass and white clover respectively, while animal productivity would increase by 27% and 6% respectively. This translates into a potential increase per hectare performance of approximately 57% in animal output.

Actual gains may be quite different from this, depending on the management systems chosen. An example of this has been documented in the dairy industry. (Eerens *et al.* 2001) showed that the use of new cultivars increased annual production by 7%, and altered the seasonal profile of feed cover in a dairy cow systems experiment using farmlets. However, a standard stocking rate and set decision rules around calving patterns, drying off and grazing management meant that those increases in pasture production were only converted into extra milk production in some seasons (Woodward *et al.* 2001).

One reason for a difference between theoretical and actual gains may be competitive interactions between grass and clover meaning that the genetic gains are not additive when species are combined. This was demonstrated by (Widdup *et al.* 1989) when a new clover cultivar was combined with an old ryegrass resulting in reduced ryegrass production and no overall shift in total dry matter production.

Dry matter production

The main measure of any pasture research has long been dry matter production. This has then been generically translated into improved carrying capacity or animal production using various indicators. Total and seasonal pasture production throughout New Zealand was described in a series of experiments in the 1970's and 80's (Baars *et al.* 1975; Cossens & Radcliffe 1978; Radcliffe 1974a; Radcliffe 1974b; Radcliffe 1975a; Radcliffe 1975b; Radcliffe 1975c; Radcliffe 1976; Radcliffe & Cossens 1974; Rickard & Radcliffe 1976; Round-Turner *et al.* 1976) and have become a benchmark to which improvements are compared.

Hamilton-Manns & Milne (1997) stated that new pastures, which are established properly, will yield 20 to 100% more production compared to the previous pasture. The most gain will be made when the new pasture is replacing a pasture with a high proportion of weeds and unwanted grasses. These results follow farmer expectations that they are renewing a pasture that has been identified as poor performing.

However there are few experiments that have directly compared resident pasture with a renewed pasture. Much of the research compares new pastures to controls e.g. Nui or Ruanui, or the standard pasture production expected for the region.

Renewed pastures were compared to improved resident pastures in a series of experiments at six sites representing 15% of farmed land throughout New Zealand in the 1980's (Stevens *et al.* 1993; Stevens & Turner 1993; Pollock & Scott 1993; Archie *et al.* 1993; Barker & Dymock 1993; Barker *et al.* 1993a; Barker *et al.* 1993b; Moloney *et al.* 1993). In these experiments a resident control was included, and variations in fertiliser and grazing management were always applied to all treatments. Measurements were made over 5 to 6 years and included total pasture production, botanical composition and persistence of sown species.

In summarizing these experiments the resident pastures performed consistently below the average production of the renewed pastures by approximately 1000 kg DM/ha regardless of the average production of the site (Barker *et al.* 1993b). However, when analysed by annual rainfall, the resident pastures performed similarly to renewed pastures when annual rainfall at a site dropped below 850 mm rainfall p.a. Dry matter production of the renewed pastures diverged significantly to be 1500 kg DM/ha above that of resident pastures when rainfall reached 1400 mm p.a.

The annual dry matter production of unimproved pasture documented at one site was 4500 to 5500 kg DM/ha while the improved resident (fertiliser plus subdivision) produced between 7850 and 10500 kg DM/ha (Stevens & Turner 1993). A further increase due to pasture renewal of 1100 and 2300 kg DM/ha was recorded at this site.

Renewal of hill country pastures with cocksfoot showed that an increase in annual dry matter production of between 1300 and 1500 kg DM/ha (approximately 18%) above the resident pasture can be achieved (Barker *et al.* 1999) depending on phosphate inputs.

Establishing clover into dry North Canterbury hill country increased pasture yield on sunny faces from 1390 to 2100 kg DM/ha/annum (White *et al.* 1972) in resident and improved pastures respectively. The increase in production on shady faces was much greater going from 1380 to 4190 kg DM/ha. The introduction of grasses on the shady sites increased the total production to approximately 4800 kg DM/ha. In all cases, however, this effect also included an addition of fertiliser.

Pasture production in a hill country farmlet study was not different when over-sown with a prairie grass, red and white clover mixture, though the contribution of prairie grass was minimal ((Webby *et al.* 1990).

Over-sowing clover is often used as a means of improving hill country. Results have shown that this practice can increase clover production, and this increase is greater when phosphate deficiencies are corrected. For example Chapman *et al.* (1993) found 4 years after over-sowing that the annual amount of white clover grown increased from 130 kg DM/ha to 280 kg DM/ha with no fertiliser but from 360 kg DM/ha to 670 kg DM/ha with 35 kg P/ha/annum. Note however, that the total amount of white clover produced was very low in all cases.

Several studies have indicated improvements in dry matter production from pasture renewal on dairy farms when compared to resident swards. Responses have ranged between 17% (Thomson 1998) 23% (Pitman 2003) and 35% (Thom *et al.* 1987). A comprehensive documentation of pasture renewal on-farm showed a significant increase of 12 to 15% in dry matter production (Edgecombe 1988).

Data from the Woodlands Research Station (Smith unpublished data, Figure 1) shows a relatively consistent increase in daily pasture growth rate of a recently renewed pasture compared to a 10 year old pasture. Total annual production was 1270 kg DM/ha greater on the renewed pasture (excluding the establishment period).

In an irrigated pasture in mid-Canterbury (Fraser unpublished data) the establishment of a new pasture by direct drilling resulted in an average annual yield of 13100 kg DM/ha over the following 3 years, a decrease of 2100 kg DM/ha compared with the control. Much of the variation between positive and negative results comes from the establishment period and grass grub attack during year 3.

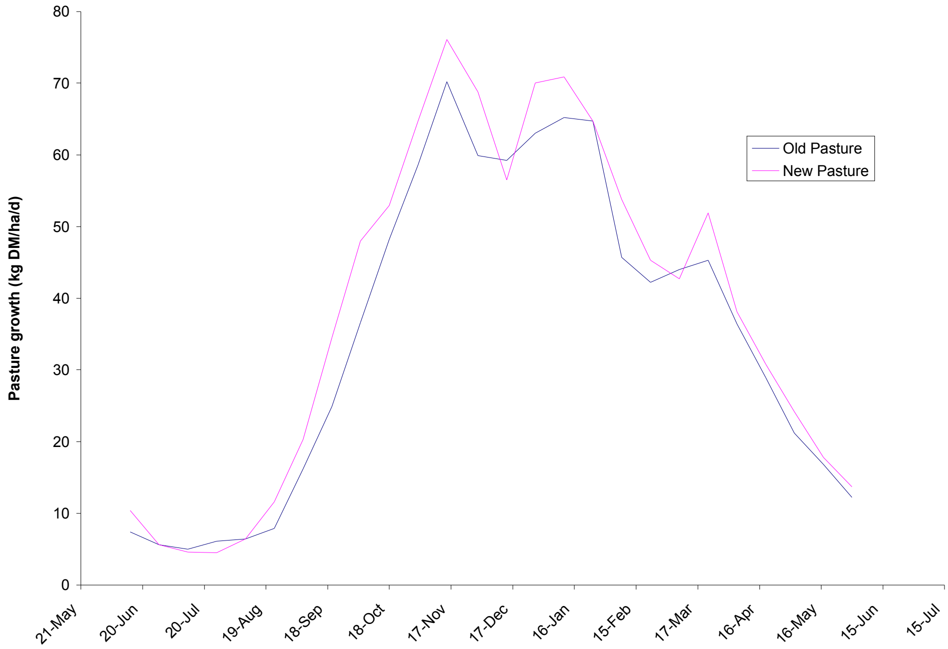


Figure 1: Pasture growth from renewed and old pasture at the Woodlands Research Station, Southland (C. Smith, unpub data)

Recently the Meat & Wool NZ Pasture Plan programme provided a significant body of data on pasture production around New Zealand. Within this programme several farmers have chosen to measure the difference between recently renewed pastures and resident pastures.

Results reported in the Pasture Plan programme (Meat & Wool NZ 2006) show a range of increased pasture production over five sites where old pasture (range of 5 to over 20 years) were directly compared to recently renewed pastures. Results ranged from an advantage of between 10 and 15 kg DM/ha/d in early to mid spring only, to 2 to 3 times more pasture throughout the year. These variations depended on previous age of the resident pasture, aspect, and soil fertility.

Hill country over-sowing has been used as part of an improvement package along with fertiliser, subdivision and increased stocking rate for many years. The most comprehensive study was done at the Te Awa research farm (Suckling 1954 -1975) which was representative of 35% of North Island farmed land. The outcome was increased annual pasture production from 7900 to 13400 kg DM/ha from 1948 to 1963, corresponding to a stocking rate increase from 3.75 to 13.75 s.u./ha (White 1973). Of note was the increase in ryegrass content from 4 to 28% and of total clover from 6 to 28%. However, the impact of the individual effect of the introduction of new seed through over-sowing is hard to determine.

Seasonality of growth

The range of pasture species and cultivars now available provides a set of tools to manipulate seasonality of pasture growth. The most significant advance in early ryegrass breeding, for example, was the increase in autumn production to better align feed supply with all-grass farming requirements (Armstrong 1977).

Recent examples of changes in seasonal pasture production resulting from pasture renewal are relatively limited.

A comprehensive study of 29 pasture species in New Zealand (Charlton & Belgrave 1992) looked at their potential range and seasonal distribution. It was felt that the investment returns from animal production on pastures renewed with new species could be more than 200%. However caution was given regarding the challenge of choosing the best species mixture for range of environments considered in this study.

Direct drilling of perennial ryegrass in autumn after spraying with herbicide increased pasture growth by 20-35% during winter and spring in the 2 years following drilling (Thom *et al.* 1987). Edgecombe (1988)

demonstrates significant dry matter production increases of 100, 50 and 100% in winter, early spring and autumn respectively when recently renewed pastures were compared to the resident sward.

Pastures renewed with improved cultivars and species produced more forage in summer (red clover), autumn (prairie grass) and winter which were identified as periods of feed deficit in old permanent pastures (Cosgrove *et al.* 2003).

Seasonal dry matter production increases were recorded when pastures were renewed in hill country. These increases ranged between 10 and 100% in autumn, -10 and 60% in winter, -16 to 60% in spring and -10 to 30% in summer by pasture renewal when compared to resident pastures in hill country (Barker & Dymock 1993; Barker *et al.* 1993a; Moloney *et al.* 1993; Stevens & Turner 1993). Negative results (Barker & Dymock 1993) were most prevalent when the original resident was mainly ryegrass and in seasons that were drier than average.

There has been a focus of improving pasture production across the seasons in dryland environments. Pastures based on perennial grasses other than ryegrass, such as cocksfoot, phalaris and tall fescue, have the potential to alter the seasonality of pasture growth. Moloney (1991) documented on-farm changes in both total and seasonal pasture production when combinations of drought tolerant species (tall fescue, cocksfoot and phalaris) were used at three sites in the North Island. These grasses produced between 1.4 and 3.7 t DM/ha/year more than ryegrass white clover pastures. These increases came in spring and summer (tall fescue/cocksfoot mix), autumn and winter (phalaris) and summer (cocksfoot/tall fescue) depending on the site. Dairy trials compared alternative pastures to traditional ryegrass/white clover pasture but a 17% increases in total dry matter production from tall fescue/phalaris only translated into increased milksolids in dry summers (Thomson 1998).

Some farmers have the expectation that the new pastures perform better after drought or extreme wet weather and complement the seasonality of the farm (Hills & Hills 1997).

Feed quality

The feed quality of a pasture is a combination of changes in botanical composition, cultivar, seeding characteristics and pasture utilisation and management.

The process of renewing pastures can also often provide a short term lift in feed quality by removing all previous herbage, including dead material, and replacing it with newly grown forage. This can extend to creating pastures free of internal parasites and fungi etc.

This section examines overall changes that have been measured and investigates some of the reasons for those changes.

As early as the 1960's quality was a focus of plant breeders with the development of Grasslands Marsden, a cultivar selected for low leaf strength (Easton *et al.* 2002). In more recent years improved digestibility rather than solely production has become important (Westwood & Norriss 1999). Often however, comparisons of feed quality have been confounded by interactions with ryegrass endophyte status.

Tetraploidy

Increased use and promotion of tetraploid ryegrass cultivars has occurred in the last 5-10 years. They have larger cells with more water, larger leaves and tillers, are darker green plants with larger seeds and to also have high water soluble carbohydrate content, making them more palatable to stock compared to diploid perennial or older ryegrass pastures.

Overseas research (Hageman et al. 1993) suggests grazing intakes may be 3% greater than for diploids and 5% greater milk solids. This was associated with changes in both rumen pH and volatile fatty profiles consistent with a more rapidly fermentable diet.

Lamb production was measured from pastures sown in tetraploid or diploid perennial ryegrass over 7 years ((Vipond *et al.* 1993; 1997). During the first three years the tetraploid ryegrass pastures gave an increase in lamb production of 16% (Vipond *et al.* 1993), and in the second four years gave an increase of 6% (Vipond *et al.* 1997), both mainly related to an increase in stocking rate. This increase in stocking rate may be an artefact of the system chosen for the evaluation. A pasture management strategy was to

maintain a sward height of 4-6 cm. If animals were achieving maximum intakes and performance then an increase in stocking rate would be required to exploit advantages.

Nutritive components

Nutritive components can vary markedly between pastures. Documentation of the differences between resident pastures and renewed pastures shows that renewed pastures often have greater protein (e.g.(White 1973) and energy concentrations (Stevens & Turner 1993; Barker *et al.* 1993a,c). This may be due to improved feed utilisation leading to lower amounts of stem and dead material or improved clover content. These differences often disappear as the pasture matures.

The Meat & Wool NZ Pasture Plan results (see Dry Matter Production) also compared feed quality. The energy concentration of the pasture was between 0.2 and 0.5 MJME/kg DM higher when the pasture had been recently renewed.

The non-structural carbohydrates, or sugars, can vary in pasture. This can be due to species or cultivar differences and these decisions are directly affected by choices made when pastures are renewed. Some efforts have been made to breed novel perennial ryegrass cultivars with high water-soluble carbohydrate (WSC) content, often known as high sugar grasses. The benefits of this to pastoral animal production are being debated. The interaction between animals, plant and the environment are not fully understood with regard to a change in WSC. One study by Davis *et al.* (2002) suggests this plant improvement creates the opportunity to conserve protein and high levels of WSC in silage, with the potential advantages of improving rumen function efficiency, animal performance and reducing the environmental impact of silage-fed ruminants. Merry *et al.* (2003) also found improvements of about 20% in nitrogen used for microbial growth in the cows' rumen whilst consuming high WSC silage compared to the control silage. However, Taweel *et al.* (2006) found that feeding high sugar grass to dairy cows may not reduce methane emissions from dairy production systems, nor did it improve the dairy cows' dry matter intake or milk yield in either stall-fed or grazing conditions.

Palatability

Palatability is a relatively undefined concept that encompasses preference and intake. In general it can be considered as the animals desire to continue grazing a particular pasture.

An example of this comes from Edwards *et al.* (1993) where several grass species were offered concurrently to sheep. Significant variations in rate of sward height reduction were measured between the species, demonstrating clear preferences. These preferences would translate into higher rates of intake and potentially greater intakes if similar grazing times were applied to all species. Interestingly much of the variation in preference was removed when grazed after the application of nitrogen fertiliser.

Preferences can also be caused by the presence and type of endophyte. Again Edwards *et al.* (1993) showed a significant impact of wild type endophyte on the preferred residual grazing height. Pastures without endophyte were grazed steadily over 6 days to a residual height of 40 mm but pastures with moderate endophyte infection (40%) were grazed to only 70 mm with no further reduction in height after 4 days. New endophytes such as AR1 have been shown to be preferred over wild-type endophytes (Hume pers. comm.).

Changes in palatability are not only important in actual feed intake but also in feed quality. If animals prefer to graze closer to the ground then more of the pasture is utilised and less is left to senesce. This means then that the build-up of dead material in pasture may be lower, and therefore feed quality improved. Closer grazing will also allow more light to the base of the pasture and potentially increase the white clover content of pastures.

In a report on the introduction of new cultivars into dairy pasture it was noted that the failure of new cultivars to increase animal performance unjustly leads to the assumption they are not better than previous cultivars, but the problem may lie in poor pasture utilisation (Goold 1985).

Animal production

The focus of any pasture renewal programme will include the impact on the animal systems that are utilising the new pasture. These include production per head, stocking rate and animal health (including endophyte effects).

Animal production can be measured in several ways. Alteration in stocking rate is the most common change made and is usually used to demonstrate straight-forward changes in dry matter production.

Short-term changes in liveweight gain can also be used as an indicator of the potential animal performance under differing conditions or between seasons.

Long term accumulations in live weight or milk production may also be used. These are often measured in put-and-take experiments where stock are added or subtracted depending on some pre-determined grazing conditions.

The most complicated approach is to use farmlet studies where whole farm management practices are replicated on a small scale. The success of these often revolves around the strength of the managements applied and the ability to build in flexibility when pre-determined managements cannot be met. Unfortunately, the small scale often combines with complexity to confound results.

A final approach is to examine case studies. This is seldom used in the farming industry, though this approach has many applications in general business management comparisons. Like farmlet studies there is a significant element of interaction between the factors. Outcomes are often the result of these interactions and the impacts of singular changes are often difficult to pin-point.

Dairy production

In a two year farmlet trial in the Waikato, no difference in milksolids production was found between the treatment areas which were direct or cross drilled with a range of improved ryegrass cultivars and the control areas (with no grass renovation) (Penno 1998; Thom & Bryant 1996). Thomson & Barnes (1990) found there was no significant change in the milk yield or the yield of fat or protein from grazing renovated pasture compared to old pasture.

Despite these general findings Penno (1998) still recommended that pastures which have run-out should be renovated, and only after the causes of the poor pasture have been rectified. He stated that a good indicator of the general state of the pasture is the amount of ryegrass evident from late autumn to early spring.

Sheep production

Lamb live weight gain on poor and medium ‘quality’ pastures were compared with finishing pastures in Southland (Stevens & Turner 1994). The poor quality pasture was a run-out pasture dominated by browntop while the medium quality pasture was a recently renewed ryegrass and white clover pasture. The finishing pasture comprised chicory, red and white clovers and *Bromus sitchensis*. Live weight gain over 18 weeks averaged 83 g/d for the run-out pasture, 135 g/d on the recently renewed perennial pasture and 185 g/d on the finishing pasture. Carcase gain also varied with conversion of liveweight to carcase weight being 5 to 10% lower as pasture quality declined.

Further comparisons of lamb and hogget live weight gains were made on a range of pasture species and compared with a resident control (Stevens 1993, 1994). These were summarised (Stevens *et al.* 2000) and indicated that average post-weaning growth rates were 110 and 200 g/d for unimproved resident and renewed pastures respectively. Stocking rates also increased with level of improvement from 15 to 25 lambs finished/ha for unimproved resident and renewed pastures respectively. When grazing management and fertiliser changes were made to the resident pasture then stocking rate increased to 21 lambs finished/ha and lamb growth increased to 170 g/d.

The effects of over-sowing white clover into hill country on sheep live weight gain have also been documented (Chapman *et al.* 1993). Little difference was recorded in annual dry matter production but stocking rate was increased by 1.3 s.u./ha from 15.0 su/ha. Total liveweight gain was increased from 478 kg to 517 kg/ha in unimproved and over-sown pastures respectively with significant increases occurring in summer (+18%) and autumn (+59%). When adjusted for stocking rate the individual animal performance was similar.

Increases in stocking rate in hill country development of 10 su/ha (White 1973) have been associated with dry matter increases of only 5570 kg DM/ha. This was associated with much higher pasture utilisation (56% compared to 26%) and higher crude protein content of the pasture (21% compared to 12%).

Beef production

Beef production on renewed pastures was compared to resident pastures in the Manawatu (Cosgrove & Brougham 1988). The weight gains of 3 to 18 month old bulls were approximately 200 kg/ha more on renewed pastures than the resident, an increase of approximately 10%. Those increases were seasonal with equal contributions during the first autumn when bulls were approximately 7-9 months old and the second summer when bulls were 16-18 months old.

Meat production from new pastures was 120 kg/ha greater than resident pastures or between 11 and 16% higher (Brougham 1981).

In over-sown hill country Barker *et al.* (1999) compared beef production from resident pastures with pasture renewed with cocksfoot. Individual bull growth rates were similar on both pastures but stocking rate was 6% higher on the renewed pastures. During autumn, the sheep stocking rate was 11% higher on renewed pastures.

Animal health

Pasture renewal can have a significant impact on animal health. Animal health is a high priority for farmers with Daly *et al.* (1999) ranking it 2nd most important after pasture quality (though pasture growth was not included in the list).

A new pasture can change the endophyte status, reduce facial eczema, be chosen to alter internal parasite dynamics or have an impact on sheep fertility. Other features may include trace element and macro nutrient supply.

Ryegrass Endophyte

Ryegrass endophyte research was reviewed and collated extensively in the Grassland Research and Practice Series volume 7 (1999). This provided a comprehensive insight into the range of endophyte related issues on New Zealand farms.

Production in dairy herds was reduced by between 6 and 23% and only in some seasons, depending on environmental conditions (Thom *et al.* 1999a; Blackwell & Keogh 1999). This did not account for losses that may be related to the inability of cows to be milked due to ryegrass staggers.

The impact of ryegrass endophyte in sheep farming also covers a range, depending on environment. In spring the live weight gain of hoggets has been decreased by up to 35%, and in summer and autumn by up to 95% (Fletcher *et al.* 1999). A delay in lambing date has also been reported, though no other impacts on sheep reproduction have been measured (Eerens *et al.* 1994; Watson *et al.* 1999).

Research into beef production has produced results ranging from no response in the Manawatu (Cosgrove et al. 1996) to a 21% decline in the growth rate of yearling heifers and weaner bulls in Northland (Easton & Couchman 1999). This indicates the importance of environment on the impacts of wild-type endophytes as more negative effects are measured when temperature and humidity increase (Easton *et al.* 2001a; Easton *et al.* 2001b)

The response of red deer to endophyte has seen little research. Elk and Wapiti types are susceptible to staggers, while red deer are more tolerant. No difference in live weight gain was detected in red deer grazing either endophyte-free or high endophyte ryegrass in Otago (Stevens *et al.* 1992).

When attempting to quantify the impacts of ryegrass staggers Everest (1983) suggested that significant costs would be incurred as a result of stock deaths which may increase by between 2 and 10%, supplementary feeding to help alleviate the symptoms, and lower live weight gain in lambs. Other costs may include the need for extra labour to monitor flock health and feed out.

Since the publication of the Grassland Research and Practice (1999) major advances in the types of endophyte available have been made. These include the commercialisation of AR1, NEA2 and AR37.

Sheep production on pastures with AR1 endophyte has been intensively studied. No significant differences in sheep growth rates, lambing percentages and dag burdens have been recorded between ryegrass with AR1 or with no endophyte. Both AR1 and nil endophyte ryegrass produced higher lamb growth rates and lower dag scores than wild type endophyte (Easton *et al.* 2001b).

Bluett *et al*. (2005) argue that ryegrass with the new endophyte had similar DM yields to those measured in ryegrass with wild endophyte and imply that the reduction in ryegrass staggers and better animal health are the reasons for the production gains. Cows grazing AR1 infected ryegrass pasture produced an extra 26kg milksolids/cow or 74 kg milksolids/ha (Bluett *et al.* 2005a).

(Urlich 2006) compared the new novel endophytes, AR1 and AR37, with wild type endophyte. Cows grazed on ryegrass infected with wild-type endophyte produced 20% less milksolids compared to the new endophyte pastures. In an indoor trial, cows fed AR1 produced 12% more milksolids than those fed AR37 and 17% more than those fed pastures with wild-type endophyte.

Slightly conflicting reports are given from a small plot trial by AgResearch where AR37 plots averaged 10-12% DM gain over AR1 plots, and most of the extra feed was available in summer and autumn (Searle 2006). It was calculated that the increase in DM from AR1 could result in an extra $450/ha/yr from extra milksolids production.

Facial eczema

Maintaining high grazing residuals is seen as the key tool for controlling facial eczema associated with the build up the mycotoxins produced by saprophytic fungi growing in ryegrass pastures (Lambert *et al.* 2004). Other strategies suggested include grazing animals on alternative forages or crops in high risk periods. This argument can be put forward to support pasture renewal practises that include alternative species to ryegrass or improved cultivars (Woodfield & Easton 2004; Lambert *et al.* 2004).

Internal parasites

Research has suggested that some pasture species may have anthelmintic properties (Grieve 1931) or influence nematode larval dynamics on pasture (Moss & Vlassoff 1993). Further research has endeavoured to investigate the true roles of pasture species in internal parasite management in more depth. Knight *et al.* (1996) found that only chicory fed lambs had regularly lower faecal egg outputs than other pasture species. Some suppressive influence of plantain and legumes were evident though not always present. Adult burdens were only suppressed by chicory diets.

Both faecal egg output and adult worm burdens are generally higher for grasses than legumes, while some herbs have some effects. Low dags are not a good indicator as Lotus tends to support high adult numbers and larval output but low dags and good animal performance (Knight *et al.* 1996;Leathwick & Atkinson 1995a; Leathwick & Atkinson 1996). There are some differences between grasses, though larval challenge is always relatively high (Niezen *et al.* 1993).

Some evidence points to variations in parasite effects between pasture species. The live weight gain, wool growth and faecal egg count was evaluated for ewe lambs grazing on a range of herbages with and without condensed tannins over a six week period. The pasture species compared were Maku lotus, *Lotus corniculatus*, sulla, plantain, lucerne and ryegrass/white clover. Drenched lambs grazing lucerne had the highest LWG (243g/day) and lambs grazed on plantain had the lowest LWG at 51g/day. The lamb growth rates were lower for the un-drenched animals ranging from those grazed on Sulla (175g/day) down to a loss of 2g/day for the animals grazing on plantain (Robertson *et al.* 1995). Wool growth followed similar patterns and the FEC's were lowest on animals grazing Sulla and highest on those grazing Maku lotus. High production levels obtained in lambs with high worm burdens grazing Sulla and Maku indicates these herbages could be used to reduce the use of anthelmintic drenches. In another trial five forage species (*Lotus corniculatus, Lotus pedunculatus, Hedysarum coronarium, Onobrychis viciifolia* and *Dorycnium rectum*) containing high levels of condensed tannins significantly improved animal production and reduced the dependence on anthelminitic drenches (Waghorn *et al.* 1998).

Parasite burdens and lamb growth was also evaluated on a ryegrass swards compared to other swards including browntop, Yorkshire fog and tall fescue. Lambs grew best on the ryegrass sward, followed by those on Yorkshire fog, then browntop and growth weights were poorest on the tall fescue swards (Niezen *et al.* 1993).

Dags in sheep

The reduction in dags also has implications for other management practices such as crutching and the risk of fly strike. Wild type ryegrass endophyte has been shown to increase the prevalence of dags (Pownall *et al.* 1993; Eerens *et al.* 1992) and *Lotus corniculatus* (Leathwick & Atkinson 1995b) and plantain (Turner 1999) have both been observed to reduce the incidence of dags.

Pests

Pasture renewal provides the opportunity to eradicate pests and diseases from pasture. Altering pest and disease populations is a double edged sword in pastures.

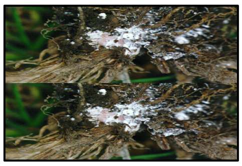
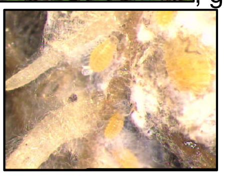
Removing grass grub and porina populations through cultivation provides short-term benefits but significant medium term costs when pastures are re-infested. Grass grub populations for example are normally low when a pasture is established but increase predictably (East & Kain 1982) to a peak in 2 to 5 years (Jackson 1990; Fraser 1994). These populations then collapse due to bacterial invasion and starvation (Kain 1975) and other biological factors (Jackson 1990).

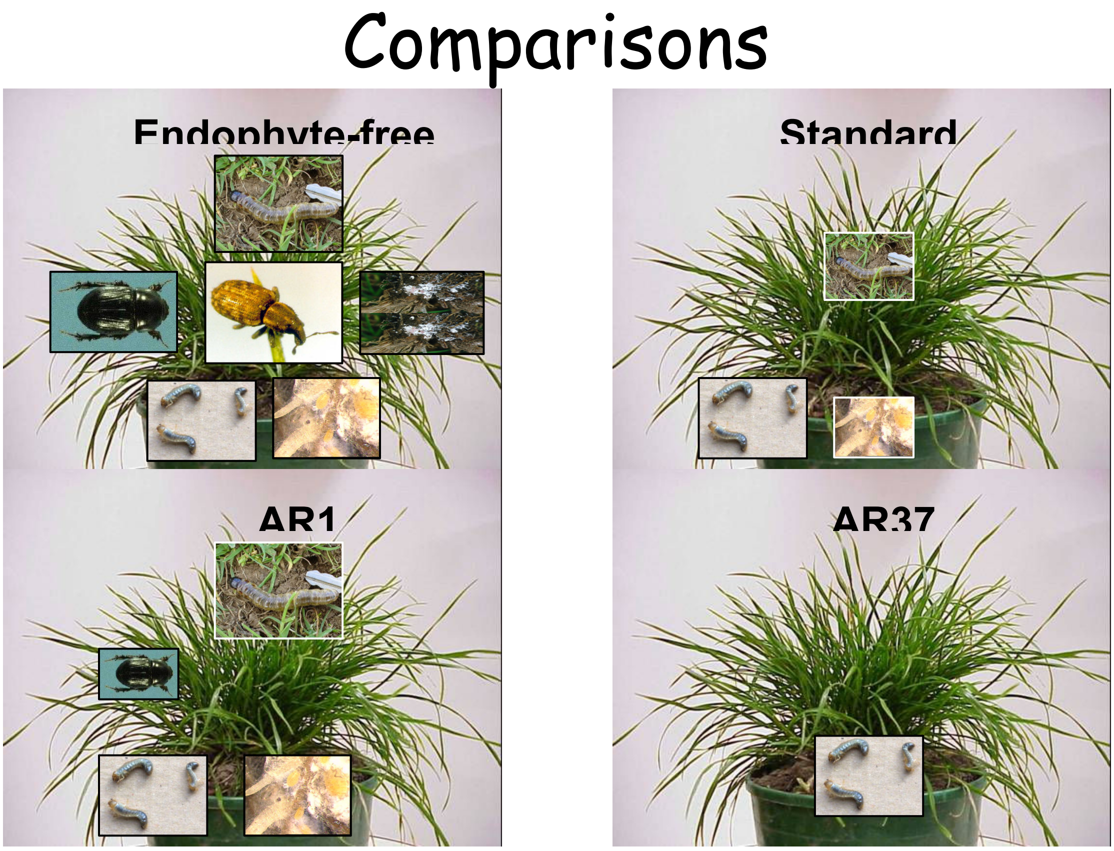
However, choosing a rust-free cultivar can have significant long term advantages in both dry matter production and pasture utilisation.

Traditional pests such as grass grub can have a significant impact on the outcomes of pasture renewal. In an irrigated pasture in mid-Canterbury (Fraser unpublished data) the establishment of a new pasture by direct drilling resulted in an average annual yield of 13100 kg DM/ha over the following 3 years, a decrease of 2100 kg DM/ha. Much of the variation between positive and negative results comes from the establishment period and grass grub attack during year 3.

Figure 2 (Hume *et al* 2006) shows the relative importance of the current ryegrass endophyte types in deterring insect damage. Their presence on the figure indicates that they are susceptible to attack from this pest. Insects included here are:

Argentine stem weevil , black beetle ,

Porina , grass grub , pasture mealy bug  and root aphids. 



Ryegrass with the new endophyte AR1 has been shown to provide an improvement in milksolids production in the range of 6.7% (Bluett *et al.* 2005b), 8.9% (Bluett *et al.* 2005a) to 9% (Thom 2006), or a 5-10% difference over a season (Willing 2001) when it's compared to ryegrass pasture with the wild or standard endophyte. These researchers generally cite the better insect protection leading to better persistence of the grass and more grass growth, especially in insect prone regions like Northland, Waikato, Bay of Plenty and Canterbury as the reason for the benefits. This has been confirmed by (Popay *et al.* 1999)(1999) over several sites throughout New Zealand, though protection against black beetle is not always robust (Popay & Baltus 2001).

Some other reasons put forward for renovating pasture are to reduce the impact of clover root weevil (Dixon 2006), as well as nematodes (Taylor 2004).

Management

There are significant impacts of the process of pasture renewal in the farming system. How important are these compared to the actual change of pasture botanical composition?

Pasture renewal can impact by changing soil fertility and physical properties, on the supplementary feed supply through cropping, and the improvement of feed quality through improving pasture utilisation. The on-going benefits of pasture renewal can also be altered by the success of the establishment process.

Soil fertility

Pasture renewal provides an opportunity to correct any soil limitations. Soil fertility may be changed through the introduction of lime to alter pH or the addition of capital fertilisers. These changes are made by the farmer and can be applied to any pasture regardless of the requirement or action of renewal.

Cultivation may alter soil fertility. The act of aerating a soil and removing the growing plant can increase the amount of nitrogen and other nutrients that are available to the establishing pasture. O'Connor (1993) cites Ludecke (1979) showing that available nitrogen in the form of nitrate increased significantly one

month after cultivation, while remained relatively static under the associated permanent pasture. This accumulation of nitrogen before sowing can significantly improve the survival and development of new seedlings, and hence on the success of establishment and potential pasture longevity.

Direct drilling can prevent nutrient dilution. Soil fertility is often concentrated in the top 5 cm under pasture (O'Connor 1993). Cultivation can dilute the nutrient concentrations in the rooting zone by mixing the fertility in the top 5 cm with the much less fertile soil below it. This in turn may reduce the yield of new sown pastures. This occurs more frequently where soil fertility is limited or fertiliser additions to the soil are relatively recent.

An example of this comes from the Meat & Wool NZ Monitor Farm programme. A single paddock was renovated in the Te Anau basin, a region where soil fertility is low and soils have been in farming for less than 50 years. Pasture yield was increased significantly when direct drilled but was reduced by full cultivation. The fertility of the soil was diluted by cultivation, hence reducing yield even though similar nutrients were applied as fertiliser (Gibson *et al.* 1999).

Overall nitrogen mineralisation under cultivated or direct-drilled soils is not significantly different when viewed over 12 months (ref). Therefore the approach to pasture renewal may be a difference between the successes of these techniques. If a significant fallow is allowed in direct drilled situations then a build-up of both nitrogen and soil moisture may significantly improve the speed and success of establishment

Supplementary feed supply

Pasture renewal may be the flow-on outcome from a farmer's need to grow supplementary feed for periods when pasture supply is short. This may occur in summer and autumn in summer dry areas, or in winter. Crops may be required to achieve this and therefore a permanent pasture must be sown out once the crop is used.

The provision of summer or winter feed becomes a significant feature of a farmer's farming system. Farmers do this to improve their outcomes through more reliable feed supply leading to improved stocking rates and animal performance.

Changing feed utilisation

Removing pastures from grazing for renovation during periods when growth exceeds animal demand provides the opportunity to increase the utilisation of feed on the parts of the farm that remain in pasture. This in turn usually improves pasture quality and future animal performance. This opportunity was recognised by all four groups of farmers that were used to help develop the Meat NZ Pasture Quality workshop programme (Lambert *et al.* 2000). Quantification of this effect has never been measured.

Impacts and variability of establishment techniques

Establishment of a new pasture can vary significantly. Techniques may range from over-sowing to direct drilling and cultivation. Methods to control resident pasture vary, as do techniques employed to alter weed and pest populations. Physical factors such as depth of sowing, seed bed compaction and soil condition also vary significantly as do seeding rates.

Despite these factors initial establishment success is often considered adequate.

Sowing rates are often kept high to suppress weeds and ensure a uniform establishment of the new species. Research to date has shown that seeding rates can be reduced significantly without any reduction in pasture productivity in good conditions.

Experiments with seeding rate have shown some evidence of weed suppression in the first 12 months. In Southland, (Harris *et al.* 1973) showed that a seeding rate of 34 kg/ha approximately halved the contribution of weed grasses when compared to a sowing rate of 17 kg/ha, but after 30 months weed grass contribution was similar.

Under irrigated North Otago dairy pasture no evidence of weed grasses was reported in pastures sown with 3.5, 7 and 10 kg ryegrass/ha, and total sowing rates of 16 kg seed/ha 18 months after sowing (Hurst *et al.* 2000).

Some environments are particularly hostile to the establishing of pastures. An example of this was reported for North Canterbury dry hill country over-sowing (Archie *et al.* 1993). Attempts to over-sow new pastures into sunny aspects were made on five occasions in autumn and winter, and both with and

without herbicide. All of these were unsuccessful for both legume and grass establishment. Average rainfall over the experimental period was 494 mm/annum.

In a higher rainfall site (575 mm/annum) in the same region White et al. (1972) reported successful establishment of both grasses and legumes on shady faces, though very limited success on sunny faces. The study also included sowing grasses with clover or 3 years after clover over-sowing. The success of grass establishment was significantly improved if clover and fertiliser had been previously introduced suggesting that soil nitrogen availability may be a significant factor in establishing grasses in these more hostile environments.

Establishment into cultivated soil in this environment was also considered a success (Archie & Vartha 1985). Adding brassicas to the pasture mix is often used by farmers to increase summer feed supply options. Increasing the rate of rape seed in a mixture from 0 to 2.2 kg/ha decreased the contribution of the pasture component by approximately half over the first 6 months from establishment in Southland, although total dry matter yield was similar (Harris *et al.* 1973).

Each of these factors can interact with the success of establishment. While establishment practices have been well documented (e.g. Pasture Renovation Manual; Pottinger *et al.* 1993), it is the variability of establishment success that can often decide the ongoing benefits. These factors are often under control of the farmer and will be part of the decision making process when balancing the risk of a certain approach with the final benefits.

Pasture reversion

A significant factor in farmer's confidence to adopt new cultivars is the lack of understanding around the longevity of perennial species and cultivars. Several studies have been initiated to describe the conditions that relate to pasture species persistence (Smith *et al.* 1998; Daly *et al.* 1999; Korte et al. 1991). One driver of such studies has been a shift from the use of ryegrass as the base grass species to other perennials such as cocksfoot, tall fescue and phalaris.

Pasture species persistence was ranked by farmers as the 4^{th} most important factor in whole farm performance (Daly *et al.* 1999) after pasture quality, animal health and soil fertility. All of these factors scored highly (17-18) on a scale of 1-20.

New pastures on dairy farms were expected to last 10 years (Hills & Hills 1997; Matthews 1986), before the pasture deteriorates and the level of unsown species increases.

Sheep and beef farmers ranked their reasons for defining a paddock as needing renewal by the species present, low pasture production, poor animal performance and age (Daly *et al.* 1999). When asked how long they thought a paddock should last 76% indicated more than 10 years and 31% more than 20 years. The average rate of pasture renewal was 5% or 20 years, consistent with farmer expectations. However, 68% of the farmers stated that their most persistent paddocks were under 20 years of age. This implies that there are significant interactions between pasture persistence and farmer ability to achieve the expected persistence. This also suggests that some farmers are getting pastures to persist for much longer than others.

Several factors impact on longevity. These include the original species sown, the presence of pests and diseases, establishment success, grazing management, soil fertility, soil physical properties and soil moisture status.

A lack of understanding of pasture ecology and the fate of newly sown ryegrass and white clover may hide the regression of renewed pastures. The visual assessment of pastures does not provide a true indicator of the longevity of the sown species because most paddocks have a significant reserve of these species (through seed or vegetative regeneration).

Examples of this are provided through comparative studies of pasture species presence in sites where ryegrass is not sown and where some genetic markers are used to track the true prevalence of the sown species.

White clover longevity

White clover can produce significant amounts of seed which creates a potentially large seed bank as buried seed (Clifford et al. 1990). As clover goes through the transition from a tap rooted plant at establishment to relying on stolon re-establishment after winter (Brock & Hay 2001) it becomes more vulnerable to damage. This provides the opportunity for resident clover to re-establish from a buried seed load.

Chapman *et al.* (1993) used genotype frequency to determine the contribution of introduced white clover to total clover production 4 years after over-sowing in hill country pastures. Estimates of the contribution of the sown clover to total clover yield were 56 to 79% from the introduced clover. Other estimates have ranged from 0 to 30-40% after 4 years (Charlton 1984; Lambert *et al.* 1986), while measurements after 20 years showed little sign of the sown cultivar (Forde & Suckling 1977).

These estimates must be viewed with caution, however, because breeding programmes have been undertaken to improve the adaptability of clover cultivars to a range of soil fertility and grazing systems. The estimates by Chapman *et al.* (1993) are for one such cultivar, bred to replace the cultivar measured in the other studies (Charlton 1984; Forde & Suckling 1977; Lambert *et al.* 1986). Further estimates (Chapman *et al.* 1995) at 8 years showed that the sown cultivars contributed 56 and 14% of the total clover present for adapted and general cultivars respectively.

More recent work has studied the persistence of cultivars bred for specific conditions. (Dodd *et al.* 2001) also showed that white clover persistence increased if the cultivar was specifically bred for the environment, with a general cultivar making up 27% of the population while a specifically bred cultivar contributing 56% of the population after 5 years, declining from 43 and 82% after 2 years respectively. Further declines were recorded with a final abundance of the sown clovers declining to 3 to 4% after 11 years.

These data also show that poorer establishment also results in lower contributions in sown species earlier in the pastures life. For example Dodd *et al.* (2001) showed that the contribution to white clover production for a well established cultivar fell from 82% in year 2 to 56% by year 5, while a poorer established clover fell from 43 to 27% over the same time period.

Ryegrass longevity

Ryegrass contamination is a common issue with the sowing of other species such as cocksfoot and tall fescue. Daly *et al.* (1999) found that pastures sown in these species had ryegrass present in 22% of cores samples in paddocks 5 to 20 years of age (estimated mean pasture age was under 10 years).

Ryegrass regression varies markedly, depending on the pasture species present before the pasture is renewed. For example, when pastures are sown into a site where ryegrass presence is minimal little contamination occurs.

This was demonstrated in a series of hill country pasture renewal studies. Where resident ryegrass content was high, the estimate of sown nil endophyte ryegrass after 4 years was 5 to 44% of the ryegrass present (Saunders *et al.* 1989). However, where little ryegrass was present a decline in ryegrass content from 80% down to 50% was the overall outcome over 6 years (Stevens & Turner 1993).

At a further site where resident ryegrass was also abundant, estimates of re-infestation based on endophyte presence suggested that only approximately 10% of the ryegrass present after 5 years was the original resident (Moloney *et al.* 1993). Again significant interactions between the cultivar and environment may occur though long term studies are relatively rare though protein banding techniques are available to distinguish between cultivars.

The impacts of climatic extremes

Specific events such as drought played a major role in step-wise reductions with sown clover contribution in over-sown hill country being halved in a single drought event, regardless of adaptation to the environment (Dodd *et al.* 2001).

Changes in endophyte occurrence in ryegrass can also reflect significant environment x pest impacts on sown cultivar presence. (Stevens & Hickey 1990) found that in a pasture sown with a low level of

endophyte, the endophyte presence in ryegrass went from 5% to 20% with a single drought event under sheep grazing.

In dairy pastures, similar impacts have been observed, again measured by changes in endophyte presence. (Thom *et al.* 1999b) reported pastures sown as non-endophytic shifting from 26% to 50% after 3 years in one trial and from 6 to 16% in another, indicating the establishment and subsequent shift towards unsown ryegrass.

These shifts may be in conjunction with variations in pest attack due to climatic conditions, as well as specific death of introduced species. It also highlights the advantage of high endophyte ryegrass in avoiding grazing (Edwards *et al.* 1993) resulting in potential overgrazing of low endophyte grasses.

This highlights the role of seed banks in the soil and introduction of new seed from other places in re-colonisation of bare ground.

Impacts of grazing

Grazing management affects both the success of the original establishment of a pasture and on the longevity of the sown pasture.

In the 12 months after establishment ryegrass production was maximised by infrequent grazing from 20 cm to 1 cm in both spring and autumn sowings compared to frequent grazing from 6.5 cm to 1 cm (Harris *et al.* 1973). White clover production in the same set of experiments was unaffected by grazing frequency after an autumn establishment but was significantly reduced by infrequent grazing after a spring sowing, especially by long spelling in the autumn (Harris *et al.* 1973).

The financial benefits will be realised only when the extra pasture production and quality is utilised effectively, so new pastures must be grazed more frequently than old pastures (Hainsworth & Thomson 1997; Hamilton-Manns & Milne 1997).

The level of grazing on establishing pasture is a concern in the wet winter months (Hockings 2006). The root systems are shallow and sparse with low tensile strength and are easily damaged under heavy grazing. Pugging damage can lead to low plant density and a decrease in dry matter production.

There is a general concern that renovating pasture with new ryegrass cultivars, especially those with novel endophyte (or high sugar content) and the associated increased palatability is resulting in less persistent permanent pasture (Bielski 2006).

Other changes in farming management may also influence the persistence of new pasture, for example in the past the standard supplement was hay and there was a greater degree of natural reseeding compared to modern situation where more silage is fed out (Bielski 2006).

Capturing the benefits

Farmers seldom consider a cost benefit analysis of pasture renewal when they replace a pasture that has run out. The benefits are perceived to be so large that they significantly outweigh the costs. The farmer can see that he will have a pasture that is ‘as good as new’ in the shortest possible time, and he will usually fix any problems with the soil fertility and physical properties.

More recently the requirement for pasture renewal has shifted from the traditional question ‘is the pasture run out?’ to a more strategic approach. One of the drivers for this has been the dramatic increase in both the range of pasture species and cultivars and the increasing diversity and specialisation in specific parts of agricultural production. Farmers moving away from general productivity to specialisation in lamb or bull finishing, or winter milk supply are taking greater advantage of a wider range of cultivar characteristics such as heading date, longevity and feed quality.

Issues of capturing the benefits arise when farmers consider renewing pastures as part of the longer term strategy of making pastures ‘better than new’. This implies some added benefits of pasture renewal to the

underlying productivity of the system. With this focus then farmer has to decide on strategies to achieve a new level of production. Cost benefit analyses and comparisons may be required of several options including capital fertiliser inputs, subdivision or even the purchase of more land. Often a change in the system is required to capture the benefits of changing seasonal pasture production and feed quality. Farmers make these decisions using processes that may range from experience and intuition to objective measurement and formal analysis. Most surveys say New Zealand farmers use a subjective-informal management model with little objective measurement (Parker 1993).

A series of investigations into the economics of pasture renewal was undertaken by Monsanto in 1999. Farm consultants identified benefits of pasture renewal in 6 regions around New Zealand (Appendix 2) and then made the assumption that farmers could capture those benefits. When this assumption was made, pasture renewal became highly economic as a means of increase pasture quantity and quality.

(Webby & Sheath 2000) investigated the impacts of changing both seasonal pasture production profiles and increasing feed quality. In their analysis they did not specify how these changes may be made, but instead concentrated on what system changes would be needed to capture the benefits. This gave the opportunity to examine the break-even value of each change. This type of approach gives farmers a framework to cost various options for changing the system or increasing production.

The literature provides many examples of ways to capture the benefits of pasture renewal. Often these are expressed as a farmer case study or computer modelling to capture the potential benefits. A standard method of evaluating the economics is to include a time to pay back the investment in pasture renewal.

The approaches taken often acknowledge that pasture renewal can often be an investment. Several consultants have done cost-benefit analyses showing the overall outcomes of pasture renewal. Of specific interest is (Collier 1994) who stated that often improvements in the region studied are gained just by adding capital fertiliser. This puts pasture renewal into the perspective of one part of a process in restoring pasture to ‘as good as new’.

Research has also tried to understand how to capture the benefits. Different approaches have been tried. Two of note are the full farmlet system and the put and take system. The farmlet system puts pasture renewal into the full system and then tries to manage that system based on decision rules to capture the benefits. Unfortunately the decision rules are often derived from the standard system which can mask the improvements if they don’t fit the standard system management. This has been seen when using tall fescue, for example (McCallum *et al.* 1992) which has different grazing requirements than ryegrass and has been used successfully by some farmers (Milne per comm.).

The put and take system is commonly used in sheep research (e.g. Westwood & Norriss 1999; Moss *et al.* 2000; Stevens *et al.* 2000). While it can accommodate variable stocking rates and grazing managements, it suffers from not demonstrating the fit of the benefits with any farm system. It leaves this step to the farmers.

Therefore the farmer is often left wondering how to reconcile the potential of pasture renewal with a gain that he might make on his farm.

Examples of documented improvements are found in the literature. Several years of research and promotion of the benefits of pasture renewal in Southland culminated in a survey of farmers to provide documentation of how farmers had benefited from pasture renewal as their primary source of change (Boswell 1996). Farmers compared their current production with previous production before pasture renewal, and were also compared to a cohort of farmers who had not increased pasture renewal. Of note were increases in stocking rate, lamb carcass weight and two tooth mating weight. Lamb sales date was also advanced and lambing percentage increased from 103 to 121 over 5 years.

Modelled outcomes of the research results (Stevens 1993, 1994) using Stockpol showed that a 20% increase in gross margin could be achieved by the time 50% of the farm was upgraded (Webby 1996). Further analysis of these figures showed that a pasture renewal rate of 10% of the farm per annum was required to significantly impact on whole farm profitability as a rate of only 5% did not keep up with the reversion of pastures (Gibson *et al.* 1999).

(Cocks *et al.* 2002) also highlighted improvements in feed quantity and quality as important factors in improving sheep farm performance, though identified pasture renewal as one of several options to achieve this.

The financial evaluation of hill country improvement which included capital fertiliser inputs, pasture renewal and intensified grazing management (Parminter 1991) identified several productivity parameters

that had to be met before pasture improvement was economic. In a previous study (Frengley & Andersen 1989) identified the critical determinants of profitability were farmer skill and farm performance, highlighting the importance of individual circumstances in capturing the benefits.

A study of the key profit drivers for the dairy industry in Victoria, Australia looked at more than 10 physical measures of farm performance including the area of pasture renovation each year (Moran *et al.* 2000). The least profitable only renovated 10% and the most profitable renovated almost 19% of the farm area.

Another factor in capturing the benefits is environment. Ogle *et al.* (2000) evaluated several years of pasture renewal on Earnscleugh Station in Central Otago. They concluded that the improvements did not improve farm profitability, mainly due to the inability to capture the benefits in a relatively hostile and low performing environment. This reflects the conclusions of Frengley & Anderson (1989) who suggested the high farm performance was a primary indicator of profitability in hill country pasture improvement.

Examples in dairy farming come both from research and farmer studies. A farmlet study (Pitman 2005) highlights that pasture renewal is one of several options to increase feed supply on a dairy farm, each with their own management parameters to ensure success.

Thom *et al.* (1987) stated that when pasture production increases occurring as a result of pasture renewal were converted to milkfat returns the cost of establishment was paid for in 1-2 years.

Pasture renewal was documented on a Waikato dairy farm (Edgecombe 1988) as a way to improve farm profitability through stocking rate and per cow performance. This study highlighted the integration of pasture renewal as a form of investment when changing farm productivity. Other studies have also indicated that per cow and per hectare performance can be improved, along with net profit by using pasture renewal (Alexander & Mouton 1996; Reid 1996). Savage & Lewis (2005) indicated that farm profitability was strongly related to increasing amounts of pasture harvested on dairy farms and pasture renewal is one method to provide extra feed for harvesting.

On the Lincoln University Dairy Farm top paddocks are estimated to produce 23 tonne (t) of dry matter (DM)/ha/yr, while the worst paddocks produce approximately 15t DM/ha/yr. The difference between the extremes is calculated to be 500kg milk solids and potentially $2000/ha with a payout of $4/kg MS (Kerr *et al.* 2006). On the LUDF a paddock was monitored before and after pasture renovation, and achieved a $1160/ha gain in income in the year of renovation, from a $550/ha cost to renovate. They stated that renovation benefits would continue of the following five years, and conservatively add up to a $5800/ha return from renovation. The management team argued that by targeting the poorest paddocks for pasture renewal and contouring production can be improved (Lee 2006). In a different particularly poorly drained paddock on the LUDF, the cost of re-levelling and sowing a 9.66ha paddock was a once only $2660/ha, which gave an immediate $3670/ha increase in milksolids income and theoretically would see an increase in income of almost $20,000/ha over five years.

More conservative benefits are reported else where (Taylor 2004), at a presentation given by ‘Pasture Partners’, Rex Webby reported a net benefit from pasture renewal of $417/ha for dairy farms based on an estimated 7 year life of the pasture.

Other farmers have indicated that pasture renewal wasn’t worth the cost or effort (Yates 1997). In an attempt to improve grass production in the summer month’s drought resistant cultivars of red clover, cocksfoot and tall fescue were introduced. Dry matter products and stock performance were assessed and no major difference was found when the over-sown paddocks were compared with other paddocks on the farm. The farmer preferred to increase productivity with drainage, fertilisation, irrigations and grazing management.

The final outcomes from these examples indicates that the most important feature for making pasture renewal pay is a mind set in the farmer that recognises the potential and goes about capturing it through changes to his system, be it stocking rate or improved utilisation. Interestingly the changes most readily occur when the current production level of the farm is high.

Cost benefit analyses reported a $76/ha return from increased grazing days per hectare on new pasture compared to old pastures which had no new species for more than 15 years (Croft 1998) for one year. However the overall conclusion made by this author was that there is large variability in renovated pastures. The rhetorical question was asked if there is large variability on a well managed farm, how a poorly managed farm could actually make improvements.

These pasture renewal programmes always occur along with changes in management, fertility and stocking rate. For the benefits of pasture renewal to be captured it is always recommended that changes

such as these are made. When changes in management, stocking rate and animal performance are required, often pasture renewal is the method by which a more appropriate feed supply is achieved. Therefore it is always difficult to allocate cause and effect.

Conclusions

Pasture production is often increased by pasture renewal. These increases are in the range of 10 to 35%, with some increases being well beyond this, due to the initial state of the pasture. Increases can be measured in most seasons. Introducing species other than ryegrass and white clover can significantly alter the seasonal distribution of pasture growth, but seldom increases total annual growth.

Individual increases in animal per head performance are greater in the sheep industry than in beef or dairy. These can be related to changing energy concentration but are often more likely to be related to changing the type of endophyte. Other influences may be factors such as improved palatability through reduced leaf disease or reduced internal parasite loadings on the pasture, though these factors are relatively un-researched.

Increases on a per hectare basis are often a result of increased stocking rate due to greater pasture production. Occasionally both per head performance and stocking rate increase. The translation of these improvements into net on-farm gains requires recognition that the potential pasture and animal responses must be converted into animal production. Important factors in this translation are utilisation of the pasture and optimisation of the system on a year round basis.

Genetic gain through plant breeding has the potential to add significantly to both pasture and animal performance if pastures have not been renewed for some time. Advances in the past 20 years have increased potential pasture productivity, for example, by 1.85 t/ha/annum and 2.5 t/ha/annum for ryegrass and white clover respectively. These gains may not necessarily be made at the same time due to competition between ryegrass and white clover, but does provide a significant opportunity for farmers. Farmers also need to realise that growing and utilising more feed means that more fertiliser is also required to maintain these pastures.

Longevity of a renewed pasture is a function of appropriate establishment, choice of appropriate species and cultivar and on-going grazing and fertiliser management. These factors are under the control of individual farmers and decisions may be made on the basis of knowledge, cost-effectiveness and cash flow. Other influences such as climate and pest attack are also important factors in the longevity of pastures. More is becoming known about these changes, for example the role of endophyte strain, and better control techniques at establishment are helping.

Sustainability leads on from longevity and little direct research has investigated this part of pasture renewal. Some work on changes in soil organic matter has been done but was not originally considered to be part of this review. More could be done to help put sustainability in perspective with the current climate change and green house gas emissions issues.

Pasture renewal has a significant place in New Zealand farming systems. Many advantages are known and more are emerging through new technologies. The recent increases in on-farm productivity are beginning to highlight the need for more pasture to be grown and pasture renewal is a cost-effective candidate for this.

Economic analysis

The economic analysis follows on from the information gathering to quantify the whole farm implications of pasture renewal. Four model farms were defined for sheep and beef, and five for dairy. Then varying increases in pasture production were applied. Benefits that were considered included pasture dry matter production, pasture quality, crop use, and endophyte.

The responses that have been put into the models are relatively conservative. A range of responses have been included to cover the most likely range found in the literature. We have used the prevalence of results so that we are leaving out ones that are not well represented or that are yet to be proven or well explained.

It is important to understand that the outcomes of any modelling are the result of the interactions between the biology encompassed in the model with the assumptions that are made. These analyses aim to put the range of measured responses into the context of a whole farm system. The final outcome is an understanding of the relative response surface that might be applied to the potential benefits that are available through pasture renewal. This provides a range of economic benefits that a farmer, for example, can interpret in their own situation. This approach helps farmers make an informed decision by integrating the economic analysis with their own experience and intuition, so combining some measured approach with the normally subjective-informal decision making process farmers usually use.

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Sheep and Beef

Improvements from pasture renewal

Pasture renewal can change a range of outcomes in a sheep and beef system. These vary depending on location and environment. Summer dry winter warm areas will benefit from changing seasonal production more than winter cold environments where the opportunity for extra growth in winter is much lower. However, these winter cold environments will benefit significantly from an associated cropping programme that transfers more feed into the winter and hence improves stocking rate and the opportunity to maximise feed utilisation at other times of the year.

Four sheep and beef systems were chosen to represent significant areas of the North and South Islands, as well as intensive and less intensive systems. Base pasture production models were chosen from the Farmax® database.

On examining the literature the most significant benefits that could be modelled for all of these cases were pasture dry matter increases, pasture quality increases, and a change of endophyte status.

Initial modelling of pasture quantity and quality changes was unable to effectively capture the benefits of pasture renewal. This is because not enough stock could be over-wintered to capture the benefits at other

times of the year. This indicated that seasonal feed profiles were important. Given the amount of feed required it was evident that the addition of feed grown through a cropping programme would be the most efficient way to add extra winter feed. Standard pasture production increases were unable to be fully utilised without the addition of winter crops to enable higher over-wintering stocking rates and therefore improved feed utilisation at other times of the year. This is similar to the change of system required to capture benefits that has been mentioned before.

Base assumptions in the sheep and beef modelling were that pasture renewal would be 10% of the farm per annum. Pasture production responses were modelled at 10, 20 and 30% to reflect the range measured in the literature. The amount of crop within the system was optimised to ensure the best possible stocking rate per annum to achieve maximal pasture utilisation and therefore does not necessarily equal the amount of pasture being renewed each year.

The process of pasture renewal was deemed to be optimised with best practice being used for establishment. This would include weed and pest control as well as addressing soil physical limitations.

Improvements modelled:

Apart from increasing pasture growth, the following assumptions were also made, based on the literature.

- Pasture quality increases with pasture renewal by and average of 0.5 MJME/kg , based on Barker *et al*. 1993, Stevens & Turner 1993 and Meat & Wool NZ Pasture Plan farm data.
- Changing to either improved or zero endophyte ryegrasses will increase weight in lambs by 5 or 10%. This is modelled for the two North Island farms to demonstrate the impact of such an effect. This will vary from region to region and year to year, depending on weather conditions. This response is relatively conservative compared to general effects that have been measured (Easton *et al*. 1999).
- The following factors are presumed to be addressed during the pasture renewal process
    - Soil fertility status (P) is good and is not a significant limiting factor to pasture productivity.
    - Soil physical limitations are addressed during the pasture renewal process.
    - Weed and pest limitations are removed during the pasture renewal process.
-
- Soil fertility status (P) is good and is not a significant limiting factor to pasture productivity.
- Soil physical limitations are addressed during the pasture renewal process.
- Weed and pest limitations are removed during the pasture renewal process.

Farm types chosen

The sheep and beef modelling were done used Farmax®. The range of farm types has been chosen to represent the major types of operation. Four sites were chosen from the Farmax® data base.

Central North Island (North Island hill country)

This farming type was chosen to represent farms that have a focus on breeding rather than finishing and have a limited area for cultivation and pasture renewal. Pasture renewal was focused on this part of the farm.

Manawatu flat (North Island finishing)

These farms are typically on flat to rolling country, use cultivation or direct drilling to renew pastures and have a significant income from finishing. They may represent both beef and lamb finishers. Often these farms have some summer growth restrictions.

Otago hill (South Island breeding finishing)

Farms in the South Island breeding finishing model are typically on rolling country with some summer moisture restrictions to growth. These farms are represented in Otago, Canterbury and Marlborough hill country with varying degrees of summer drought. Some lambs are finished on-farm, while others are sold store.

Southland fertile (South Island finishing)

Finishing farms in the South Island are usually under irrigation (Canterbury) or in summer moist areas (Otago and Southland). A base flock of breeding ewes may be present, but significant numbers of extra sheep and beef are bought in to finish.

Pasture production response

The area renewed in each case was 10% of the farm per annum. The amount of extra pasture grown was modelled at three levels, and in each case the longevity of the response was modelled over the same time.

The response to pasture renewal over the base data was calculated at 3 levels

Base + 10% extra pasture growth

Base + 20% extra pasture growth

Base + 30% extra pasture growth

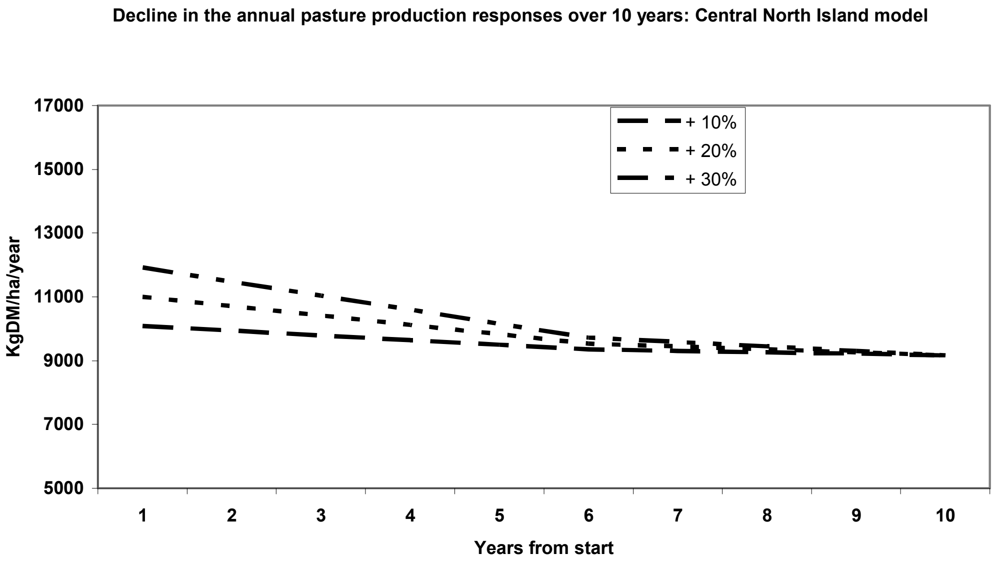
It was assumed that the new pasture would revert back to base production after 10 years with a decline in production of 16% from the first year after the first year, then 32%, 48%, 64% and 80% from the gains made between the old pasture and the new, after which the pasture production would decline at 5% to be at the old level at 10 years. Therefore:

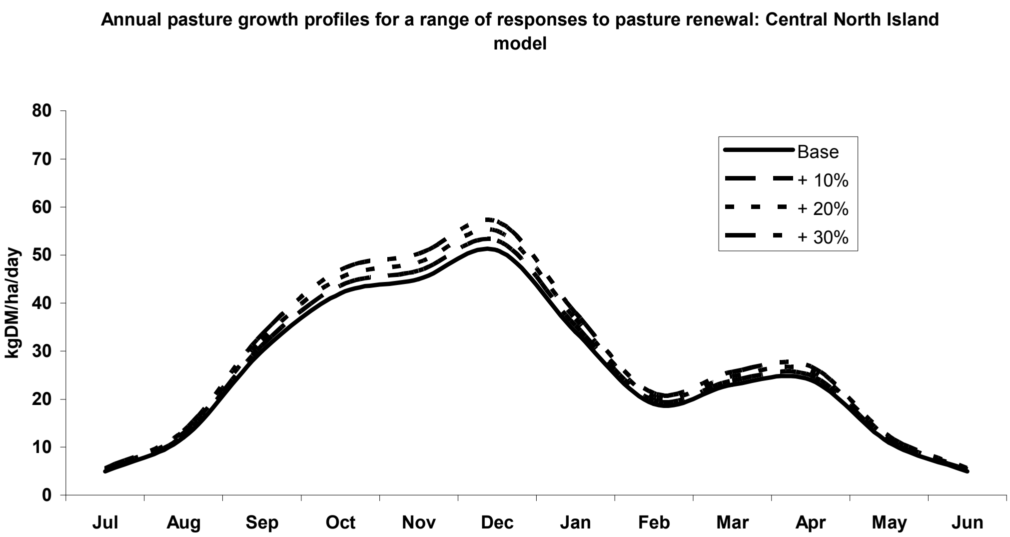
Pasture production = New pasture production – ((New pasture production) – (Old pasture production x the decline)).

This production curve provides most of the decline in production during the first five years. Relatively little data is available to examine this effect. Data from Radcliffe (1974) indicated a plateau for approximately 4 years after establishment before production declined, as did Stevens & Turner (1993). Other longevity work has indicated that sown species contributions were still at 40 to 50% after 5 years (Section: Pasture Reversion). However, other research suggests that reductions in sown species may be step-wise, depending on significant events such as insect attack or drought. Therefore the final response modelled was considered to be an intermediate position between these observations.

Annual pasture production and monthly profiles are shown below. The first figure in each pair shows the contribution of a new pasture to annual production over the 10 year life of the pasture. The second graph shows the final average monthly pasture production profile that is generated for each level of initial pasture production increase.

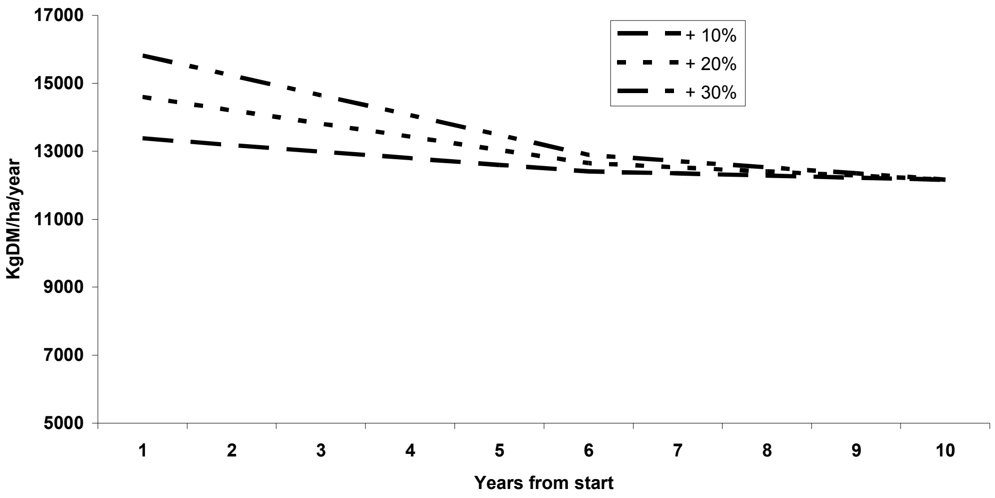
Pasture profiles for the Central North Island model (derived from the Farmax® data base).



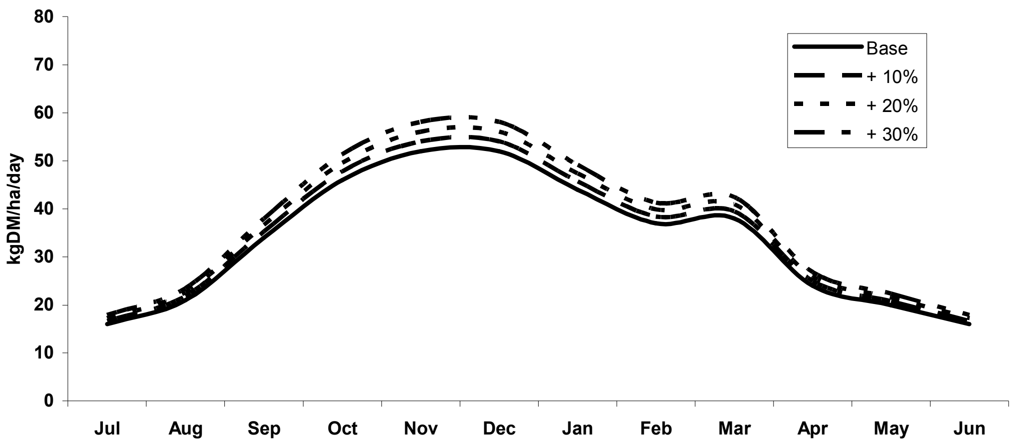


Pasture profiles for Manawatu flat model (derived from the Farmax® data base).

Decline in the annual pasture production responses over 10 years: Manawatu Flat model

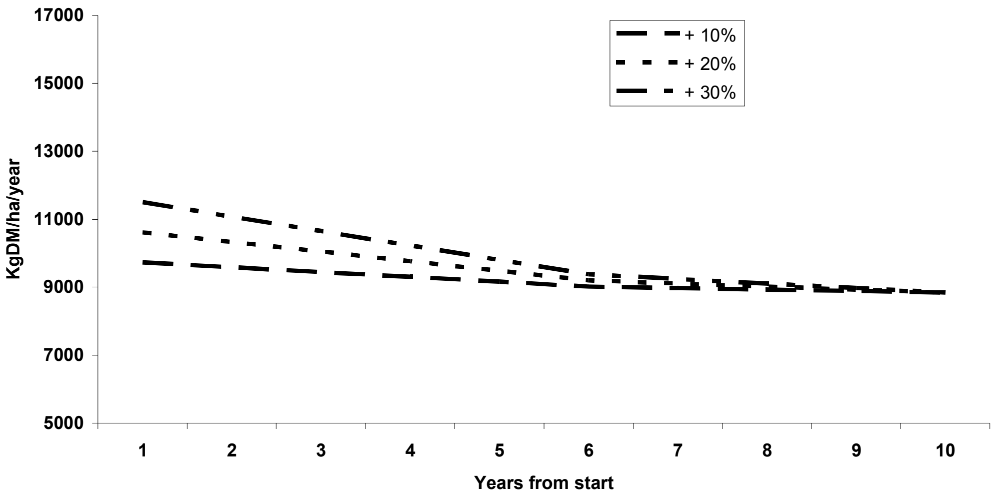


Annual pasture growth profiles for a range of responses to pasture renewal: Manawatu Flat model

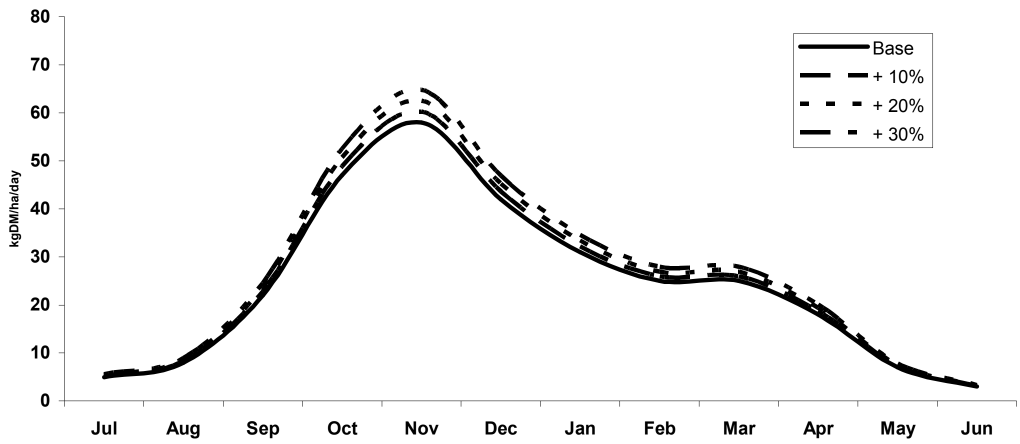


Pasture profiles for Otago hill model (derived from the Farmax® data base).

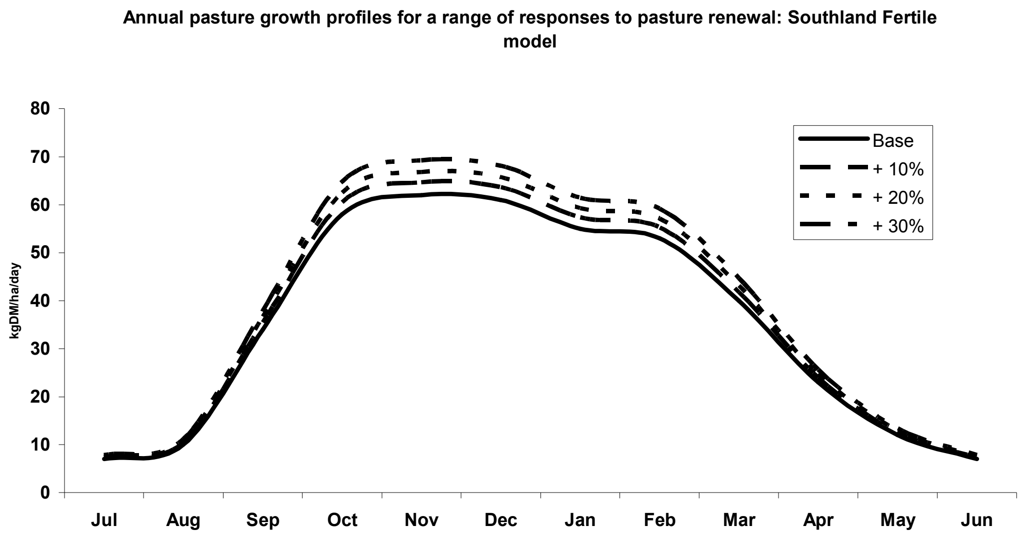
Decline in the annual pasture production responses over 10 years: Otago hill model

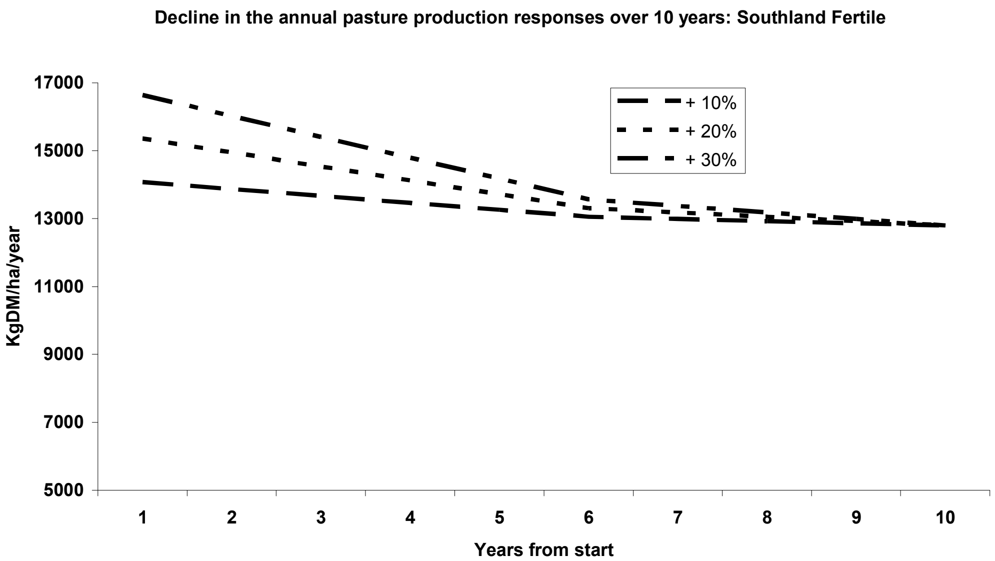


Annual pasture growth profiles for a range of responses to pasture renewal: Otago hill model



Pasture profiles for Southland fertile model (derived from the Farmax® data base).





Other assumptions in the modelling

- The average outcome for each farm type was done by modelling each of the 10 years of the pasture growth response profiles and then generating a weighted average response that is represented in the figures above.
- Silage was made and fed to balance winter feed deficits at 10.5c/kgDM, or $350/ha to make. In some instances these deficits could also be filled by the use of nitrogen fertiliser, depending on farmer circumstance.
- The costs of cropping and pasture renewal were added to the models and included in the gross margin calculations. Crops were cost at $600/ha and pasture renewal following crop at $350/ha.

- The crop chosen in the North Island models was kale at a yield of 11t/ha. The crop chosen in the South Island models was swedes at a yield of 15 t/ha.
- The Farmax® gross margin takes into account interest on capital in livestock and is inclusive of the other specific costs such as silage, cropping, animal health and shearing listed in the table.
- The crop and silage amounts were optimised in each system to maximise pasture utilisation at other times of the year.
- No crops or pasture renewal were included in the base system.
- Pasture growth in January, February and March was not altered with pasture renewal in the Manawatu flat and the Otago Hill models on the assumption that soil moisture was limiting more than pasture species.

Sheep and Beef model outcomes

The modelling showed that the overall result of pasture renewal provided a greater return per hectare in every case. The gains were lowest in the Central North Island hill country model ($89/ha for a 30% increase in pasture production from pasture renewal) and greatest in the two South Island models ($169 and $170/ha for a 30% increase in pasture production in the Otago hill and Southland models respectively).

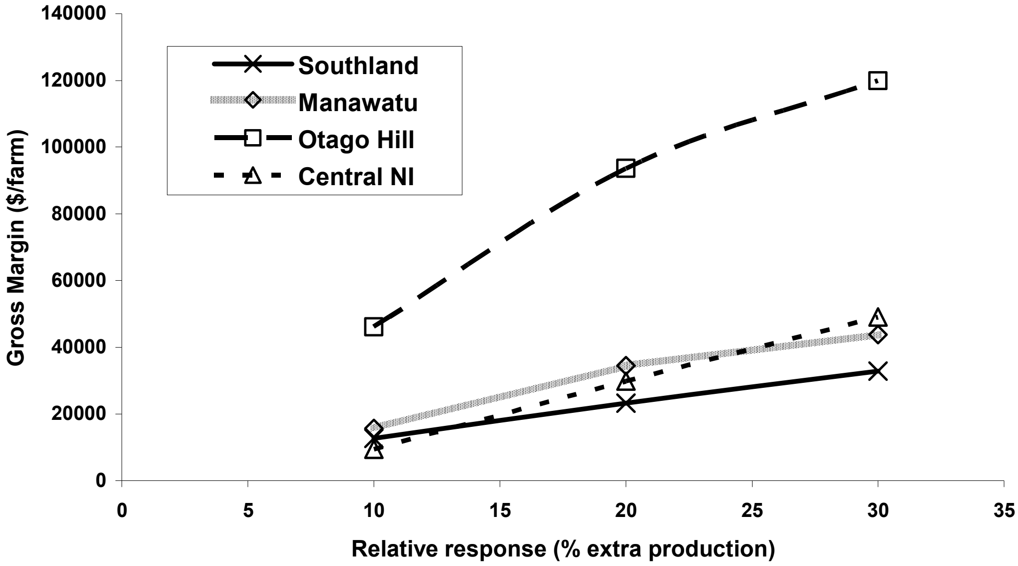
The gross margins per farm are graphed below and show the similar response for three of the four models. The one that stands out is the Otago hill model with both a high gross margin per hectare and a large land area. While this model appears to make significantly more money per farm it has to be remembered that this farm type also has significant fluctuations in pasture production from year to year due to climatic variation. The other farm models have a similar range of gross margin response per farm even though they range from 194 to 550 ha in size.

Previous results have suggested that a farm that is less productive would have a lower gain from pasture renewal but this is not the case in the models used here. The models are however optimised for the systems and this optimisation is a critical part of ensuring that extra grass grown is profitably utilised.

Another feature of the models is the different shifts in the amount of feed utilised as the benefit from extra pasture growth increases. In the two North Island models the maximum gain was made when the benefit from renewal increased from 10 to 20%, while the Otago hill model had the greatest gain with the initial 10% gain. The Southland model had similar gains with all increments of extra production.

To capture the benefits of pasture renewal the amount of crop had to increase as the amount of extra pasture growth increased. The two North Island models and the Southland model all increased similarly from 2.5 to 2.7% of the farm in crop at a 10% increase to 7.7 to 8.2% of the farm in crop if the increase in pasture growth was 30%. The Otago hill model differed from this being lower for all increments of extra pasture growth (2.1 to 6.3% of the farm in crop).

Changes in gross margin per farm on sheep and beef farms as the relative response to pasture renewal increases



The total product return ($/kg) produced a similar result in most cases. The value of product in the Central North Island model declined by $0.08 or 4% as the amount of extra pasture increased. This decline was 3% for the Manawatu flat and the Otago hill models, but was only 1% for the Southland model. This means that the results can be reasonably applied to production changes that may occur within this range of responses.

Outcomes of pasture renewal in two North Island farm models

		Region							
		Central NI				Manawatu			
Effective farm area	**(ha)**	550				393			
Impact of pasture renewal		Base	+ 10%	+ 20%	+ 30%	Base	+ 10%	+ 20%	+ 30%
Stocking rate	**(su/ha)**	12.3	13.9	16.1	18.0	14.9	16.5	18.4	20.0
Feed eaten	**(kgDM/ha)**	6790	7659	8875	9895	8174	9083	10132	10980
Area Crop	**(ha)**	0	15	30	45	0	10	20	30
Area silage	**(ha)**	45	45	45	45	20	20	20	20
Physical outputs									
Meat	**(kg /ha)**	175	192	216	240	322	350	380	401
Wool	**(kg /ha)**	47	51.5	58.2	62.9	48	52	56.5	59.6
Total product	**(kgDM/kg)**	29.7	29.7	29.7	29.4	21.9	21.9	21.9	21.9
Income									
Sheep	**($/ha)**	319	350	395	427	463	502	546	575
Wool	**($/ha)**	119	130	147	159	94	102	110	116
Cattle	**($/ha)**	179	196	220	245	314	340	370	390
Costs									
Silage	**($/ha)**	29	29	29	29	18	18	18	18
Crop	**($/ha)**	0	26	52	78	0	24	48	73
Health	**($/ha)**	46	51	57	62	50	54	59	62
Shearing	**($/ha)**	41	44	50	54	33	35	38	40
Gross margin	**($/ha)**	422	439	476	511	737	777	825	848
Total product return	**($/kg)**	1.9	1.86	1.84	1.82	1.99	1.97	1.95	1.93

Also modelled was the effect of improved lamb liveweight gain if the impacts of endophyte were removed. These were modelled for the two North Island models with a benefit of either 5 or 10% increase in lamb growth rate in summer and autumn. In the Central North Island model an increase in lamb growth rate of 5% and 10% improved the gross margin by $2/ha and $18/ha respectively. In the Manawatu flat finishing model the gross margin increased by $13/ha and $33/ha with lamb growth increases of 5 and 10% respectively. These increases were due to earlier sales date, resulting in improved pasture covers going in to the winter, and hence slightly higher stocking rates.

These responses are particularly important as the 10% response of lamb growth rate to changing endophyte is approximately the same size as a 10% improvement in pasture growth for these two models (being $17 and $40 for the Central North Island and Manawatu models respectively).

Outcomes of pasture renewal in two South Island farm models

		Region							
		Otago Hill				Southland			
Effective farm area	**(ha)**	710				194			
Impact of pasture renewal		Base	+ 10%	+ 20%	+ 30%	Base	+ 10%	+ 20%	+ 30%
Stocking rate	**(su/ha)**	11.3	13.2	14.9	16.2	18.3	20.8	23.1	25.5
Feed eaten	**(kgDM/ha)**	6202	7270	8206	8909	10085	11414	12717	14007
Area Crop	**(ha)**	0	15	30	45	0	5	10	15
Area silage	**(ha)**	50	50	50	50	20	20	20	20
Physical outputs									
Meat	**(kg /ha)**	188	215	245	264	294	324	351	376
Wool	**(kg /ha)**	54.6	62.6	71.2	76.8	96	106	115	123
Total product	**(kgDM/kg)**	25.4	25.4	25.3	25.4	25.5	25.5	25.5	25.5
Income									
Sheep	**($/ha)**	503	577	656	707	849	936	1015	1086
Wool	**($/ha)**	132	152	172	186	242	267	290	310
Cattle	**($/ha)**	62	72	82	88	44	48	52	57
Costs									
Silage	**($/ha)**	25	25	25	25	36	36	36	36
Crop	**($/ha)**	0	20	40	60	0	24	49	73
Health	**($/ha)**	43	49	56	60	73	80	87	93
Shearing	**($/ha)**	29	34	38	41	55	60	65	70
Gross margin	**($/ha)**	537	602	669	706	830	896	950	1000
Total product return	**($/kg)**	2.22	2.2	2.17	2.15	2.13	2.11	2.1	2.1

Sheep and Beef conclusions

Pasture renewal was profitable on sheep and beef farms throughout the range of extra pasture production responses from 10 to 30%. The pasture renewal rate of 10% of the farm was chosen to match the estimated reversion rate of 10 years. It also uses previous modelling outcomes that generally suggest that a pasture renewal rate of 10% is required to provide an economic result on sheep and beef farms.

The response rate of a 30% improvement in pasture growth gives increases in pasture consumption of between 2700 and 3900 kg DM/ha. This translates into a total production of 8900 to 14000 kg DM/ha. These responses are well within what could be expected on sheep and beef farms within the regions modelled, suggesting that the final outcomes are realistic.

Key to capturing these benefits was optimising the cropping for each scenario. To capture extra pasture growth, more stock had to be taken through the winter and therefore the amount of cropping had to be adjusted upward as the amount of extra pasture grown was increased.

Further economic benefits could be added if lamb growth could be improved by changing endophyte type. The improvement associated with a 10% increase in lamb growth was of a similar economic value to a 10% increase in pasture growth in the two North Island models.

It is important to realise that the outcomes are constrained by the assumptions made at the beginning of the modelled process. Many of the factors entered into the model are conservative. At the same time, the results are also dependant on the ability of the chosen system to capture the benefits. Often the large benefits from lamb growth are less able to be captured by the whole system unless an increase in autumn and winter feed supply can also be achieved, as the underlying driver of profitability is the over-wintering stocking rate. It is an important principle to understand before the full benefits of any change in animal and pasture production can be integrated profitably. Another factor here is the ability of the farmer to change systems to capture benefits.

Dairy

Improvements from pasture renewal

The literature indicates that the major feature of change with pasture renewal in dairy farming is an increase in the amount of feed grown. Further changes due to feed quality and endophyte are relatively small. Therefore the models for dairy farms were based on increasing pasture growth rates by between 15 and 35%. Seasonal production changes were not taken into account though could provide a significant advantage in some regions, depending on pasture growth profiles and summer moisture deficits. Relatively little data supported a shift in the per head performance.

Some endophyte effects have been documented but these have had several interpretations. Of most significance are the impacts of high ergovaline concentrations in hot conditions (Balckwell & Keogh 1999) and may be important in the Northland Bay of Plenty model. Other changes in voluntary intake have been recorded, though impacts in the farm system will be dependent on also having an increase in pasture growth, otherwise the harder grazing induced by higher voluntary feed intake may negate the effect as the pasture will be shorter at the next grazing. These interactions are some of the reasons why features such as palatability may not translate into better animal production on-farm. Results that suggest greater pasture production because of a change to new endophyte strains such as AR1 and AR37 have been accommodated in the general pasture growth responses.

Farm types chosen

Models for dairy farming are based on geographic regions (Dexcel Profit Watch Farms) and were simulated using UDDER™. Dexcel's Annual Economic Survey database (predominantly the 2003/04 season) was used to provide data on the average and top 10% farms by selecting herds on a milk solids/hectare (MS/ha) basis. The database contained comprehensive information including farm size, cows milked, MS production, and use of supplements including grazing off.

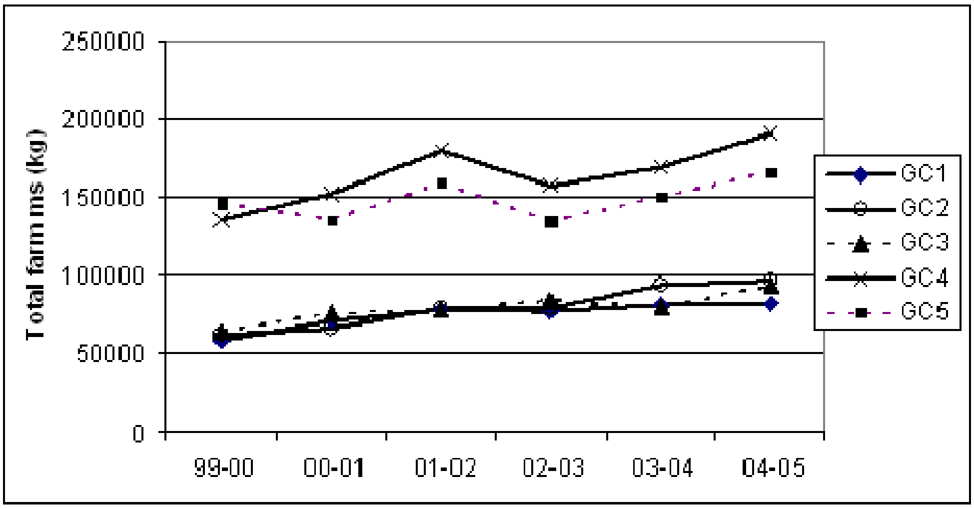
This information was used to construct UDDER™ models of average and top 10% farms within three geo-climatic regions. The derived estimates of seasonal pasture growth for the different farm categories provided a basis for understanding how the top 10% farms achieved their performance levels.

Description of how farms were grouped within geo-climatic (GC) regions.

GC number	Description of areas included in GC region
1	Northland, Bay of Plenty, North Island East Coast
2	Waikato
4	Canterbury, North Otago: irrigated farms

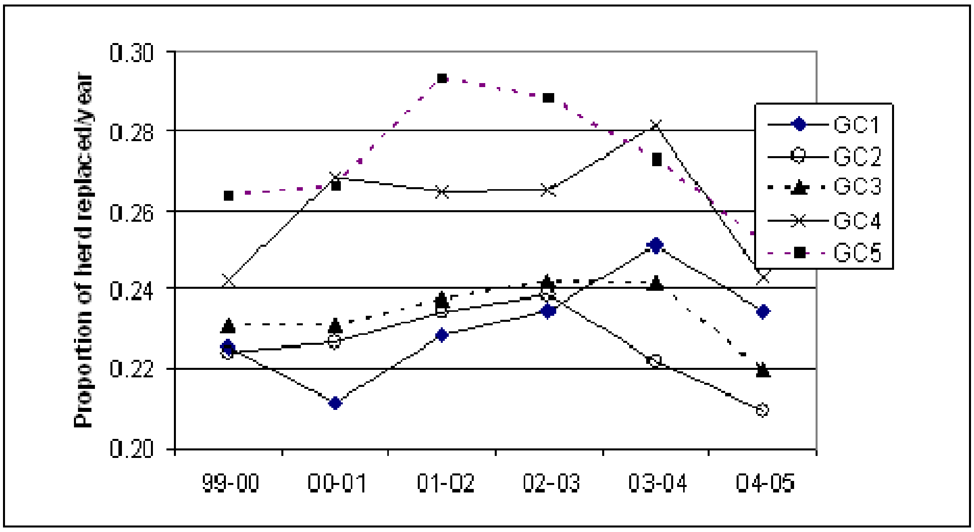
Typical dairy farms within geo-climatic regions were modelled primarily from data collected for the 2003/04 and 2004/05 seasons rather than a multi-year average. This was because of the steady changes in New Zealand dairy farm population dynamics observed in recent years which have been primarily driven by increasing herd and farm size and conversion of sheep and beef farms to dairying. While the New Zealand herd has been increasing, replacement rates within herds have been high. Therefore, to model a "steady state" situation replacement rates for the 2004/05 season were used as a benchmark for

the simulated farms in this project as these figures indicated replacement, rather than replacement-plus-growth, was occurring.



Average milk production (ms) produced per farm within geo-climatic regions. Source: Dexcel Annual Economic Survey database (September 2005).

Once all the relevant descriptive data were collated from the survey data within geo-climatic regions, simulation of “average” production farms was carried out using the whole dairy farm simulation model UDDER™.



Average proportion of herd replaced per year per farm within geo-climatic regions. Data source: Dexcel’s Annual Economic Survey database.

Development of Top-10% farm simulation models

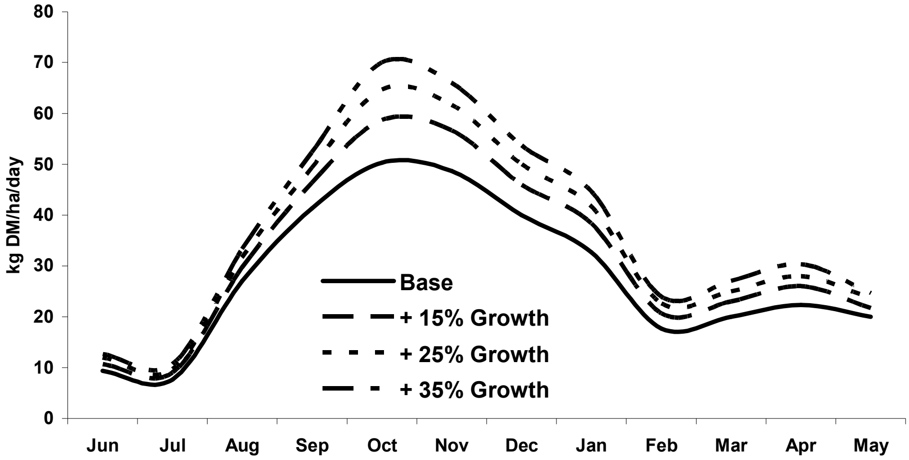
Data on the top-10% farms, as determined by MS/ha were obtained from the Dexcel Annual Economic Survey database by sorting the farms on a MS/ha basis (Note: sample size was only 2-3 farms for geo-climatic region 4). There was wide variation between years in the estimates of supplementary feed used on these farms. This variation was probably due to variations in pasture supply, affected in turn by climate, availability of supplementary feed and price. In producing the UDDER™ models, the modeller had to choose an appropriate middle point or typical amount used on these farms.

Pasture production responses

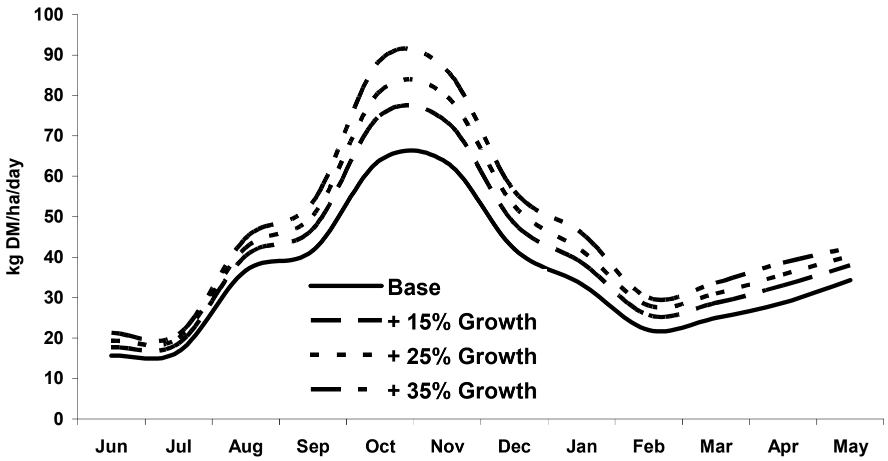
The simulations yielded base pasture growth rates for each geo-climatic region. This happens because the UDDER™ models were built on known farm production levels, herd and farm sizes and use of nitrogen and supplements. These factors determine how much metabolisable energy intake must be occurring on that particular farm. The modeller adjusts pasture growth rates until the model simulated the correct production level for that farm.

These pasture growth curves were then adjusted by adding the range of pasture growth responses indicated previously.

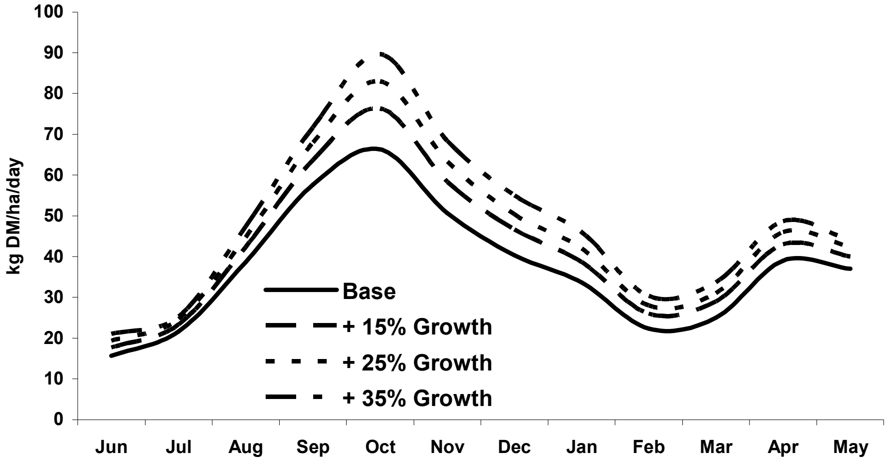
Annual pasture growth profiles for a range of responses to pasture renewal: Northland/Bay of Plenty model



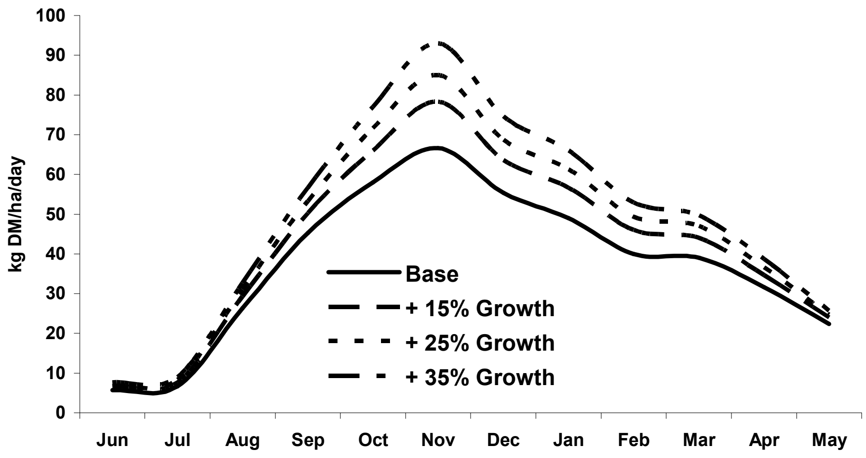
Annual pasture growth profiles for a range of responses to pasture renewal: Waikato model



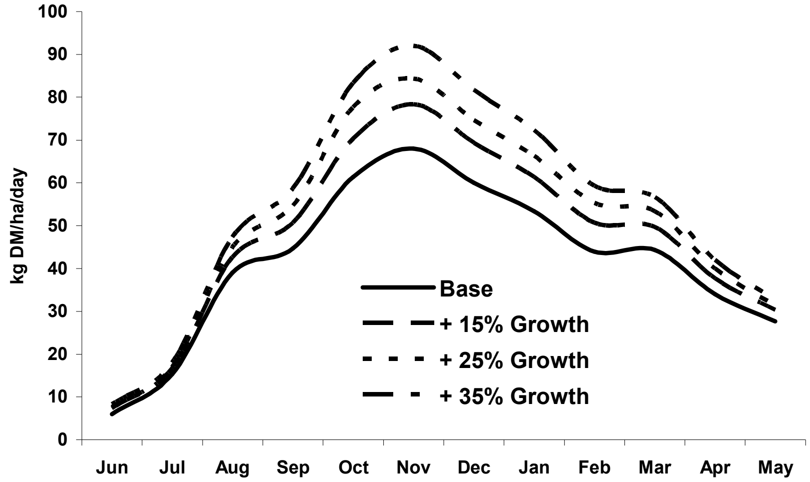
Annual pasture growth profiles for a range of responses to pasture renewal: Waikato top 10% model



Annual pasture growth profiles for a range of responses to pasture renewal: Canterbury model



Annual pasture growth profiles for a range of responses to pasture renewal: Canterbury top 10% model



Dairy model outcomes

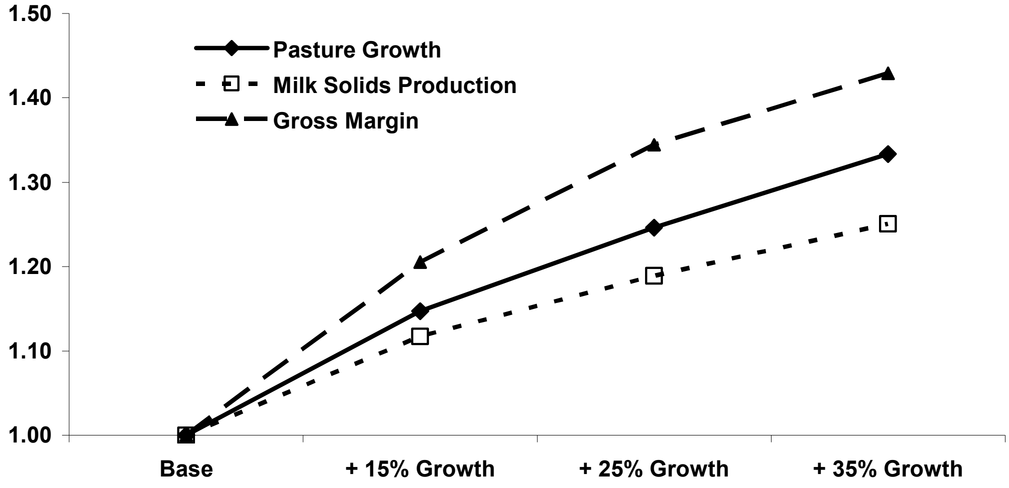
Northland-Bay of Plenty average dairy farm

This farm is modelled on an effective area of 105 ha, 266 cows wintered and a gross margin of the base farm of $113,600. Physical and economic factors are described.

Geo climatic region 1		Avg values		Difference
		Dexcel	Udder	Udder-
Inputs and outputs	**Units**	**survey data**	**model**	**Dexcel**
Farm area effective	ha	105	105	0%
Seasonal herd?	yes/no	Yes	Yes	
Cows wintered			266	
Cows surviving to milked			0.98	
Cows milked		261	261	0%
Total milk solids (ms)		81384	81481	0%
ms/ha		772	776	1%
ms/cow milked		311	312	0%
Stocking rate: cows milked/ha			2.49	
Planned start calving (PSC)		18-Jul	20-Jul	0%
PSC to mean calving (all yrs)	days	22	21	-5%
Drying off (main group)			10-May	
Pasture cover I June	kgDM/ha		2000	
Condition score 1 June			4.5	
Cow liveweight 1 June	kg		460	
Adult cows	%	77	77	0%
First calvers	%	23	23	0%
Calves	%	23	23	0%
Topping?	yes/no	?	Yes	
Heifers off?		Yes	Yes	
Calves off?		?	No	
Herd wintered off? %		Small amount	No	
Herd wintered off? Weeks			0	
Herd winter grazing	t DM			
Nitrogen use	kg N/ha/yr	97	95	-2%
Silage made on farm	t DM		48.6	
Silage fed on farm	t DM		53	
Silage purchased	t DM		4.4	
Maize silage made on farm	t DM		0	
Maize silage purchased	t DM		50	
Grain purchased	t DM			
Other feed purchased	t DM			
Total feed imported (excl grzg)	**t DM**		**54.4**	
Total feed imported/ha	t DM		0.52	
Total feed imported/cow	t DM		0.20	
Silage made on farm	t DM/cow		0.18	
Silage fed on farm	t DM/cow		0.20	
Cow genetic potential			1.00	
Pasture growth factor			1.00	
Pasture quality factor			0.95	
Pasture renewal	%/yr		0	
Pasture digestibility	Jan %		66.5	
Irrigation		No	No	
Pasture growth kg DM/ha	Jan		35	
	Feb		15	
	Mar		20	
	Apr		25	
	May		20	
	Jun		15	
	Jul		8	
	Aug		20	
	Sep		30	
	Oct		55	
	Nov		40	
	Dec		40	
Potential pasture growth DM/ha/yr			9825	
Pasture DM consumed/ha/yr			9800	
DM eaten/kg ms incl purchased feed, herd wintering off, excl young stoc			13.3	

The relative changes in pasture growth, per hectare production and gross margin are represented on the graph below. Relative improvements in the gross margin are greater than the improvement in growth or production. For example, a 15% increase in pasture production returns an increase in 21% in gross margin. This relates to a whole farm increase of approximately $23,800, and this is then the maximum amount that can be spent gaining this improvement.

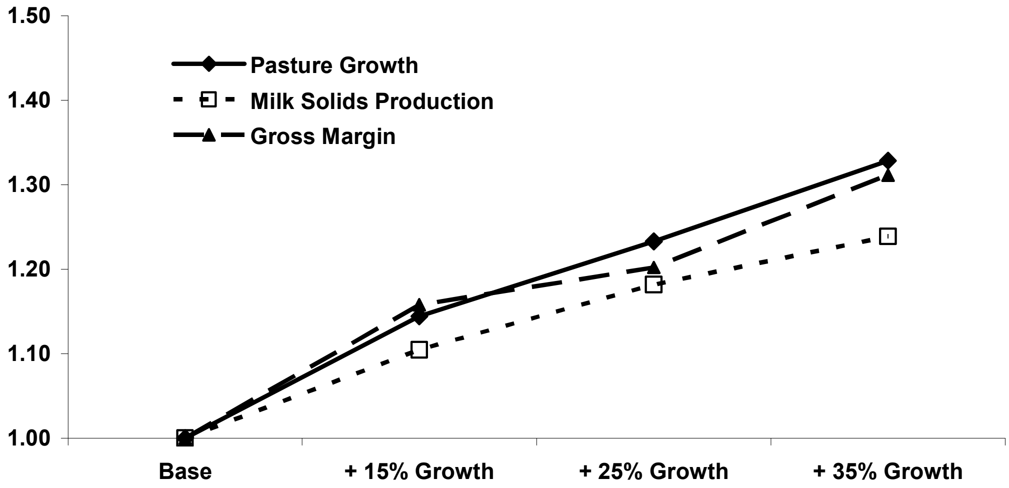
Relative changes as the response to pasture renewal increases: Northland Bay of Plenty average



Waikato average farm

This farm is modelled on an effective area of 97 ha, 291 cows wintered and a gross margin of the base farm of $157,450. Physical and economic factors are described below

Relative changes as the response to pasture renewal increases: Waikato average



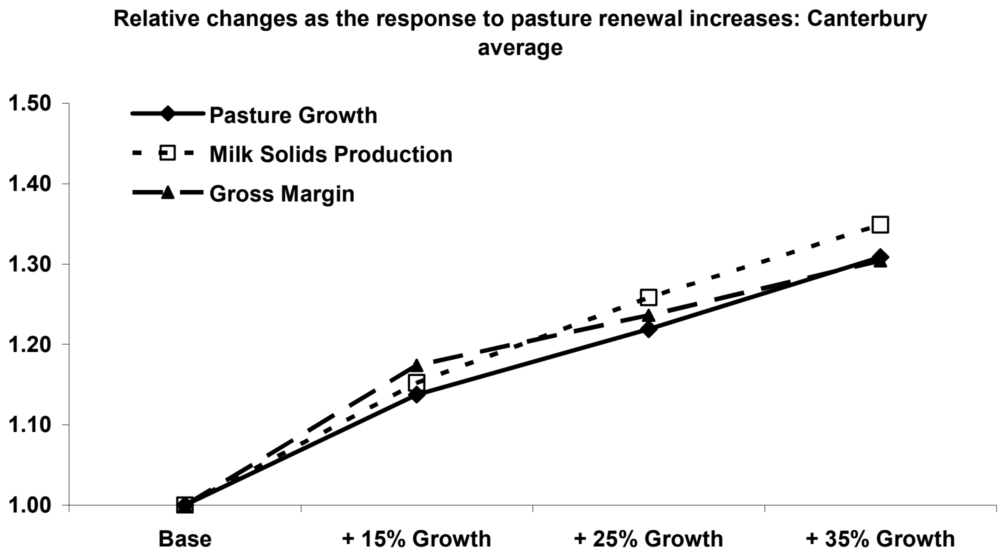
Relative improvements show a trend for the 15% improvement to be slightly more profitable than greater improvements.

Geo climatic region 2		Avg values		Difference
		Dexcel	Udder	Udder-
Inputs and outputs	**Units**	**survey data**	**model**	**Dexcel**
Farm area effective	ha	97	97	0%
Seasonal herd?	yes/no	Yes	Yes	
Cows wintered			291	
Cows surviving to milked			0.98	
Cows milked		285	285	0%
Total milk solids (ms)		95631	94182	-2%
ms/ha		988	971	-2%
ms/cow milked		324	330	2%
Stocking rate: cows milked/ha			2.94	
Planned start calving (PSC)		19-Jul	20-Jul	0%
PSC to mean calving (all yrs)	days	23	22	-4%
Drying off (main group)			10-May	
Pasture cover l June	kgDM/ha		2200	
Condition score 1 June			4.5	
Cow liveweight 1 June	kg		460	
Adult cows	%	79	79	0%
First calvers	%	21	21	0%
Calves	%	21	21	0%
Topping?	yes/no	?	Yes	
Heifers off?		Yes	Yes	
Calves off?		?	No	
Herd wintered off? %		Small amount	No	
Herd wintered off? Weeks			0	
Herd winter grazing	t DM			
Nitrogen use	kg N/ha/yr	127	124	-2%
Silage made on farm	t DM	0	62.8	
Silage fed on farm	t DM	0	61	
Silage purchased	t DM		-1.8	
Maize silage made on farm	t DM		0	
Maize silage purchased	t DM		54	
Grain purchased	t DM			
Other feed purchased	t DM			
Total feed imported (excl grzg)	**t DM**		**52.2**	
Total feed imported/ha	t DM		0.54	
Total feed imported/cow	t DM		0.18	
Silage made on farm	t DM/cow		0.22	
Silage fed on farm	t DM/cow		0.21	
Silage purchased	date (t DM)			
Cow genetic potential			1.00	
Pasture growth factor			1.00	
Pasture quality factor			1.00	
Pasture renewal	%/yr		0	
Pasture digestibility	Jan %		70.0	
Irrigation?		No	No	
Pasture growth kg DM/ha	Jan		35	
	Feb		20	
	Mar		25	
	Apr		30	
	May		25	
	Jun		15	
	Jul		10	
	Aug		25	
	Sep		30	
	Oct		65	
	Nov		60	
	Dec		40	
Potential pasture growth DM/ha/yr			11558	
Pasture DM consumed/ha/yr			11600	
DM eaten/kg ms incl purchased feed, herd wintering off, excl young sto			12.5	

Canterbury average dairy farm

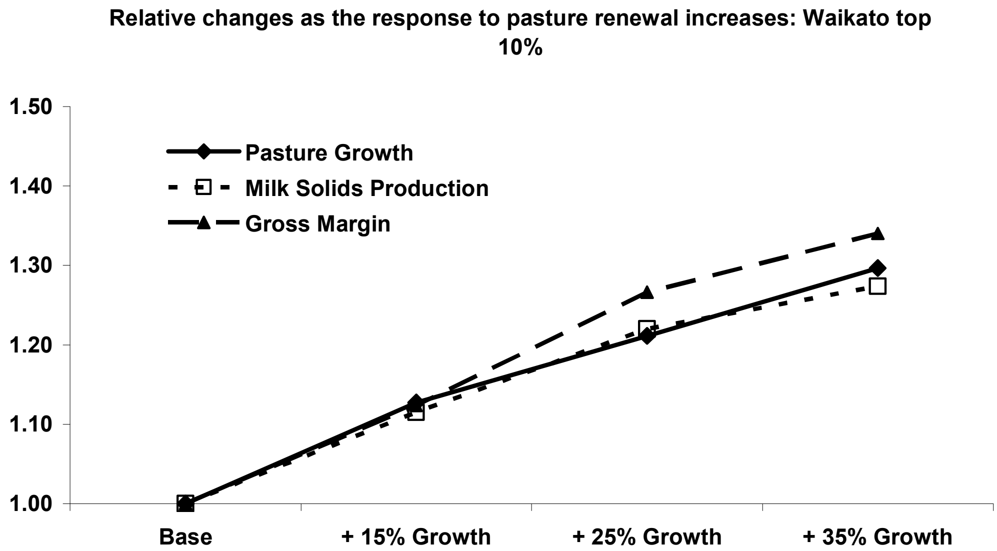
This farm is modelled on an effective area of 154 ha, 540 cows wintered and a gross margin of the base farm of $332,600. Physical and economic factors are described below.

Geo climatic code 4		Avg values		Difference
		Dexcel	Udder	Udder-
Inputs and outputs	**Units**	**survey data**	**model**	**Dexcel**
Farm area effective	ha	151	151	0%
Seasonal herd?	yes/no	Yes	Yes	
Cows wintered			470	
Cows surviving to milked			0.98	
Cows milked		461	461	0%
Total milk solids (ms)		179803	177953	-1%
ms/ha		1195	1178	-1%
ms/cow milked		374	386	3%
Stocking rate: cows milked/ha			3.05	
Planned start calving (PSC)		6-Aug	5-Aug	
PSC to mean calving (all yrs)	days	19	20	5%
Drying off (main group)			25-May	
Pasture cover I June	kgDM/ha		2100	
Condition score 1 June			4.5	
Cow liveweight 1 June	kg		500	
Adult cows	%	76	76	0%
First calvers	%	24	24	0%
Calves	%	24	24	0%
Topping?	yes/no	?	Yes	
Heifers off?		Yes	Yes	
Calves off?		Yes	Yes	
Herd wintered off? %		Yes, 100%	Yes	
Herd wintered off? Weeks		12	10	
Herd winter grazing	t DM		230	
Nitrogen use	kg N/ha/yr	174	172	-1%
Silage made on farm	t DM	0	53.6	
Silage fed on farm	t DM	0	52	
Silage purchased	t DM		-1.6	
Maize silage made on farm	t DM		0	
Maize silage purchased	t DM		0	
Grain purchased	t DM		283	
Other feed purchased	t DM			
Total feed imported (excl grzg)	**t DM**		**281.4**	
Total feed imported/ha	t DM		1.86	
Total feed imported/cow	t DM		0.60	
Silage made on farm	t DM/cow		0.12	
Silage fed on farm	t DM/cow		0.11	
Cow genetic potential			1.00	
Pasture growth factor			1.00	
Pasture quality factor			1.02	
Pasture renewal	%/yr		0	
Pasture digestibility	Jan %		70	
Irrigation		Yes	Yes	
Pasture growth kg DM/ha	Jan		45	
	Feb		40	
	Mar		30	
	Apr		15	
	May		10	
	Jun		5	
	Jul		0	
	Aug		20	
	Sep		30	
	Oct		60	
	Nov		65	
	Dec		55	
Potential pasture growth DM/ha/yr			11406	
Pasture DM consumed/ha/yr			11200	
DM eaten/kg ms incl purchased feed, herd wintering off, excl young stc			12.4	



Waikato top 10% (ms/ha) farm

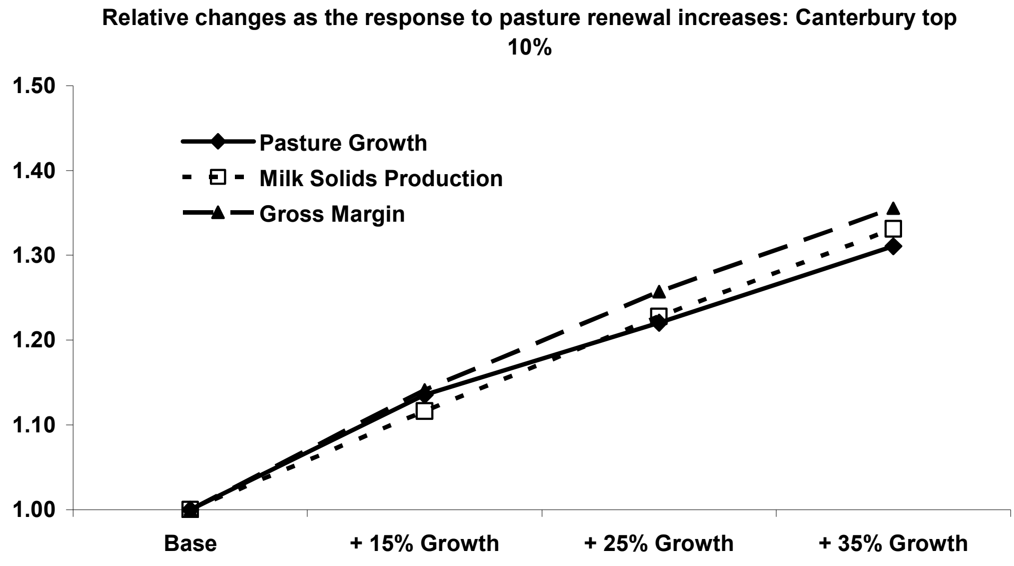
This farm is modelled on an effective area of 75 ha, 285 cows wintered and a gross margin of the base farm of $156,740.



Relative gross margin improvements are greater at higher growth improvements than production, and higher responses than the average Waikato dairy farm.

Canterbury top 10% (ms/ha) farm

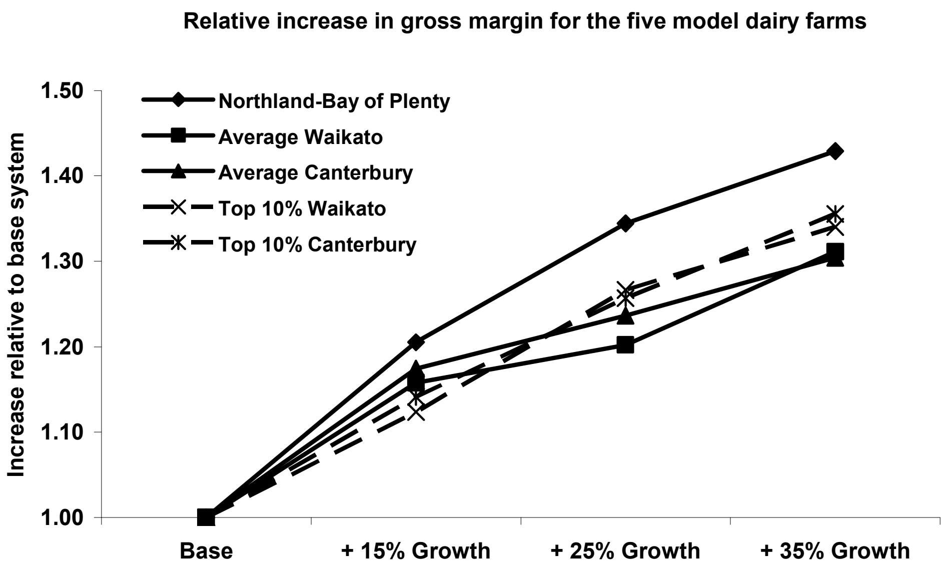
Relative increases in all factors are closely related.



Summary and conclusions

Using all year round increases in pasture growth, a total of 23 UDDER runs were done:

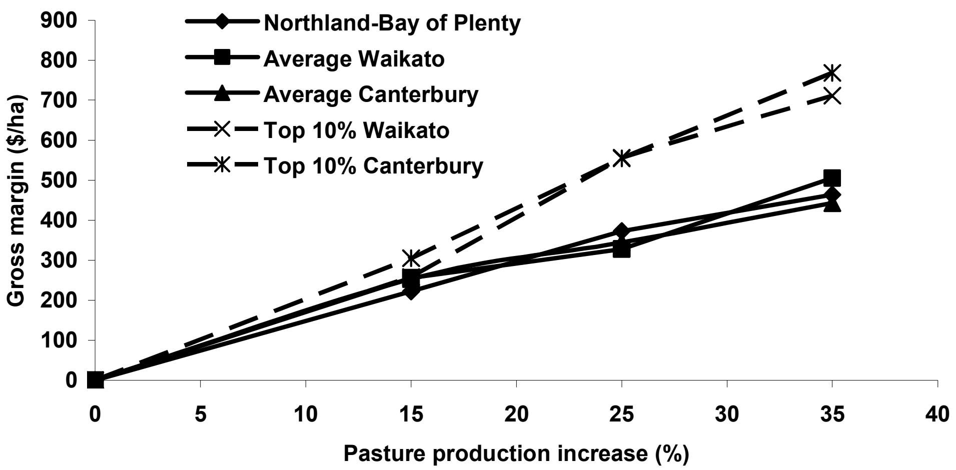
Examination of the relative gross margins for each of the simulated dairy farm scenarios shows that the Northland Bay of Plenty model had the greatest response to increasing pasture growth. Both the Waikato and Canterbury average models showed the most significant gain moving to 15% extra pasture growth, with smaller increases in relative gross margin after this. This may reflect the more seasonal nature of the responses and would indicate that changes in seasonal pasture production may have a greater impact than an overall increase in pasture growth once over the 15% increase. The two top 10% milk solids examples showed a lower increase in gross margin at a pasture production increase of 15%, but were able to better capture the value when pasture production increases were 25 and 35%.



When converted into per hectare gross margins it is apparent that the top 10% milk solids production models are much better able to capture the benefits of higher pasture increases. These values can be

compared to the cost of pasture renewal. If the longevity of the response was 5 years at any given level of production increase then the pasture renewal rate would need to be 20% per annum. Current estimates of pasture renewal cost are between $600 and $700/ha or $120 to $140/ha on a whole farm basis. All of the gross margin increases are well above this level.

Changes in per hectare gross margin on dairy farms as the relative pasture production increases with pasture renewal



General observations from the simulations include:

- A (for example) 25% increase in inputted growth into the model does not necessarily give a 25% increase in true pasture growth in the model output –due to average pasture mass at some times of the year being outside the optimum growth band of 750 to 1500kg DM/ha above grazing residuals.
- The trends in relative values, going from relative growth to relative GM are not totally consistent. All you can really say is that say, a 35% increase in pasture growth (in the optimal mass growth band of 750 to 1500kg DM/ha above grazing residuals), yields:
    - a slightly lesser % increase in annual farm pasture growth
    - a slightly smaller % increase in production, except in the Canterbury region for some reason
    - a generally similar or bigger % increase in GM profit.
- The increased pasture growth was manifested in increased cows carried with variable and usually incremental changes in MS/cow. Changes in calving date did not look worth chasing because although you grow more feed in the spring, you still have to get the extra cows through the winter. A change in the systems to, for example, increase the amount of crop, and therefore winter stocking rate, may help change the overall stocking rates and profitability of the systems in some examples.

These results demonstrate the decision that a farmer must make when examining the use of pasture renewal to improve whole farm feed supply. The gain in gross margin must be equal to or greater than the cost of pasture renewal, and the benefit must be greater than choosing another form of increasing feed supply, such as buying in feed.

Appendix I. Terms of the review

The aim of this review is to collate information pertaining to the benefits of regular pasture renewal. The campaign concept recognises benefits from accelerated pasture renewal in the areas of stock performance, management flexibility and overall financial reward.

This review would aim to address each of these benefit streams by drawing together scientific data, on-farm experiences and anecdotal evidence into a single report that would be available to the campaign partners.

The information in this review will provide information for use in the two remaining phases of the programme.

A number of issues need to be considered in scoping the content of the review;

Sources of information

Such information can be accessed from a number of sources with varying "credibility" based on trial design, statistical analysis and interpretation, and level of peer review, i.e. ranging from peer-reviewed scientific papers at one end through to anecdotal reports at the other. It is suggested that for the purposes of the review all available material be accessed in the first instance, and the review authors pay due regard to the varying levels of report credibility in their review.

- Scientific literature
- Seed company data
- Monitor Farms
- Dexcel
- Lincoln University Dairy Farm
- Dairy Insight
- AgResearch
- Monsanto/NuFarm
- Consultants through NZIPIM
- Lincoln and Massey Universities
- On Farm Research (Paul Muir)
- Leading farmers experience
- Seed specialists

Type of information

Some of the relevant reports will contain financial benefit analyses, but many useful reports will not i.e. where benefits have been assessed through measurements of forage dry matter accumulation (total and/or seasonal) or forage quality. It is suggested that for the purposes of this review all this information be captured whether financial benefits have been calculated or not. Effects of establishment methodology on renewal success will be reviewed as a means of obtaining information on success with different techniques e.g. cultivation versus direct drilling. This information will be required for the financial analyses. However, a full review of methods of establishing pastures will not be part of the contracted work.

Additional financial analyses

Much of the information alluded to in point 2 above will be used for further financial analysis using farm simulation models. Financial analyses will be carried out for a range of model dairy farms and sheep & beef farms, 4 in each case i.e. a total of 8 model farms. The farm simulation models UDDER (dairy) and Stockpol (sheep & beef) will each be set up to represent typical model farms using existing industry survey data. Simulation runs will be made for each model farm using a range of pasture renewal from no renewal through to high levels of renewal. Effects of the renewal practices on forage supply and animal production, and costs of renewal will be drawn from information gathered during the literature review.

Negative information

There will be information located during the review process that will report/suggest that pasture renewal may not be financially beneficial in some situations. It is suggested that for the purposes of the review all available material be accessed in the first instance whether apparently supporting the aims of the overall campaign or not, and the review should be confidential to the contracting group in the first instance. This will remove any hint of bias and will assist in defining some of the current and potential future barriers to stimulating increased pasture renewal rates.

Factual and current

The review should give a completely factual report of current information, and should not attempt to present it in such a way as to support the campaign objectives. Formulating the messages that will be conveyed to the market is a separate process that will take into account results of the parallel market survey.

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