

Regrassing trends and drivers in the New Zealand dairy industry

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Abstract

Pasture renewal is an important strategy for farmers to improve the yield of home-grown forage. This paper quantifies long-term national and regional trends in regrassing within the dairy sector and links these patterns to suggested major drivers, using simple regression analysis. Dairy farm financial data relevant to regrassing expenditure were sourced from annual dairy sector economic reports and DairyBase, while regional potential evapotranspiration deficit data were sourced from climate records and cropping data from a recent MPI report. Real and relative expenditure on regrassing has increased over this period, and appears to be positively associated with both cropping activity and drought severity, particularly in some North Island regions. The emergent picture is one of a complex of interacting drivers (climate, production, prices, forage products, soils and time) which fuel a vicious cycle of poor persistence and re-sowing. This situation draws attention to the need for solutions to protect regrassing investments.

Keywords: climate, DairyBase, farm survey, pasture renewal, potential evapotranspiration deficit

Introduction

Pasture renewal is an important strategy for farmers to improve the yield of home-grown forage. The adoption of new forage cultivars should improve pasture yield because there has been genetic gain in dry matter (DM) yield in perennial ryegrass (Woodfield 1999; Harmer *et al.* 2016). However, a number of environment and management factors reduce pasture yield and degrade the composition of sown pasture species on a seasonal or annual basis (e.g., drought, Chapman *et al.* 2011; pest outbreaks, Bell *et al.* 2011; weed ingress, Tozer *et al.* 2011). Pasture renewal is a means of recovery from such disturbances, so that the supply of high quality forage is at least maintained.

Kerr *et al.* (2015) suggest five drivers for pasture renewal at the farm level: a requirement for regrassing following crops, a historical pattern reflecting the farmer's financial preference, a response to an adverse event (e.g., flood or drought), an opportunity for development of new grassland or pasture species and a result of a positive benefit/cost analysis. Often these

factors interact, such as using a crop to offset the cost of pasture improvement. The favourable cost/benefit ratio of pasture renewal in dairy systems has been well described in the New Zealand grassland literature (e.g., Bryant *et al.* 2010; McLean 2011).

Widespread dissatisfaction exists amongst farmers, particularly in the northern North Island, with the persistence of recently renewed, ryegrass-based pastures (Kelly *et al.* 2011; Rijswijk & Brazendale 2016). A number of factors have been suggested and debated as contributing to this problem (e.g., Clark 2011). A major influence is likely to be climatic stress, as evidenced in a recent long-term Waikato study on pasture persistence that included functionally diverse ryegrass cultivars and a range of sowing rates (Lee *et al.* 2017).

The aim of this paper is to quantify long-term national and regional trends in regrassing within the dairy sector and link these trends to some of the major drivers noted by Kerr *et al.* (2015). In particular, this paper focusses on the relationship between climate, cropping activity, potential pasture production and regrassing activity.

Methods

Farm data

Dairy farm data on regrassing spend, farm working expenses (FWE), milk price and milksolids production were sourced from a) dairy sector Annual Survey economic reports at the national scale (DairyNZ, 1997-2016); and from b) DairyBase at the national and regional scale (DairyNZ, 2005-2016). The data are from a sample of owner-operators, and are reported on a whole-farm basis, as well as by land area (ha) and by cow numbers. Owner-operators represent the majority of farm systems and responsibility for regrassing expenditure may vary in sharemilker systems. The time series data in a) were inflation-adjusted using the Farm Prices Index (FPI) from Infoshare (StatsNZ 2017). The Dairybase data in b) enable a breakdown of regrassing spend to a regional level, though the number of farms in each region are accordingly lower.

Both the annual economic survey data and the primary source of that data (DairyBase) were used on the basis that each source has particular advantages.

* research was conducted during a secondment to DairyNZ

The economic survey has a much longer record while DairyBase enables a regional breakdown, recognising that drivers such as climate are strongly regional. While DairyBase includes approximately 2000 individual farm records, the annual survey is a subsample of approximately 200-300 individual herds (based on supply numbers) for owner-operators.

The time series data include the annual amount spent on “regrassing”. Regrassing specifically includes the costs of seed, spray, cultivation/drilling, and contractors, but excludes fertiliser, fuel and vehicle costs. “Cropping” and “Weed and Pest Control” constitute two separate cost categories hence there is potentially some variation between individual farms in the categories to which some of the costs associated with regrassing were assigned. In the recent editions of the annual survey the data are presented in four tables (Appendices 7.1-7.4) on the basis of average spend by farm, effective hectare, cow and kg milksolids produced. The FPI-adjusted spend per effective hectare, per cow and per kg is assumed to be a good proxy for the total amount of regrassing activity on dairy farms.

Dairy farm cropping and pasture renewal data

Supplementary feed use on dairy farms nationally since 1990 has been estimated for the Ministry for Primary Industries (MPI 2016). The report estimates total area and the proportion of crop mass used in dairy systems for a range of fodder crops. To best represent cropping activity on dairy farms the area multiplied by the proportion for five crops where the estimated proportion is greater than 40% were summed (maize silage, fodder beet, kale, turnips and swedes) (Tables 7, 12, 13, 15 and 16 in MPI 2016).

Ryegrass annual seed sales data from 2008-2015 were sourced from the New Zealand Plant Breeders Research Association (T. Chin pers. comm.). The tonnage was converted to estimated areas sown on dairy farms by assuming a sowing rate of 20 kg/ha and 46% of the total national area in pasture renewal attributed to dairying (StatsNZ unpubl. census data 2012).

Climate data

The complex orography and climatology of New Zealand means that regional patterns of drought stress occur. Salinger & Porteous (2014) have applied an index of agricultural drought (Potential Evapotranspiration Deficit, PED) to define five spatially distinct regions of similar drought pattern over time, using a long-term time series of climate data (1941-2013) from 46 weather stations across New Zealand. PED is a cumulative daily water deficit (PET-rainfall) over a growing year (July-June) that equates to the amount of water that would need to be added via irrigation to avoid a loss in forage yield. It assumes a fixed soil moisture storage

capacity (150 mm) so does not take account of regional variation in soil types. Nonetheless, it is a broad proxy for drought severity in any given year.

To align with the DairyBase regions, the data from 29 of the 46 weather stations were grouped by region as follows, Northland: Kaitaia, Whangarei, Dargaville, Warkworth; Waikato: Ruakura, Paeroa; Bay of Plenty: Tauranga, Rotorua, Whakatane; Taranaki: New Plymouth, Hawera; Lower North Island: Whanganui, Dannevirke, Waingawa, Palmerston North, Paraparaumu; West Coast (South Island): Appleby, Tarakohe, Westport, Hokitika; Marlborough/ Canterbury: Blenheim, Kaikoura, Hanmer, Lincoln, Timaru; Otago/Southland: Naseby, Musselburgh, Gore, Invercargill.

Pasture growth modelling

Given the recent focus on climatic issues related to pasture persistence in the northern North Island (e.g., Lee *et al.* 2017), long-term pasture growth potential in this region was explored by using the last 40 years of climate data for one typical site (Ngatea, Hauraki Plains) and simulating climate-driven pasture production trends over time with a pasture growth model. The Rezare pasture growth forecaster (Ogle 2015) was used to simulate daily pasture growth potential, which in the model is influenced strongly by two temperature and moisture growth limiting factors that are combined into a single daily stress index (scaled from 0-1). The stress index typically accumulates during high summer temperatures when pastures are moisture limited and declines during periods when there is adequate soil moisture for evapo-transpiration demand. The model output, in terms of both daily net pasture production and the daily value of the stress index, was accumulated over each growing season (July-June) for 40 years to indicate long-term trends in climatically-induced stress and annual pasture production.

Data analysis

A simple least-squares regression analysis was conducted using Microsoft Excel on the regrassing expenditure data, against the potential influential factors: milk price, milksolids production and regional PED.

Results and Discussion

Regrassing spend over time

The amount spent on regrassing by owner-operator dairy farmers ranged from \$17 to \$72/effective ha/year over the last 2 decades (Figure 1). The Annual Survey and Dairybase data are reasonably consistent for the period 2005-2016, with the larger dataset showing less fluctuation, as might be expected. Based on the Annual Survey, expenditure on regrassing

increased over the period covered by the time series data, at an average rate of approx. \$2.69/effective (eff.) ha/year. Expenditure as a proportion of farm working expenses similarly increased over the last 2 decades, by approx. 0.03% points/annum, i.e. from 1.0 to 1.6% over 20 years. There was an apparent step change in expenditure on regrassing in 2007/2008. Before this point, farmers spent between \$20 and \$40/eff. ha/year, whereas in 2007/2008 and thereafter, they spent between \$50 and \$70/eff. ha/year.

Regrassing and milk price/production

Expenditure on regrassing may be influenced by the price received for milksolids (MS), an indicator of ability to pay for regrassing; and the MS production/ha, as an indicator of the intent to increase MS productivity supported by both cropping and pasture improvement. Figure 2 shows the relationship between the average annual spend on regrassing and milk price, for owner-operators, based on the economic survey data. The data indicate a weak positive relationship, which is also the case for MS production (data not shown). However, the points cluster into low and high levels of spend, which correspond to the pre- and post-2007 periods. Essentially, high levels of regrassing are associated with the last decade, as are relatively high milk prices and relatively high MS production seasons. Thus, the moderate correlations are likely spurious and influenced by other factors, such as increases in supplementary feed input.

National scale cropping activity

In terms of the broad trends during the last 20 years,

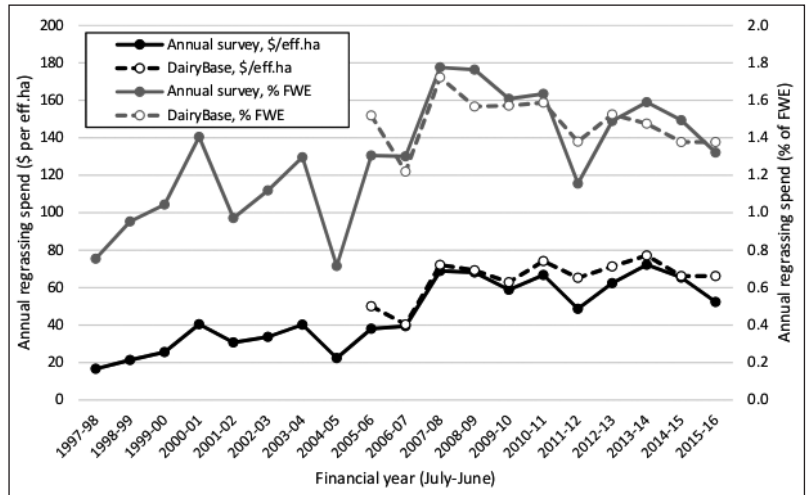


Figure 1 Annual average inflation-adjusted expenditure on regrassing per effective hectare for owner-operators (dark lines), and the proportion of farm working expenditure spent on regrassing for owner-operators (grey lines), based on the Annual Survey (solid lines) and DairyBase (dashed lines). %FWE = percentage of farm working expenses.

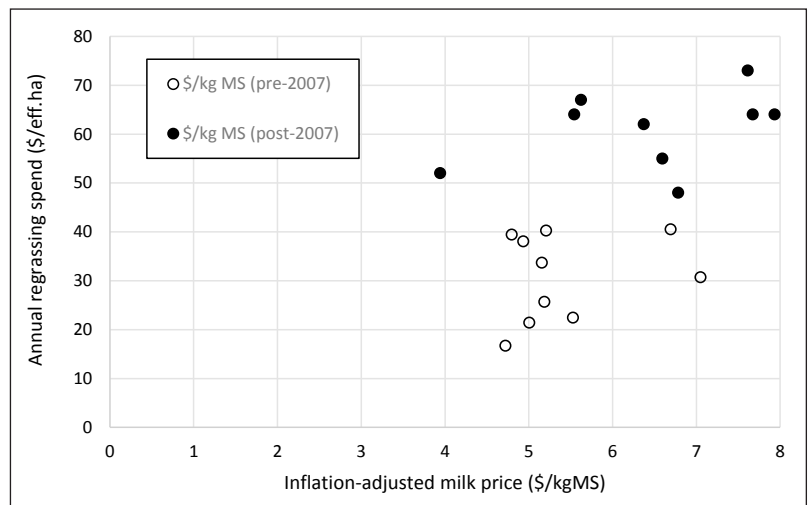


Figure 2 Scatterplot of the annual average inflation-adjusted expenditure on regrassing per effective hectare for owner-operators and inflation-adjusted milk price pre-2007 (open symbols) or post-2007 (filled symbols). MS = milk solids.

the area sown to crops was related to the amount of regrassing activity (as indicated by \$ /eff. ha) until 2012-2013 (Figure 3). In terms of relating this proxy of total regrassing activity to actual areas, long-term annual data specific to dairy are not available, but the 2012 census recorded a total of 172 768 ha in pasture renewal on dairy farms nationally (StatsNZ unpubl. data). This was close to our estimate of approx. 179 000 ha. A particular feature of the cropping pattern is a large increase in area (mainly maize) during 2006-2008, which accelerated the long-term increase, followed by a decline in cropped area during 2008-2011, then an

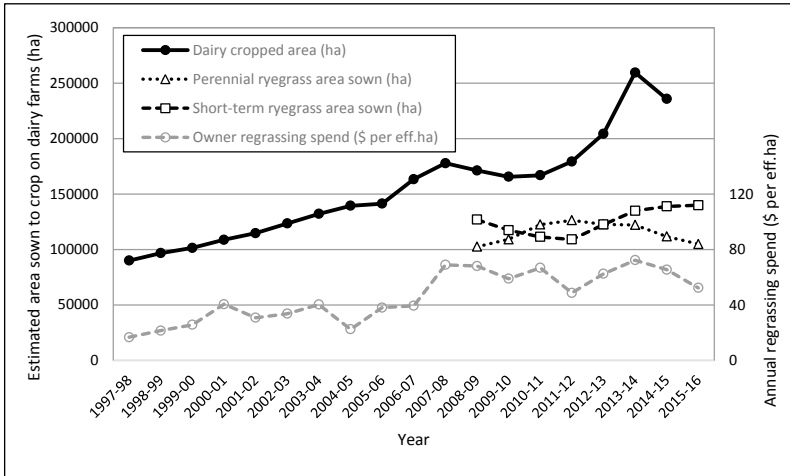


Figure 3 Annual estimated area sown to crops on dairy farms (dark solid line) compared with annual average inflation-adjusted expenditure on regressing/eff. ha for owner-operators (grey dashed line) and annual estimated area sown to perennial (triangles) and short-term (squares) ryegrass.

even steeper increase from 2012-2015. This medium-term pattern was also evident from the regressing spend data, although there were individual year deviations (e.g., 2000-2001, 2004-2005, 2010-2011). An additional pattern is illustrated by the estimates of ryegrass area sown, based on seed sales. Two phases are evident, involving an increase in the use of perennial ryegrass from 2008-2011 followed by a decline from 2012-2015, relating to an area of approx. 22 000 ha. Mirroring this was a decline, then an increase, in the use of short-term ryegrasses, relating to an area of approx. 30 000 ha, which tracks the pattern of crop area sown.

Regional scale climate and regressing spend

Across all regions, a general pattern was found of increasing farm expenditure on regressing as the regional PED values increased (Figure 4). For example, expenditure was typically much greater in Marlborough-Canterbury than in Taranaki, as were the typical PED values. However, it is the within-region relationships that are of most interest, since there will be less influence of regional-scale drivers, such as the use of irrigation or regressing costs. For example, the extensive use of irrigation in the eastern South Island is likely to be a strong influence on regressing activity, and would explain the poor within-region relationship between regressing and PED. Another apparent anomaly is that the data for West Coast/Tasman are spread across a wide range in annual expenditure in an environment with consistently low PED.

The correlation varied from being positive in the Waikato, Bay of Plenty, Taranaki and the Lower North Island, to neutral in Northland, West Coast-Tasman, Otago-Southland, to negative in Marlborough-

Canterbury. The within-region temporal regression analysis showed that in only two regions was there a significant positive association between annual regressing expenditure and PED. These were Taranaki ($P < 0.01$) and Waikato ($P < 0.05$) and hence the least-squares linear fit lines are indicated on Figure 4.

Of some concern in the context of climate change is an apparent medium-term increase in PED values indicated in Salinger & Porteous (2014). They identified five regions of New Zealand as distinct in terms of their response to

atmospheric circulation patterns, four of which they have shown to have long-term increases in PED. The northern North Island in particular appears to have experienced consistently greater annual PED values over the last decade (see Figure 8 in Salinger & Porteous 2014).

The pasture growth model simulation data for the Hauraki region show that the last decade has been particularly challenging in terms of the effect of increases in climatic stress on pasture production (Figure 5). Of additional note is the apparent increase in the inter-annual variability in climate stress. As a result, potential pasture growth at this site is likely to have also shown high inter-annual variability, with the last decade showing relatively low potential pasture production as indicated by the 5-year running average. This trend is likely to be a major factor behind the farmer reports of persistence failure in recent regressing activities on-farm (Reynolds 2013; Scott 2013). Recent experience with a cultivar \times sowing rate experiment in the Waikato over this period (sown in 2011) bears this out (Lee *et al.* 2017).

The generally moderate strength of the simple relationships at broad scales explored in this paper support the idea that regressing levels are the result of a range of interacting factors (Kerr *et al.* 2013). More detailed surveys of farmer decision-making at farm scale would be required to better define whether these drivers are changing over time. However, the patterns observed can suggest an interpretation of the cause of poor pasture persistence in the Northern North Island region as a set of interacting factors, including time, perhaps best expressed as a narrative.

During the mid-2000s cropping activity on dairy

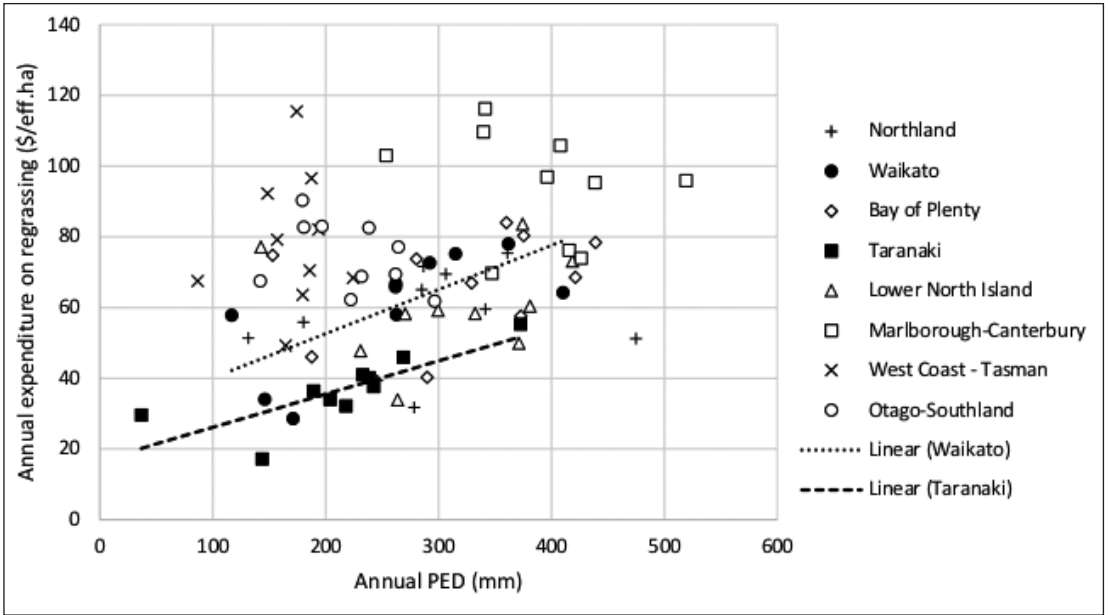


Figure 4 Correlation between annual expenditure on regrassing and annual potential evapotranspiration deficit (PED) for eight regions of New Zealand.

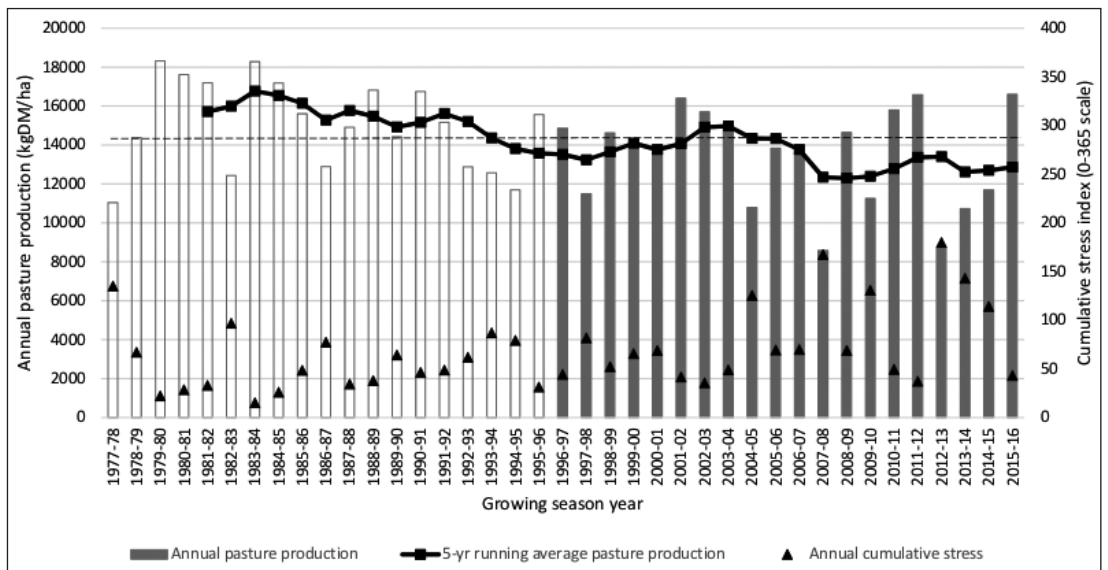


Figure 5 Simulated annual pasture herbage accumulation from 1977-2016 using the Rezare pasture growth forecaster based on climate data from Ngatea (grey bars, shaded for the period of regrassing data 1997 onwards). Also shown are the 5-year running average (dark squares), the 40-year long-term average (14 200 kg DM/ha/year, dashed line) and the annual cumulative value of the daily stress index (dark triangles).

farms increased substantially, along with associated cultivation and regrassing activities (assuming the trends in Figure 3 are also representative of the region), at a time when milk prices were improving (Figure 2) and the availability of a range of new ryegrass cultivars was increasing (M. Harmer pers. comm.).

The nationwide drought of 2007-2008 represented a severe setback for pasture production in non-irrigated areas and appears to have been the start of a decadal period of increased moisture and temperature stress, particularly in the northern North Island (Figure 5). The farmer response appears to have been initially a

reduction in cropped area and an increase in regrassing with perennial ryegrass (Figure 3). But, the subsequent climatic environment for the establishment of permanent pastures after cropping in this region has been particularly unfavourable. This has more recently been reflected in an increase in area being sown to short-term forage systems based on annual crops and short-term ryegrasses at the expense of perennial ryegrass use. The availability of short-term ryegrass cultivars with endophytes since 2012 may also have been a positive driver. There is also anecdotal evidence of repeated cultivation creating a poor soil environment for perennial pastures (Lane 2011). Thus, northern North Island dairy farmers appear to be trapped in a vicious cycle of regrassing and recropping.

Conclusions

Based on inflation-adjusted farm spending data, rates of regrassing appear to be increasing over the long-term, with high levels of inter-annual variability. This variability appears to be driven by many factors, both opportunity-based (e.g., crop use) and problem-based (e.g., drought). Differences between regions in the implied relationship between drought and annual regrassing spend are apparent. Long-term increases in expenditure on regrassing in the dairy industry draws attention to the need for development of solutions for poor pasture persistence, to protect the investment of dairy farmers in improved forages. This is particularly important given the apparent medium-term trends in climate stress likely to be influencing pasture performance, and the increased reliance on short-term forage solutions.

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