Economic benefits of resilient pastures

Philip R. JOURNEAUX
AgFirst, 26D Liverpool Street, P O Box 9078, Hamilton 3240, New Zealand
Corresponding author: phil.journeaux@agfirst.co.nz

Highlights

An improvement in the resilience of New Zealand pastures will have significant economic benefits to the country. The renewal of pastures on-farm is an important aspect of this resilience, which involves a range of costs and benefits. This paper illustrates three aspects of these costs and benefits:

(i) That the cost of growing pasture can be substantial, with a combination of direct and indirect costs;
(ii) Modelling of an increase in re-grassing level on a representative dairy farm, from 8% to 15% per year, showed a significant Net Present Value and Internal Rate of Return; and
(iii) The increase in costs and benefits on-farm, also show a significant multiplier effect on the wider regional economy.

Keywords: cost of pasture, pasture renewal, re-grassing

Background

The pasture-based livestock production industries are the largest sectors within the collective New Zealand primary sector, both by virtue of land area involved and gross export revenue generated (Stats NZ 2019; Ministry for Primary Industries 2020). Key drivers behind this are our temperate climate which promotes good pasture growth, and good farm management, which converts the pasture grown into products, such as milk, meat, and fibre.

As a means of illustrating the benefits of increased resilience to the sector and the nation, this paper reports an analysis of some of the economic factors around the cost of growing pasture, the benefits of pasture renewal via maintaining a high-producing pasture on a representative dairy farm, and the wider macro-economic impacts. Pasture renewal is used to reflect these benefits, as it is a known factor in lifting pasture productivity.

Methods

The analysis was conducted in three steps: calculation of the base costs of growing pasture; the economic benefits for farm businesses of increasing the rate of pasture renewal; and the flow-on effects of those benefits to the wider economy. The methods used in each step are described below.

The cost of growing pasture

The cost of growing pasture at the farm level was calculated using the AgFirst financial survey of dairy farms across Waikato/Bay of Plenty, and the financial survey of central North Island hill country sheep and beef farms, based on the 2018/19 year (AgFirst 2020). The models used to report on these surveys are based on data from DairyNZ (DairyNZ 2021a) and the Beef + Lamb New Zealand Economic Service (https://beeflambnz.com/data-toolshttps://beeflambnz.com/data-tools) and represent an average farm business for the two regions/sectors. The models were created in the FARMAX® farm systems modelling software (www.farmax.co.nz) which allows for computation of pasture grown and eaten.

The key parameters used in these model farms are shown in Tables 1 and 2.

Table 1 Physical parameters of the 2018/19 Waikato/Bay of Plenty dairy model (AgFirst 2020).

Factor	Unit
Effective area (ha)	127
Cows wintered (head)	373
Replacement heifers (head)	80
Cows milked 15th December (head)	365
Stocking rate (cows/ha)	2.9
Total milksolids (kg)	127245
Milksolids per ha (kg/ha)	1002

Table 2 Physical parameters of the 2018/19 central North Island hill country sheep and beef model (AgFirst 2020).

Factor	Unit
Effective area (ha)	614
Breeding ewes (head)	2440
Replacement ewe hoggets (head)	675
Other sheep (head)	35
Breeding cows (head)	120
Rising 1-year cattle (head)	149
Other cattle (head)	115
Opening sheep stock units (ssu)	3185
Opening cattle stock units (csu)	1873
Opening total stock units (su)	5058
Stocking rate (su/ha)	8.2

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There are two distinct aspects to the cost of growing pasture: direct and indirect costs.

Direct costs

These are the costs associated with ensuring that pastures continue to grow, and include:

- fertiliser – the cost of providing (maintenance) nutrients for the pasture to grow.
- re-grassing, representing the cost of renewing pastures.
- weed and pest control – the cost of preventing weed invasion and/or pest degradation of the pasture.
- topping on dairy farms – while this cost is usually hidden within machinery repairs and maintenance (R&M), and fuel usage, many farmers often top pastures to maintain pasture quality, and therefore is included as a cost of growing pasture.
- irrigation costs – not included here, but a factor on some farms.

It could be argued that there is a cost to establish the pasture initially. This was ignored here on the basis that (a) this cost is minute when discounted over several years and over many tonnes of dry matter (t DM) grown over this period, and (b) the farm was assumed to be in pasture, where the main objective is to grow it as well as possible. There is also the issue of endeavouring to improve the quantity and quality of pasture grown, which is discussed later.

Indirect costs

These are the costs involved in farming, but which are germane to producing pasture. There are two key aspects to this:

- the value of land. There is a cost of holding and maintaining land to grow pasture, although the market value of farmland has only a moderate to poor relationship with the productive capacity of the land (Journeaux 2015). Within the analysis, a "cost of capital" charge was used (equivalent to a debt servicing cost) as a cost of holding the land, along with various costs of maintaining the land, e.g., rates, R&M, depreciation (e.g., on buildings), and insurance.
- managerial input. A key aspect in producing pasture is the level of managerial input into operating the farm, particularly grazing management. Good grazing management enhances pasture growth, while poor grazing management would hinder pasture growth. Within the financial survey expenditure, there is an imputed "wages of management" (WoM) cost of $85000 for the dairy farm and $75000 for the sheep and beef farm, which represents the farmer's managerial input into running the farm business.

The proportion of WoM attributable to grazing management of the farm, as opposed to all the other aspects of running the farm business, was determined from expert opinion via discussion with a number of farm consultants, since there is no literature available on this subject. Expert opinion varied according to the individual consultant's views regarding what should be included in "grazing management". Generally, it was felt that selection of paddocks to graze, shifting breaks, feed budgeting, pasture growth assessments, determining the feed ration (e.g., the amount of pasture relative to supplements), and fertiliser applications should all be included.

The estimated proportion of management time required to perform these tasks ranged from 10-15% to 40-45%. One of the high estimates also included training farm staff in feed budgeting/grazing management. The overall consensus was to apportion 35% of WoM to the various tasks that make up grazing management.

Pasture growth rates

Estimated (from FARMAX) total gross pasture production for the dairy farm model was 13975 kg DM/ha, excluding any impact from nitrogen (N) fertiliser. This figure is about 600 kg DM/ha less than the mean of 13 farms in the Waikato and Bay of Plenty regions used as a guide for pasture production levels by DairyNZ (DairyNZ 2021b).

Gross pasture production was adjusted within the FARMAX model to allow for wastage, comprising:

- adjustment for crop grown. The farm grew 4.8 ha of maize, which reduced the grazing area and therefore reduced the average amount of pasture grown across the farm.
- loss of potential. This accounts for reductions in pasture growth resulting from pasture cover being either too high (shading) or too low (inadequate leaf area).
- decay. This accounts for the effects of high pasture cover on pasture senescence and decay.
- Net pasture growth after these adjustments was estimated to be 11625 kg DM/ha/yr (Table 3), equating to a utilisation rate of 84%. Net pasture growth was used for the subsequent analysis of the cost of growing a kilogram of pasture DM.

Estimated (from FARMAX) gross pasture production for different slope classes of land in the sheep and beef farm base model is shown in Table 4. After adjustments (as explained above for the dairy farm model, excluding the crop factor), weighted farm average net growth was estimated to be 4990 kg DM/ha, or 75% of estimated gross pasture production.

Net pasture production per hectare was divided by the total per hectare direct and indirect costs itemised above to calculate pasture growing costs for both systems. Sensitivity analysis was also carried out by varying the two key factors which had the greatest impact on the outcome of the analysis: amount of DM grown, and land values.

The benefits of pasture renewal

This has been addressed several times previously, mostly using partial budgeting techniques (Pasture Renewal Charitable Trust 2010; Kerr et al. 2015; Barenbrug 2020). Here, a model of the Waikato/Bay of Plenty dairy farm was set up in FARMAX (same model as discussed above), which allowed for the modelling of the impact of increased pasture renewal at a whole farm level.

Expenditure on re-grassing varies between years. Table 5 presents average re-grassing expenditure for the past 3 years on Waikato/Bay of Plenty dairy farms included in the AgFirst monitoring database. The average expenditure over those 3 years of just under $10000 per year equates to a re-grassing rate of approximately 10 ha per year if a mean cost of $1000 per hectare is used (Barenbrug 2020), or 7.9% of the Base Waikato/Bay of Plenty farm system modelled in FARMAX (total farm area = 127 ha).

For the purposes of this analysis, two key assumptions were made:

(i) The current level of re-grassing is sufficient to just maintain average pasture growth on the farm. There is limited evidence for this: pasture cuts recorded by DairyNZ (2021b) show no real increase in average pasture growth for dairy farms in Waikato and Bay of Plenty (especially once the effect of N fertiliser is removed). In noting this, Mills & Neal (2021), based on DairyBase data, show a slight negative trend (~ 40 kg DM/ha/yr) in pasture and crop eaten per hectare per year on Waikato dairy farms from 2005/06 to 2018/19 (again after adjusting for variation in N fertiliser use).

Table 3 Net pasture growth in the dairy farm model (kg DM//ha/yr).

Potential growth	Adjusted for crop area	Loss of potential	Decay	Net growth
13975	13835	1795	415	11625

Table 4 Sheep and beef model pasture growth rates.

Slope	ha	Gross kg DM/ha/yr
Steep	273	4650
Rolling	279	7635
Flat	62	10920
Total	**614**	**Weighted average: 6635**

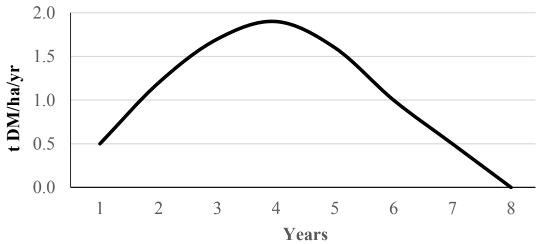

Figure 1 Increase in total pasture grown over time following re-grassing, relative to pasture grown prior to re-grassing.

(ii) The analysis is based on re-grassing 15% of the farm (19 ha) each year, with the intent of lifting average pasture production over the whole farm. In effect, it means that the pasture on the farm is renewed every 8 years. This means that there is an additional 9 ha being re-grassed every year above the base (10 ha, Table 5), and the analysis is based on this extra 9 ha.

The amount of extra DM grown via re-grassing can vary (Glassey et al. 2010; Pasture Renewable Charitable Trust 2010; Kerr et al. 2015; Tozer et al. 2015; Barenbrug 2020; Chapman et al. 2021). For the purposes of the analysis, an improvement in pasture growth was largely based on Tozer et al. (2015), which showed an improvement in pasture growth in the initial years, before declining back to the base level, over an 8-year period (Figure 1). [Note that the Pasture Renewable Charitable Trust (2010) booklet assumed a 10% reduction per year on a diminishing basis, which actually gives a 30+-year advantage to the new pasture].

The effect of this pasture renewal programme was a total extra 8.4 t DM/ha grown on the re-grassed area, over the 8-year period. When extrapolated in space and time across the whole farm, this was equivalent to an extra 529 kg DM/ha over the 8-year period, or 66 kg DM/ha/yr. Increasing re-grassing by 9 ha per year adds an extra 595 kg DM/ha over the whole farm over the 8-year period, or 74 kg DM/ha/yr.

There were also two other key assumptions:

(i) An increase in average megajoules of metabolisable energy (MJ ME). This was assumed to be 0.6 MJ ME/kg DM in the additional (9 ha) area being re-grassed, which translated to an extra 0.015 MJ ME/kg DM across the whole farm.

Table 5 Waikato/Bay of Plenty dairy farm monitoring data for re-grassing expenditure ($/ha).

2017/18	2018/19	2019/20	Average	Hectares*	% farm
10238	7081	12600	9973	10.0	7.9%

*Based on $1000/ha (Barenbrug 2020)

(ii) There is an opportunity cost to the extra re-grassing, in that there is a reduction in pasture availability during the time the new pasture grows through to first grazing. For this analysis, it was assumed that this loss occurred over March and April; the 9 ha was the equivalent of losing 2 kg DM/ha/day in March, and 2.1 kg DM/ha/day in April, across the whole farm, which was built into the FARMAX model.

The analysis was based on increasing per cow production from the increased feed, rather than increasing cow numbers, as this gives the best economic returns. All other feed inputs to the farm (purchased supplements, crops, N fertiliser) were held constant.

Macro impacts – the multiplier effect of re-grassing

The multiplier effect is where a change in spending in one area of the economy stimulates a change in spending in other areas. In a re-grassing situation for example, farmers spend on inputs such as grass seed, fertiliser, and contractors to carry out the re-grassing activities. In turn this means that the companies and contractors providing the materials and services spend on replacing inputs such as the materials used and wages, with the workers in turn spending on further services they need, and so on (Journeaux et al. 2019).

This accords with economic theory which states that if there is an increase in final demand for a particular product (or service), it can be assumed that there will be an increase in the output of that product, as producers react to meet the increased demand: in economic jargon, this is the 'direct effect'. As these producers increase their output, there will also be an increase in demand on their suppliers and so on down the supply chain: this is the 'indirect effect' (i.e., Type I multipliers). As a result of the direct and indirect effects, the level of household income throughout the economy will increase due to increased employment. A proportion of this increased income will be re-spent on final goods and services: this is the 'induced effect' (i.e., Type II multipliers) (Butcher 1985).

In addition, there are both forward and backward linkages: backward linkages relate to the services each industry buys in to provide their goods, while forward linkages relate to the processing/manufacturing process through to the wharf. For the re-grassing example, the backward linkages are for the materials purchased by the farmer (e.g., seed, fertiliser) and the services provided by the contractors. The forward linkages relate to the additional product produced as a result of the increased pasture growth (Journeaux et al. 2019).

Industry Input/Output tables are based on census data (e.g., Stats NZ 2016), and show the statistical relationship between different industries, where outputs from one industry are the inputs into other industries, and vice versa. Within these tables, 114 industries are listed, of which the key ones relating to re-grassing are:

- services to agriculture, hunting and trapping (contractors, retailers)
- mixed cropping (growing seeds)
- fertiliser manufacturing (fertiliser)

Any increase in spending by farmers on re-grassing would therefore primarily benefit these sectors. The extent to which they would benefit also depends on two key factors:

- Whether the increase in expenditure was permanent or not. If, for example, there was a particularly good year payout or schedule-wise, the increased spending would certainly flow through the value chain, but only temporarily, until "normal service" was resumed. However, such a temporary upswing (or downswing as the case may be) would not result in any permanent change – the suppliers of the goods and services would themselves adjust temporarily (e.g., work overtime, hire more workers short-term). The full impact of the multiplier effect will only be felt if the change in spending is permanent.
- Whether the spending was "new" money, or simply a transfer within the same category. For example, if the farmer decided to spend more on re-grassing, but funded this by reducing expenditure on (for example) clearing drains/repairing tracks and races, then this would simply represent a transfer of money within the "Services to agriculture, hunting and trapping" sector. Individual contractors may be affected, but the amount of money flowing through that sector would be the same, so the multiplier effect would be zero.

For the purposes of this analysis, the increase in expenditure was assumed to be permanent, and new.

Results and Discussion

The cost of growing pasture

The estimated combined direct and indirect operating cost of growing pasture in the dairy farm model was \$0.07 per kg DM (Table 6).

To this must be added the opportunity cost of the value of the model farm, which was assessed at \$39260/effective ha based on the mean of Waikato dairy farm sales in 2019 (AgFirst 2020). Assuming an interest rate of 5%, this gave an annual figure of \$1963/ha, or \$0.17/kg DM. Varying the rate by 1% (i.e., down to 4% or up to 6%), resulted in a 3c/kg DM movement.

Finally, adding the imputed cost of the WoM allowance for grazing management (\$234/ha or \$0.02/kg DM) brings the total estimated cost of growing pasture to \$0.26/kg DM (Table 7).

The equivalent analysis for the sheep and beef farm model returned a total estimated cost per kg DM of \$0.15 (Tables 8 and 9).

Sensitivity analysis

For the dairy farm model, each $10000/ha increase or decrease in land value, resulted in the cost of growing pasture varying, up or down, by $0.05/kg DM (averaged across the whole table), whereas the cost decreased by $0.02/kg DM for each 1000 kg increase in the amount of DM grown per hectare (again averaged across the whole table, Table 10).

For the sheep and beef model, the pattern was more mixed, although again there was an increase in cost per kg DM as land values increased, and a decrease in cost if kg DM grown increased (Table 11).

Benefit of pasture renewal

Based on the assumptions outlined in the Methods section, lifting the pasture renewal rate from 8% of pasture area per year to 15% per year increased profit by $40/ha, or 1.3% (Table 12).

This was then analysed within a cost/benefit framework, covering the whole 8-year cycle of pasture renewal. This gave a Net Present Value (NPV) of $1344/ha (assuming a 5% discount rate – current New Zealand Government discount rate), and an Internal Rate of Return (IRR) of 56%. [If the analysis is conducted for an individual year, NPV = $198/ha, IRR = 56%.]

The quantum of benefit is directly related to the percentage of the extra feed grown, which is consumed. Halving the percentage utilisation decreases NPV and IRR by a factor of ~ 2 (Table 13). The efficiency of utilisation of the extra feed grown is very much related to the grazing management expertise of the farmer, and the degree to which pasture may be substituted for by supplements. In this respect it could be expected that WoM would vary depending on the percent utilisation, but this was not factored into the analysis.

Table 6 Direct and indirect costs ($) of growing pasture for the dairy farm model.

Direct Costs	Total	per ha	per kg DM
Fertiliser	25768	202.90	0.017
Re-grassing	7081	55.76	0.005
Weed & Pest	4161	32.76	0.003
Topping Allowance	4950	38.98	0.003
Total		**$330.40**	**$0.03**
Indirect Costs	**Total**	**per ha**	**per kg DM**
Rates	20750	163.39	0.014
Administration	20915	164.69	0.014
Building Depreciation	2564	20.19	0.002
R&M land/buildings	17250	135.83	0.012
Insurance Buildings	2555	20.12	0.002
Total		**$504.22**	**$0.04**
Land value ($/ha)	39260		
Interest rate	5%	**$1963.00**	**$0.17**
Wages of Management	85000		
Proportion to grazing management	35%	**$234**	**$0.02**

Table 7 Summary of all pasture growing costs ($) for the dairy farm model.

	Cost/kg DM
Direct Costs	0.03
Indirect Costs	
Opportunity cost of land	0.17
Other land costs	0.04
Wages of Management	0.02
Total	**$0.26**

Table 8 Direct and indirect costs ($) of growing pasture for the sheep and beef farm model.

Direct Costs	Total	per ha	per kg DM
Fertiliser	63550	103.50	0.02
Re-grassing	2855	4.65	0.001
Weed & Pest	10849	17.67	0.004
Total		**$125.82**	**$0.03**
Indirect Costs	**Total**	**per ha**	**per kg DM**
Rates	22269	36.27	$0.007
Administration	15988	26.04	$0.005
Building Depreciation	2336	3.80	$0.001
R&M land/buildings	42254	68.82	$0.014
Insurance Buildings	6567	10.69	$0.002
Total		**$145.62**	**$0.03**
Land value ($/ha)	8406		
Interest rate	5%	**$420.30**	**$0.08**
Wages of Management	75000		
Proportion to grazing management	35%	**$43**	**$0.01**

Table 9 Summary of all pasture growing costs ($) for the sheep and beef farm model.

	Cost/kg DM
Direct Costs	0.03
Indirect Costs	
Opportunity cost of land	0.08
Other land costs	0.03
Wages of Management	0.01
Total	**$0.15**

Macro impacts – the multiplier effect of re-grassing
Within the re-grassing modelling example discussed earlier, the average increase in farm expenditure was $9000/farm. If this is extrapolated across all farms in the Waikato and Bay of Plenty regions, numbering 4580 (DairyNZ 2021a), this gives an increased annual expenditure of $41.2 million. The additional income generated, if extrapolated in a similar fashion, gives a regional increase of $23.3 million.

The multipliers pertaining to the agriculture, forestry and fishing support services sector are shown in Table 14.

Applying these multipliers leads to the estimated employment and value-add impacts shown in Table 15, assuming all dairy farms in the Waikato/Bay of Plenty regions followed the increased re-grassing regime.

This illustrates the value of having high-producing and resilient pasture species on the wider economy. The total value-add figure in Table 15 represents 2% of the agricultural Gross Domestic Product (GDP) for the Waikato and Bay of Plenty regions, or 0.3% of the total GDP for the two regions.

Conclusions

This paper has highlighted three key economic aspects around growing pastures, and pasture renewal. The first is the cost of growing pastures. While the direct costs of doing so are relatively low, it is the indirect costs, especially the opportunity cost of farmland, which significantly increases the overall cost of growing pasture. The second is the benefit of a regular pasture renewal programme. Moving from an 8% per year renewal programme to 15% per year resulted in a significant return on investment.

The third aspect is the multiplier effect of pasture renewal – the impact beyond the farm gate of increased productivity and economic activity. The analysis presented here indicated a significant gain in employment throughout the region, accompanied by a

Table 10 Sensitivity of dairy cost of pasture to land values and DM grown ($/kg DM).

Gross t DM/ha	Value of land ($/ha)				
	20000	30000	40000	50000	60000
10	0.25	0.31	0.37	0.43	0.49
12	0.21	0.26	0.31	0.36	0.41
14	0.18	0.22	0.26	0.31	0.35
16	0.16	0.19	0.23	0.27	0.31

Table 11 Sensitivity of sheep and beef cost of pasture to land values and DM grown ($/kg DM).

Gross t DM/ha	Value of land ($/ha)				
	5000	8000	10000	15000	20000
5	0.15	0.19	0.22	0.28	0.35
6	0.13	0.16	0.18	0.24	0.29
7	0.11	0.14	0.16	0.20	0.25
8	0.09	0.12	0.14	0.18	0.22
10	0.08	0.10	0.11	0.14	0.18

Table 12 Impact of re-grassing modelling results.

	Base	Re-grass[1]	Difference	Difference%
EBITDA/ha[2] ($/ha)	3019	3059	40	1.3
MS total	127245	128993	1748	1.4
MS/ha	1002	1016	14	1.4
MS/cow	352	357	5	1.4

[1]Average over the 8-year period
[2]EBITDA = Earnings before interest, tax, depreciation, and amortisation

Table 13 Sensitivity analysis on re-grassing benefits by varying percentage of extra feed consumed.

% of extra feed consumed	NPV ($/ha)	IRR (%)
84	1344	56
63	888	42
50	605	32
42	432	26

Table 14 Agriculture, forestry and fishing support services multipliers.

Type	Multiplier[1]
Employment to Gross Output Ratio	9.41
Type I Backward Linkage Employment Multiplier	1.44
Type II Backward Linkage Employment Multiplier	1.45
Type I Backward Linkage Value Added Multiplier	1.69
Type II Backward Linkage Value Added Multiplier	1.71

[1]Pers. comm. G McDonald, Market Economics

Table 15 Total employment and value-add impacts of increased re-grassing.

Impact	FTEs	$ million[1]
Direct Employment Impact	388	23.3
Indirect	171	16.1
Induced	4	0.5
Total	**563**	**39.9**

[1]Based on increased EBITDA figure from Table 12

gain to regional GDP, and is consistent with the figures generated by Sanderson & Webster (2009), who showed that if dairy farm pasture renewal increased from 6.6% (measured in 2010/11) to 12%, the value of national dairy products would increase by $122 million. If the figures derived in this analysis are extrapolated to the national level, total estimated value-add is $97 million.

As can be appreciated, there are a number of assumptions which underpin the analysis, any of which could be challenged. However, given the size of the NPV/IRR result, there is obvious scope for downsizing the assumptions and still show a healthy positive result which is consistent with previous analyses of the benefit of re-grassing.

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