

Investing in off-paddock facilities?

Making an informed decision

Assessing the benefits of off-paddock facilities



DairyNZ 

Contents

Making an informed decision	1
Nutrient budget benefits	2
More efficient production	4
Collect effluent for application at a later date	6
Reduced soil and pasture damage	7
Reduced feed wastage	9
Less risk of summer over grazing	10
Less heat stress	11
Less cold stress	12



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Making an informed decision

There is any number of reasons for investing in off-paddock infrastructure such as covered feed pads or cow housing. A few of these reasons include:

- Achieving the farm business and ensuring you are running your farm as efficiently as possible. production or profit goals
- Reducing the impact of climatic conditions, e.g. drought
- Meeting environment targets
- Animal welfare

Regardless of the reason, the decision to invest needs to be based on sound analysis of the farm business and ensuring you are running your farm as efficiently as possible.

Do your homework

- Be sure any changes you're wanting to make will solve the problem you're wanting to address – ensure any changes fit with your goals
- Confirm proposed changes with independently qualified people
- Use the correct capital investment tools (net present value)
- Ancillary costs (e.g. effluent, labour, machinery) could add 30%-100% to the build cost
- Understand the risks and the skills associated with running a system with off-paddock facilities.

Run your farm as efficiently as possible

- Know your own farm and situation – don't think that what others are doing will necessarily meet your objectives or farm situation
- Identify areas through benchmarking where efficiency can be gained and apply practices that minimise wastage.
- Make appropriate infrastructure responses to environmental challenges – look at cheaper options
- Avoid over reliance on expensive imported feed sources
- Avoid paying too much for land.

Nutrient budget benefits of getting cows off pasture

Off-paddock facilities, combined with effluent management best-practice (storage and application back to land), can reduce N (nitrate) leaching by 25-55%, especially when targeted at the higher risk autumn winter period.

Nitrate N promotes pasture growth, but is readily leached below the root zone and lost

In grazing systems, cows urinate onto pastures with urine N typically being deposited at rates equivalent to 500 to 1000kg N/ha¹. The N in the urine is very quickly (usually within 7 to 21 days) converted to nitrate N which is highly mobile.

The amount which leaks down through the soil profile depends on soil type (permeability), the amount of N present, rainfall and pasture growth rate which drives removal of nitrate N by the roots. The vertical leakage means that riparian strips etc, which mitigate P loss, are not very effective for N leaching. Ryegrass (and other) plants benefit from this N. In doing so they remove at least some N before it is lost below the root zone, provided soil temperature favours rapid growth as in spring and summer and assuming other factors are not limiting growth.

N deposited in late summer and autumn has a high risk of being leached because it can be present in the upper profile of the soil in high amounts after a dry summer-autumn period and there is less time for plant uptake to occur before the start of the drainage season. Cool winter temperatures and winter rainfall provide conditions for high N leaching. Stock density and crude protein content are two key elements that drive the amount of urine N deposited.

Impacts of off-paddock facilities on N leaching vs conventional grazing

Off-paddock facilities allow for removal of cows from pastures onto that facility. Assuming best practice effluent management (storage and application back to land at appropriate rates when conditions allow), farm systems utilising these structures can have a large impact on N leaching as shown below, especially when targeted at the higher risk autumn and winter periods.

Table 1: Effects of an off-paddock system on N leaching vs. conventional pasture grazing or crop wintering systems^{1 2 3 4 5}

System	Reduction in N leaching	Change in total losses *
Cows off pasture 24/7		
Nil grazing: cows off pasture all year	55 to 65%	+10 to 35%
Restricted: cows off 5 months autumn & winter	35 to 50%	-10 to +5%
Cows in barns winter vs. on crop	25%	
Cows in barns autumn vs on pasture	30%	
Cows in barns autumn & winter (5 months)	55%	
Restricted grazing (on-off grazing)		
Southland, cows grazed 3hrs, standoff 21 hrs for March, April & May	20 - 40%	
Waikato: cows grazed off over winter	25%	

* Includes N leaching and gaseous losses to the atmosphere as ammonia and nitrous oxide

While significant benefits can occur, there are potential disadvantages to constructing and using off paddock facilities to mitigate N leaching. These include:

1. Impacts on pasture growth; timely return of dung and urine is important (discussed elsewhere)
2. Increased gaseous losses of N from the system. These gases include ammonia and nitrous oxide, with GHG (greenhouse gas) implications
3. The capital, maintenance and operating costs of the facilities, which are also discussed elsewhere. A response to offsetting these costs can be to import more feed for more production and income. This intensifies the system and the amount of N cycling through it, potentially to the point where N leaching returns to where it was before the off-paddock facility was installed.

References

- ¹ Dalley et al, 2014. SIDE conference. Paper 2.5. <http://side.org.nz/past-proceedings/>
- ² de Klein et al, 2010. Proceedings of the 4th Australasian Dairy Science Symposium. 14 – 28. A review.
- ³ de Klein et al, 2006. Agriculture Ecosystems and Environment. 112, 192 – 199.
- ⁴ de Klein and Ledgard, 2001. NZ Journal of Agricultural Research. 44, 201 – 215.
- ⁵ Monaghan and de Klein, 2014. Journal of Agricultural Science. 1 – 12.

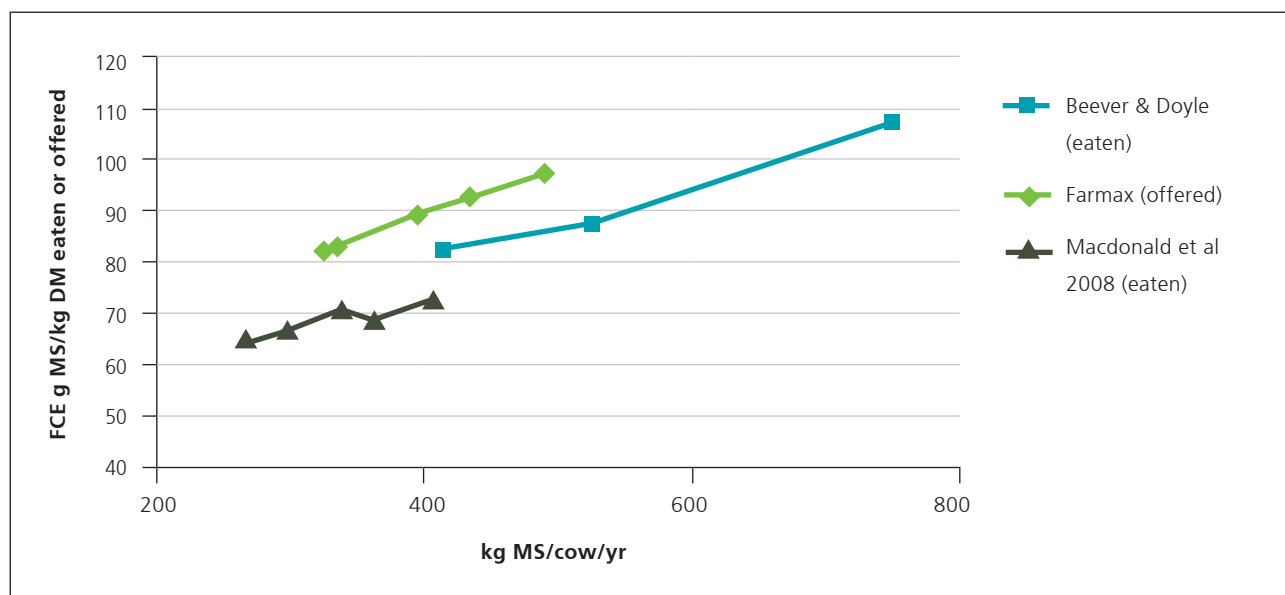
More efficient production from off-paddock facilities

Off-paddock facilities offer the opportunity for more supplementary feeding of dairy cows. This can lift feed conversion efficiency per cow and production per cow and per hectare to help pay for the cost of the off-paddock facility. But, this supplementation can damage pasture utilisation.

Higher producing cows have better FCE (feed conversion efficiency)

A higher producing cow is more efficient, because, of the total feed eaten, a higher proportion goes to milk production vs. her maintenance requirements (Figure 1)^{1 2 3}.

Figure 1: Demonstration that systems with higher producing cows have better FCE (feed conversion efficiency) per cow on a whole year basis. FCE is described by production (g MS) per kg of DM offered or eaten. Higher values imply greater efficiency.



High pasture utilisation and profit are strongly linked

Where pasture (our cheapest feed source) is an important part of the diet, use of supplementary feed will result in substitution⁴. High pasture utilisation and maintenance of quality requires a degree of grazing pressure to ensure pastures remain in a leafy state. Lower utilisation (higher grazing residuals) inevitably results in either a loss of pasture quality or increased topping or silage production, both of which add cost to the system.

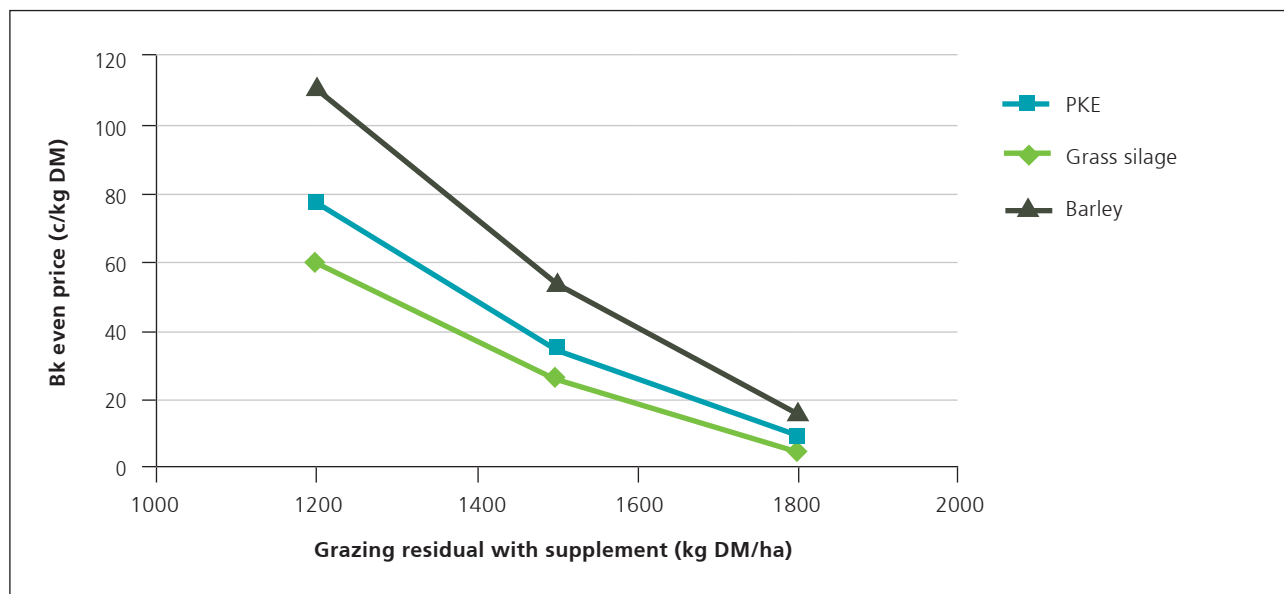
As demonstrated on numerous occasions, maximum profit and high pasture utilisation occur at stocking rates higher than required for maximum production per cow. As a result, FCE per cow is below potential, but feed conversion efficiency per farm (total pasture eaten) and profit are maximised. As cows are increasingly well fed, they have increasing opportunity to choose what they eat or substitute; one food for another.

A large survey in Ireland⁵ indicated that on average, for every 1kg of supplement DM introduced to the system, 0.6kg less pasture DM was consumed. This is a problem, because more expensive feed (purchased supplement) is replacing cheaper feed (pasture). In addition, pasture not eaten loses quality or energy density and eventually is wasted.

Substitution and the price that can be paid for supplement varies depending on grazing pressure

Perversely, substitution is not always 60%. It decreases as cows get increasingly hungry, as measured by residual pasture mass post-grazing⁴. This determines how much can be paid for supplements, described in Figure 2 by the breakeven price. Although on-farm costs, including feeding out, were 3.5 to 6c/kg DM in these examples, they can be a lot higher, up to 50 to 100% of the farm gate price of the supplement.

Figure 2: The breakeven purchase price for supplementary feed as affected by substitution, in turn driven by cow hunger, measured in this instance by residual herbage mass, and at a payout of \$5.50/kg ms. Derived from the Supplementation Model on the DairyNZ website.



Some managers successfully integrate high supplement use with high pasture utilisation

DairyNZ survey data demonstrate that some farmers successfully operate high input systems with high production per cow and high pasture utilisation. Anecdotal evidence indicates that less than 5% of managers are able to do this. Their defining features include relentless and regular monitoring of all aspects of their system, accurate allocation of both pasture and imported feed and strict adherence to decision rules around residual pasture mass through to supplement purchase prices. They make good profits when payout is high but are disadvantaged when the payout to feed purchase price is unfavourable.

References

- ¹ Beever and Doyle, 2007. Australian Journal of Experimental Agricultural. 47, 645 – 647.
- ² Farmax Dairy. A dairy farm simulation model. Rezare Systems, Ruakura, Hamilton
- ³ Macdonald et al, 2008, 2011. Journal of Dairy Science. 91, 2151 – 2163 and 94, 2581 – 2586.
- ⁴ Holmes et al, 2002. A book: "Milk production from pasture", Massey University. Pp 306 – 307.
- ⁵ Ramsbottom et al, 2015. Journal of Dairy Science. In press.

Off-paddock facilities collect effluent which can be spread later to grow more pasture than conventional grazing

Capturing and storing effluent from off-paddock facilities allows timely and even application of the effluent at a later date, but the benefits for pasture growth can be either positive or negative.

Off-paddock facilities capture and store effluent which should confer benefits later

Off-paddock facilities allow for the capture and storage of effluent. Intuitively, collecting dung and urine from cows on stand-off areas in autumn and winter, storing it in a pond and then evenly spreading it on pasture in spring should be a good idea with pasture growth benefits as well as reductions in N leaching. There are also other benefits in terms of reduced pugging damage and N leaching (see elsewhere for details). Conceptually simple, it is quite difficult to separate the potentially beneficial effects of reduced treading/pugging from those of even reapplication of effluent.

Estimated benefits of even return of dung and urine vs conventional return via the grazing animal

Under conventional grazing, only 30% of the grazed paddock area receives dung and urine via the animal in any one year. This grows 50% of the annual DM of the paddock. The remaining areas (70%) however, provide a less fertile environment which favours clover production (provided nutrients such as P and K are present), to produce our cheapest source of N input¹.

De Klein¹ modelled the potential benefits of returning effluent from storage ponds and applying it evenly to the whole paddock in spring and summer when pastures can utilise the N, in particular, before it is leached below the root zone. The idea of even application of effluent is that the whole paddock benefits and also those nutrients are applied at rates that can be utilised by the pasture. This compares to effluent return via the animal where N is applied at the equivalent of 500 to 1000kg/ha at the urine patch and cannot all be utilised by the plant before it leaches below the root zone during drainage, which typically occurs in cooler months if rainfall is high.

De Klein¹ estimated that under a system of nil grazing (animals housed year round); pasture growth rates should increase by 20% from applied effluent. Under a restricted grazing system (animals housed 24/7 for 5 months in autumn-winter); growth rates should increase by 2 to 8% ahead of conventionally grazed pasture.

However, field work has indicated that reducing the duration cows spend grazing, can have a negative effect on pasture growth, if effluent is not adequately returned. A 5-year grazing trial² showed that halving grazing durations year-round resulted in a 20% reduction in pasture accumulation in the year no effluent was returned to pasture. In the years effluent was returned, pasture response ranged from -14% to +6%, compared to standard grazing durations. The nutrient composition of the effluent and application timing influenced this response. The key to improved response from effluent applications is to maximise the return of mineral N in effluent at a time of year when pasture will be most responsive to added N.

Gaseous N losses to the atmosphere can become a significant source of loss in housed cow systems and in effluent storage ponds. Therefore, long periods of storage in warm conditions should be avoided to minimise these losses. Besides being a loss to the soil-pasture system, they are a GHG (green-house gas) emission problem.

References

¹ de Klein, 2001. NZ Journal of Agricultural Research. 44, 217 – 235.

² Christensen et al, 2014. Duration-Controlled Grazing on Dairy Farms. In: Nutrient management for the farm, catchment and community. Occasional Report No. 27. FLRC, Massey University, NZ.

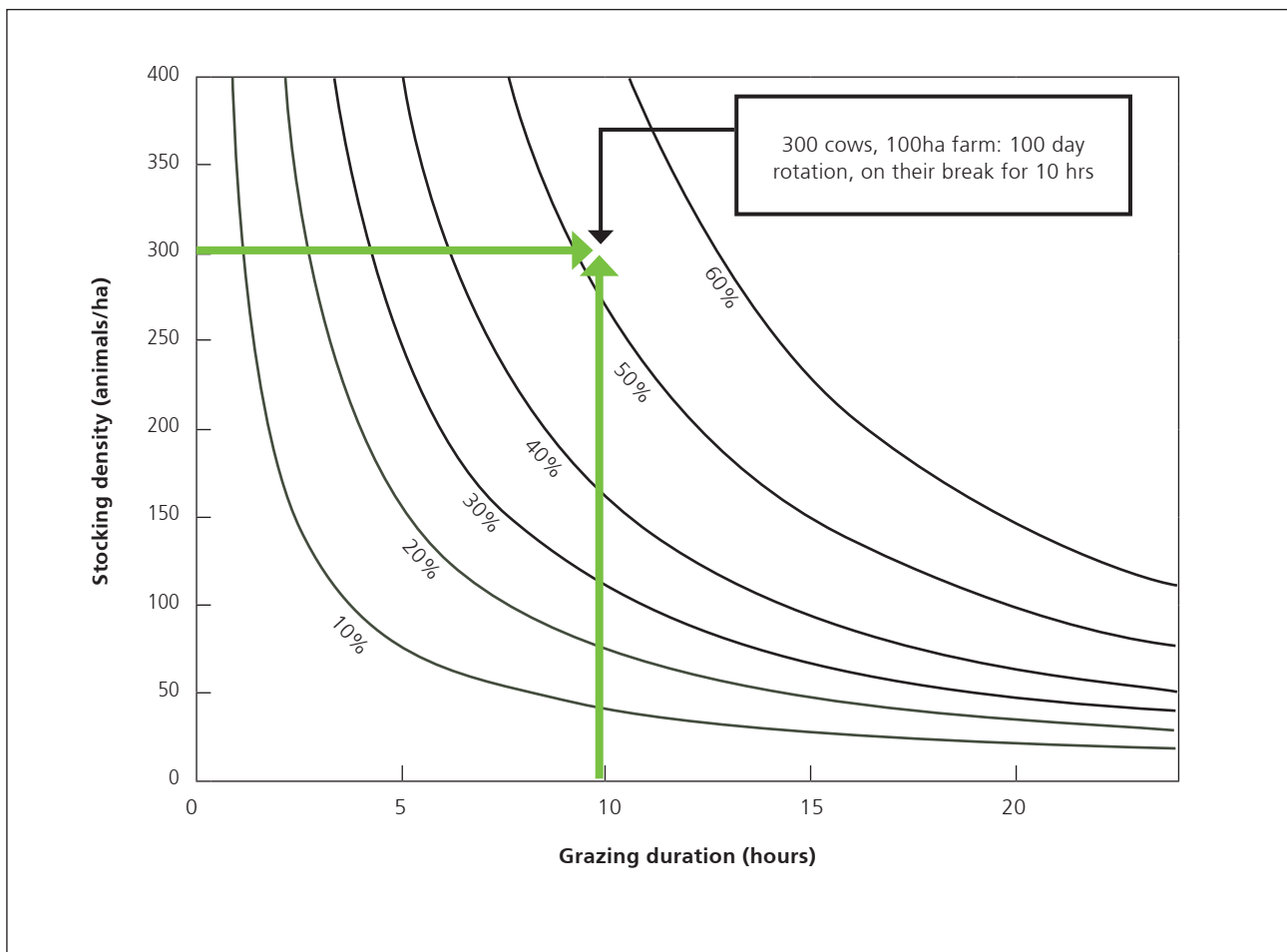
Reduced soil and pasture damage, with benefits for pasture growth

Expect a small increase in farm pasture growth and production and a 5% or smaller increase in profit as a result of reduced pasture damage by standing cows on off-paddock facilities: highly soil type and rainfall variable.

Protecting soils from pugging damage has benefits for pasture production

Off-paddock facilities allow for removal of cows from pastures onto that facility, thereby avoiding soil and pasture damage when conditions are wet. This can be particularly beneficial for farms on sensitive soil types. An early case study¹ indicated that subsequent pasture growth on the pugged area was depressed by a maximum of 52% for up to 21 days, after which it steadily returned to normal 2 months after the pugging event. Anecdotal evidence indicates that nuisance weeds such as willow-weed, docks etc. can also invade these damaged areas. A further study by Betteridge¹ demonstrated how contrasting stocking density and grazing duration combinations, in high risk periods, can affect pasture yield following pugging damage (Figure 1).

Figure 1: Effects of grazing duration and stocking density on the depression in pasture growth (contour lines) in the month following the damage event (clay soil type in wet conditions).



Implications of isolated pugging events on whole farm pasture production

The section above describes the damage on the pugged area of a particular paddock. Over the whole farm however, the effect is much smaller, per pugging event. For example, in case study 1 above, it can be calculated that the event would cost about 550kg DM/ha (1ha, 100 day round, assumed growth rates, etc). Per hectare per year this amounts to a 5% growth rate reduction on the pugged area. On a 100ha farm basis, the impact would be 0.05% per pugging event. There would have to be 20 pugging events of similar magnitude in the winter to affect farm annual pasture growth by 1%. Note that severely pugging an entire grazing break (1ha in this case) is quite extreme.

In another example, Figure 2 and Table 1 below are modelled estimates^{2 3} of the effects of different stand-off systems and pugging events on whole farm production for Telford farm, South Otago.

Figure 2: Modelled impacts of pugging on % of the whole farm damaged in any one month. Variation between years is due to rainfall patterns used in the modelling for this South Otago farm.

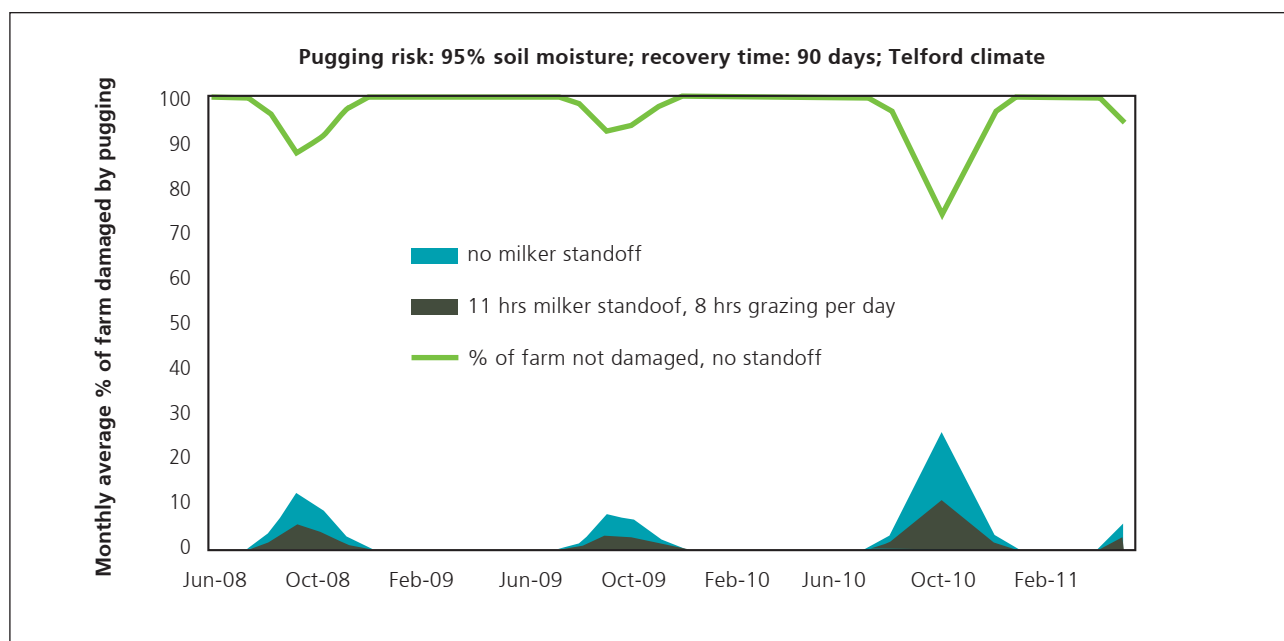


Table 1: Modelled milk production and profit effects of pugging damage, for Telford Farm, South Otago, which is on a clay soil type^{2 3}: The results are the average of 3 years. Interest on capital costs of off-paddock facilities is included.

Farm system	Production (MS/ha/year)	Operating profit (\$/ha/year)
Milkers; no standoff: Dries wintered on crop	983	2290
Milkers; no standoff: Dries wintered 24/7 on standoff pad	1086	2185
Milkers; standoff 11hours/day*: Dries wintered 24/7 on standoff pad	1086	2341

* Cows grazing 8 hours/day, rest of time in milking shed etc

References

- 1 Betteridge et al, 2003. A booklet (35p): "Managing treading damage on dairy and beef farms in NZ". AgResearch, Hamilton, NZ.
- 2 Beukes, 2014. DairyNZ, Unpublished results.
- 3 Beukes et al, 2013. NZ Journal of Agricultural Research. 56, 224 – 238.

Reduced feed wastage

The available evidence supports this assumption.

Our estimate of the value created by a reduction in wastage from 30% to 10% for maize silage, or from 25% to 5% for PKE, is an extra \$80 of milk income per tonne of DM fed from an extra 200kg DM eaten/tonne DM fed. Alternatively a saving in feed wastage can be viewed as less feed required to purchase to maintain the same production.

To arrive at this figure we used DairyNZ's published estimates of feed wastage¹ and assumed an improvement from average wastage for feeding out in the paddock to minimal levels of wastage for feeding out in constructed feeding facilities.

	Average wastage paddock feeding	Minimal wastage feeding bins	Difference in wastage
Maize silage	25%	5%	-20% (200kg DM/tonne DM offered)
PKE	30%	10%	-20%

There are few recent comparisons of different feeding methods and their impact on the volume of feed offered but not eaten. Particularly in wet weather conditions it's very difficult to measure feed wastage unless there are controlled experimental conditions.

Dairy Australia² conducted a study in 2009 which compared six different feed out methods on 50 commercial dairy farms. The assessment of feed wastage was conducted under dry conditions.

- The average feed wastage was 9% for paddock feeding compared with 2% for a system using permanent feeding facilities designed for minimal waste and maximum control of feeding.
- The worst examples of wastage for each of these systems were 22% and 6% respectively.

Definitions

Paddock feeding was where partially mixed rations were fed on the paddock where cows were grazing, on top of the grass, or under an electric fence.

Permanent, minimal waste, maximum control was where a mixing wagon was used in a purpose built feed-out facility with a cement surface for the cows and a roofed feed alley. Headlocks or electric wires were used to prevent feed losses due to trampling.

References

¹ DairyNZ: Facts and Figures for New Zealand Dairy Farmers, page 31

² <http://www.dairyaustralia.com.au/~media/Documents/Animal%20management/Feed%20and%20nutrition/Feeding%20Systems%20latest/DA%20Grains2Milk%20feed%20wastage%20study%20-%20summary%20report.pdf>

Less risk of summer over grazing

It's safe to assume farmers can add to the return from their off-paddock facilities by using them to prevent cows from grazing below 4cm in summer.

Having a purpose built facility is not essential to achieve this but may also provide two other benefits simultaneously, i.e. reduced heat stress, and reduced feed wastage.

Recent droughts have moved farmers to protect pasture from overgrazing by taking cows off paddock for part of the day to feed supplement and reduce grazing time. The potential benefits are improved pasture persistence and reduced re-grassing costs.

The current recommendation is to prevent cows grazing below 3.5 to 4cm during summer which is the same height recommended for other seasons (except winter). The research evidence is historical¹, but recent relevant research^{2,3,4} does not contradict the early work. This research¹ found that the annual yield for pastures grazed to 2.5cm in summer was 35% less than pastures grazed to 7.5cm. In addition there was a carryover effect into the following winter and spring (-20%). The conclusion was that summer grazing management is important for persistency of pasture DM yield.

One estimate of the cost of overgrazing (to less than 3cm) on a regular basis is that it will reduce Operating Profit/ha by \$300-600/ha⁵. Another consideration comes from a case study farm that reported a reduction in the annual cost of grass seed for pasture renovation since using an off paddock facility to prevent overgrazing.

The cost of under-grazing

Repeated under-grazing also reduces pasture growth rates, pasture quality and Operating profit/ha. Pastures grazed at greater residual height have higher leaf death rates, lower average net growth rates and annual yields. Missing the target range for optimum residuals (11 clicks RPM v 7-9) is estimated to cost \$74/ha/grazing in lost feed supply.

The research result⁴ in the table illustrates the potential cost of under-grazing through repeatedly leaving high residuals.

Height of cutting above ground level (cm)	kg DM/ha (mean of 2 years)
3	17450
5.5	17005
8	16550

MS value of 0.9t DM/ha: 75kg MS x \$5/kg MS = \$375/ha if extra feed grown is converted to MS.

References

¹ Brougham, R.W. (1960). The effects of frequent hard grazings at different times of the year on the productivity and species yields of a grass-clover pasture.

² Lee, J.M., Donaghy, D.J., Roche, J.R. 2008. Effect of defoliation severity on regrowth and nutritive value of perennial ryegrass (*Lolium perenne* L.) dominant swards. *Agronomy Journal* 100, 308-314.

³ Garcia, S.C., Holmes, C.W. 2005. Seasonality of calving in pasture-based dairy systems: its effects on herbage production, utilisation and dry matter intake. *Australian Journal of Experimental Agriculture* 45, 1-9.

⁴ Rawnsley, R.P., Langworthy, A.D., Pembleton, K.G., Turner, L.R., Corkrey, R., & Donaghy, D.J. (2014). Quantifying the interactions between grazing interval, grazing intensity, and nitrogen on the yield and growth of dryland and irrigated perennial ryegrass. *Crop & Pasture Science*. Published on line, 4 July 2014.

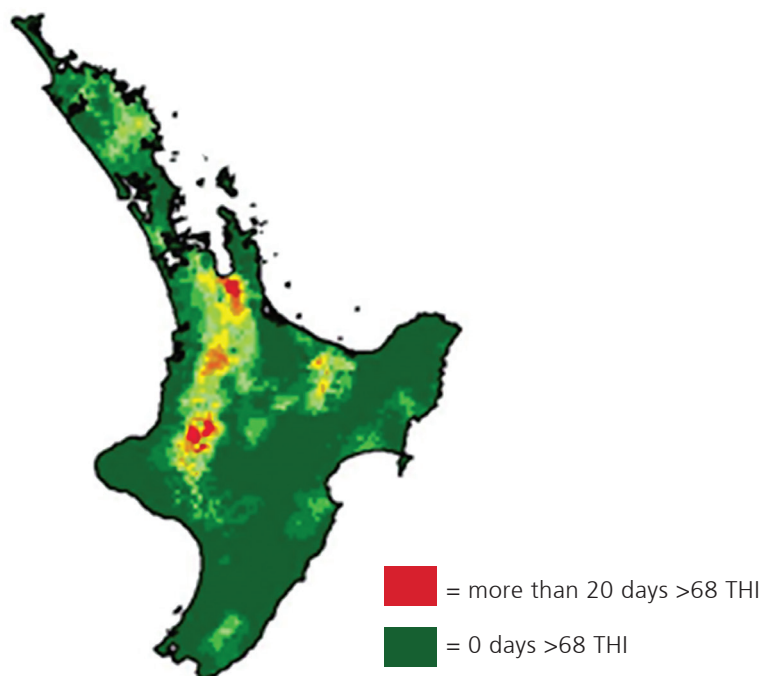
Less heat stress

For an average climate year this assumption can only be supported for cows farmed in the northern North Island. Reducing heat stress for a 500 cow Holstein-Friesian herd in the central Waikato has potential benefits of \$10,000/year based on a \$5 milk payout*.

Air temperatures greater than 21°C accompanied by relative humidity more than 75% reduces feed intake and lowers production in Friesian cows. The combination of these two measures forms the Temperature Humidity Index (THI). An online calculator is available to calculate THI for a district if both temperature and relative humidity data is known¹. The threshold THI for heat stress in Holstein-Friesians is 68. Jerseys are more tolerant of THI with a threshold of 75. An increase in THI above threshold by 1 unit is expected to decrease milksolids production by 0.01 kg MS/cow/day².

It's not known if all "off-paddock" facilities with roofs reduce THI impacts. No science in New Zealand has examined the cooling effect by facility type. Facility design should consider summer cooling effects for many North Island regions.

Figure 1: Average THI data 1997-2011³



* Assumes 73 days where THI exceeds 68. 4kg MS/cow production gain x \$5/kg MS

References

¹ <http://www.dairynz.co.nz/animal/health-conditions/heat-stress/>

² Bryant, J.R., Lopez-Villalobos N., Pryce, J.E., Holmes, C.W. & Johnson, D.L., (2007). Quantifying the effect of thermal environment on production traits in three breeds of dairy cattle in New Zealand. *New Zealand Journal of Agricultural Research*, 50: pp327-338.

³ NIWA report. Impact of projected Climate Change on Thermal Stress in Dairy Cattle.

Less cold stress

Dairy cows are tolerant of cold conditions, particularly when lactating when they generate greater heat production from a high intakes and their metabolism.

Non-lactating cows can also withstand cold temperatures (up to -13°C) when there is no wind or rain and they are adequately fed. If non-lactating cows are wet, cold stress will start occurring at 0°C. Strong wind with no rain will induce cold stress at 4°C, while both wind and rain raises this threshold to 7.5°C

Weather conditions	Temperature thresholds for cold stress (non-lactating cows) °C
Strong wind and rain	+7.5
Strong wind and no rain	+4
Rain and no wind	0
No wind or rain	-13

When cows are under cold stress they require extra energy to maintain their body temperatures.

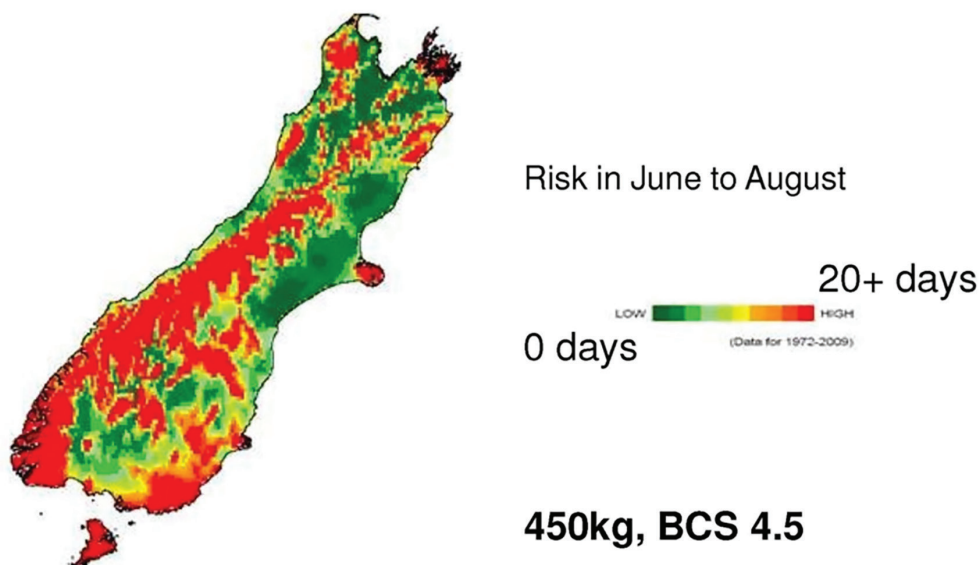
In windy, wet conditions (30 mm rain/day), at 0°C, a dry cow could require an extra 35 MJME/day to maintain her temperature.

The likelihood of weather events in winter where non-lactating cows might require more than an additional 5 MJME/day to maintain body temperature is mapped for the South Island in Figure 1.

One estimate of the extra feed requirements for non-lactating cows wintered outdoors near Invercargill was a 17% increase in energy requirements or an average of 1.5 Kg DM/cow/day.

If its assumed that housing would reduce this requirement to 0 then the potential saving is \$54/cow over 90 days, (1.5kg x 90days x 40cents), assuming the feed saved has a value of \$0.40 cents/kg DM.

Figure 1: Days in average winter that cows need 5+ MJ extra for cold



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