A study of traits other than production in the New Zealand dairy industry National Breeding Objective

What is an extra lactation worth?

What is the true value of liveweight?

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"He who joyfully marches in rank and file has already earned my contempt. He has been given a large brain by mistake, since for him the spinal cord would suffice" - Albert Einstein

Executive Summary

The selection goal of the New Zealand dairy industry National Breeding Objective (NBO) is to identify animals whose progeny will be the most efficient converters of feed into farmer profit. Desired traits and their relative importance in the form of an economic value are combined to produce an index known as Breeding Worth (BW). This provides a method of ranking bulls and cows on their expected ability to breed replacements which will fulfill the national objective.

This study sought to challenge some of the assumptions in the current index and investigates the value of an extra lactation and the value of liveweight in the NZ dairy herd using economic models. The models were informed by industry data for both economic and farm systems analysis.

The value of an extra lactation was calculated by comparing two model herds, whereby one herd had reduced longevity of 10 days per cow. The value of an extra lactation was shown to be $146.90 per cow and $56,703 per average NZ herd of 386 cows. If every cow in the national herd survived an extra lactation this would be worth $655 million to the industry.

Cow survivability is complex and influenced by a range of factors, so there will never be one single fix to improve longevity. However, it is well established through international and NZ research that Traits Other Than Production (TOP) describing physical characteristics of a cow, and in particular udder and dairy conformation, play a significant role in cow longevity. The current NBO review should further evaluate the merits of specifically (i.e. not within another trait such as longevity) including udder and dairy conformation traits.

Modeling showed that per cow, per ha and overall farm profit is increased for a farm scenario milking cows with an average liveweight of 550 kg compared to cows with an average liveweight of 450 kg in both system 3 and system 4 analysis at fixed feeding levels, fixed comparative stocking rate (CSR) and fixed production as a proportion of liveweight. The 550 kg cow scenario demonstrated increased per cow profit by $445.12 and $451.18 for system 3 and system 4 respectively. Per hectare profit was greater in the 550 kg cow scenario by $1143.91 for system 3 and $1297.47 for system 4. Overall farm profit was greater for the 550 kg cow scenario, returning $171,587 more for system 3 and $194,620 more for system 4.

Overseer ® analysis showed no significant differences in nitrogen loss or nitrogen conversion efficiency between the model farms.

The principles of higher overall maintenance for a heavier cow are generally well accepted. However, maintenance per kg liveweight and feed conversion efficiency are not adequately accounted for in the NBO liveweight model. A negative value on liveweight assumes that just because an animal is small that it is an efficient converter of feed into milk. Liveweight in itself is not a measure of efficiency, but our NBO attempts to apply it in that way. Another way of looking at the value of liveweight should be explored, in the context of feed conversion efficiency, productive capacity and metabolic liveweight. There is also scope in the current liveweight model to include considerations for capital costs per cow and account for environmental impact.

Last but not least, more information needs to be made available in an easy to understand form to rural professionals and to farmers about the NBO and the principles underlying the NBO so that those using the index can make informed decisions about bull and cow selection.

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1. Preface

Dairy cattle improvement is the result of breeding the best sires to the best cows and retaining the best of the heifers (Holmes *et al*., 2002). Improvement requires the definition of "best", which is where the concept of a selection objective becomes important. Once the definition of "best" is agreed, then there needs to be a mechanism for identifying those "best" animals.

A selection objective is a description of the traits that are desirable to improve. Breed Societies have played an important role in defining selection criteria since the 1800's. Prior to that, decisions were based on individual preference of what an animal should look like, and any that didn't fit the preferred appearance were culled.

Genetic merit of a dairy herd can be improved by three practices: breeding of replacements by sires of high genetic merit; culling cows of low genetic merit; and selection of replacement heifers of the highest genetic merit.

In the last 50 years selection objectives have been developed more precisely, based around quantitative genetics which uses an equation based on profit to develop selection objectives for cows to be retained, selection of replacement heifers and selection of sires.

The development of a selection objective involves 3 steps:

- Identify selection goals (e.g. profitability)
- Identify a list of traits which will help reach the goal (e.g. production, conformation)
- Determine the relative importance of the traits in the list in terms of how they contribute to the goal.

The selection goal of the New Zealand dairy National Breeding Objective (NBO) is to:

“"Identify animals whose progeny will be the most efficient converters of feed into farmer profit" (NZAEL website).

The list of traits (each of which has an individual Breeding Value), and relative importance (Economic Value) in the current NBO are outlined in Table 1.

Table 1. Traits in the NBO and their relative importance as expressed in BW (Anon 2012a).

Breeding Value (BV)	Economic value	% weighting in total selection index	% of weighting for production versus conformation traits
Milkfat	$1.92	12.3%	Production 66%
Protein	$8.685	39.3%	
Milk (volume)	-$0.094	14.5%	
Liveweight	-$1.48	14.1%	Functionality and health 34%
Fertility	$3.118	7.7%	
Somatic Cells	-$31.46	6.4%	
Residual Survival	$.048	5.8%	

The resulting index from this list of traits and weightings is known in as Breeding Worth (BW). This is a single index designed to provide a method of ranking bulls and cows on their expected ability to breed replacements which will be efficient converters of feed into farmer profit. BW estimates are intended to be comparable across herds, ages, breeds and different farming systems.

In addition to BW, the Production Worth (PW) and Lactation Worth (LW) are also important parts of herd improvement. The relationship between the three is outlined in Figure 1 below.

In comparison to indexes from major dairying countries around the world the NZ NBO has a 20% larger emphasis on production and a 9% larger emphasis on functionality and health with no specific emphasis on conformation traits other than those included within the Residual Survival BV.

Since the development of BW in 1996 another index known as the NZ Merit Index (NZMI) was developed and introduced in 2005 by CRV Ambreed, a private breeding company. Table 2 shows the comparison between BW, NZMI and world indexes. When BW is compared to NZMI it shows that BW has a 25% greater emphasis on production than NZMI. NZMI puts greater emphasis on both functionality/health (7%) and type/conformation (18%).

The NBO as we know it today, commonly known as BW, has become a national index that is used across the industry for many different reasons. Over the last 16 years the dairy industry in New Zealand has evolved at a rapid pace. However it could be said that the NBO has not evolved in line with the rest of the industry and it seems that the NBO has become less relevant to an increasing proportion of the dairy industry in the application of breeding decisions. The fact that another index

(NZMI) has been developed shows that the current NBO has not remained relevant to all farmers. Many in the industry believe that New Zealand's NBO has fallen behind in recognition of type and conformation. The importance of type and conformation to the profitability of an animal will be outlined in the rest of this study.

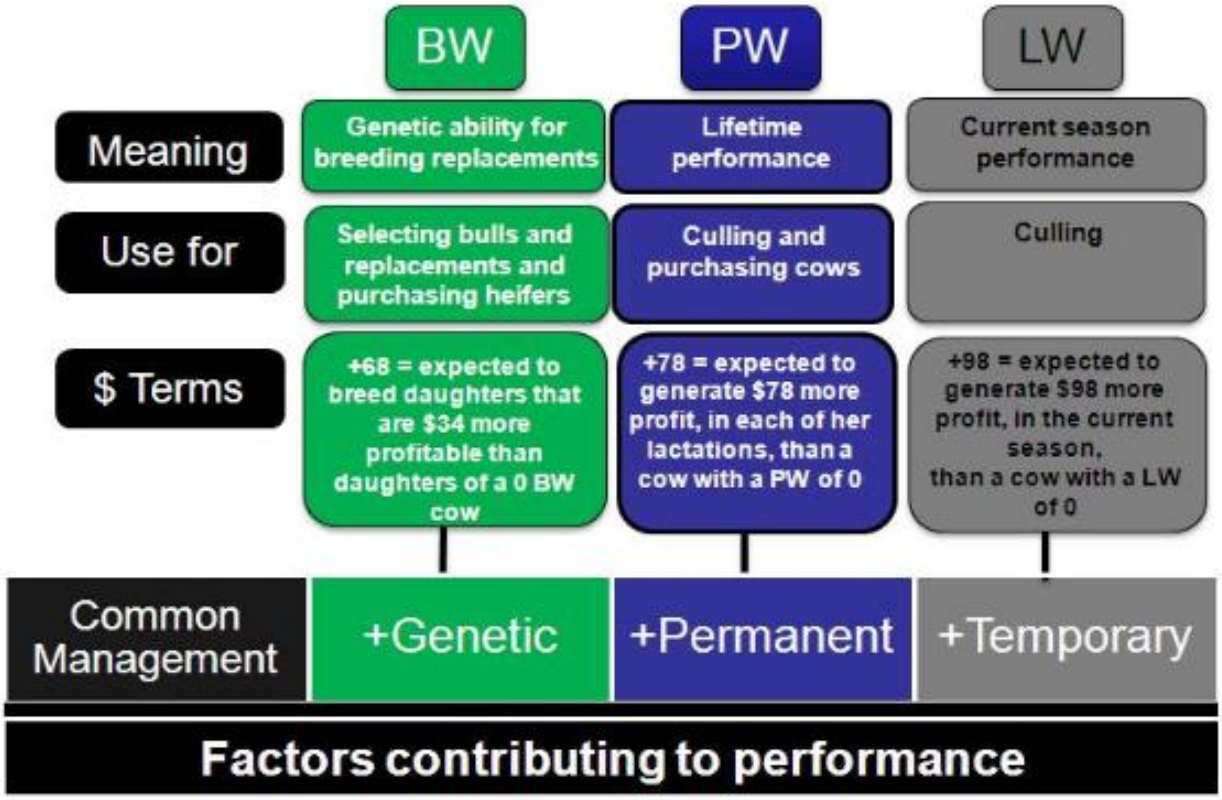

Figure 1. Relationship between cow indices BW, PW and LW (NZAEL 2012).

Table 2. Comparison between weightings in BW, NZMI and world indices (NZHFA 2012a).

	NZ – BW	NZ – NZMI	Average of World*
Production	66%	41%	46%
Functionality/health	34%	41%	25%
Type and conformation	0%	18%	22%

**Indexes included in this average are from 7 of the larger dairying nations – Australia, Canada, USA, Italy, Scandinavia, Ireland and Germany.*

Functional properties of traits other than production

In the early days before a breeding index existed in NZ, cows were selected based on physical attributes of the cow (phenotype) and there was sound reasoning behind the preferred list of physical attributes. As the industry has evolved, there has been more emphasis on genotype (genetic attributes) and analysis based on quantitative genetics looking at correlations between certain genotypes, and using weightings as described above in the BW to select animals with the preferred genetic potential to produce future offspring.

Type and conformation in the context of the modern NZ dairy industry are often seen by some as concepts of the past. This could not be further from the truth. There are very real economic reasons for placing emphasis on breeding a cow with the right physical attributes, and this can be done in conjunction with selecting for production.

Traits other than production (TOP) are important because they relate to functional properties of the cow, which in turn relate to profitability. This is not always clearly understood, and it has been a common misconception in the industry in recent times that those farmers who are interested in traits other than production are solely focused on breeding a "show cow".

In NZ, breeding values are estimated for 16 TOP traits. This is carried out under a classification scheme where two-year-old in milk heifers are inspected and scored by a qualified inspector. All TOP traits are scored on a scale from 1 to 9, and then expressed relative to the Genetic Base.

Table 3 summarises how some of the areas assessed in the classification process relate to functional properties and to profitability. This allows farmers to assess cows for selection that are more durable and functional.

Review of the NBO

A review of the NBO was initiated by the NZ Animal Evaluation Unit Ltd in 2011 and is currently underway in consultation with stakeholders and the industry. This is the first formal review of the NBO since its introduction in 1996. It is intended that this study will help inform the review alongside other stakeholder and industry submissions, and stimulate further discussion about the role of traits other than production in the NZ dairy industry.

Table 3. Conformation traits and their relationship to functional properties of the cow.

Trait / Area of assessment	Functional properties of a cow	Relationship to profitability
Capacity	Heart and lung capacity	For every litre of milk the cow makes, more than 400 litres of blood must pass through the udder to deliver the nutrients and water for making milk
Udder	Udder durability, uniformity and ability to produce milk.	Somatic Cell Count Mastitis Longevity Ease of milking Production
Hips and legs (Rump angle, rump width, legs)	Ability to stand and walk. Ability to calve.	Lameness Longevity Calving ease
Conformation overall	Durability, ability to stand/walk, ability to eat, capacity (see above), udder properties	Longevity Production

2. What is an extra lactation worth?

"There is no such thing as the perfect cow but a cow that will last longer in your herd will make you more money" – Denis Aitken, NZAEL TOP Advisory Committee, Dairy Exporter July 2012.

2.1 Introduction

It is recognised worldwide that longevity in dairy cattle is a trait with considerable influence on farm profitability (Holmes et al. 2002; Berry et al. 2005). Longevity is a complex trait influenced by a large range of factors including milk production, fertility, health and physical characteristics of the cow (Berry et al. 2005).

For a sire to get a highly reliable breeding value for longevity, the daughters have to have had the opportunity to survive beyond fifth lactation. To overcome this issue, the industry uses genetic evaluations of predictor traits to provide an early indication of longevity. Total longevity is included in the NBO using a multiple trait animal model which includes 9 predictor traits which were determined by Harris and Montgomerie (2007), who used data from the Dairy NZ core database to find a subset of traits that would be useful predictors of longevity. The traits included in the model are 4 survival traits and 9 predictor traits (Anon 2012b). The survival traits are:

1) Survival from first to second lactation (SV12)
2) Survival from first to third lactation (SV13)
3) Survival from first to fourth lactation (SV14)
4) Survival from first to firth lactation (SV15)

The 9 predictor traits are all recorded in first lactation, apart from CR42, which is recorded for the start of the second lactation. Table 4 shows the genetic correlations between two of the survival traits and the 9 predictor traits, as calculated by Harris and Montgomerie (2007).

A further calculation is performed to remove the components of the list above that are already included in the BW, so that they are not counted twice. These include factors relating to herd life such as production, liveweight, fertility and somatic cell count. The resulting number is known as Residual Survival. The relationship between Total Longevity and Residual Survival is outlined in Figure 2.

Table 4. Genetic correlations between two survival traits and the 9 predictor traits in Total Longevity (Harris and Montgomerie 2007).

	Survival from lactation 1 to lactation 2 (SV12)	Survival from lactation 1 to lactation 5 (SV15)
Protein yield	0.424	0.418
Somatic cell count	-0.156	-0.040
CR42	0.841	0.478
Body condition score	0.370	0.240
Milking speed	0.072	0.220
Overall opinion	0.330	0.379
Legs	-0.119	-0.074
Udder overall	0.113	0.113
Dairy conformation	0.235	0.183

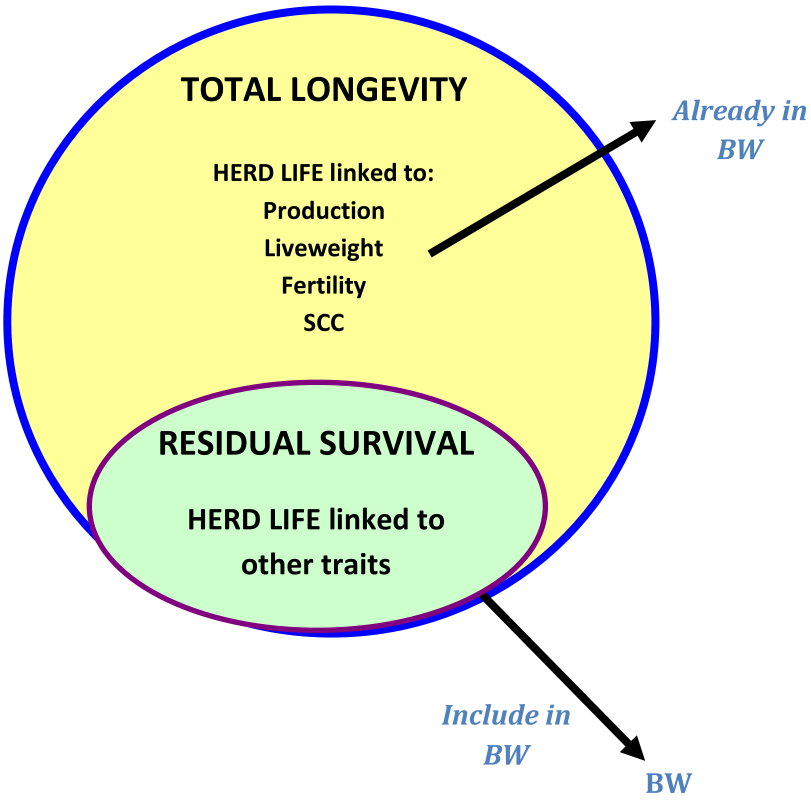

Figure 2. Relationship between Total Longevity and Residual Survival (Anon 2012b)

Total Longevity is defined as the interval (in days) from the date a cow has her first calf to the date when she has her last herd test. The breeding value is expressed relative to the base cow. Residual Survival is defined as “Herd-life after accounting for the genetic effects of production, liveweight, fertility and milk somatic cells on herd life” (Anon 2012b). Residual Survival is where TOP are accounted for in the index.

Given the largely recognised influence of longevity on farm profitability, it is interesting to note that Residual Survival accounts for only 5.8% of our NBO. This study attempts to calculate the current value of longevity outside of the context of the NBO.

2.2 Method

Chapter 24 in Milk Production from Pasture explores the economic value for longevity using data from 1984 (Holmes et al. 2002). An example farm budget for a single year was used to demonstrate the calculation for economic value for longevity. This study replicates the original methodology, with the main difference being that this study uses ten year rolling average data from the Dairy NZ Economic Survey, NZAEL and Beef and Lamb NZ to demonstrate average economic value over time rather than just in a given year.

Calculating an economic value for longevity must take into account the age structure of the herd. The age structure influences total herd productivity because young and very old cows produce less milk than cows aged four to seven years old (Holmes et al. 2002). The age structure also determines the number of replacements required, and the replacement rate influences the number of calves and cull cows available for sale.

The study considers a farm with age typical of the current national average. The survival rates are taken from the 2010-2011 NZ Dairy Statistics and are the result of both voluntary and involuntary culling from the herd. Causes of involuntary culling include death, disease or being empty, while causes of voluntary culling include low production, mastitis, temperament, milking speed or various aspects of conformation. The assumed replacement rate is 21%, which is used in the NZAEL model. The typical herd is compared to a reduced longevity herd which assumes that a particular characteristic causes a progressive decrease in survival with increasing age and that it reduced longevity by an average of 10 days. The average age structure of the average NZ herd and reduced longevity herd is shown in Table 5.

Milk yield varies with age of cow, and the differences in milk production for this study were derived from NZ Dairy statistics 2010-2011 and are shown in Table 6.

These values were combined with Table 5 to calculate yields for the average herd and the reduced longevity herd, which are shown together with milk income in Table 8.

Ten year weighted average figures used in calculating profitability were obtained from the Dairy NZ Economic Service, Beef and Lamb Economic Service, and NZ Animal Evaluation Unit. Per cow and per hectare costs were fixed in the same proportions as the current NZAEL model. Values for income and costs used in this study are shown in Table 7.

The feed requirements for the two herds, for cows and replacements calves and heifers were derived from their theoretical energy requirements as outlined in Dairy NZ Facts and Figures (Anon

2010). Figures were calculated in MJ ME and converted to DM assuming a feed source of 11 MJ/kg DM.

Replacement numbers were based on proportions used in Holmes et al. 2002, and required 25.7 calves and 22.6 yearlings for the model herd and 26.5 calves and 23.2 yearlings for the reduced longevity herd. The total requirements for dry matter (DM) for each cow (including replacements) in both average and reduced longevity herds are presented in Table 8.

Microsoft Excel spreadsheets were utilized to build the model and perform the calculations.

2.3 Results

Results for differences in surplus between the two model farms are shown in Table 9, and results for the value of an extra lactation are shown in Table 10. Sensitivity analysis was carried out by altering inputs into the model. Results for sensitivity analysis are shown in Table 11.

Table 5. Average age structure of two herds: one with an average age structure (based on 2011-2012 Dairy Statistics plus 21% replacement rate from NZAEL Economic Update 2012) and the other with reduced longevity (by ten days per cow).

Age of cow at calving	**Proportion of each age group surviving to the next age group**	**Percentage of herd in each age group**	
		Average herd	Reduced longevity herd
2	0.817	21.0	21.6
3	0.862	18.1	17.9
4	0.872	15.8	15.7
5	0.860	13.6	13.5
6	0.811	11.0	11.0
7	0.768	8.5	8.4
8	0.712	6.0	6.0
9	0.657	4.0	3.9
10	0.500	2.1	1.9

Table 6. Average milk yields and liveweight per cow for cows at different ages. Source: NZ Dairy Statistics 2010-2011.

Age of cow at calving	Liveweight	Milk (L)	Milkfat (kg)	Protein (kg)
2	397	3177	153	121
3	481	3773	181	144
4	515	4192	197	159
5	520	4343	205	165
6	533	4357	206	164
7	526	4271	202	160
8	533	4150	197	155
9	531	4026	192	149
10+	531	3690	175	136

Table 7. Values for milk income, beef income and fixed costs used in the model.

	Value	Source
Fixed cost per ha	2501	Sam Howard, Personal Communication, ten year average
Variable cost per cow	283	Sam Howard, Personal Communication, ten year average
Milk fat per kg	3.07	Sam Howard, Personal Communication, ten year average
Milk protein per kg	8.11	Sam Howard, Personal Communication, ten year average
Milk volume per litre	-0.094	NZAEL Economic Update 2012
Beef price/kg		
<145 kg	2.25	NZAEL Economic Update 2012
145-170 kg	2.52	
170-195 kg	2.67	
195-220 kg	2.74	
>220 kg	2.83	
Bobbies each	16.35	Calculated with assumption of 30 kg animal boning out at 50% with beef price of $1.09 per kg

Table 8. Yields of milk, fat and protein for both herds, together with milk income, beef income and total feed requirements (all expressed per lactating cow), and the stocking rate (lactating cows per hectare).

	Average herd	Reduced longevity herd
Milk (L)	3928.7	3923.9
Fat	186.7	186.5
Protein	148.5	148.3
Milk income	1407.79	1406.14
Beef income	133.85	134.86
Total feed requirements*	5809.9	5832.7
Stocking rate**	3.098	3.086

*Assuming 11 MJ ME/kg DM

**Assuming 18t DM eaten per hectare, including supplements and grazing off

Table 9. Values of income from milk and beef, and from costs and surplus from the two herds, expressed as $ per hectare (with 18 T DM eaten per hectare).

	Average herd	Reduced longevity herd
Milk income	4361.56	4339.40
Beef income	414.68	416.18
Total (Milk + Beef) Income	4776.24	4755.58
Farm costs*	3377.78	3374.35
Surplus (Income-costs)	1398.46	1381.23

Table 10. Value of an extra lactation extrapolated from value of an extra day longevity.

Difference per hectare between the two farms	$17.23
Equivalent value per t DM eaten	$0.96
Value per 5.6t DM eaten by the average cow and replacement	$5.36
Since the two herds differ by 10 days in longevity, equivalent value per cow unit per extra day of longevity	$0.54
Equivalent value for a cow surviving an extra 274* day lactation	$146.90
Value per year for 100 cows that survive an extra lactation	$14,690.27
Value per year for average NZ herd of 386 cows*	$56,703.40
Value per year for 1000 cows that survive an extra lactation	$146,902.67
Value across entire NZ dairy herd	$665,283,390

*Average lactation length and average herd size values from NZ Dairy Statistics 2010-2011.

Table 11. Sensitivity analysis of longevity model: value per cow unit per extra day of longevity for a range of different scenarios.

Scenario		Result for default model = 0.54	
	Default value	Plus	Minus
Beef price change by $0.50 per kg	Ranges over weight classes	0.53	0.54
Milk volume price change by $0.10 per litre	-0.094	0.73	0.34
Protein price change by $0.50 per kg	8.11	0.57	0.50
Fat price change by $0.50 per kg milk solids	3.07	0.58	0.49
Fixed costs change by $50 per cow	283	0.52	0.55
Survival rates based on Holmes et al 2002 herd distribution from 1984		0.53	

2.4 Discussion

The value of longevity

The results show that the average NZ herd of 386 cows (Anon 2011a) would benefit by $56,703.40 if every cow in the herd survived an extra lactation. The total benefit across the entire NZ dairy herd would be $665 million.

In comparison, using latest NZAEL figures (Anon 2012) the value of an extra day of longevity (based on the Residual Survival BV) is $0.048 and an average herd would benefit by $5,076.70 if every cow survived an extra lactation and the entire NZ dairy herd would benefit by $60 million. This is a difference of around tenfold between the two figures.

One of the reasons for this difference is because the gross analysis conducted in this study includes all causes of voluntary and involuntary culling which contribute to decreased longevity, such as fertility, somatic cell count and production, whereas the Residual Survival BV includes only those traits not already included in BW (as illustrated in Figure 2). Figure 3 reiterates the difference between the two measurements, with values from this study as an example. However, this implies that the value of longevity relating to production, fertility and somatic cell count is $0.49, which seems excessive.

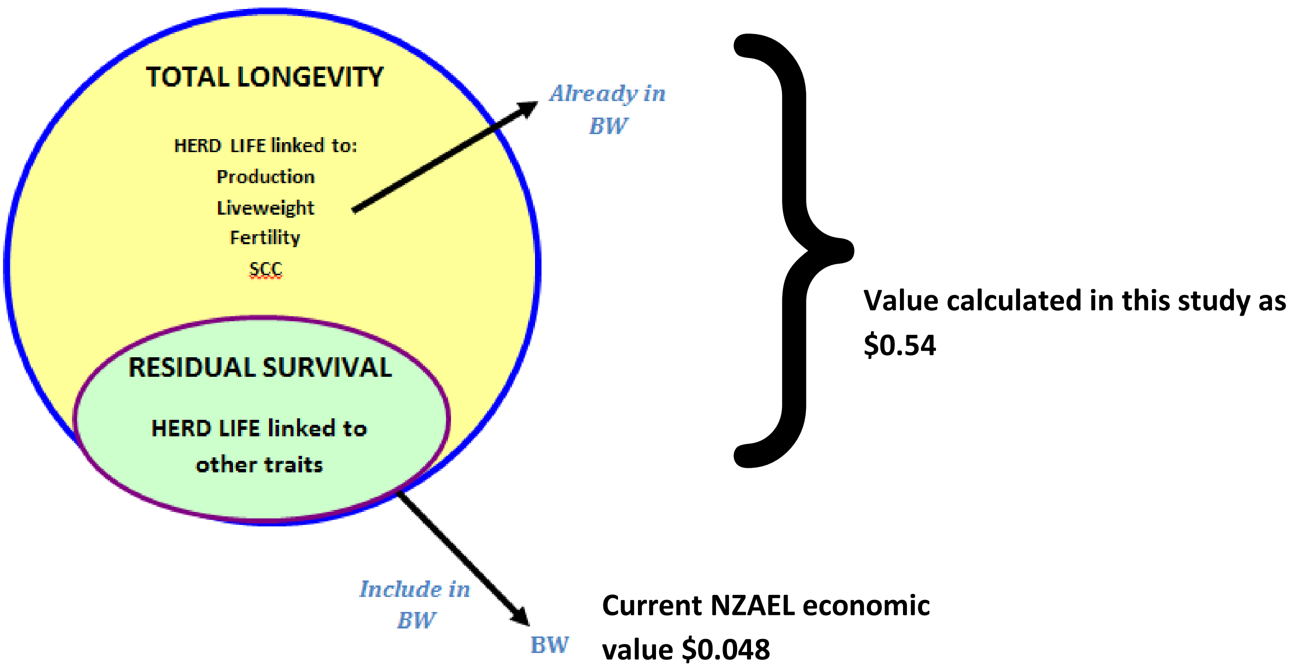

Figure 3. Relationship between Total Longevity and Residual Survival and values calculated in this study compared to value in the NBO.

Any other reasons are extremely hard to deduce because the Residual Survival model is not openly available for analysis, and indeed not intricately understood by many. Nonetheless, $665 million per year across the NZ dairy herd is a substantial figure which warrants more attention on the subject of longevity.

Sensitivity analysis figures outlined in Table 11 show that the model is quite sensitive to milk volume price, milk fat price and milk protein price. It is also moderately sensitive to beef price and per cow costs. Age structure of the average herd used in the model has a major impact on the outcome of the model (Holmes et al 2002), but the difference between the 1984 average age structure and 2010-2011 average age structure is not significantly different, so comparing the two in the current model shows only slight difference in the final value for longevity. If the model started with a herd of a 22% replacement rate the outcome is likely to be significantly different. Changes to DM consumed per hectare and fixed costs per hectare have no effect on the value of an extra day of longevity because the model makes the comparison between the herds on a per hectare basis.

The effect of replacement rate on profitability

The benefits of improved longevity accrue mainly because when cows survive longer in the herd there is greater proportion of cows in the herd at their productive optimum (5, 6 and 7 years old) contributing to better efficiency, and costs of replacing cows in the herd is reduced through a lower replacement rate.

There have been a range of studies over the years which investigate the effect of replacement rate on profitability. Replacement rate affects the age structure and genetic merit of the herd and productivity and profitability of the dairy farm. The overall objective when attempting to apply the optimum replacement rate is to keep replacement costs low, retain a high proportion of higher yielding mature cows in the herd, whilst ensuring improved genetic gain over time.

Lopez-Villalobos and Holmes (2010) concluded through modeling that a herd with a 15% replacement rate in combination with selection of high genetic merit replacement heifers achieved the highest gain in BW for milksolids and achieved the highest farm profit at year 20. Two dairy farmers (Vollebregt and Vollebregt 1998) also concluded that a replacement rate of 15% ensured good genetic gain with maximum production of milksolids and minimum replacement costs. Dairy NZ suggest an optimum replacement rate of 18% (Anon 2010), and the suggested optimum age structure is shown in Figure 4.

Figure 4 compares the current average herd age structure, the average herd age structure in 1984 and the suggested optimal herd age structure. It is clear that the NZ dairy herd is not operating at optimum age structure, and there are significant economic gains to be made in this area in terms of survivability and reduced replacement rate. Furthermore, the current values show that cows in the 8 years and over age group have less chance of survival than previously, and much less chance of survival than the suggested optimum.

The other factor to consider when thinking about Figure 4 is that the national dairy herd has been growing, in particular growing at an increased rate over the past 10 years (Anon 2011a). The cows required to grow the national herd have to come from somewhere. This indicates that the level of involuntary culling is likely to be much lower than it used to be, which means that we are probably keeping cows that are not contributing to improved genetic gain i.e. we are keeping our sub-optimal cows. This is compounded by the fact that empty rates in the national herd have increased (Bourke and Fowler 2007), so that essentially everything in calf is kept and there is little or no involuntary culling for health or conformation issues. Anecdotal evidence shows that there has been a significant increase over the past 10 years of trade in “young empties” and the average age of herds being sold in Canterbury is 4.5 years old (Victor Shikker, Personal Communication, 17 September 2012). The 2007 dairy boom in the South Island alone required an additional 90,000 cows. In the Canterbury region 2 stock agents traded over 2000 young empties (2, 3 and 4 year olds) last year. This is a significant number when multiplied across all stock agents in Canterbury.

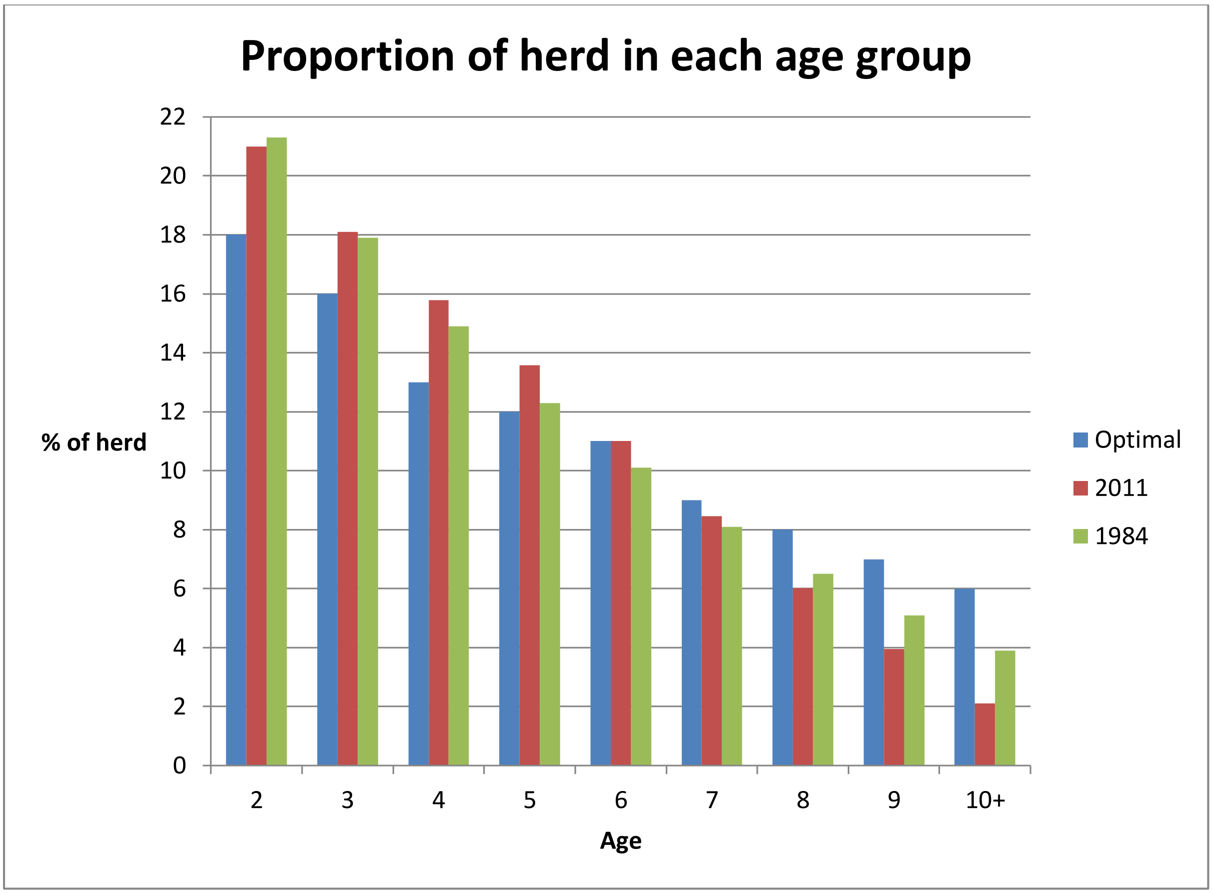

Figure 4. Optimal herd structure (Dairy NZ Facts and Figures), 2011 national herd structure (NZ Dairy Statistics 2010-2011) and 1984 herd structure (Holmes et al 2002).

The impact of high replacement rate and low survival on profitability can also be demonstrated by comparing efficiency of milk production over a cow lifetime. A significant amount of feed, labour and other costs are invested in raising a replacement heifer, and in getting the cow to its peak lactation age. This is demonstrated in Figure 5 which shows that a cow reaches her optimal milksolids production per kg DM consumed over her lifetime at around age 6. This is an issue if a larger than desired proportion of cows leaves the herd through voluntary or involuntary culling around the age of 5, 6 or 7. They have only just reached their optimal efficiency.

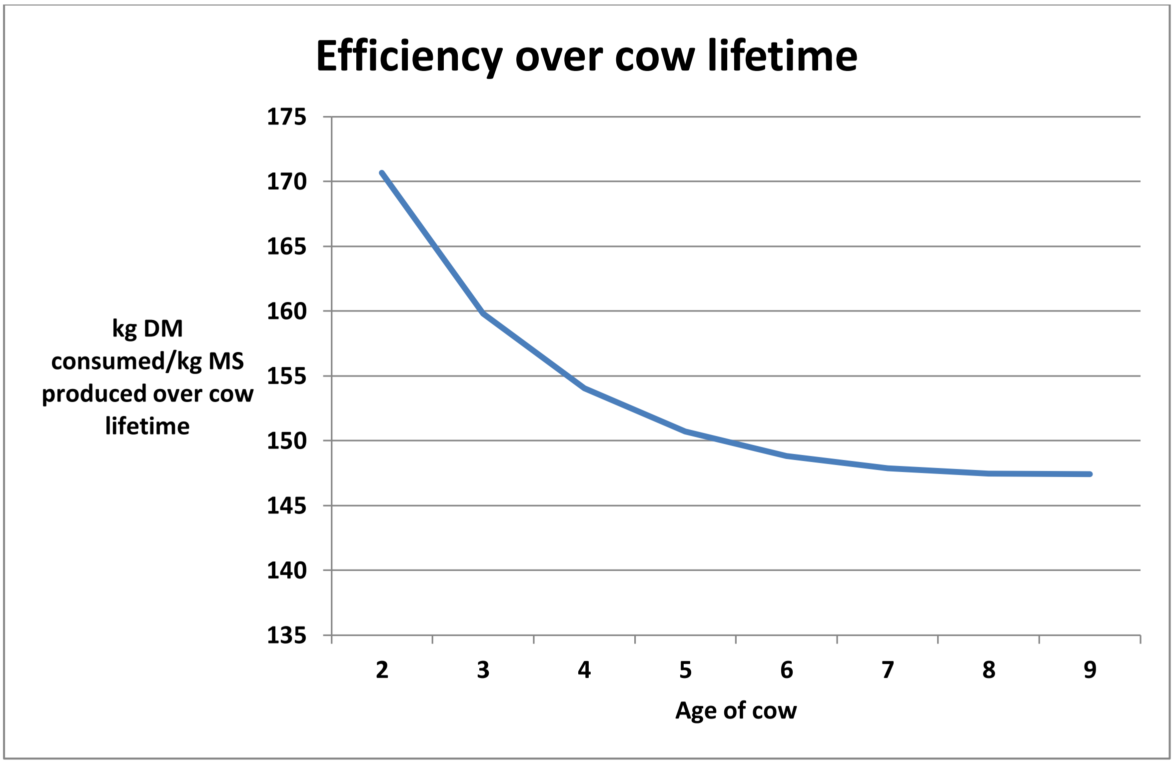

Figure 5. Efficiency of MS production over cow lifetime. Source: 2010-2011 NZ Dairy Statistics.

Involuntary culling for infertility

As discussed earlier, a disproportionate number of culled cows (nearly half of all culls) are because they are empty or due to calve very late (Bourke and Fowler 2007). This is also reflected in the fact that percent mated in the first 21 days of a herds mating period and 42-day calving rate are both strong predictors for survival (Harris and Montgomerie 2007).

The NZ seasonal dairy system dictates that if a cow is not in calf, she is generally culled because it will be another year before she has the opportunity to get back in calf and will not be providing a return to the farmer during that time. Many cows in NZ leave the herd early because they are empty, not because they are not built right to survive. This is another issue outside of the scope of this study which needs further attention, and is not necessarily related only to a genetic solution.

Higher production requires a more robust cow

New Zealand dairy systems are shifting over time towards high stocking rates, higher per hectare production and higher per cow production (Anon 2011a). If we assume that cow liveweight has remained the same since 1992, statistics show us that milksolids production as a percentage of liveweight has increased from 57% to 74% over the last 20 years. The optimal milksolids to production liveweight is 80-90% (Penno 1999). Over the five year period from 2005/2006 to 2009/2010 the proportion of NZ dairy herds running system 1 (no imported feed) dropped by 9% and the proportion of herds running system 4-5 (20-40% imported feed) rose by 7% (Matthew Newman, Personal Communication, 13 August 2012).

Over the past 20 years, physical conformation of our dairy herds has not been challenged due to the fact that they are in low intensity systems with low production. As we continue to challenge cows even further (and indeed if we want to reach the 80-90% optimum) their physical traits become more challenged. For example, as milksolids production per cow goes up, pressure on the udder, heart, lungs and frame also increases.

It is therefore likely that with increasing per cow production in the NZ dairy herd we will be more reliant on selecting for a robust cow with strong functional and conformation traits in order to maintain longevity and prevent early involuntary culling from the herd.

The relationship between longevity and traits other than production

Several studies internationally have looked at the genetic relationship between TOP and longevity in dairy cattle (Berry et al. 2005; Larroque and Ducrocq 2001; Vollema et al. 2000). Longevity is assessed as the ability of a cow to avoid voluntary culling or a combination of voluntary and involuntary culling.

Adjustment of longevity for differences in milk production allows the estimation of the relationship between TOP and longevity independent of milk production. This is known as functional longevity and takes account of the assumption that a cow will survive longer in the herd if she produces more due to delayed voluntary culling.

Berry et al. (2005) used data from the Dairy NZ core database to investigate the phenotypic (visual) effects of TOP on longevity. Results from this study showed that all TOP were significantly related to true and functional longevity. Separate analysis was carried out for registered and unregistered herds, and there were obvious differences in the relative influence of individual TOP on longevity.

Farmers of pedigree herds are placing more emphasis on conformation of the animal, while commercial farmers are more likely to cull slow milking cows with poor temperament.

Of the individual TOP describing physical characteristics of a cow, the udder related TOP had the largest influence on functional longevity. In commercial herds, udder overall and dairy conformation had large influences on true and functional longevity. Cows with a high probability of being culled tended to have lower scores for stature, udder support, fore udder attachment, rear udder height, and dairy conformation. Capacity, rump angle, rump width, and font and rear teat placement were optimum at intermediate levels, with cows at either extreme more likely to be culled. The five main TOP accounting for longevity are outlined in Table 12.

These results are aligned with international research which has shown that udder related TOP scores have some of the largest influences on true and functional longevity, especially in cows from commercial herds. The relative risk of culling consistently decreases as udder overall score increases (Schneider et al 2003). In addition to Table 12, udder support has also been shown in international studies to be one of the most important udder traits influencing true and functional longevity (Larroque and Ducrocq 2001; Vollema et al. 2000; Schneider et al 2003).

Table 12. % of variation in TOP accounting for true and functional longevity in NZ commercial herds (Berry et al. 2005).

TOP	% accountable for variability
Farmer opinion	25
Udder support	13
Udder overall	7
Dairy conformation	5
Speed of milking	5

Results from this study, supported by findings from international studies, clearly shows that TOP are suitable as phenotypic indicators for cow longevity.

When deciding on the traits and their weighting to be included in the NBO, it is logical that there is always a trade-off in terms of selecting more for one trait over another. At the moment it seems that we are selecting heavily for production which accounts for 66% of index weighting, potentially at the expense of longevity. This is especially true when we consider that higher production requires a more robust animal. If we are to select more for TOP such as conformation related traits or fertility traits, we also need to think clearly about the trade-offs we are making. It is possible that with the current review perhaps we can strike more of a balance than the current NBO between production, health and functionality, and conformation which all contribute to profitability.

Given the significant value of an extra lactation as demonstrated in this study, it is worth revisiting the weighting applied to a range of TOP in the context of the NBO and breeding index, in particular udder support, udder overall and dairy conformation.

Traits other than production in the national herd

Data from TOP scoring shows that there has been a continued improvement in TOP traits over time. Many in the industry use this data to justify the current weighting put on TOP traits. However, the data the industry is drawing from is an unrepresentative sample set which is too small and skewed to make this conclusion. If we look at production figures over the generations we can be fairly comfortable we are making genetic gain in the national herd because we know around 70% of the national herd undertake herd testing (Anon 2011a). For TOP traits the proportion of animals that are TOP scored is a specialized subset of the national herd that are either pedigree herds or sire proving herds. For the 2011-2012 season there were 27,658 two year olds TOP scored (Tony O'Connor, Personal Communication, 13 November 2012) which is less than 1% of the national herd or less than 5% of the national two year old population (Anon 2011a). Of the Holstein Friesians TOP scored in 2011-2012, 55% were for sire proving herds and 45% were for pedigree herds. 100% of cows TOP scored were from pedigree herds (NZHFA 2012b).

It is therefore not accurate to conclude that TOP traits in the national herd have improved based on the small subset. Some in the industry may believe that if the TOP traits for sires used over the national herd are improving, then by inference the national herd must also be improving. Anecdotal evidence from farmers complaining that their cows don't last may suggest otherwise. The only way to know for sure is to TOP score a larger and more representative subset of the national herd.

Further information required

There are several pieces of information which the NZ dairy industry are lacking when making decisions about inclusion of traits in the NBO. In particular, the reasons for voluntary and involuntary culling from dairy herds in NZ are not well recorded. This makes it difficult to assess the specific reasons for cows leaving the herd. The industry needs to put more emphasis on understanding the reasons for voluntary and involuntary culling if it is to improve the longevity of the national herd.

The most recent genetic evaluation for cow longevity was completed in 2007 and informs the residual survival BV in the NBO. This was completed on the basis of expected life regression which predicted longevity for cows in the dataset with “censored records”. At the time of the study it was recognised that a full multiple trait approach including the predictor traits and actual longevity data jointly would have been better, and a further look at this analysis should be considered.

Conformation trends of the national dairy herd over the past 20 years would also be worth exploring. If we are growing the national herd and practicing less than optimal voluntary culling, then logic tells us that less than optimal cows are continuing to contribute to the national genetic pool. Furthermore, with a 66% weighting on production and less than 6% weighting on conformation within the Residual Survival BV, it would be useful to investigate whether conformation scores of our national herd have declined since the inception of our current index. The best way to assess this in future would be to TOP a larger and more representative subset of the national herd.

3. What is the true value of liveweight?

"We were chasing stock units and wondering why our production was going down" - Chris Kelly, CEO Landcorp, Straight Furrow 7 August 2012

"During these few weeks [calving] New Zealand has a higher rate of cattle kill than either Australia or Canada – but we are killing them at the beginning of their lives, not the end" – Hugh Stringleman, New Zealand Farmers Weekly, 13 August 2012

3.1 Introduction

Liveweight is an important functional trait of dairy cows due to the dependency of feed demands for body maintenance on metabolic liveweight, and its relationship to profitability. A way of measuring efficiency while accounting for liveweight is required in order to compare cow efficiency between cows of different weight , as the Holstein-Friesian and Jersey breeds differ in mature liveweight by a factor in excess of 25% at the same body level condition (Montgomerie 2007).

The liveweight model in the NBO is a repeated record, single trait, additive genetic effects model. Liveweight breeding values are estimated from information derived from weigh scales and 2 year old TOP scores. This is information is then run through a model where each animal is compared relative to her contemporary group (all animals with the same age, year, season of calving) with some adjustments for permanent environmental effects, hybrid and hybrid vigor. The method to estimate breeding values also includes the genetic relationship between individuals in his or her pedigree who may have left equal, smaller or larger than average progeny for liveweight.

The model calculates a value per tonne DM consumed, and for BW this is adjusted to a number for every 4.5 tonne DM consumed, which was approximately the annual consumption of the average dairy cow when the model was developed in 1996.

The current value of liveweight in the index is -$1.48 and accounts for 14% of the total index. This means that for every 1 kg increase in liveweight with no change in production we expect a decrease in net farm income of $1.48. If an animal has a + 10 kg liveweight BV then the progeny of this sire are expected to be 5 kg heavier than a sire with liveweight BV of zero. The reason the current value is negative is because the model accounts for higher maintenance requirements as a cost, therefore reducing profitability as an animal gets heavier with no increase in production compared to a lighter animal. However, it is difficult for many farmers to follow this logic because clearly if an animal weighs more then she should be producing more. Furthermore, at a set feed intake with set production, a small animal will be rewarded simply for being small.

It is well established that heavier animals generally have bigger energy requirements than lighter animals, because of the larger tissue mass to be maintained. However, energy requirement for maintenance does not increase in direct proportion to body weight (Holmes et al 2002). The energy requirement for maintenance per kg of bodyweight is therefore smaller for heavier animals than lighter ones. This relationship is outlined in Figure 6.

A heavier dairy animal generally has capacity to produce more milk. Roche and Reid (2002) demonstrated that in the parts of New Zealand such as the South Island where there is access to reasonably priced high quality supplements that do not always require significant capital expenditure per kg of additional milksolids, higher yielding cows allow increased milk production without increasing the weighted average cost of capital. The net result is an overall improvement in profitability.

Therefore, it is difficult to understand at first glance the logic of the economic weighting for liveweight being negative, when the maintenance per kg bodyweight is lower for heavier cows and those heavier cows have the capacity to produce more milk. The reason for the negative weighting is because it is calculated at a set level of production, therefore a heavier animal producing the same amount as her lighter counterpart is considered less efficient.

In theory if an animal is producing well, but is heavy, then the positive effects of production on BW will be outweighed by the negative effects of liveweight, therefore giving that animal an overall good BW (Bevin Harris, Personal Communication, 5 September 2012). However, in order to achieve efficiency and to have the positive effects of production outweigh the negative effects of liveweight, then a cow must be producing an optimum amount of milksolids for her bodyweight. Economically optimum production per kg of bodyweight is considered to be around 80-90% (Penno 1999).

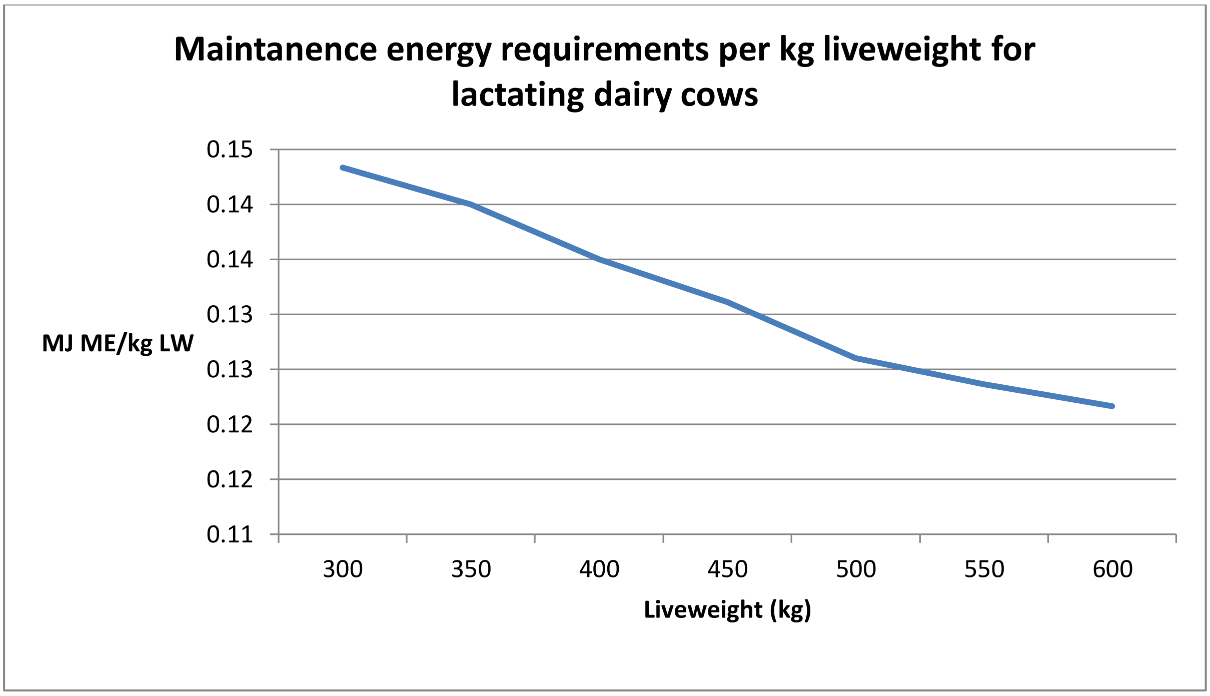

Figure 6. Maintenance energy requirements per kg liveweight for lactating dairy cows. Source: Holmes et al 2002.

High yielding cows are important for profitability, as they are more efficient at converting feed energy into milk. Heavier cows that are high yielding are more profitable than lighter cows because they use less energy for maintenance and more energy for milk production, as shown in Figure 7.

If we think about this in a farm systems context, the decision that has to be made by the farmer is essentially whether to breed for “light” cows and maintain a high stocking rate or breed “heavy” cows and have a lower stocking rate.

One of the costs which are not taken into account in the NBO when we think about this choice a farmer has to make, is the capital cost of the higher stocking rate. For example, with more cows there is more wear and tear on the cow shed, potentially more staff which require accommodation, motorbikes and equipment, and more pressure on repairs and maintenance in areas such as farm tracks.

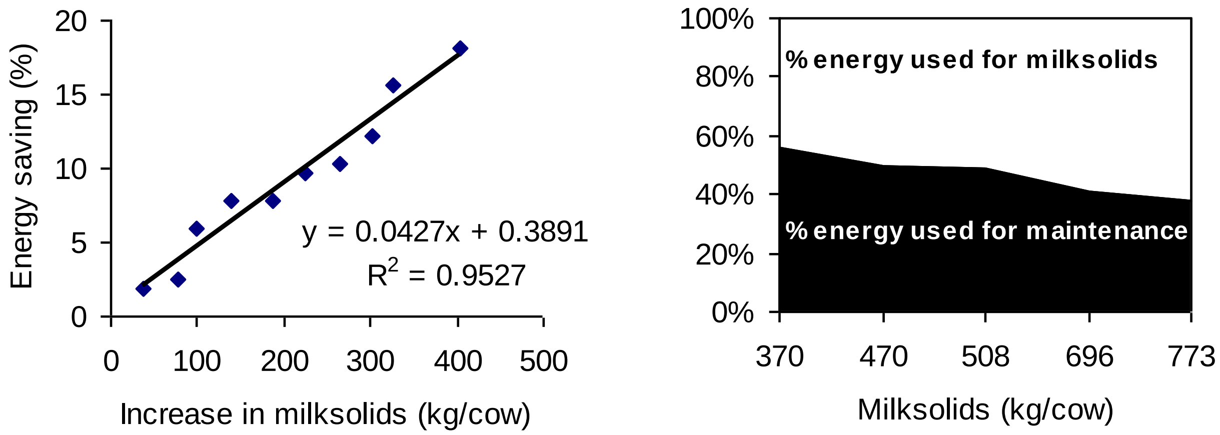

Figure 7: Energy requirements for maintenance and milk production in dairy cows (500 kg liveweight) differing in milksolids yield (Roche and Reid 2002).

Another factor which is not taken into account in the NBO is environmental impact. This is increasingly becoming an important consideration in farm systems analysis, especially with the development of regulations by Central and Local Government which seek to limit the amount of nutrients being lost from the farm system. There will be some traits which relate directly to environmental impact, such as production, feed conversion efficiency and greenhouse gas emissions. There are also some traits which relate indirectly, for example liveweight impacts on stocking rate which in turn impacts on the environment.

This study seeks to challenge the assumptions in the liveweight model by modeling farm profit for two herds of different average liveweight per cow at a fixed feeding level, fixed comparative stocking rate and fixed production as a proportion of liveweight. It also takes into account capital costs associated with more cows (which are not accounted for in the NZAEL model) and investigates the environmental impact of the two different herds.

3.2 Method

Two herds were compared for profitability at fixed feed levels, fixed comparative stocking rate (CSR), and fixed production as a proportion of liveweight. Fixing these variables allowed a comparison where the only changing variable was cow size, ensuring that all other traits remained constant to calculate the economic value of liveweight. Comparisons were made for both system 3 and system 4 farms, whereby system 3 is defined as importing around 10-20% of total feed and system 4 is defined as importing around 20-30% of total feed (Anon 2010a).

Stocking rate is considered a key performance indicator when analysing dairy farm systems, and CSR is suggested as the best method for calculating how many cows to milk (Penno 1999, MacDonald and Clark 2011, Speight 2002). Stocking rate expressed as cows per hectare has been a simplistic terminology used in the dairy industry for over 50 years. Cows per hectare is a simplification of the relationship between feed demand and feed supply. However, cow size and annual milk production determine the feed requirements of the cow, and cows per hectare are no longer accurate or relevant to today's dairy farmers. The new measure is known as CSR is calculated as:

CSR = kg LWT / t DM

Where:

- kg Lwt is the total liveweight of the herd (including first calvers) 2 months before calving. It is assumed that young-stock are excluded from the farm area.
- t DM is the total amount of feed supplied to the herd over 12 months including pasture production, and any bought-in supplement or cow grazing.

Speight (2002) suggests that the optimum CSR for production and profitability is between 80 and 90. If the CSR is low (below 80), this generally means that while cows are well fed, feed is probably not being well utilised. If CSR is high this generally means that while feed utilisation is high, production is probably lower than optimum due to lower per cow intakes. MacDonald and Clark (2011) concluded from a trial that optimum CSR is 77 kg LW/t DM. This study uses a CSR of 80 kg LW/t DM.

Ten year weighted average figures for calculating profitability were obtained from the Dairy NZ Economic Service, Beef and Lamb Economic Service, and NZ Animal Evaluation Unit. Per cow and per hectare costs were fixed in the same proportions as the current NZAEL model.

Cow feed requirements for maintenance, pregnancy and milk production were calculated using theoretical energy requirements from Dairy NZ Facts and Figures (Anon 2010a) assuming 11 MJ ME per kg DM.

Additional capital cost estimates relating to stocking rate were based on data from milking efficiency studies (for dairy shed depreciation calculations), personal communication with track maintenance contractors (for track repairs and maintenance calculations), and the Dairy NZ Economic Survey (for cows per full time equivalent to calculate staff capital costs). Some capital costs such as machinery were not included, and only the main costs that were in some way quantifiable are dealt with here.

Microsoft Excel spreadsheets were utilized to build the model and perform the calculations.

Overseer® Version 6 was used to model each farm and system type to provide nitrogen loss and nitrogen conversion efficiency figures.

Assumptions for Overseer® modeling:

- 150 ha farm on Lismore silty stoney medium texture soil in the Canterbury region, 20 km from the coast
- Default values were used wherever provided in Overseer®
- Effluent was applied at low rate to whole farm, with solids separated
- Centre pivot irrigation was applied at low rate from November to March
- N application of 100 kg N for the year with 12 kg N per application
- Total imported supplements for system 3 was 300 tonne DM pasture silage and 150 tonne DM wheat, and system 4 was 500 tonne DM pasture silage and 400 tonne DM wheat.

3.3 Results

Modeling showed that per cow, per ha and overall farm profit is increased for a farm scenario milking 550 kg cows compared to 450 kg cows in both system 3 and system 4 analysis at fixed feeding levels. The 550 kg cow scenario demonstrated increased per cow profit by $445.12 and $451.18 for system 3 and system 4 respectively. Per hectare profit was greater in the 550 kg cow scenario by $1143.91 for system 3 and $1297.47for system 4. Overall farm profit was greater for the 550 kg cow scenario, returning $171,587 more for system 3 and $194,620 more for system 4.

Each cow also had an associated capital cost, and capital costs were slightly higher in herds with more cows. However, these costs were not large in comparison to overall farm costs.

Assumed values for milk income and beef income are outlined in Table 13. Capital cost calculations are outlined in Table 14. The results for per cow and overall farm profitability, and Overseer® modeling for the four farm scenarios are outlined in Table 15.

Nitrogen loss (kg N/ha) and nitrogen conversion efficiency for each scenario are summarised in Table 15. The margin of error for Overseer® is around +/- 20% (Stewart Ledgard, Personal Communication, 17 September 2012), therefore these values show no significant difference in N loss or N conversion efficiency between the two scenarios for both system 3 and system 4 farms. Overall, N loss for these farms is below the Canterbury average and N conversion efficiency is above the Canterbury average (Anon 2012c). These scenarios assume best practice in terms of irrigation, effluent management and fertiliser use.

Table 13. Values for milk income, beef income and fixed costs.

	Value	Source
Fixed cost per ha	2501	Dairy NZ Economic Service, ten year weighted average
Variable cost per cow	283	Dairy NZ Economic Service, ten year weighted average
10 year average pay-out	5.21	Dairy NZ Economic Service, ten year average
Beef price/kg	2.58	Beef and lamb Economic Service, ten year weighted average
Bobbies each	16.35	Calculated with assumption of 30 kg animal boning out at 50% with beef price of $1.09 per kg

Table 14. Values and calculations for capital cost estimates.

	System 3		System 4	
	Heavy cows, less per ha	**Light cows, more per ha**	**Heavy cows, less per ha**	**Light cows, more per ha**
Number of FTEs	3.00	3.50	3.50	4.00
Motorbike depreciation	1050	1225	1225	1400
House depreciation per year	15000	17500	17500	20000
Shed depreciation per year	29764	32083	33823	36458
Track R&M	1929	2079	2192	2363
Total capital costs per herd	47743	52887	54739	60221
Shed depreciation calculations	**Heavy cows, less per ha**	**Light cows, more per ha**	**Heavy cows, less per ha**	**Light cows, more per ha**
Milking hours per day (TD milking)	3.86	4.16	4.38	4.73
Milking hours per year	1069	1152	1214	1309
Milking hours in 30 years	32055	34553	36426	39265
Average shed life hours (30 years @ 10 cows/ bail)	35899	35899	35899	35899
Shed life based on milking hours	34	31	30	27
Depreciation rate % per year	3	3	3	4
Shed value	1000000	1000000	1000000	1000000
Net depreciation per year	29764	32083	33823	36458
Track R&M calculations	**Heavy cows, less per ha**	**Light cows, more per ha**	**Heavy cows, less per ha**	**Light cows, more per ha**
Length of track (m)	2000	2000	2000	2000
Maintenance @ $4/m	8000	8000	8000	8000
Cost per cow @ 500 cows for 4 years	16	16	16	16
Cost per cow per year	4	4	4	4
Cost for herd	1929	2079	2192	2363

Assumptions:
Cows/FTE = 154 (Anon 2011b)
Cows milked/hr through 54 bail rotoary = 250 (Jago 2011)
Average lactation days = 277 (Anon 2011a)

Table 15. Stocking rate, profitability and environmental impact of two modeled farms on 150 ha in Mid Canterbury with fixed feed and CSR on two different farming systems.

	System 3		System 4	
	Heavy cows, less per ha	**Light cows, more per ha**	**Heavy cows, less per ha**	**Light cows, more per ha**
Cows	482	520	548	591
Average cow liveweight (kg)	550	450	550	450
Stocking rate (cows/ha)	3.21	3.47	3.65	3.94
LW/ha	1760	1760	2000	2000
kg DM offered per ha	22000	22000	25000	25000
Comparative stocking rate (kg LW per ha/t DM per ha)	80	80	80	80
Production per cow (kg MS)	501	410	501	410
Production as % of LW	91%	91%	91%	91%
Production (MS/ha)	1609	1419	1828	1612
Feed intake per cow (kg DM)	5817	5397	5817	5397
Feed offered per cow (kg DM)	6844	6349	6844	6349
Feed intake per kg MS	11.62	13.18	11.62	13.18
	System 3		**System 4**	
	Heavy cows, less per ha	**Light cows, more per ha**	**Heavy cows, less per ha**	**Light cows, more per ha**
Per cow				
Variable costs per cow	283.00	283.00	283.00	283.00
Capital cost per cow	99.01	101.76	99.90	101.96
Fixed costs per cow	778.03	721.79	684.67	635.17
Total cost per cow	1,160.05	1,106.54	1,067.57	1,020.13
Milk income per cow	2,607.61	2,133.50	2,607.61	2,133.50
Beef income per cow	142.98	118.47	142.98	118.47
Total income per cow	2,750.59	2,251.97	2,750.59	2,251.97
Profit per cow	**1,590.54**	**1,145.42**	**1,683.01**	**1,231.83**

	System 3		System 4	
	Heavy cows, less per ha	Light cows, more per ha	Heavy cows, less per ha	Light cows, more per ha
Per hectare				
Variable costs per ha	909.71	980.60	1,033.76	1,114.31
Capital costs per ha	318.28	352.58	364.93	401.47
Fixed costs per ha	2,501.00	2,501.00	2,501.00	2,501.00
Total costs per ha	3,728.99	3,834.18	3,899.69	4,016.79
Milk income per ha	8,382.18	7,392.57	9,525.21	8,400.65
Beef income per ha	459.61	410.50	522.29	466.48
Total income per ha	8,841.80	7,803.07	10,047.49	8,867.12
Profit per ha	**5,112.80**	**3,968.89**	**6,147.81**	**4,850.34**
Total farm profit (EBIT)	**766,920.45**	**595,333.55**	**922,170.96**	**727,550.62**
N loss modelled by Overseer® kg N/ha/year	24	21	24	21
N conversion efficiency modelled by Overseer® Total N inputs/Total N in product	36	34	36	34

3.4 Discussion

This analysis demonstrates that per cow, per hectare and overall farm profit can be increased by farming heavier cows with fewer cows per hectare. However, there are two caveats to this claim.

Firstly, the cows must be producing at their economic optimum. That is, producing somewhere in the vicinity of 80-95% of MS per kg of liveweight. This is something we do not do particularly well in NZ. Latest NZ dairy statistics show that on average the current national herd weighs 491 kg and produces 334 kg MS, which equates to 68% of MS per kg liveweight (Anon 2011a).

Secondly, the model assumes efficient utilisation of pasture and supplements. Management capability must be adequate to maximise pasture and supplement utilisation in order to achieve higher profitability from heavier cows with fewer cows per hectare. As Penno (1999) describes, it is not enough to simply milk fewer cows and hope.

The value of liveweight

As discussed in the introduction, the current value in the BW index is -$1.48 and accounts for 14% of the total index i.e. for every 1 kg increase in liveweight at a set feed and set production rate we expect a decrease in net farm income of $1.48. This is a very simplistic way of viewing liveweight, and this analysis demonstrates that improved profitability can be gained by farming heavier cows with an optimal CSR along with good feed utilisation and high levels of production per cow.

A negative value for liveweight assumes that just because an animal is small it is a more efficient converter of feed into milk. However, this is not necessarily true, as outlined in the introduction to this section.

Penno (1999) concluded from stocking rate studies that at the economically optimum stocking rate of 85 kg Lwt/t DM, 375 kg Jersey cows are required to produce 335 kg MS and 500 kg Friesians are required to produce 405 kg MS/cow. This equates to 80-90% of production per kg liveweight. Ensuring a cow is producing at her optimum is critical for improving profitability. A cow producing less than 80% of her body weight is likely to have sub-optimal profitability regardless of her weight.

The analysis in this study was repeated using set production as a proportion of liveweight, with fixed feed levels but varying CSR. Production per kg LW was set at 91% for both the 550kg/cow herd and 450 kg/cow herd. The results aligned with the results from the fixed CSR analysis and again showed that farming heavier cows at a lower stocking rate is more profitable.

Lowering stocking rate and improving per cow production

There have been several NZ studies advocating the concept of lowering stocking rate and improving per cow production. Because each extra cow farmed carries additional costs into the system, the optimal stocking rate for profitability will generally be lower than that for production. Clarke et al (2011) and MacDonald and Clarke (2011) found that lowering stocking rate may be a profitable option on some farms, but must be combined with high genetic merit cows which have high intake capacity, high MS yield, high fertility, BCS recovery, high health, and high survivability. These attributes link strongly with the health and conformation traits mentioned earlier in this report.

Penno (1999) showed that there is a strong inverse relationship between stocking rate and annual milk solids production per cow i.e. the lower the stocking rate, the higher production per cow. He also suggests that there are economic benefits in lowering stocking rate, as the high genetic merit cow has a large capacity to respond to additional feeding resulting from reduced stocking rates. However he cautions that if stocking rates are to be reduced, per cow production must increase to compensate. Good grazing management is essential to achieve optimal profitability. The changes to farm management that will be necessary to bring this about must be carefully planned and in place before the stocking rate is changed.

Lincoln University Dairy Farm lowered stocking rate and increased per cow production in the 2011-2012 season and showed good results for profit and environmental impact (LUDF Website).

Environmental impact of fewer cows

Environmental impact is often measured by communities and regulators in the form of N loss, expressed in kg N lost per hectare. It is well known that urine patches from cows are the biggest source of N loss on a dairy farm. Therefore, logic would suggest that the less cows per hectare, the lower the N loss. However, N loss is not simply a function of stocking rate, but rather a complex estimation influenced by a wide range of factors within the farm system. Some of these factors are management related (e.g. feed, fertiliser and effluent) and some are not (e.g. soil type and rainfall). Also, the Overseer® model assumes that if there are more cows, they are spreading urine patches more evenly across the paddock with less concentrated urine per cow, hence the lower N loss for the more cows eating less per cow scenario (Stewart Ledgard, Personal Communication, 17 September 2012).

The results from this study show that the effect of changing stocking rate on N loss and N conversion efficiency is relatively minor in the scenarios modelled. However, the concept is worth further exploration. Clark et al (2011) used modelling to show that reduced stocking rate combined with increased per cow production and lower N fertiliser use can be profitable and have less impact on the environment in terms of N leaching. Other studies have also shown environmental benefits from lower stocking rate and increased per cow production (Beukes et al, 2011a; Beukes et al 2011b; Beukes et al, 2012). Benefits included lower N loss and reduced greenhouse gas emissions. The common factors in these modelling studies that contribute to improved production with less environmental impact were increased genetic merit cows combined with lower stocking rate and longer lactations, lower replacement rates, lower N fertiliser use and use of low N feeds such as grain. Again, many of these factors link strongly to health and conformation traits mentioned earlier in this study.

Further information required

The calculations in this study are based on industry average figures for income and costs, annualized figures for feed and production, and undertaken in a gross way using Excel spreadsheets. To gain a more in depth understanding of farm systems, CSR and cows per hectare changes on profitability, analysis of model farms could be repeated using more in depth models such as Farmax for specific farm scenarios.

There are very few people in NZ who have an in-depth understanding of the NBO liveweight model. However, the concept of fixing feed level and production level to assess the value of liveweight seems very simplistic, given that the intake, productive capacity and metabolic liveweight will be different for cows at different liveweight. Furthermore, a negative value on liveweight assumes that just because an animal is small that it is an efficient converter of feed into milk. Is this assumption correct? A further look at the principles behind the model and open industry discussion are warranted, given that liveweight currently accounts for 14% of the index and has a considerable effect on decisions for selection.

4. Conclusions and recommendations

Two things have become very apparent during this study:

- Firstly, there are only a handful of people in New Zealand who really understand the NBO and models behind our national index known as BW.
- Secondly, profitability of dairy production in New Zealand can improved dramatically if every cow produced at its economic optimum and survived to at least the age of 6 years old.

It seems that we have been so focused on being highly productive that we have lost sight of sustainable selection. Sustainability in this case means selecting for a robust cow that is able to produce, get in calf, be healthy and survive to an age where she is highly profitable across her lifetime.

Cow survivability is complex and influenced by a range of factors, so there will never be one single fix to improve longevity. However, it is well established through international and NZ research that TOP, and in particular udder and dairy conformation, play a significant role in cow longevity. It is therefore disappointing to see that there is no mention of udder or conformation traits in the current BW, and there is no mention of including them in the recently released NBO discussion document. From what I have learnt through this modeling and review of literature I would strongly recommend that the current NBO review carry out further evaluation on the merits of specifically (i.e. not within another trait such as longevity) including udder and confirmation traits in the NBO.

This study has also highlighted the ever increasing issue of declining fertility in the national dairy herd, and the impact this has on replacement rates, lack of ability to carry out voluntary culling, and overall profitability. The recent NBO review discussion document recognises the issue of declining fertility; however it is not genetics alone that will deliver a solution. I would recommend that the industry as a whole convene a working group to develop a programme that addresses both the genetic and management aspects of infertility within the national dairy herd.

The current model for liveweight in the NBO needs reviewing. Liveweight in itself is not a measure of efficiency, but our NBO attempts to apply it in that way. The principles of overall higher maintenance for a heavier cow are generally well accepted, however the complexity of feed conversion efficiency per cow, feed supply and feed demand as expressed by comparative stocking rate are not adequately accounted for in the model. At a set feed intake with set production, a lighter cow automatically gets points for being small, while a heavier cow automatically loses points for being large. We need to explore whether there is another way of looking at the value of liveweight, in the context of productive capacity and metabolic liveweight. There is also scope in the current model to include considerations for capital costs per cow (which increase as stock numbers increase), and account for environmental impact.

Last but not least, more information needs to be made available in an easy to understand form to rural professionals and to farmers about the NBO and the principles underlying the NBO. It is encouraging to see this recommendation in the NBO review discussion document. Far too many farmers and rural professionals have become reliant on BW numbers and "bull packs" and "bull of the day" without really realising what they are selecting for, or indeed paying more money for when purchasing cows. Most farmers do not peruse catalogues and nominate bulls because our NBO and BW system is not well understood. Some may argue that as long as BW is high, then the industry is moving in the right direction. I would argue - is "moving in the right direction" enough? Why not strive to be as profitable as possible?

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