A HISTORIC EVALUATION OF RESEARCH INDICATORS IN BCRC PRIORITY AREAS

April 2012

Submitted by:
Canfax Research Services
310, 6715 8th St. NE
Calgary, Alberta T2E 7H7
Phone: 403.275.8558

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EXECUTIVE SUMMARY

The Beef Cattle Research Council (BCRC) commissioned the development of a study to define research indicators that can be monitored on an ongoing basis to evaluate the contribution of research to the beef cattle industry in Canada. This historical analysis is Phase 1 of that project. The value of specific investments in priority areas will be examined in separate reports.

Research is a slow process that takes many years to go from basic scientific concepts to practical application on the farm. In many cases the new technologies being implemented today result from research done several years ago. Therefore, it is important to understand the historical contributions of research and value of continued investments in research.

There have been significant gains from research over recent decades that have contributed to the Canadian beef industry's ability to compete internationally and stabilize beef demand domestically. A large part of this has been managing input costs and adding value through finishing and processing. Future growth in productivity will be largely determined by today's investment in research and development. Research offers measureable improvements in:

Production/Feed Efficiencies appear to be quickly adopted by industry at both the feedlot and cow/calf levels. Large gains have been seen in weaning and slaughter weights. The steer carcass weight represented 1.17 of the cow carcass weight in 1980; this has increased to 1.26 in 2010. The technology to increase animal gain and overall performance is readily available and widely publicized. Research into this area is being done by private pharmaceutical companies who are able to see a return on their investment by selling patented products. However, there is still basic research that needs to be done to assist in the advances made in this area. The goal is to find ways to increase average daily gains, reduce feed:gain ratio and keep a manageable sized, fertile cow that can be efficiently fed through the winter.

Animal Health appears to have improved over time with higher reproductive efficiency; however survival rates to slaughter have not seen the same progress overtime particularly in the post-weaning period. Survival to weaning is challenged in some areas due to natural predators and varies significantly across the country. The proportion of condemnations in slaughter increased from 2003 to 2008 but has since declined in 2009 and 2010 to be back at 99-02 levels. It is important to note that despite improved treatment strategies and the development of new products by private companies, there continues to be a large number of deaths by unknown causes; representing 44% of all deaths over the entire feeding period (according to U.S. sources).

Forage and Grassland Productivity shows that hay yields have been declining over time and a larger number of acres are required to produce enough forage for the beef industry. This inefficiency means producers need a larger land investment than US competitors. Increasing yield on marginal land to be internationally competitive will be important to the entire industry over the long run. There have been a number of new varieties developed over the years but they do not appear to have fully compensated for the move to increasingly marginal land. Variety development cannot only focus on drought resistance or stand longevity but must also improve yield. Public investment into forage varieties is necessary, as the ability of companies to recoup their initial investment is low in a self-pollinating crop that is only re-seeded every 5-8 years.

There is a lot of research available in the area of rejuvenating forage stands making technology transfer key in this area. While fertilizer has been shown to result in significant yield improvements in hay, it is rarely used. Two clear drawbacks to the research on forages currently available are that (1) it is often not done by soil type and therefore producers in different regions may not see similar results and (2) it does not include an economic cost/benefit analysis.

Beef quality and food safety are key factors in maintaining beef demand. It is difficult for research in these areas to provide a return to a private investor; however the return to industry as a whole from advancements in these areas is significant.

Beef Quality in Canada lags behind the US in terms of production of AAA and Prime beef. In addition, per capita consumption is lower in Canada. Despite the fact that analysis has demonstrated that Canadian consumers are willing to pay more for beef, improvements in yield have plateaued and actually reversed in some cases. Market signals from increased dollars from heavier weights and higher marbling (a AAA vs. AA quality grade) have offset the penalty for a yield grade 2 or 3 animal. The incidence of dark cutters has increased since 2004, particularly in the West and while overall numbers have declined since 2008, levels are still above the historic average. In contrast, dark cutters in the East have fallen to the lowest levels in over 10 years.

A lack of consistency in tenderness has plagued the beef industry for years. An ability to measure tenderness would be of significant value to the industry if it can be affordable and implementable as a routine practice in plants or done on live animals. Once tenderness can be measured more consistently and efficiently, methods to improve tenderness consistency can be pursued; including aging, enzyme technologies and other strategies.

Food Safety is of critical importance to consumer confidence in beef. The reported incidence rate of *E.coli 0157* has been declining over the last decade. At the same time detection levels have improved significantly with new assay's shown to be 100% specific and have sensitivity at industry standards of less than 1 CFU/25 g (0.04 CFU/g - CFU = colony forming units). However, it is unclear whether the reduction in the number of outbreaks has been due to an overall reduction in the amount of *E.coli* present or due to the adoption of test and hold procedures that has resulted in this product being removed from the supply chain. While protecting the consumer is of the utmost priority, if the actual amount of *E.coli* present in beef has not been reduced there is still a cost to industry to dispose of the product safely. The use of test and hold procedures mean the need for rapid screening methods that can be completed within 6.5-8 hours and meets industry standards for sensitivity, need to be developed.

Antimicrobial resistance is a concern on two fronts, that of animal health and consumer confidence. Studies in 2008 and 2010 have found no association between antimicrobial use in the western Canadian feedlot industry and antimicrobial resistance (with no indicator organisms found between human pathogens or cattle pathogens). However, considering the wide-spread use of in-feed antimicrobial agents and the frequency of beef cattle that shed *E.coli* and *Campylobacter* there needs to be on-going monitoring to demonstrate industry's diligence in this area.

Table 1 summarizes the research indicators discussed throughout the report. When the average increase from decade to decade is larger/smaller than the performance over the last decade (2000 to 2010) advancements have slowed. While gains have plateaued in some areas others continue to see advancements. It is important to note in specific areas there can be a point when further incremental improvements become extremely costly. While it takes only 20% of the time to get 80% of the way, gaining the last 20% can take up 80% of the time. This needs to be considered when prioritizing research dollars.

Table 1. Summary of Research Indicators

Production Efficiencies	1980	1990	2000	2010	Avg Decade	Last Decade
Steer Carcass Weights	668	706	813	850	9%	5%
Steer Carcass Weights - US		741	797	835	6%	5%
Productivity Per Cow	406	503	617	587	15%	-5%
Productivity Per Cow - US		518	614	626	10%	2%
Steer CW /Cow CW	1.17	1.18	1.19	1.26	3%	6%
Weaning Weights (lbs) *		477	608	576	28%	-5%
Feed Efficiency		**1980s**	**1990s**	**2000s**		
Feed:Gain Ratio *		7.4	7.6	6.7	3%	-12%
Average Daily Gain *		2.7	2.9	3.0	7%	3%
Dry Matter Intake (KG) *		9.2	9.3	8.7	1%	-6%
Animal Health	**1980**	**1990**	**2000**	**2010**	**Avg Decade**	**Last Decade**
Survival Rate		74	75	74	0%	-1%
Survival Rate - US		67	76	74	5%	-3%
Condemns per 10,000 slaughtered			34	28		-18%
Reproductive Efficiency	71	76	85	90	9%	6%
Reproductive Efficiency - US	90	90	89	87	-1%	-2%
Forage & Grassland Productivity						
Grain Yield - CDN Barley		46.5	59.5	60.6	15%	2%
Grain Yield - US Corn		118.5	136.9	164.7	19%	20%
Hay Yield - CDN Tons/Acre	1.91	2.33	1.41	1.92	0%	36%
Hay Yield - US Tons/Acre	3.06	3.29	3.47	3.4	4%	-2%
Alfalfa Varieties	6	21	88	186	+10%	111%
Beef Quality						
Per Capita Consumption	63.27	54.7	51.59	44.55	-10%	-14%
Per Capita Consumption - US	76.6	67.7	67.8	59.6	-7%	-12%
Beef Demand Index	100	60.33	52.25	50.12	-17%	-4%
Beef Demand Index - US	100	59.43	49.24	46.51	-18%	-6%
Quality Grades - % AAA			45.5	53.8		18%
Dark Cutters			0.9	1.4		56%
Yield Grade 1		70	62.87	52	-13%	-17%
Food Safety		**1990**	**2000**	**2010**		
Incidence of E.coli			5	2		-60%
Detection		10-100CFU/g	1CFU/25g	<1CFU/25g 100% Specific		

** Average for each decade instead of single year observations.*

INTRODUCTION

The Beef Cattle Research Council (BCRC) commissioned the development of a study to define research indicators that can be monitored on an ongoing basis to evaluate the contributions of research to the beef cattle industry in Canada. This historical analysis is Phase 1 of that project. The value of specific investments in priority areas will be examined in separate reports.

Research is a slow process that takes many years to go from basic scientific concepts to practical application on the farm. In many cases the advancements in production currently being utilized are derived from research done several years ago. Therefore, it is important to understand the historic contributions of research and value of continued investments in research. The Canadian beef industry depends on export markets for approximately 50% of its production. The industry as a whole needs to stay competitive in the international marketplace and be able to provide a cost competitive product that meets the standards and quality expectations of both domestic and international customers. There are many areas to consider when looking at a country's competitive standing including the demand for product, profitability of the industry, and biological/mechanical technology readily available to the producer.

In recent decades, the private sector has increased its investment in agriculture and food innovations. Factors spurring on private investment include the emergence of biotechnology, stronger intellectual property rights (IPR), new regulatory requirements, the expansion of markets for improved agricultural inputs and food products, and rising consumer demand for more diverse foods. The USDA Economic Research Services estimates that private sector research and development dollars have increased 4.3% per year from 1994 to 2007[1]. The most rapid increases were seen in crop breeding/biotechnology, followed by farm machinery and food manufacturing. At the same time, real (adjusted for inflation) R&D spending for crop protection chemicals and animal nutrition declined. It was found that generally the four to eight largest firms in a sector accounted for around 75% of the R&D in that sector; with large firms investing more as a percentage of product sales than small firms. Consequently sectors dominated by small firms (i.e. cow/calf sector) invest a smaller percentage than sectors dominated by large firms (i.e. feedlot sector). This is partly also a function of specialization of expertise and a single focus verses a diversified operation with multiple farm enterprises and potentially off-farm income. This leaves a large role for industry and public investment in agricultural research and development.

This paper provides a historical review of research advancements in the priority areas funded by the BCRC. It should be noted that any historical look at general indicators from the marketplace will not be able to separate out the impact from specific research investments made by the BCRC, other public funders, and private investments. The research indicators will provide an overall trend of the contribution of research to industry advancements. While BCRC was created in 1999, due to the long term nature of investment and returns in research a historical approach is taken back to 1950 where data is available. As research advancements become available, this does not mean they are adopted by industry. Some research indicators show no advancement where progress was expected - highlighting potential opportunities on areas that would benefit from improved technology transfer.

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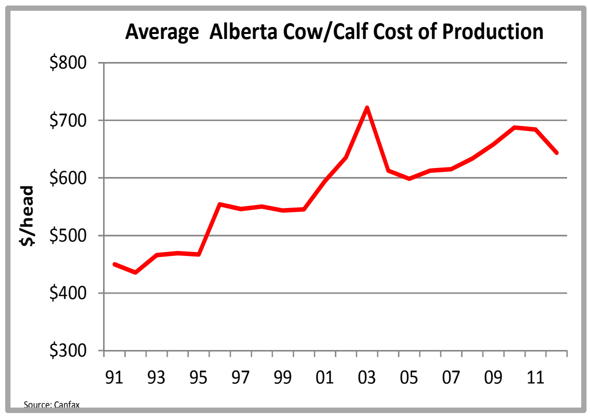
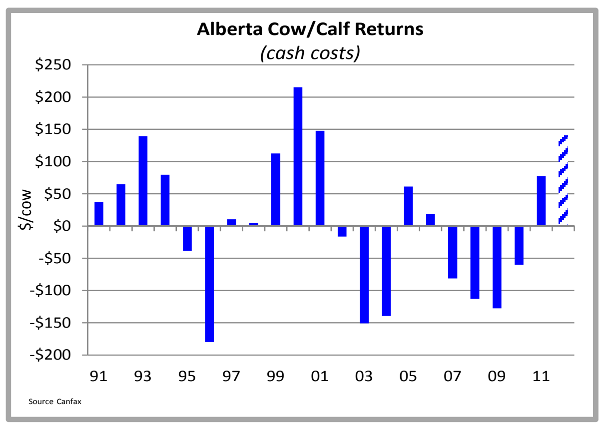
[1] http://www.ers.usda.gov/publications/eib90/

WHY IS RESEARCH IMPORTANT?

As input costs increase the ability to compete internationally on the cost side becomes increasingly important. The country with the lowest costs will see expansion first and grow its herd relative to less competitive countries, making it able to gain market share in importing countries. While the cost structure at the cow/calf level determines if the industry expands or contracts, feedlot costs determine where cattle will be finished and costs at the packer level determine where cattle will be processed with value added to the carcass. The long-term sustainability of the Canadian beef industry is contingent upon the health of all sectors along the supply chain and ensuring the vast majority of cattle are processed in Canada.

COW/CALF COST OF PRODUCTION





Input costs for Alberta cow/calf producers increased by 33% in the 90s and an additional 15% over the last 10 years. Hay prices increased 41% in the '90s and another 15% in the last decade. Barley prices increased 45% in the 90s and another 54% in the last decade; increasing the incentive to look for alternative protein sources.

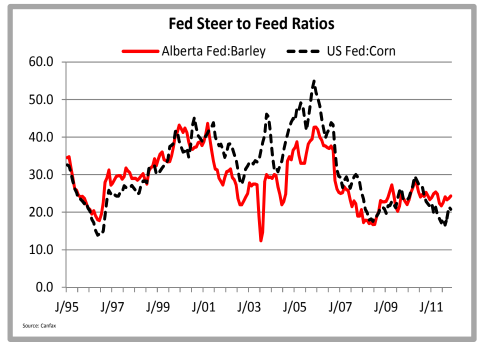
Fuel prices increased 10% over the 90s and have since doubled in the last decade. This makes alternative ways of feeding that reduce the use of inputs to produce, harvest, and deliver feed more desirable. Farm labour costs have also accelerated increasing 15% in the 90s and 47% over the last decade.

Many of these increased costs have also been experienced by U.S. counterparts. However, the difference comes in the price U.S. counterparts received. During this period of increased costs Canadian producers have faced depressed prices with a stronger Canadian dollar and wider basis. It has only been recently with tighter supplies that the basis has narrowed. Returns over cash costs for Alberta cow/calf producers are estimated to have been negative for seven of the last 10 years. This has been a drain on the sectors equity and resulted in consolidation in the industry.

Globally higher feed, land, labour, and other input costs have resulted in a narrowing in the relative cost of production between different countries. Previous low cost producers of beef (i.e. Brazil) have seen land values, labour, and feed prices all increase with increased competition for acres and growing economies driving higher costs. Higher costs in these countries slowed expansion efforts to only 1% annual growth in beef cow inventories from 2006-08. This has since accelerated to 3.5% in 2010/11. As beef prices increased in 2011 only Brazil is expanding with Australia, Argentina and Canada all stabilizing their herds and gearing up for an expansion phase.

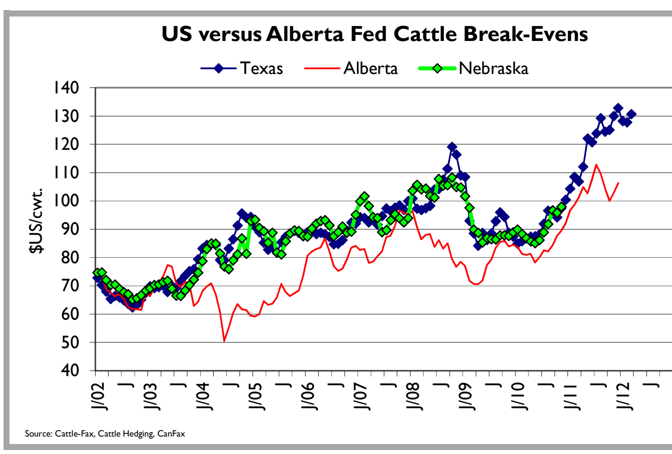
Despite its own challenges with high costs of production, Canada has an advantage over many other beef production systems. Grass-based typically take 4 years from the time the cow herd expands until larger production is seen. In contrast, a grain based production system only takes 2-3 years from expansion in the cow herd until larger production is seen.

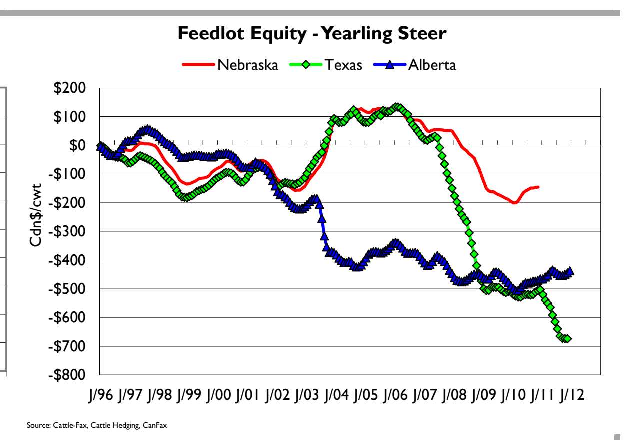
FEEDLOT COST OF PRODUCTION



The fed steer price to feed ratio is an indicator of profitability in the feedlot sector. A higher ratio indicates that fed prices are relatively high compared to feed costs and encourages the industry to expand or at least send a stronger price signal to the cow/calf sector. However, the ratio does not always decline when feed costs increase if fed prices increase accordingly. Canadian and U.S. fed cattle to feed ratios tend to move together in North America with the exception of the 2003 to 2007 period when the U.S. industry saw larger returns. This difference was caused by depressed cattle prices in Canada, an appreciating dollar which pressured profitability and a higher cost of gain in 2007 and 2008 when barley prices were higher than corn. Since 2008 the feeding sector on both sides of the border has seen historically low ratios at around or just above 20:1 indicating that margins are very tight or negative. In 2011, the ratio has been higher in Alberta ranging between 22 and 25 due to a lower barley price relative to corn; in the U.S. the ratio continues to range between 16 and 21.

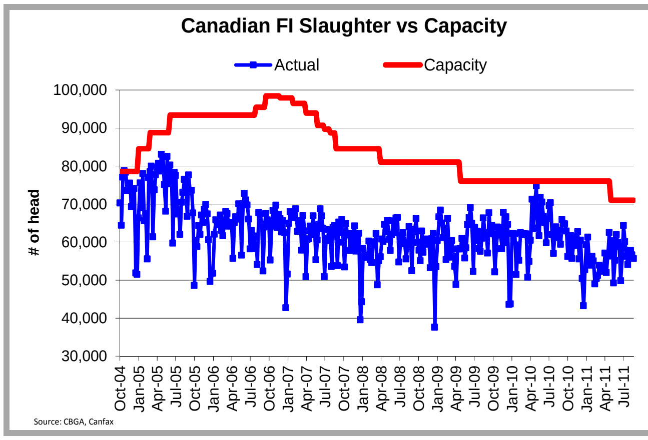
Feedlot breakevens have moved steadily higher over the last decade with a short reprieve in 2009 and the first half of 2010 following the financial crisis in fourth quarter 2008 and the global economic struggles. Without corresponding price increases there has been substantial equity loss in the feedlot sector in North America. While the U.S. feeding sector saw some good years in 2003 to 2008, Texas has since lost as much equity as their Canadian counterparts with Nebraska doing only slightly better.

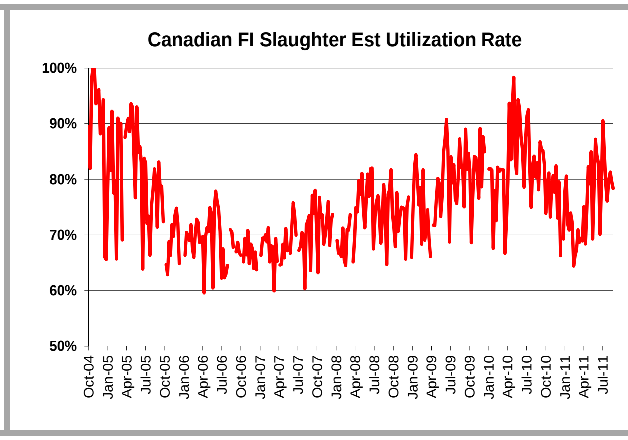




PACKER COST OF PRODUCTION

Annual **utilization levels** have been challenged in Canada and U.S. packing plants as supplies tighten in an industry that already has excess capacity. Annual utilization levels fell from a high of 91% in 2004 to a low of 69% in 2006 before slowly increasing back to 82% in 2010. Utilization levels fell to 77% in 2011, with lower supplies of both fed and non-fed cattle available for domestic slaughter reducing the average weekly slaughter from 61,000 head in 2010 to 56,000 head in 2011. Lower utilization levels increase the fixed costs that need to be covered by each animal going through the plant. Research indicates that levels below 90% are extremely inefficient. Overcapacity and low utilization rates have resulted in a number of Canadian packing plants closing since the fall of 2006.





Packers are able to make changes in the long run such as reducing the number of operating days in a week. However, these changes make it difficult to increase production over the short term or take advantage of seasonal changes.

Fluctuations in the CDN/US **exchange rate** have implications when comparing the competitiveness of Canadian plants to their U.S. counterparts. Particularly labor costs, which are negotiated and contract to cover a number of years, are difficult to adjust to the rapid changes in the exchange rate. A par dollar will take a number of years for the packing industry to fully adjust to. In the meantime, the sector must gain efficiencies to compete with U.S. packers. The long list for SRMs (specified risk material) also increases the cost of processing OTM cattle in Canada. Being able to profit from these items instead of incurring the cost of disposal will be important for the industry over the long run.

HISTORIC REVIEW OF CATTLE GENETICS IN CANADA

Research and improvements in animal breeding and genetic selection have been a significant contributor to advancements made in the cattle industry throughout history. Contributions have been made to beef quality, production efficiency, animal health, and feed efficiency. As genetics transcends a number of BCRC's priority areas it is a good place to start. This section provides an overview of trends throughout time.

Western Canada was pioneered with predominantly British breeds. Research had shown that docile temperament increases cattle profitability through lowered production costs and better meat quality. By 1900, livestock breeders had imported enough British stock to become breeders in their own right. In the 1950s the show ring was advocating smaller framed cattle. The theory was that smaller family sizes meant a smaller animal was preferred at butcher time. Extreme selection for early maturity in the British breeds promoted by livestock shows lasted until the late 1960s.

Continental breeds were first imported in 1956 from the United States and later directly from France. Imported breeds were selected for their growth potential coming from a larger frame than the traditional British breeds. Commercial ranchers were looking to increase the size of their herds as they were unhappy with the purebred breeder dwarf animal.

In 1967, Canada had started importing breeds from Continental Europe; these breeds were big and grew rapidly. At the same time a move towards a higher concentrate in the ration was occurring. Imports greatly expanded the gene pool to select from, with 25 different breeds entering Canada.

The "exotic" boom lasted until 1974 when the cattle cycle turned down. At the same time British breeds were being crossed with Continental cattle at the commercial level to increase size and growth ability. The speed of genetic change was rapid with cattle getting larger into the early '90s.

By the mid-'90s there were a lot of large framed cross bred cows and there was increased interest in British breeds to moderate size. With larger herds ranchers were also interested in minimizing production issues and increasingly looked to British breeds that had fewer disease problems. Over the last few years there has been an increase in the amount of cross breeding, with Continental bulls used on British cows.

The wider genetic base which now exists to select from has provided opportunities in the commercial herd for cross-breeding. The commercial industry has successfully adopted systematic crossbreeding programs, which increase production (of milk, beef and puberty traits) and efficiency. Since the 1950s we can see that breed preference was based on convenience traits desired by the rancher or farmer.

INSTITUTIONS AND TECHNOLOGY

Genetic advancement has played an important part in industry evolution as solutions are found to genetic challenges and herd improvement has occurred through steady selection practices. Dickerson and Hazel (1944) point out that the rate of genetic improvement involves four components: intensity of selection, accuracy of selection, generation interval and genetic variability[i].

Producers have been assisted in selection decisions through a variety of performance evaluation programs over the years. In the U.S. performance evaluation started with a handful of breeders, extension specialists and researchers on a one-on-one basis. Between 1945 and 1950 extension beef cattle improvement programs were started. In January 1967 the Beef Improvement Federation (BIF) was developed with the purpose of developing guidelines for recording beef performance, including those for national sire evaluation. BIF was established to provide uniformity, assist in program development, encourage education and build confidence in performance.

The first national sire summary was published in 1971 in the U.S.; by the mid-1980s Expected Progeny Differences (EPDs) were being developed by individual breed associations. EPDs are the comparison of the genetic merit of various traits within the same breed. An EPD predicts the genetic difference in performance of future offspring of a parent, as compared to the progeny from other parents, when each are bred to mates of equal value. EPDs are calculated for birth, growth, maternal and carcass traits. EPDs are used by both seedstock and commercial producers when making breeding decisions. However, the use of EPD's are limiting in that they can only be used within a breed and cannot be used for example to compare between an Angus or Hereford bull or when examining cross-breeding opportunities.

Recently the addition of genomic information to EPDs has improved their dependability, which is reflected in higher accuracy values. Researchers indicate that for females these improvements are equal to more than a lifetime of progeny performance records. Advantages of genomic-enhanced (GE-EPDs) are that information is available at a younger age before there are any progeny records. This enhances the scope of information available for difficult, time-consuming and hard-to-measure traits when making selection decisions. This mitigates the risk of using younger animals and speeds up genetic progress.

CHALLENGES TO WIDESPREAD USE AND ADOPTION OF GENETIC TECHNOLOGY

Genetic advancement is typically a slow process due to the limited heritability of traits, low reproductive rate and long generation intervals. In cases of high heritability it is important to remember the unintended consequences. For example, when choosing a bull for growth in order to positively impact income, it also increases the mature size and maintenance costs of the cow herd through the retained heifers.

Some traits are controlled by a single gene, but most traits of economic importance are controlled by a large number of genes. Marker Assisted Selection (MAS) uses markers which are linked to traits of interest to be selected. Combined with traditional selection techniques, MAS becomes another tool in selecting traits of interest. The use or adoption of MAS in order to advance genetic improvement in breeding stock is limited by heritability of desired traits and the requirement to use of related or correlated traits. Therefore, the cost of genetically testing an entire cow herd becomes a questionable investment if the outcome is not significantly improved over traditional selection methods. MAS is thought to be most valuable for traits that are difficult or expensive to measure, with hard to find markers due to lack of phenotypic data.

Marker Assisted Management (MAM) is available to feedlots in order to group similar cattle together in order to minimize feed costs, maximize feed efficiencies and target specific programs by identifying cattle that are most likely to qualify. There are numerous tests currently available for both MAS and MAM traits. The question then becomes, what tests are valuable to assist in decision making? DeVuyst et al. (2011) analyzed data from Igenity panel scores for average daily gain (ADG), marbling, rib-eye area, tenderness, fat thickness and USDA yield grade. Results revealed statistically significant but low correlations between carcass measurements and corresponding Igenity panel scores.

One of the largest challenges in the widespread use and adoption of genetic technology is that the selection for specific traits varies along the supply chain and consequently incentives for aligning production with desired traits may not be consistent throughout the chain. What matters to the cow/calf producer is having a live calf. Therefore calving ease and birth weight become the top priority over other traits, unless the buyer is willing to recognize the investment into another trait that benefits them or a cow-calf producer is retaining ownership. Also an older cow that consistently produces a calf puts money in the pocket of the cow/calf producer. But a longer lived cow slows the rate of genetic advancement and potentially the return to economically relevant trait at the cow/calf level. The challenge with a trait like tenderness is the feedlot rarely gets paid for it through the current quality grading system and there can be trade-offs, with the advancement of one trait such as tenderness offsetting gains in another trait such as feed efficiency. Large investment into the genetic base of the cow herd will only come if the operation is profitable and receiving clear market signals for traits of interest further along the supply chain.

Additional challenges include:

- The cost of adopting genetic technology for a large commercial producer
- The long period of time before a pay-off is realized
- Clear communication from commercial producers of traits they are looking for from the seedstock industry

The current market lacks in its ability to pay down the line more directly for specific traits (i.e. tenderness, beef quality, etc.) and therefore does not encourage cow/calf producers to invest in genetic advancement. While this occurs in vertically integrated relationships, it rarely occurs in the current market system where cow/calf producer sell their calves at weaning and do not receive feedback on performance. It is also important to note that the benefits received to shift to desired traits that are beneficial farther along the supply chain (i.e. feed to gain, tenderness) must be substantial enough to offset any reductions in desired traits at the cow-calf level (i.e. weaning weight), which may occur when alternate traits are selected for.

The Beef InfoXchange System (BIXS) is an opportunity to pass information back down the supply chain; particularly on what traits are being paid for. However, this information needs to go a step further and be analyzed in a way that informs genetic selection decisions. The limitation to such a system is that progress may not be made because what the market pays for (in turn signaling producers to improve in a certain area) may or may not align with industry goals.

Table 2A shows the genetic correlations between various traits of interest to the cow/calf producer and the feedlot and packer. A negative correlation indicates that to increases one trait has a negative effect on the other, highlighting the difficulty of making advancements at the packer level when there are negative correlations between the traits they are interested in and what the cow/calf producer is interested in.

Table 2B then shows the genetic correlation between various traits of interest to the feedlot and packer which are generally positive, showing how working together these two sectors can both see improvement in traits of interest.

Table 2A.	**Feedlot**			**Packer**				
Cow/Calf	***F:G***	***ADG***[5]	***Dressing percentage***	***HCW***	***Cut ability***	***GREA***	***Marbling***	***tenderness***
Birth Wt	-0.46	0.32	-	0.60	0.05	0.31	0.31	n/a
Calving Ease[1]	n/a	0.54	n/a	n/a	n/a	n/a	n/a	n/a
Wean Wt[2]	-0.50	0.44	-0.50	0.71	0.57	0.49	-0.09	n/a
Milk prod[3]	n/a	0.11	n/a	n/a	n/a	n/a	n/a	n/a
Age at first calving[4]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Conception rate	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Source: Koots, KR 1994 Animal Breed Abstr. 62:309-338, 825-853.

[1]calving ease (direct): influence of the calf's genes on how easy it is born.

[2]weaning weight (direct): this is an estimate of the calf's genes on its own weaning weight.

[3]weaning weight (maternal) used as proxy for milk production; this is an estimate of the influence of the dam's genes on the calf's weaning weight.

[4] Note that "longevity" is not a trait that geneticists consider. Selecting for longevity result in longer living cows and a lower replacement rate with newer genetics; consequently genetics do not improve as rapidly in the herd, robbing producers of genetic progress. The problem with that reasoning is that there is a significant cost raise heifers into productive females. Being able to spread those costs over more calves (through longevity), provides "free calves" once the cost of raising the heifer is covered. Besides who says that the cow calf producer actually wants to make genetic progress in any particular direction? If a producer is happy with his herd as it is, and wants to keep the average the same, focus may be placed on tightening up the genetic variability.

[5]used post-weaning gain instead (gain from weaning to yearling).

Table 2B.	**Packer**				
Feedlot	***HCW***	***Cut ability***	***GREA***	***Marbling***	***tenderness***
F:G	n/a	n/a	n/a	n/a	n/a
ADG[1]	0.87	0.18	0.32	0.11	n/a
Dressing percentage	0.04	n/a	0.36	0.25	n/a

[1]post-weaning gain

RESEARCH INDICATORS

Research Indicators are long term indicators of the overall, broad based impact of research on the beef industry. These indicators are influenced by many outside factors and therefore over the short term are difficult to interpret, while long term trends provide indications of progress. These items are outside of BCRC's direct influence, but can be monitored relative to other major international competitors to determine progress, as well as identify opportunities and areas where the Canadian industry could gain in terms of competitive advantage and consequently increased investment would be of value. While reducing production costs over time is a laudable goal, it is not always possible particularly with rising oil and feed prices. Therefore to evaluate progress a comparison to major competitors is of value to determine Canada's ability to maintain or create a competitive advantage over time.

Research indicators should not be confused with performance measures. Performance measures are more specific measures utilized to measure results of specific research projects funded by the Council.

The following list of research indicators was agreed upon in consultation with the BCRC staff to ensure they match the industry's overarching strategic direction. It is recognized that an organization's strategic direction drives which indicators are the right measures of performance.

The Research Indicators have been grouped as follows:

1. Production/Feed Efficiency
2. Animal Health & Welfare
3. Forage & Grassland Productivity
4. Beef Quality
5. Food Safety

Research often takes a long time to produce small improvements. Having realistic expectations of when results will show up in these indicators is important as most research will not show up for several years.

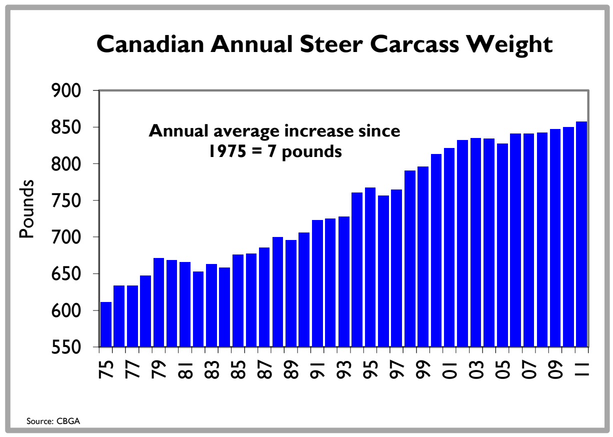
PRODUCTION EFFICIENCY

There have been significant gains in productivity over the last 20 to 30 years which the beef industry has benefited from. Productivity advances through larger carcass weights and reproductive efficiency mean fewer cows are required to produce the same amount of beef. This can result in reduced costs of production (i.e. fewer cows to feed over winter to produce the same volumes) and allows fixed costs to be spread across increased total production. For the producer reducing the per unit cost of production has a direct impact on profitability and therefore receives much attention.

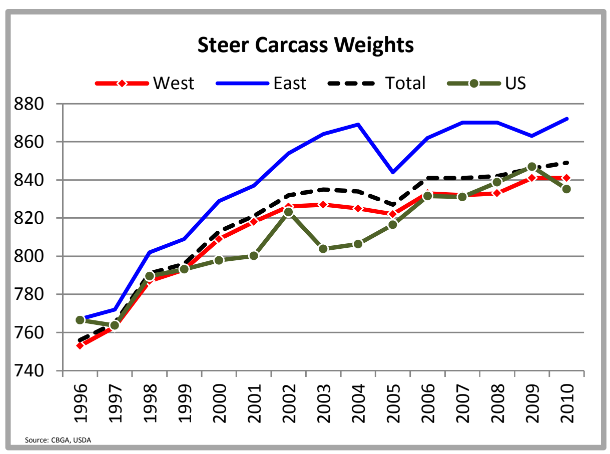
It is important to note that gains in productivity do not only benefit individual producers, but also society. Improvements in feed efficiency reduces the number of days on feed, which not only reduces feed costs but also reduces the amount of methane gas (greenhouse gases) produced and manure produced, which benefits the environment. Fewer cattle slaughtered to produce the same quantity of product also reduce water requirements at packing plants. However with larger carcass weights come other challenges such as larger cuts; requiring new cutting methods to provide the appropriate portion size.

STEER CARCASS WEIGHTS

There have been significant gains in fed cattle carcass weights since 1975 with increases averaging 7 lbs per year. In the 80s Canada's average steer carcass weight was 674 lbs. Carcass weights increased by 12% in the '90s to average 752 lbs and have increased another 11% to average 833 lbs in the last decade. In 2011 the average steer weight was 857 lbs[2].



In the '80s and '90s U.S. steer carcass weights were heavier than Canada's by 8% and 2% respectively. However, steer weights have grown at a slower rate in the U.S. with only a 5% increase between 1980 and 1990 and a modest 7% increase to 820 lbs in the last decade. This has resulted in Canadian steer carcass weights being 2% heavier in the last decade[3].



Australian carcass weights are significantly lighter than North America's. However, they have grown at a similar rate over the last 30 years, with a 12% increase from the '80s to '90s and a 10% increase

[2] Source: Canadian Beef Grading Agency, Canfax
[3] United States Department of Agriculture (USDA)

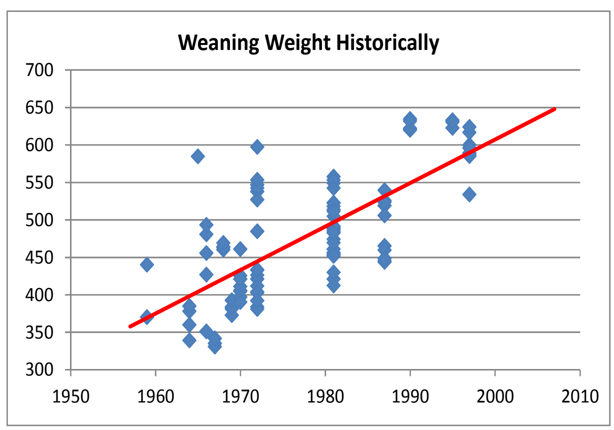
from the ‘90s to ‘00s[4]. Overall, Canadian carcass weights have seen the fastest growth of the three countries examined since ‘80.

Since 1996 eastern Canada has had larger carcass weights than western Canada or the U.S. However, while western Canada has generally seen steady growth with short periods of steady weights, eastern Canada has had a couple of years (2005 and 2010) where carcass weights have declined year over year. Since reaching 869 lbs in 2004 carcass weights in eastern Canada have not moved much higher, peaking at 872 lbs in 2010.

There has been some question as to the continued feasibility to increase carcass weights and yet technologies continues to come forward that increase carcass weights. The most recent advancement has been the introduction of Zilmax; a feed additive fed twenty days prior to slaughter that adds an average of 33 lbs to the hot carcass weight in research trials by Merck Animal Health (trials included 50,000 head). However, there are some concerns about adverse effects on beef quality and grading.

Larger carcass weights are being driven by the economics at the feedlot. *Which calf is the most profitable? The one with a carcass value of $211/cwt, carcass weight of 680 lbs or the one at $185/cwt, carcass weight of 1,017 lbs?* Any feedlot selling on a grid will work at feeding cattle to get more positives than negatives on the rail. This is a complex market as any review of carcass data information can attest to including discounts on various carcass characteristics. Cattle Network summarized some results from the Dickinson Research Extension Centre (March 2012[ii]). In a set of 24 carcasses, 15 had a carcass value equal or higher than the base price set at *Choice Yield Grade 3*. The highest valued carcass per hundredweight at $211/cwt actually brought the lowest total value at $1,438. In stark contrast, the carcass with the most discounts from the base price at $185/cwt was the fifth most valuable in terms of total dollars at $1,886. Clearly showing how the move towards larger carcass weights has occurred and continues to occur with a heavier weight offsetting quality and yield discounts.

WEANING WEIGHTS



Weaning weights have increased on average around 7 lbs per year from around 350 lb in the 1950s to around 600 lbs in 2010. This increase is equal to the average annual gain in slaughter weights, which is not surprising since feedlot practice is generally to have cattle on feed for a minimum number of days to produce the desired marbling regardless of the weight cattle enter the feedlot. Therefore, as in-weights increase out-weights have also increased by a corresponding amount. The correlation between weaning weight and slaughter weight at 0.74 is high. This implies that cow/calf producers have been successful in adopting genetics and management practices that increase productivity and that the

[4] ABARE, MLA

increases in slaughter weights have originated at the cow/calf level with the adoption of improved genetics.

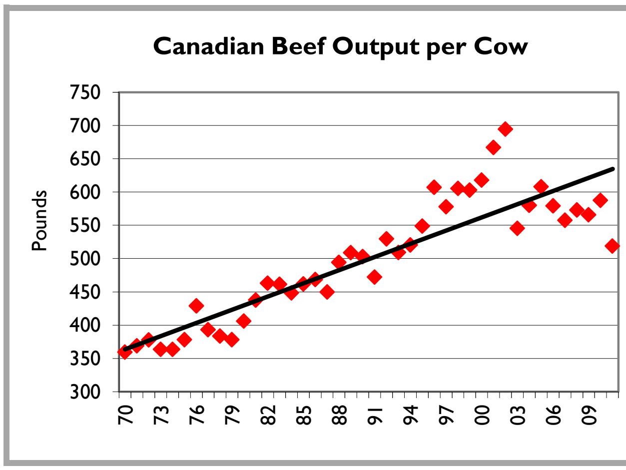
PRODUCTIVITY PER COW

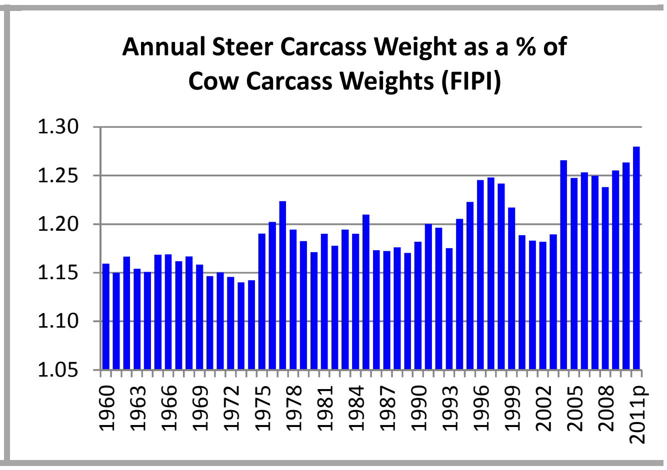
The productivity per cow is measured by total beef production (including live cattle exports) divided by the total number of cows (beef and dairy) from two years prior[5], as those would have been the cow herd that produced them. Productivity per cow will vary considerably in years of large cow slaughter but the overall trend will reflect the increases in reproductive efficiency, survival rate, and carcass weight advancements and therefore is a combined indicator of advancement in the cattle industry.

Table 3. Productivity per Cow (lbs/cow)

	Canada	U.S.	Australia
1980s	460	490	268
1990s	548	553	316
2000s	599	609	321
80s/90s	19%	13%	18%
90s/00s	9%	10%	1%

Production gains were large in all countries considered from the '80s to the '90s, with cross breeding and increased use of grain in diets. Canada had the largest gains at 19% before slowing to 9% from the 90s to the current decade. Overall the U.S. has the highest productivity per cow at 609 lbs in the current decade, which is 10 lbs heavier than Canada. Productivity gains in Australia slowed the most to 1% in the last decade and continue to be well behind North America due to significantly different production practices with it taking three years or longer to finish a steer on grass.





5 Ideally cow efficiency would be measured as follows:
Cow Efficiency = Feed Intake / Lifetime pounds of calf weaned / # calves weaned
This would need to take into consideration calving death loss, pre-weaning death loss, and fertility which are examined separately in the Animal Health section.

The above calculation can have considerable variation from year to year due to cow slaughter, which is demonstrated in the left hand graph. Another drawback is that it does not take into account the larger cow, which is required to product larger framed cattle, and at the same time consumes more. The right hand graph takes the *steer carcass weight as a percentage of cow carcass weights* to see if there is any change in relative size or if overall size has moved together. It is recognized that this ratio could be impacted over the short term by lower cow weights from older, thinner cows. But over the long term provides an indication on if gains in steer weights are only coming from larger framed cows or if there is actually a bent growth curve taking place with larger finish weights coming from steady framed cows. Since 2004, the relationship has been steady around 1.24 to 1.26 compared to the lows of 1.18 seen in 2001.

FEED EFFICIENCY

The objective of research on improving feed efficiency is developing and validating economical methods to identify more feed efficient seedstock and by developing alternative feeding strategies. *Improving feed to gain by 1% would save Canada's feedlot sector an estimated $11.6 million annually.* As feed costs increase (either through higher grain prices or a shortage of forage) feed efficiency plays an even larger role in the value equation, with inefficient cattle or management strategies costing more. A difference in conversion of one pound represents $90 per head, based on US$4 corn. There are many aspects of feed efficiency – but broadly speaking there is genetic improvement and management.

Genetic Improvement

The heritability in feed efficiency is around 35-40%, so selecting feed efficient breeding stock will improve the feed efficiency of the population over time. The challenge is that measuring how much feed each individual animal consumes in order to calculate Residual Feed Intake or Feed to Gain Ratios is time consuming and expensive. Feed:gain is genetically correlated with average daily gain. About a quarter of the genes involved in growth rate are also involved in feed:gain ratio. This stands to reason, since average daily gain is part of the feed:gain calculation. So selecting for average daily gain will also improve feed:gain ratio. In addition, identifying and validating reliable DNA markers for feed efficiency could reduce testing costs and speed the rate of genetic improvement.

Feed efficiency encompasses a variety of traits associated with feed utilization (i.e. feed conversion ratios (F:G), residual feed intake (RFI), efficiency of growth, maintenance efficiency). The advancement of feed efficiency in beef production depends on the combination of many traits accounting for the breeding herd and terminal cattle, growth rate, mature size and reproductive rate. Selection for a lower RFI can lead to a reduction in the intake of young cattle and cows with no compromise in growth performance or increase in cow size. However selection for a reduced feed:gain ratio to improve growth rates can lead to larger cow size and feed intake. The challenge is seeing benefits derived from genetic selection strategies at both the cow/calf and feedlot levels, when each is looking for different characteristics that may be negatively correlated.

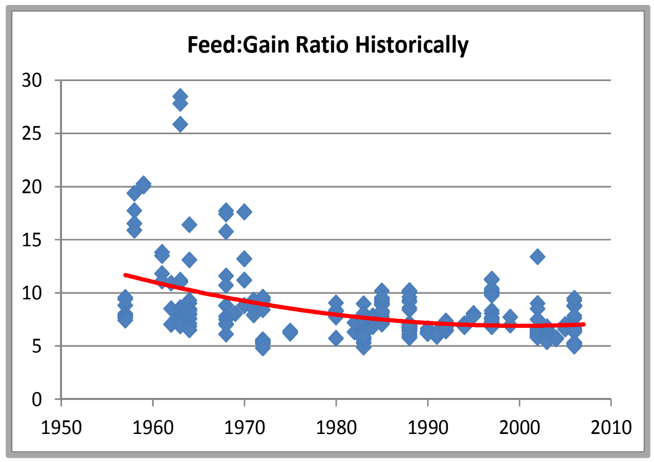
Management Strategies to Improve Feed Efficiency

The second aspect of feed efficiency is management at the feedlot and cow/calf level. Every breed is different with unique feeding requirements. By grouping similar animals together an operator can maximize the feed efficiency of the group. There is no silver bullet, some cattle marble well and therefore can be targeted to specific grading and branding programs. Other cattle will gain well but not grade as well. By managing each group for a specific purpose the industry can enhance feed efficiency and performance as a whole.

There are trade-offs with higher grading cattle not necessarily being the best converters and sometimes being the worst. This requires one to find an optimum medium between performance and carcass quality. Due to strong competition on all sides the feedlot industry is relatively homogeneous in purchase and selling price of cattle and grain costs. Therefore, feed efficiency becomes the most important factor a feedlot can control to gain an advantage over the competition.

FEED:GAIN RATIO

Two largest variable costs facing the cattle feeding sector are the feeder animal and the feed needed to finish it. This makes the feed:gain ratio a key measure of efficiency. While there are challenges with using the Feed:gain ratio, as discussed above, it provides an indication of industry progress. The data in this section was collected from peer-reviewed journal articles. Feed:gain ratios in finishing trials have decreased and become more consistent over time.

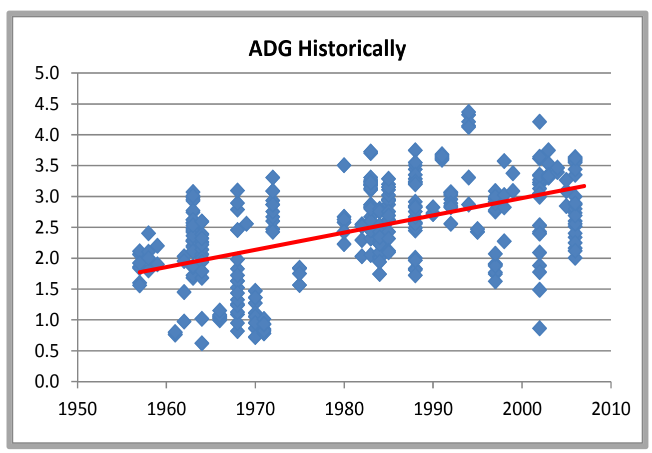


The average feed:gain ratio over the entire period was 7.14 with a standard deviation of 1.33 giving a range of 5.81 to 8.47 to capture a 95% confidence interval. Average daily gain, daily dry matter feed intake and the year explain 91% of the change in the feed:gain ratio since 1955 (see Appendix I).

Improvements in feed:gain have come largely from increased average daily gain rather than decreased intake because it is too expensive to measure on a routine basis. Higher average daily gains have come through improvements in animal management, as phenotypic data is more readily available (Phenotype = genetics and environment/management).

AVERAGE DAILY GAIN

The average daily gain on finishing ratios has increased over the last 50 years from 1.75 lbs to 3.2 lbs, an annual increase of 0.03 lb. Advancements in daily gains have come from changes in diet, moving from primarily forage-based diets to higher grain concentrate. Advancements in daily gain have also come from changes in feedlot management.



Information on improvement in days on feed could not be pulled from the Journal article data as there appeared to be a preference by researchers towards shorter trials using yearlings that would only be on feed

Table 4. Summary Statistics	Mean	Range	St. Dev.
Feed:Gain	8.07	4.80-28.5	3.17
ADG (lbs)	2.52	0.61-4.40	0.79
Dry Matter Intake (KG)	9.87	5.22-14	

THE CHALLENGE OF REDUCING WINTER FEEDING COSTS FOR COWS AND IMPROVING FEEDLOT FEED:GAIN

Reducing winter feed costs for 4.78 million beef cows and heifers by 1% would save Canada's cow/calf sector an estimated $3.6 million annually[6]. Research has shown that cow efficiency is dependent on the level of nutrition they receive. Efficiency in the cow herd is dependent on feed quality and availability. Larger higher-producing cows are the most efficient in lush, high nutrition environments and smaller low-producing cows are the most efficient in limited nutrition environments. Measuring beef cow efficiency includes determining the amount and quality of feed consumed compared to the net return. Cow efficiency includes her live weight and therefore her maintenance requirements, calf weight gained from birth to weaning and cow reproductive efficiency. A better (lower) feed conversion ratio such as 17 vs. 24 kg DM/kg of calf weaned can be achieved from a lower mature body weight and therefore lower energy requirement for the cow, higher weaned weight (includes higher calf survival rate), or higher reproductive efficiency. The idea is to have a low birth weight, same mature weight but a heavier weaning weight, resulting in a bent growth curve (see Figure 1) with faster maturing cattle.

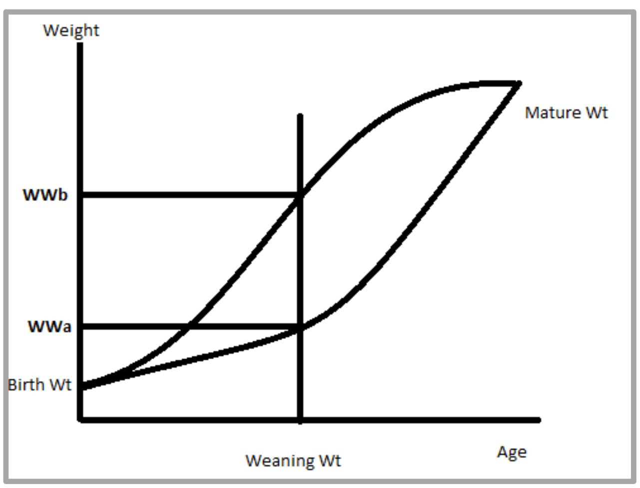


Figure 1. Bent Growth Curve

Residual feed intake (RFI) is of interest to breeders who want to improve feed efficiency without increasing the size of their cattle. RFI tries to identify differences in feed intake that are caused by differences in the animal's metabolic "idling" rate by factoring out things like growth rate and fat thickness that affect feed intake. RFI and feed:gain also have about half of the same genes in common, so selecting for improved RFI in breeding stock will also lead to improved feed:gain in feedlot progeny. The GrowSafe feed intake system (developed in Canada) has made it easier to measure feed intake in cattle, and has become a highly valued tool at a number of university, federal and private research feedlots.

[6] Based on 1% decrease in hay intake valued at $54/tonne, days on feed were varied by province.

Understanding how genetics influence the winter feed requirements of pregnant beef cows, fetal growth and calf performance will clarify the benefits of selecting for residual feed intake or a proxy. Eliminating the worst 10% will increase performance faster than spending a lot of dollars looking for the best. However the base of any selection process is good data.

The measurement of feed intake with current technology is expensive and is a major barrier to industry adoption. The absence of affordable, accurate methods to measure pasture intake by individual animals prevents testing for RFI on pasture and therefore the ability to demonstrate benefits to cow/calf producers. A lack of information on the economic benefit for the cow/calf producer is also a barrier to adoption.

MOVING FORWARD WITH PRODUCTION/FEED EFFICIENCY

Strategies to improve production/feed efficiency appear to be quickly adopted by industry at both the feedlot and cow/calf levels. Large gains have been seen in weaning and slaughter weights. Steer carcass weight represented 1.17 of the cow carcass weight in 1980 and has increased to 1.26 in 2010. The technology to increase animal gain and overall performance is readily available and widely publicized. Research into this area is being done by private pharmaceutical companies who are able to see a return on their investment by selling patented products. However, there is still basic research that needs to be done to assist in the advances made in this area. Carcass weights will continue to increase as long as the market signals are provided to do so. This is partly due to the cost of processing a carcass which is similar regardless of size so large carcasses are more profitable as more meat is produced and spread over more pounds – assuming the meat is of the same value.

The most important advancement in production efficiency is in feed efficiency and a lower feed:gain ratio in finished cattle at all stages of the life cycle (pre-weaning, post-weaning, backgrounding, grassed and feedlot). However, this must not be done at the expense of the cow herd efficiency. On the cow side feed:gain is of little value given that cows are no longer growing but maintaining or regaining body condition (BCS) making RFI the more appropriate measure.

The goal is to find ways to increase average daily gains, reduce feed:gain ratio and keep a manageable sized, fertile cow that can be efficiently fed through the winter. This will be a balancing act driven primarily from the cow/calf sector who is adopting genetic improvements. Programs like the Beef InfoXchange System (BIXS) that provides cow/calf producers information that has not been historically available to them through traditional indicators (i.e. EPDs, weaning weights, etc.) will help industry advance in this area of feed efficiency.

ANIMAL HEALTH AND WELFARE

The objective of research on animal health is to develop effective and economical management, diagnostic, and treatment tools to reduce the costs and losses incurred by major production limiting diseases and animal health issues that affect primary production sectors. Infectious disease problems and metabolic disorders[7] occur at various stages of the beef production cycle. Problems in cow/calf operations differ from those seen in stocker and feedlot operations due to difference in age and in metabolic stressors. Feedlot cattle experience considerably more metabolic disorders due to the high-energy diets fed to maximize feedlot performance.

Approximately 65-80% of total morbidity occurs within the first 45 days on feed, primarily from respiratory disease, but acidosis also may occur in this timeframe with transition of diet. Morbidity is typically less than a third of this rate after 45 days in the feedlot. Miscellaneous issues, respiratory, and digestive disorders represented 44.1%, 28.6% and 25.9% of deaths respectively over the entire feeding period.

While mortality (death loss) is of primary concern, morbidity (sickness) represents a significant cost to the feedlot operator as there is the expense of medication, labour in treatment, and the expense of reduced performance during and after the illness. The difference in ADG between calves that remain healthy and calves that suffer from respiratory disease can be substantial. In a 90 day feedlot trial Morck et al. (1993) showed calves with a single episode of respiratory disease had a 0.18 kg lower ADG than healthy calves; and calves sick twice or more had a 0.33 kg lower ADG than the control[iii]. Sickness reduces performance and potentially has an absence of compensatory gain. Digestive disorders depress ensuing performance due to reduced intake or digestive function. The presence of parasites in the digestive tract can leave persistent scars that will depress digestibility for several months.

In 1999 the USDA's National Animal Health Monitoring System (NAHMS) conducted a study of feedlots with 1,000 head or more bunk capacity within the 12 largest cattle feeding states. These feedlots represented 85% of U.S. feedlots in 1999 and accounted for 96% of the U.S. cattle on feed as of January 1, 2000. This report examined the major causes of feedlot mortality[iv].

- Bovine Respiratory Disease (BRD) was the most common disease condition in feedlots affecting 14.4% of placements. A greater percentage of placements were affected with BRD on large feedlots greater than 8,000 head (15.5%) than on small feedlots (8.7%).
- The second most common disease was Acute Interstitial Pneumonia (AIP) affecting 3.1% of all placements. The cost of medicine to treat one sick animal for bovine respiratory disease was greater in large feedlots ($16.26/head) than in small feedlots ($11.09/head).

Economic losses from mortality include but are not limited to the purchase price of the animal, cost of feed from arrival until death, processing and medical costs incurred, disposal costs, labour for disposal and interest on invested money. In 2000, Bowland and Shewen estimated that $640 million is lost annually in the United States from BRD, with the majority of losses coming from pneumonic pasteurellosis "shipping fever"[v]. However, it was acknowledged that any estimate would be unable to

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[7] Metabolic disorders i.e. acidosis, bloat or grain overload.

account for animals with a low prevalence of BRD that are not treated, but have lower gains and do not perform as well.

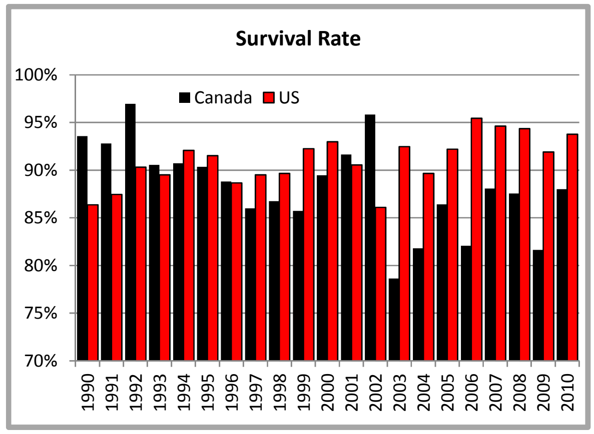
SURVIVAL RATE

Survival Rate (weaning to slaughter) is estimated using the number of calves from the July 1st Inventory report compared to the number exported as feeders, heifers retained and fed cattle slaughtered the next year. This indicator of death loss has ranged between 82% and 88% over the last 6 years. The average of 86% in the '00s was 4% lower than in the '90s. Survival rate is higher in the U.S. at 92% in the '00s, up from 90% in the '90s.

Table 5. Survival Rate – calf to slaughter

	Canada	U.S.	Australia
1980-89	94%	84%	n/a
1990-99	90%	90%	n/a
2000-10	86%	92%	n/a

**Unable to replicate with Australian data due to grass finished system with much larger cow numbers, lower reproductive efficiency and longer feeding period which meant more cattle were slaughtered than there were calves produced in a given year.*



A Western Canada Study of Animal Health Effects Associated with Exposure to Emissions from Oil and Natural Gas Field Facilities (2006) indicated that risk of treatment or calf mortality for the 2002 calving season for calves from all cows in the herd before the first bull contact were as follows:

- Risk of mortality 3.6%
- Risk of any calf treatment 12.9%
- Risk of calf treatment for pneumonia 2.2%
- Risk of calf treatment for diarrhea (scours/enteritis/colitis) 5.8%
- Risk of calf treatment for navel ill (omphalitis) 1.3%

The above numbers add up to 83.8% survival and are focused solely on the feedlot. This number is lower than the estimate for **Survival Rate** from inventories which was 96% for the 2002 year and encompasses the period from weaning to slaughter – therefore includes losses during pre-conditioning, backgrounding and grass. It should be noted that the estimates from inventories vary significantly from year to year depending on climatic conditions.

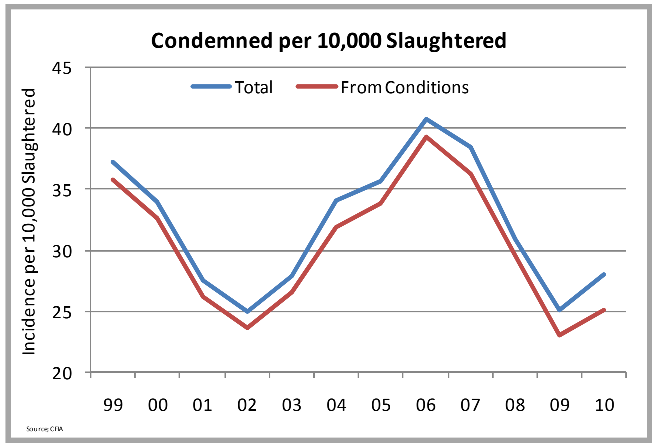
Feedlot Survival is estimated by the percentage of cattle placed being marketed using cattle on feed data from Canada and the U.S.[8] Feedlot survival was high ranging from 87-99% over the last decade in Canada and 94-100% in the U.S. The U.S. data starts in 1996 and shows small improvement with the average in the '00s at 97% versus 95% in the '90s.

[8] The Cattle on Feed Reports in Canada and the U.S. are similar with reporting from finishing feedlots with >1,000 head bunk capacity. The methodology between the two countries is the same.

CONDEMNATIONS

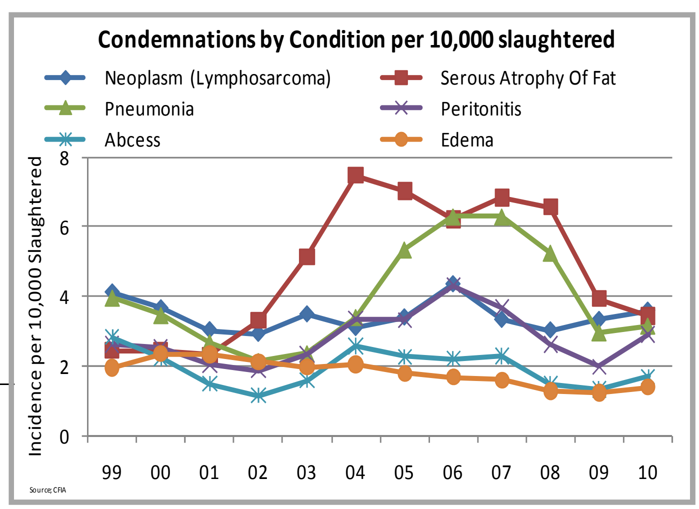
The Canadian Food Inspection Agency (CFIA) will condemn product, including carcasses and portions of carcasses, which upon inspection or re-inspection are found to be affected by disease or an abnormal condition that renders them unfit for human consumption. This includes animals condemned on ante mortem inspection, animals that died en route to the registered slaughter establishment and animals that died in the yard or a livestock holding pen of the registered slaughter establishment. A higher proportion of condemnations at slaughter could indicate that these animals should have been moved earlier before their health deteriorated. Higher rates of on arrival deaths could raise concerns about longer hauls with plant closures over the last five years. A higher proportion of disease caused condemns could indicate that on farm animal health was lower. The concern here is from a public image and regulatory standpoint.

Condemnation rates in Canada declined from 1999 to 2002 then increased to a peak of 40.7 per 10,000 head slaughtered in 2006 before declining to 25.1 in 2009, similar to the previous low in 2002. In 2010 rates increased slightly to 28.0 per 10,000 head slaughtered. The number found dead or condemned at slaughter was relatively steady around 4-6% from 1999 to 2008 but increased to 8% in 2009 and 10% in 2010. All of the increase came from animals rejected ante-mortem (before death).



While the overall condemnation rate has fluctuated over the last decade, the number of cows condemned as % of cow slaughter has remained relatively steady. Since the reopening of the U.S. border in November 2007 to allow the export of cows, higher cow prices have encouraged producers to bring all cows to market despite their condition. Packers are charging for disposal and clearly communicating to producers that they do not want problem cows with obvious health problems such as downers and cancer eyes. Animals that never should have left the farm are being put down at auction markets before they even reach the packer. These before death condemnations are expected to continue as long as cow prices remain historically high. It is important to communicate to producers their options with these cows; particularly moving them sooner while they are healthier and how to avoid large disposal fees charged by auctions and packers.

Cows are not the only source of condemnations, with fed cattle being a significant contribution to the pattern over the last decade. The top five reasons for condemnations (Neoplasm – Lymphosarcoma, Serous Atrophy of Fat, Pneumonia, Peritonitis, Abcess and Edema) have increased from 50% of total condemned in 1999 to 65% in 2010. Since 2002, Serous Atrophy of Fat has been the



number one condition that cattle are condemned for with a peak of 7.48 per 10,000 head slaughtered in 2004. This has declined to 3.44 in 2010 but remains above the 1999-2002 average of 2.63. Pneumonia was the second leading cause from 2005 to 2008 and has averaged 3.07 in 2009 and 2010.

REPRODUCTIVE EFFICIENCY

There are two things that will have a significant impact on a cow/calf producer's bottom line regardless of what price calves are selling for: maximizing reproductive efficiency and minimizing feed costs relative to feed efficiency. For a cow/calf operation good reproductive rates are critical to operational success and profitability. It is generally expected that each breeding age female in the herd produces a healthy calf each year and raises each calf to weaning. Cows that do not produce calves on an annual basis use resources that could be used to support more productive cattle.

$$\text{Reproductive efficiency} = \frac{\text{No. of cows weaning a calf}}{\text{No. of females exposed}}$$

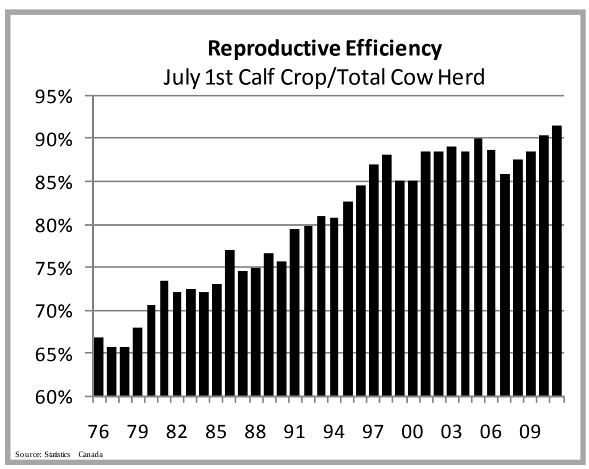
The use of the term cow and female is deliberate. By definition a cow is a female that has calves and does not include first bred heifers until they have calves. As such the July 1st inventories are used as all calving females are included in the term "cow". The July 1st calf crop number as a percentage of the total cow herd (beef and dairy) has improved from 74% in the 80s to 82% in the '90s and 88% in the '00s.

The most common open cows are the young first calf heifers. After putting significant investment into these young cows as yearlings they are typically kept even if found open after their first calf. Focus could be placed on management /feeding strategies that would maximize the percentage of heifers that cycle and get bred when under the stress of supporting their first calf.

Part of the flat line over the last decade has been profitability and producers not investing in their herd genetics. Therefore, this is something that can be expected to correct itself with time. The U.S. has seen a relatively flat percentage at 89% over the last 3 decades. This may imply that moving beyond 90% is costly compared to the returns. However, western Canada has averaged 92% over the last decade.

Table 6. Reproductive Efficiency by Region[9]

	East	West	Canada	U.S.	Australia
1980s	58%	83%	74%	89%	40%
1990s	66%	90%	82%	89%	42%
2000s	74%	92%	88%	88%	38%



The lower percentage in the East is partly due to the higher proportion of dairy in the east with veal slaughter reducing the percentage. However, a

[9] Statistics Canada, Canfax, USDA, MLA

higher proportion of dairy in the U.S. herd has not reduced their percentage to the same degree. This indicates that there is room for improvement in this area. Reproductive efficiency in Australia is considerably lower than in North America. Year round calving means there is no time in the year when the majority of cows have calves at their side.

A Western Canada Study of Animal Health Effects Associated with Exposure to Emissions from Oil and Natural Gas Field Facilities (2006) indicated that the risk of non-pregnancy for all study herds in 2002 was 8.2%[vi].

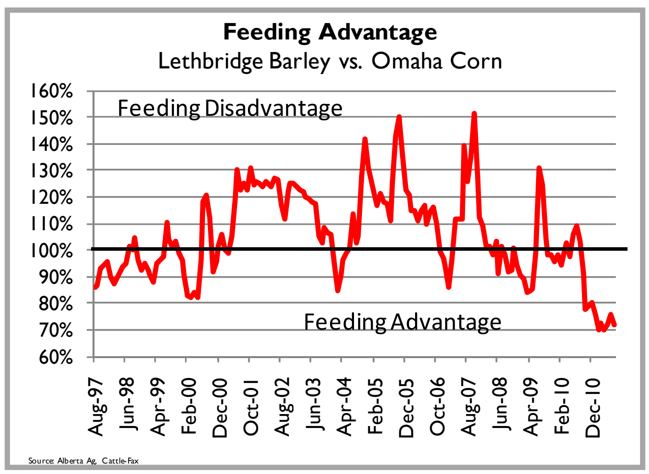
- Risk of abortion was 1.6% (2001/02)
- Risk of stillbirth was 2.6% (2002)
- Risk of calf death between 1 hour and 3 days of age 1.2%
- Risk of calf death between 4 days and weaning 2.8%

This supports the above estimates for reproductive efficiency.

Reproductive efficiency has largely plateaued at 90%. Fluctuations above and below this number can partially be attributed to adverse or ideal weather conditions. It would most likely take significant dollars to advance further.

DRIED DISTILLER GRAIN USE

As the production of ethanol has increased and feed grain prices have moved higher Dried Distiller Grains (DDGs) have become an alternative source of feed for cattle and hogs. While typically lower in price, DDGs also have a lower nutritional content reducing their value for the livestock sector. In addition due to differences in product, feeding DDGs to cattle can be difficult particularly if there is any inconsistency in nutritional content leading to changes in rate of gain or animal health concerns.



For large parts of the last decade barley prices have been offside to corn, putting western Canada at a cost of gain disadvantage. The ability of producers to switch feed to the least cost alternative is important to the long term viability of the industry. Corn imports over the last decade have averaged 2.5 million tonnes with Eastern Canada importing 58% of the total.

Consistency in quality and nutrient content of product being imported is the largest concern for livestock producers feeding DDGs. Routine tests of DDGS suppliers for mycotoxin screening and amino acid profile is important. There are large differences between sources in nutrient content; knowing where the plant product is sourced from can provide a measure of consistency. One of the barriers to producers using corn DDGs is having the nutritional and animal health expertise on hand to identify if anything goes wrong.

Research funded by the BCRC has found that up to 50% corn-based distiller grains plus solubles can be fed in a 90% concentrate finishing ration without adversely affecting animal performance, carcass weight, quality or yield grade. However, the impacts on animal health are less clear. Lower liver abscess scores might suggest that the rumen was healthier when cattle were fed distiller grains, despite the pH at slaughter being the same for all diets tested. Kidney weights indicate that the kidneys may work harder to excrete excess minerals when DDGs are fed. Increased nutrient content in the urine and manure may increase the land base required to spread manure over.

There is considerable research done in the U.S. around feeding DDGs to cattle. This raises the question on if there is a need for Canadian research (potentially specializing in wheat DDGs) or is the need for connecting Canadian feedlots with the appropriate research and information coming out of the U.S. focused on corn DDGs.

ANIMAL WELFARE

The objective of research on animal welfare is to develop a scientific base for best management practices and assist in effectively communicating current industry practices to consumers. The cattle industry is being increasingly pressured to demonstrate the impacts of current practices on animal welfare and address consumer perceptions. Being able to provide scientific information that explains the impact of practices used by the industry would be beneficial in advancing best management practices, identifying areas of priority, as well as supporting industry and public communications.

Animal welfare is closely linked with animal health. Overall, understanding how multiple stressors affect the animal and determine the least stress alternatives will inform industry decisions. For example, should treatments be separated due to the increased animal stress or does the additional handling create even more stress, consequently doing everything at one point provide the least overall stress on the animal. Welfare is primarily concerned with transportation practices and pain control (castration, dehorning).

Developing a research indicator in this area is not possible at this time with given data in the area. Particularly since consumer perceptions (which are measurable) do not align with industry practices and what is happening in industry (measurable by survey) may or may not align with best management practices currently being recommended.

MOVING FORWARD WITH ANIMAL HEALTH & WELFARE

Animal Health appears to have improved over time, with higher reproductive efficiency. However survival rates to slaughter have not seen the same progress overtime; especially when compared to the U.S. Survival to weaning is challenged in some areas due to natural predators and varies significantly across the country. The proportion of condemnations in slaughter increased from 2003 to 2008 but has since declined in 2009 and 2010 to be back at 99-02 levels. In terms of animal health at the production level, similar to research in feed efficiency and productivity, private drug companies are able to see a return on their investment by investing in and developing patented products. However there continues to be a large number of deaths by unknown causes, representing 44% of all deaths over the entire feeding period, providing opportunity for further improvements.

There is limited Canadian data on disease incidence at the cow/calf and feedlot levels. Having a baseline study that lays out the disease incidence in the cow/calf, backgrounding and feedlot sectors would provide a better understanding of what issues need work and provide a measuring stick for performance moving forward. At the same time, research is needed on understanding immunity, stress and disease in general that would benefit all areas of animal health and welfare. In addition, with increased consumer concern and pressures around antibiotic use, finding alternative products and practices is needed.

FORAGE AND GRASSLAND PRODUCTIVITY

The objective of research on forage and grassland productivity is to increase research program capacity to develop annual and perennial forage varieties with increased yield, drought resistance, maintain or improve nutritional value, and an economic alternative to current sources. As well as improved grassland management to increase productivity and sustainability.

Approximately 80% of Canada's beef production occurs while animals consume only forage. Cow/calf producers tend to feed livestock with preserved forages for periods as long as October to May depending on location and annual weather. It is estimated that two-thirds of the feed protein in Canada comes from hay, grazing or forages and fodder corn production. *Keeping all of Canada's beef cows and replacement heifers on pasture for one more day every winter would save the cow/calf sector an estimated $3.5 million annually.*

Canada's forage resources include both native rangelands and cultivated crops. The forage resource used for livestock grazing and production of forage crops covers over 36 million hectares or 3.6% of Canada's land base, compared to 25 million hectares in grain and oilseed crops. This is divided into 72% native range (26 million hectares), 11% cultivated pastures (4 million hectares) and 17% forage crops (6 million hectares).

The four western provinces have 96% of the 26 million hectares of Canadian rangeland used for livestock production with 36% in British Columbia, 29% in Alberta, 24% in Saskatchewan and 8% in Manitoba. The western provinces also have 82% of the nation's cultivated pasture, 64% of the nation's forage crop area, and 84% of the nation's beef cow herd. Cereals are grown on the majority of cultivated lands but the farm value of forage conserved as hay and silage account for 40-60% the value of feed grain crops. Canadian hay production was estimated at 30 million tonnes in 2010.

Well-managed forage crops provide a number of benefits including reduced soil erosion, improved soil quality, increased soil organic matter levels and enhance the sustainability of other agricultural cropping systems.

EXTENDING THE WINTER GRAZING SEASON

The largest cost for the cow/calf operation is winter feed and bedding (36%) followed by grazing (27%). Over 90% of cow/calf operations in Alberta were found to use baled forages as a significant roughage source during the winter (Kaliel, 2004[vii]). Greenfeed and barley silage (used by 35% of producers in Alberta) are also common sources of winter feed for the cow herd. Supplementation of grain often depends upon winter temperatures, cow condition, roughage supplies, market prices and availability of substitutes (i.e. pellets, grain screenings, chaff collection, DDGs, etc.). Kaliel (2004) found that 61% of producers supplement with grain at some point. Higher and more volatile feed grain prices are making this difficult and demand for alternatives such as pellets has pushed prices higher as well. The ability to extend the grazing season represents a significant opportunity to reduce winter feeding costs.

AAFC (2007) reported that types of extended winter grazing vary from early spring forge, late fall forage, swath grazing, and stockpiled growth. The use of these types varies across the soil zones in Western

Canada. There is low adoption of these alternatives in the Boreal Plains, with 31% of producers using no extended grazing at all, as compared to 21% of producers in the Brown soil zone The depth of snow cover can limit grazing of standing forage in certain regions, however stockpiled forges can still be utilized in the late fall and early spring when vegetative growth is not available.

Table 7. Practices Used to Extend the Grazing Season across Western Canada[viii]

Type of Extended Season Grazing	Per cent of Farms Extending Grazing Season			
	Brown Soil Zone	Dark Brown Soil Zone	Black Soil Zone	Boreal Plains
Early Spring Forage	37%	30%	21%	17%
Late Fall Forage	26%	25%	20%	18%
Swaths	22%	27%	24%	19%
Stockpiled Growth	38%	36%	24%	16%
No Extended Grazing	21%	22%	26%	31%

There has been a move over the last decade from confined feeding, which was labor intensive with the need to deliver feed to cows, haul manure, and provide portable windbreaks for shelter. Cattle are more and more only brought into corrals for handling and during calving. While this still requires delivering feed daily, the cost of manure removal is reduced or eliminated.

In addition to looking at extending the winter grazing season low cost producers tend to pay more attention to the nutritional needs of various groups within the herd (i.e. first calvers, mature cows, etc.). Instead of feeding the entire herd in one group and targeting the needs of the 'average' cow, separating animals into targeted groups allows the manager to target those specific needs. Communicating low cost alternatives is something that must be done regularly with information easily accessible by producers.

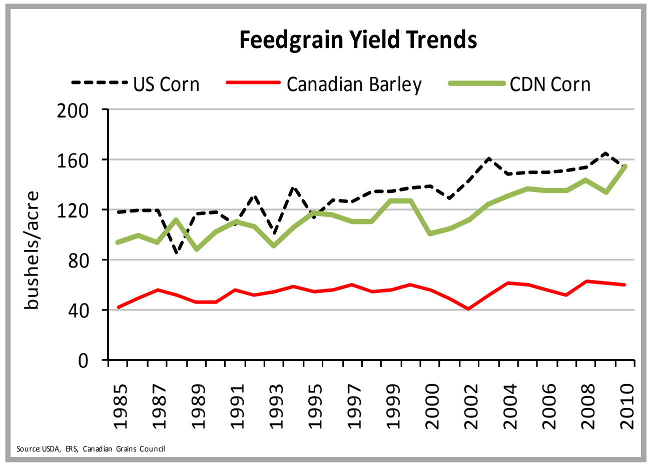
There is a need to measure and evaluate the costs associated with the feed consumed by beef cows not only over the winter feeding period but also for the extended grazing system. While there has been research conducted on the viability of various winter grazing alternatives, often a thorough economic analysis is missing. In order for an alternative feed strategy to be adopted the cost/benefits must be clearly outlined for producers, with both near term and long term costs and benefits considered.

YIELDS

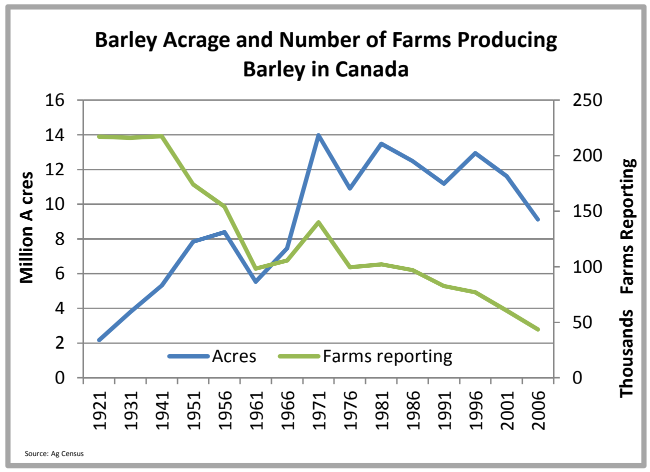
Grain Yield

In the '90s Canadian corn yields averaged 10% smaller than in the U.S. Over the last decade Canadian corn yields have averaged 16% smaller. In 2010 yields were comparable with weather patterns in much of the Corn Belt and Ontario being similar. Delays in technology being made available in Canada have resulted in corn yields trailing the U.S., constantly in catch up mode. Delays in variety approval have occurred and left the plant breeding industry in flux, while competitor countries continue to innovate. This adds to the economic burden of domestic producers. Businesses thrive in minimum risk environments where outcomes from the regulatory reviews are for the most part predictable and of short duration.

U.S. Corn yields increased 17% in the '90s and another 12% in the '00s. In comparison, Barley yields in Western Canada increased 20% from 1990 to 2000 and another 6% from 2000 to 2010. Overall barley yields increased 28% over the last 20 years, while U.S. corn yields increased 30%. This difference in percentages is relatively small but when you consider that corn yields in 1990 were 118 bushels per acre, while Barley yields were 46.5 bushels per acre the difference has been amplified.



Barley's competitive disadvantage is highlighted by the fact that the number of acres in barley production has declined 16% from 1976 to 2006 with the number of farms growing barley down 56% (Ag Census[ix]).



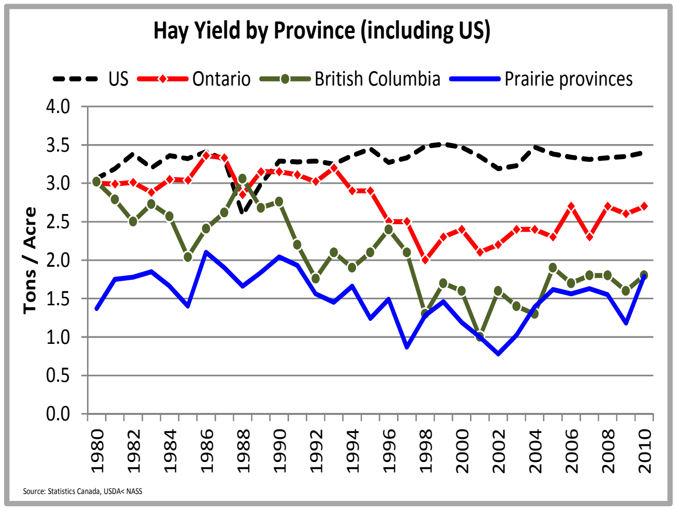
When the producer does not have to purchase certified seed, the plant breeder receives no royalty. This is the situation with most self-pollinated cereal crops in Canada, namely wheat and barley. Canada's Plant Breeders Rights (PBR) system, introduced in 1990, gives plant breeders the exclusive right to produce and sell seed in Canada for 18 years. Farmers may purchase the seed, which includes a royalty. However, producers have "Farmer's Privilege" and can use farm saved seed (FSS) without paying an additional royalty. Consequently there is little opportunity for the private sector to recoup its investment from developing new varieties of these crops in Canada and as a result they are not invested in. The issues that are most detrimental to progress in Canadian feed grains research includes Plant with Novel Trait (PNT), the CWB/Canadian Grains Commission (CGC) grade system and the protracted seed sector review.

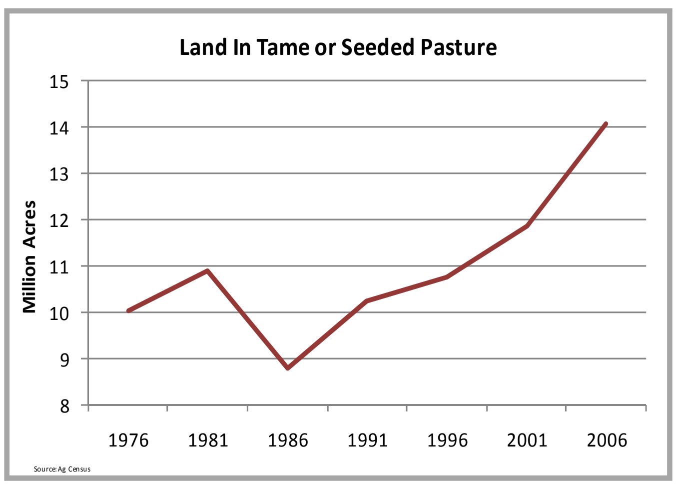
The United States Department of Agriculture (USDA) accounts for 15% of wheat breeders, making the public sector responsible for 58% of the wheat breeding effort in the U.S. Forty-two per cent of U.S. wheat breeders are in the private sector, as compared to Canada where almost all wheat breeding is the responsibility of the public sector. Forage breeding in the U.S. is dominated by the private sector, with 62% of all forage breeders, while 29% and 9% of U.S. forage breeders work through State Agricultural Experiment Stations (SAES) and the USDA respectively. Most forage breeding in Canada is the responsibility of three forage breeders in AAFC. Investment in Canadian agricultural research lags behind its competitors, which is of concern moving forward[x].

Hay Production

Hay production is an important part of the Canadian beef industry; being the primary feed source for the cow herd and high roughage backgrounding rations. Forages make up more than 80% of livestock feed in Canada and most producers use seeded forages to produce tame hay or silage. There has been a significant decline in investment and expertise dedicated to research in forages.

While annual forage yields can be significantly impacted by weather patterns (drought, flooding) long term trends show that after seeing an increase in hay yields in the 1970s in the prairie provinces they were steady in the '80s and have actually declined over the last 20 years by 25% [xi]. In British Columbia hay yields were up 15% in the 1970s, steady in the '80s, but fell a dramatic 23% in both the '90s and '00s. Hay yields in all the western provinces over the last decade have been the smallest in over 50 years. Despite smaller yields total hay production has been maintained and even increased 23% since 1980 with a 64% increase in acreage.





Ontario hay yields were up 13% in the 1970s and up another 21% in the '80s but were down 10% in the '90s and down another 13% in the last decade. Overall hay production is down 25% since 1980 with a 4% decline in acreage and a 21% decline in yield. At 2.41 tons/acre Ontario has the highest hay yield of all the provinces. However this is still 28% below the average hay yield in the U.S. of 3.34 tons/acre.

A low forage yield is the most commonly cited reason for termination of a stand. While renewing stands is expensive, prolonged low productivity also represents an opportunity cost to the producer as more acres are needed to supply the hay needed. As annual crop acreages increase, producers grow forages on increasingly marginal land, which makes maintaining yield and productivity more difficult [10]. Productivity improvements and rejuvenation through fertilization would be expected to be more difficult on marginal land. This scenario applies adverse economic pressure to cow-calf operators. Saskatchewan Ag & Food estimates that the yield loss from 1973-2003 represents a loss of $145 million annually to producers[xii]. Not only is there lost revenue but fixed costs for land, taxes, machinery operation and labour remain the same regardless of yield and therefore represent increased higher costs per pound produced to harvest.

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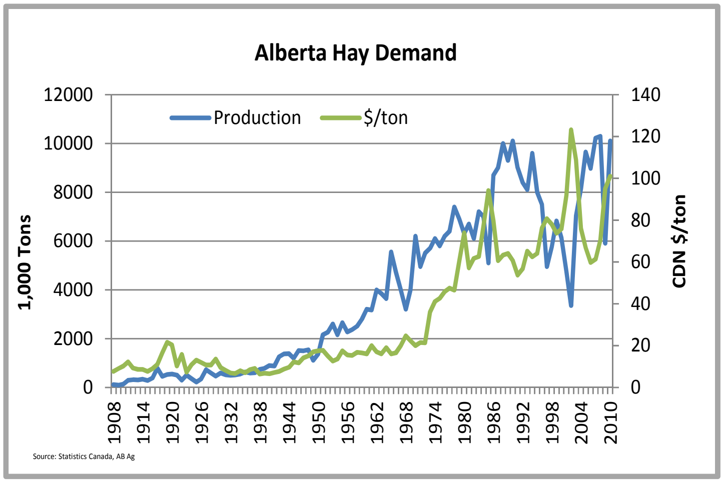
[10] It is acknowledged that productivity in the brown soil zone will never be like that in the black soil zone but the long term trend shows an overall decline in hay yields across Canada.

With lower yields, total hay production is being supported by larger acreage, the area of land in tame seeded pasture has increased 40% from 1976 to 2006 (Ag Census), as marginal land broken up for cropping during the grain booms has been put into perennials under various green cover programs. During the same time period the number of acres in crop production increased 27%.

Hay yields for Alberta were available from 1991 to current for specific species and production practices. Average yields were compared for the 2000-2009 period versus the 1990-1999 period.

- Alfalfa (>50%) yield increased 4% from the '90s to the '00s
- Grass (<50% legume) was up 10%
- Irrigated Alfalfa was down 3%
- Dryland Legumes (>50%) was up 9%[xiii]

The poor performance of irrigated alfalfa over the last decade would indicate that moisture was not the limiting factor in performance on the prairies. *And if not moisture then what?* A number of reasons could answer this question including: (1) Producers did not renew stands as often as would be ideal for optimal performance resulting in a lower average productivity overall; (2) Performance is limited by the varieties available; and (3) There is a deficiency in soil nutrients due to a lack of fertilizer use to replace the nutrients harvested each year.

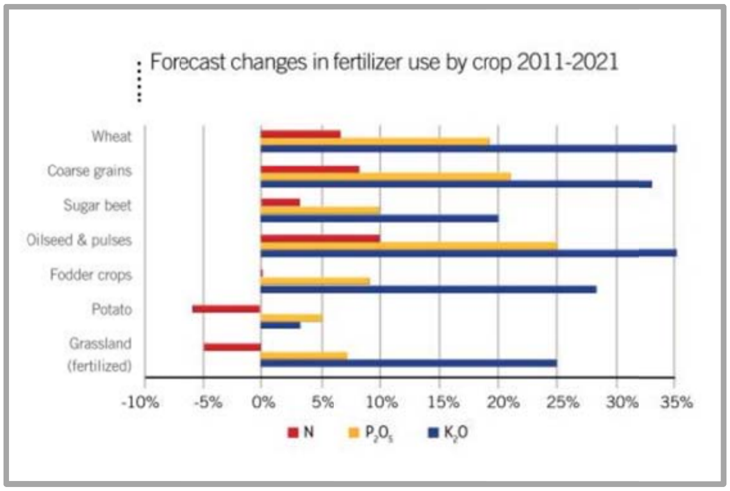


FERTILIZER

Despite the importance of forage crops, limited information is available on the use of fertilizers on perennial forages. It is estimated that only 25% of improved pasture and hay is fertilized and only 15% of alfalfa hay fields (Lickacz and Johnston 2001[xiv]). Rising fertilizer prices have discouraged producers from using it in hay fields and low usage of fertilizer is likely a contributing factor to lower yields over time. Given the level of nutrient removal by forages, particularly phosphorous, low fertilizer application rates are undoubtedly a contributing factor to the fact that forage stands are only maintained for 3-5 years in high moisture regions of western Canada and 6-9 years in semi-arid regions.

For healthy growth, plants need 13 or more essential nutrient elements from the soil. The required amounts of these nutrients vary widely from year to year for a given crop and also vary considerably from one forage crop to another. In general, Nitrogen and Phosphorus are deficient under most soil and crop conditions, and potassium and sulfur may also be deficient in certain areas. Deficiencies of other plant nutrients are not very common. Like most annual crops, forages respond well to the application of fertilizers on nutrient deficient soils.

While a legume like Alfalfa can produce its own nitrogen, it cannot generate phosphorus or potash. Alfalfa is known for needing a lot of potassium but also has yield responses to phosphorus when soil is low. An extra 5 tonnes per hectare (2 tons per acre) have been reported when supplying adequate potassium and phosphorus. Nitrogen has been shown to significantly increase forage yield in Timothy stands (Ziandi et. al. 2000[xv]). The Government of Saskatchewan has summarized research on fertilizer management for improving seed production of perennial grasses and legumes in Saskatchewan[11].



While the average yield on hay land is highly variable depending on soil quality, climate, and forage species Canadian hay yields trend below the U.S. and the EU which ranges between 2-5.25 tons DM/acre. Fertilizer rates on forage in the EU range between 0-59 kg K/ha, 0-32.7 kg P/ha, and 1-201.4 kg N/ha depending on the country (FAO, country surveys 2000). In the EU use of P_2O_2 and K_2O on grasslands is expected to increase 7% and 25% respectively over the next 10 years and increase 9% and 28% on fodder crops. In contrast, application of N is forecast to decrease by 5% on grasslands and be steady on fodder crops (Fertilizers Europe Forecast 2010-2020[xvi]).

Just because other countries are using more fertilizer on grassland and forages does not mean Canadian producers need to. Each producer needs to look at their soil profile and what the nutrient needs of the plants are. Due to the high cost of fertilizer many producers do not apply it to pastureland. Having a clear understanding of the cost and production advantages is important in evaluating when it would be appropriate to apply fertilizer. An economic analysis of the cost/benefit and breakeven price for fertilizer based on known productivity gains would provide producers with information to make informed decisions on when it would be appropriate to invest in fertilizer for pastureland. Communicating these benefits to producers is critical for optimal use. There is a lot of work available on production response from fertilizer application but the economic analysis is rarely done and is not available for the current fertilizer prices, across the various soil zones. Alternative methods of stand rejuvenation could also be explored.

FORAGE VARIETIES

New varieties of forages can be protected by Plant Breeders Rights legislation or released under contractual agreements, whereby the plant-breeding organization receives royalties on the new releases. Before the new varieties can be registered they must be tested for 3-4 years at several locations. After proving their merit, the selections are propagated by the plant breeder. This seed is

[11] http://www.agriculture.gov.sk.ca/Default.aspx?DN=85fce0f4-f256-4d9b-8a73-65096196eb10

then grown as foundation seed by selected forage seed growers who have been certified growers for at least 7 years by the Canadian seed trade. Fields are inspected each year for purity of stand and freedom from weeds. The seed production from the foundation crop is planted for production of certified seed, which is sold to farmers. Common seed can be sold in Canada which reduces the demand and price for certified seed. ***One of the challenges when grain prices are high is finding certified growers who are willing to grow forage seed instead of Canola or another crop***. As a result the industry has not yet benefited from the research done on all of the new varieties mentioned below. Table 8 provides the number of forage and feed grain varieties registered with CFIA as of July 2011.

Table 8. Number of Forage/Feed Grain Varieties Available, July 2011

Type	Varieties	Type	Varieties
Spring Triticale	15	Annual Ryegrass	19
Winter Triticale	4	Perennial Ryegrass	17
Total Triticale	**19**	Altai Wildrye	3
Barley, six-row, Spring	118	Dahurain Wildrye	2
Barley, six-row, Spring, Hulless	7	Russian Wildrye	4
Barley six-row, for spring forage	7	**Total Ryegrass**	**45**
Barley, two-row, Spring	85		
Barley, two-row, Spring, Hulless	15	Alsike Clover	4
Barley two-row, for spring forage	2	Red Clover, single cut	2
Barley, Winter	3	Red Clover, double cut	31
Total Barley Varieties	**237**	Sweet Clover	2
Alfalfa	206	White Clover, low-growing	1
Alfalfa Hybrids	3	White Clover, tall-growing	13
Total Alfalfa	**209**	**Total Clover**	**53**
Meadow Brome	7	**Bird's-Food Trefoil**	**11**
Smooth Brome	12	**Orchardgrass**	**44**
Total Bromegrass	**19**		

Source: CFIA

Grain Varieties

Swath grazing extends the grazing season; reducing feed, labor and manure handling costs for producers. Annual cereals are seeded in mid-May to early June and swathed from late August to mid-September when the crop reaches the soft to late dough stage and before killing frosts. The swaths are left in the field for the cattle to graze during the fall and winter.

Barley and oats are the most common crops used for swath grazing. Producers and researchers have found that high yielding grain varieties generally produce higher forage yields. Forage quality at the time of swathing can be enhanced by selecting late maturing forage type varieties. Foxtail millet and corn can also be for winter grazing systems; however both crops require adequate heat units and moisture. Research has indicated that foxtail millet is adapted to late spring seeding, but it is slow to establish and should be seeded on clean ground to limit weed competition. Research at Brandon has also shown that corn is slow to establish and requires a herbicide program to limit weed competition. Corn is usually managed as a standing crop for winter grazing programs.

Barley has the most registrations at 237 varieties, however forage varieties of barley are limited with only 9 (7 six-row and 2 two-row varieties) available. Barley varieties for crop production have seen an increase in the number of registrations, with six-row spring barley at 2 registrations in the 1970s, 13 in the '80s, 35 in the '90s, 62 in the '00s and 7 since January 2010. Similarly two-row spring barley registrations increased from 2 in the 1970s, 5 in the '80s, 25 in the '90s, 45 in the '00s and 7 since January 2010. Development of Six-row hulless barley varieties was confined to the 1993 to 2002 time period. While two-row spring hullless varieties continue to be developed with 1 in the '80s, 6 in the '90s, 9 in the '00s and 2 in 2011. All of the forage varieties have been developed since 1998.

There are currently 15 varieties of spring triticale registered and 4 varieties of winter triticale. The four winter varieties were all registered by Alberta Agriculture.

Legume Varieties

Emphasis on new forage varieties has been placed not only on productivity, but also longevity; particularly Alfalfa varieties. Alfalfa represents the largest legume acreage in Western Canada with 206 varieties and 3 hybrids. The main limitation has been the decline in stand productivity over time. Crested Wheatgrass, Ryegrass and Bromegrass are all commonly mixed with alfalfa to prevent bloat in cattle when grazing. These grasses tend to choke out alfalfa overtime, resulting in a 100% grass stand within several years. Therefore, research efforts have been put into extending the lifespan of an individual stand.

Much research has been done around alternative legumes to alfalfa which do not cause bloat in cattle but provide the average daily gains in cattle and perform in a variety of environments. Any alternative must not winter-kill, prove to be drought resistant and have stand longevity as producers are not interested in the hassle and expense of reseeding.

While alternative species to alfalfa have been developed and made available, the adoption by industry has been slow for a number of reasons:

- ***Birds-Foot-Trefoil*** with 11 registrations has a long productive life and does not cause bloat. It can be used for hay production in many areas not suitable for alfalfa and is ideal for long term pasture production. On well drained soils alfalfa produces 40% more dry matter however this is a short term advantage, in contrast birds-foot trefoil will reseed and last for 10 or more years. On acidic or poorly drained soils Trefoil will produce more dry matter and survive longer than alfalfa. Trefoil preforms best in a mixture with timothy.
- ***Orchardgrass*** with 44 varieties available can be very productive, particularly in pastures and hay fields with aggressive cutting schedules. It is a very fast growing, perennial, cool-season grass. However, because it heads so very early in the spring and then declines quickly in digestible energy and protein, it has not been as widely used for stored forage compared to other forage grasses. Most recently, plant breeders are researching and developing newer orchardgrass varieties with later maturity time.
- ***Sainfoin*** has been raised as an alternative to grass in alfalfa stands to reduce the risk of bloat. Only one variety (Melrose) is licensed in Canada. Sainfoin recovers slower than alfalfa after cutting or grazing and does not produce as much re-growth. It has winter-killed in Canada and is not recommended for dryland production in areas with annual precipitation less than 12 inches. It is tolerant of spring and fall frosts and is immune to the alfalfa weevil but is potentially shorter-lived than alfalfa.

Given the increased demand for hay and reduction in yields it is not surprising to see the explosion in alfalfa varieties that have been developed over the last 20 years.

Table 9. Alfalfa Varieties

Decade	Number of Alfalfa Varieties Registered
1960s	3
1970s	3
1980s	15
1990s	67
2000s	97 + 1 hybrids
2010s to date	23 + 2 hybrids

Orchardgrass has also seen an increase in variety registrations from 2 in the 1970s, 6 in the '80s, 13 in the '90s, 19 in the '00s and 3 since January 2010. Similarly, Timothy varieties have increased from 2 in the 1960s, 6 in the 1970s, 9 in the '80s, 17 in the '90s and 20 in the '00s. Development of wheatgrasses was the greatest in the '80s, while development of clover varieties was the greatest in the '90s. Ryegrass registrations decreased in the '90s but in the last decade increased to 14 similar to the '80s (13). Birds-Foot-Trefoil has had only 5 registrations in the '90s and 2 in the last decade.

Given the decline in forage breeding research in Canada, it is possible that these new varieties being registered are actually coming from the U.S. where they have been developed in different soil and climate regions.

CONTROLLING BLOAT ON ALFALFA

As feed costs rise producers are looking at grazing more legumes. In addition to alternative forages to alfalfa, work has been done on reducing the risk of bloat when grazing alfalfa. Alternative technologies/additives to facilitate the feeding of alfalfa include **ALFASURE®.** Trials in 2004 across the Prairie Provinces involved more than 7,000 head and a wide variety of grazing conditions showed mortality was less than one animal in 100,000 grazing days. Steer gains averaged 2.5 lbs/day and heifers 2 lbs/day. Stocking density averaged 0.5 acres per cow/calf pair. An injection of 50% Alfasure®/water administered orally directly to the rumen was used to treat acute cases of bloat successfully. Critical to its effectiveness is that Alfasure® must be administered through a single water source in pastures such as a water tank. Any bloat losses in trials were when livestock had access to sources of untreated water. It should be noted that the registration for Alfasure® was pulled in 2006 due to labeling issues and is no longer commercially available.

The ability to add products to water is often not available so other methods are needed to control bloat. **Bloat Guard** or Poloxalene - the Cattle Care Bloat Guard mineral introduced in 2006 is registered as a medicated top dress for feed. It is to be added to the feed at 1 – 2 grams/100lbs of animal weight/day. Feeding the animals while on pasture can create problems. Cattle Care Bloat Guard Mineral was developed as a way to allow intakes of poloxalene (Bloat Guard) without daily feeding of grain or water treatments.

Tools such as Alfasure®, Bloat Guard, and Rumensin® boluses cannot be a replacement for poor grazing management but are rather tools to aid good management practices. Alfalfa cannot be grazed like grass and good management is critical to keeping animals alive.

NATIVE PASTURE PRODUCTIVITY

There is a vast variety of native species and pasture compositions across Canada in different typographical regions and rainfall areas. Pasture land similar to hay land has nutrients being taken away in terms of more pounds of calf that are produced, but not put back onto the land. Maintaining healthy soil and microbes requires leaving food for them including residue. This raises the question of what is the overall health of pastures in Canada and there productivity.

The mixed prairie represents the driest portion of the Northern Great Plains in Canada. Approximately 6.5 M ha of the original 24 M ha have retained their native character (Willms and Jefferson 1993[xvii]). The native prairie supports approximately 5.3 M animal unit months (AUMs) or about 15% of all beef cattle present on the Canadian prairies. This region is dominated by needle-and-thread, western wheatgrass (both cool season grasses) and blue grama (warm season). These species define the major plant communities of the mixed prairie and determine their production potential. Production is limited by water availability and soil nutrients, which also influence the species composition. Removing litter can reduce production by 60% and repeated defoliation favors the more drought tolerant but less productive species. Water and soil nutrients impose the greatest constraints on productivity. Agronomic practices that increase production are generally not feasible or have undesirable environmental consequences related to the establishment of monocultures. However, WUE can be increased by promoting species that are deep rooted and complete their growth before the summer drought.

Monitoring pasture productivity is difficult as it varies greatly from year to year with rainfall. However, the goal of supporting a healthy and productive native grassland would be for a more resilient grassland in drought years.

MOVING FORWARD WITH FORAGE AND GRASSLAND PRODUCTION

Forage and Grassland Productivity indicators show that hay yields have been declining over time and a larger number of acres are required to produce enough forage for the beef industry. This inefficiency means producers need a larger land investment than U.S. competitors and what they previously required. Increasing yield on marginal land to be internationally competitive will be important over the long run. There have been a number of new varieties developed over the years but they do not appear to have fully compensated for the move to increasingly marginal land. Variety development cannot only focus on drought resistance or stand longevity but must also improve yield. Public investment into forage varieties is necessary as the ability of companies to recoup their initial investment is low in a self-pollinating crop that is only re-seeded every 5-8 years.

An in-depth look at soil nutrient requirements under hay and pasture would provide an understanding of where this priority is at for fertilizing forage stands. There is a lot of research available in the area of rejuvenating forage stands, making technology transfer key in this area. While fertilizer has been shown to have significant yield improvement on hay it is rarely used. Communicating the economic costs and benefits to renewing stands is important, with analysis including the minimum yield that represents the threshold where producers would invest.

BEEF QUALITY

The objective of research on beef quality is to increase the demand for Canadian beef through production improvements to reduce inconsistencies and increase quality, product development, implementing alternative strategies and technologies that enhance the value of underutilized cuts, and continue investment in carcass quality and grading technology research.

Consumer preferences are constantly changing based on economic and cultural pressures. Factors contributing to beef demand include:

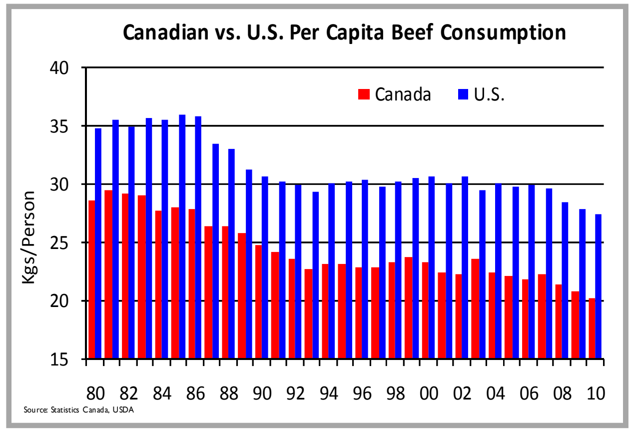
1. Disposable Income - Beef is a normal good therefore as disposable income increases, consumption increases. As the baby boomer generation retires, age and fixed finances will mean they are looking for a smaller portion size. The result of a smaller portion size is an overall decline in per capita consumption.
2. Price and price relative to competing proteins - Beef is the most expensive protein and therefore the most impacted when financial difficulties hit and consumers trade down to cheaper cuts or cheaper proteins. However, it is also a comfort food and expected to be center plate on certain occasions.
3. Health Concerns - There is significant competition in the protein section, with nutrition, fat levels, and other health factors all playing a role in selecting the proteins consumed.
4. Food Safety Concerns – Food safety is utmost priority to both consumers and industry. Consequently significant emphasis is placed on reducing the risk of contamination. With an increasingly greater number of consumers having limited knowledge in the kitchen there is a large need for communication around proper food handling and cooking to extend food safety management beyond the production, packing, and retail sectors.

Meat product attributes – Tenderness, consistency, and convenience are the top three attributes of priority to consumers. Shifting trends have results in certain beef cuts (i.e. roasts) falling out of favor due to the skill and time required to prepare a meal. Consequently industry needs to provide alternatives uses for underutilized products that drive greater value and educate consumers on how to utilize existing and new products.

A significant challenge with beef demand historically has been the high variability in quality. In 1995 the top five ranked beef quality concerns in the United States were: (1) low overall uniformity and consistency; (2) inadequate tenderness; (3) low overall palatability; (4) excessive external fat; and (5) high price for the value received. Low satisfaction with beef tenderness has been around for several years. Quality grades have historically been assumed to differentiate steaks by tenderness, but have been found to be inadequate. Without clear market signals linked to beef quality it is difficult to make progress in this area. Current genetic research is trying to identify tenderness traits and there is also focus on increasing tenderness of undervalued cuts via processing interventions.

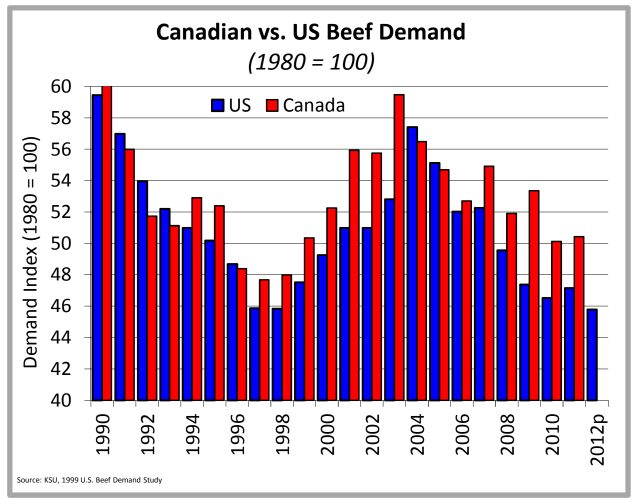
BEEF CONSUMPTION & DEMAND

Canadian **per capita beef consumption** declined 17% from 1980 to 1992; then was relatively stable until 2007 and has declined another 9.5% in the last four years. Over the last 30 years beef consumption has fallen 30% from 28.7 kgs in 1980 to 20.2 kgs in 2010. Despite the falling per capita consumption, overall consumption of beef in Canada has been relatively steady over the last decade at around one million tonnes (carcass weight), with population growth maintaining total disappearance.



Canadian beef consumption has tended to be lower than the U.S. per capita beef consumption. U.S. consumption averaged 24% higher in the '80s, 28% higher in the '90s and 34% higher over the last decade with smaller declines in U.S. per capita consumption which is only down 21% since 1980. While trending below the U.S., year over year percent changes have been similar in the two countries.

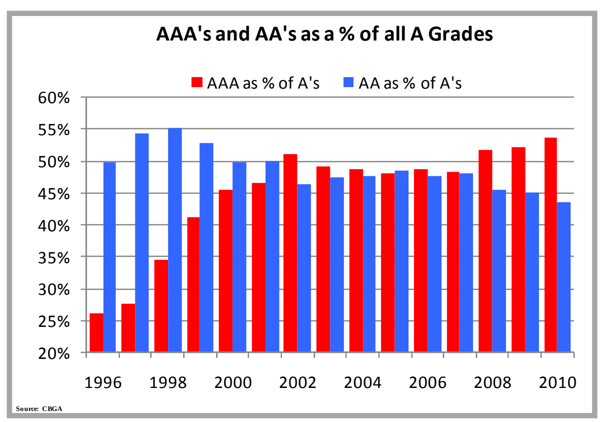
The **Beef Demand Index** is a measure of consumer willingness to pay for the per capita consumption based on deflated retail beef prices. Over the last 20 years the Canadian beef demand index has fallen from 60 in 1990 to a low of 47 in 1997 before climbing back to 59 in 2003. Over the last five years the index has declined from 55 to 50.



In the U.S. the beef demand index has followed a similar trend falling from 59 in 1990 to a low of 45.8 in 1998 before climbing to 57 in 2004 but has fallen to 45.8 in 2011. The Canadian index rebounded to be higher than '90s levels in 2003 while the U.S. index remained below their '90s level. Also the Canadian index while higher than the U.S. trended very similar until 1994, since then the Canadian index has been at times significantly higher than the U.S. index[12].

QUALITY GRADES

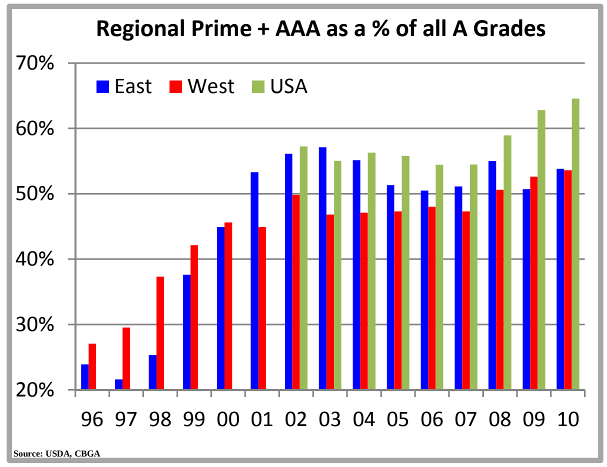
The Canadian grading system consists of both quality (i.e. Prime, AAA, AA and A) and yield grades (YG 1, 2, 3). The quality grade is based on the proportion of marbling (i.e. intramuscular fat) in the rib-eye which is an indicator of juiciness and flavour. Over the years there has been significant focus placed on quality grades. This focus has resulted in the AAA product as a percentage of all A grades increasing from 20% in 1993 to 54% in 2010 while AA product has declined



[12] Canfax, USDA

from 50% in 1993 to 44% in 2010. However, after increasing rapidly from 1993 to 2002 by an average of 3% per year AAA production has been relatively flat since then ranging between 48-54%.

In Eastern Canada AAA and Prime production as a percentage of all A grades increased from 25.3% in 1998 to 53.8% in 2010. In Western Canada the percentage increased from 37.3% in 1998 to 53.6% in 2010. While Western Canadian performance was better in 1998, this advantage rapidly disappeared and Eastern Canada had higher production of AAA and Prime beef from 2001 to 2008 averaging 53.7% over that period versus 47.7% in the west. From 2002-04 while Eastern Canada was producing over 55% AAA and Prime this was similar to the levels seen in the U.S. Since then Canada has fallen well behind the U.S.



While Canadian data shows limited gains in Prime and AAA carcasses over the last few years, the U.S. data shows continued year over year gains of Prime and Choice graded cattle. The percentage of prime and Choice increased from 57% in 2002 to 65% in 2009 and 2010. Weekly highs have reached 71% in February 2011.

Gains in AAA production in Canada have frequently been connected with higher carcass weights as the two follow similar seasonal patterns. It would follow, that higher proportions of Prime and Choice product in the U.S. would then need to have higher carcass weights as well. This is not the case with steers averaging 850 lbs in Canada as compared to U.S. steers at 833 lbs in 2010. In the '90s steer weights in Canada averaged 2% below the U.S. but have averaged 2% higher over the last decade. This indicates the U.S. is finishing higher grading cattle at lower weights.

The higher percentage of Choice product in the U.S. market has allowed retailers to make changes in offerings. Of note, is the change by Wal-Mart in August 2011 to carry Choice product in addition to Select product after historically only offering Select. This change was due to a number of factors including the desire to provide a wider variety of options to shoppers and availability of supply but also because the Choice/Select spread was so narrow at the time Choice provided a very good value to shoppers. Such changes by a large Canadian retailer are difficult due to the smaller annual production of AAA product as well as the seasonal fluctuations with AAA and Prime only representing 45% of A grades in the June and July time period. In contrast, the lowest weekly production of Choice and Prime in the U.S. over the last two years has been 61.7%.

INCREASING TENDERNESS – AGING, ENZYMES & OTHER PROCESSES

A significant amount of research has been done around aging beef, with the aging of specific cuts found to be the most valuable as compared aging the entire carcass for a longer period of time.

The most common form of aging done in North America today is called wet aging where cuts of beef are vacuum-sealed in packaging and stored under controlled temperature conditions. Research has shown that not all cuts respond to the aging process with the same degree of increased tenderness as the loin and rib-eye cuts. The blade eye, chuck tender, eye of round and striploin were the most tender at 35 days of aging and become less tender at longer aging times. In contrast, the inside round did not benefit from aging at all and the outside round become less tender with longer aging. Meat should only be aged to optimum tenderness with each cut being unique.

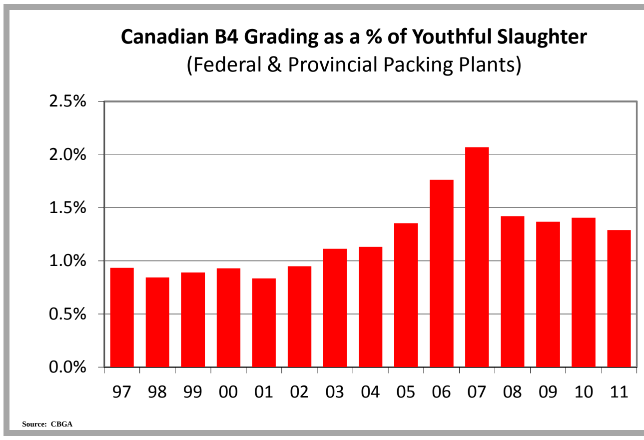
In addition to aging the application of ***enzyme technology*** could assist beef processors in their efforts to meet consumer expectations for product quality and consistency. However, this requires the individualized tailoring of enzyme levels to complement enzyme type and cooking method to achieve improved tenderness.

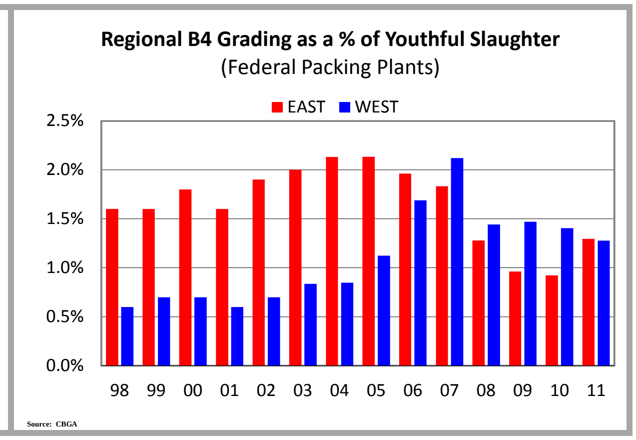
INCIDENCE OF DARK CUTTERS

Dark coloured meat at retail is perceived to be older and undesirable by consumers, despite it not tasting discernibly different once cooked. Therefore, dark cutters (B4's) typically find their way into foodservice, which avoids the consumer perception around colour. Dark coloured meat does have a shorter shelf-life, with the higher pH level in dark cutting meat causing it to spoil faster. Due to the limited market for this meat it is significantly discounted by the packer on rail bought cattle. While dark cutters are not monitored in the United States grading system these carcasses can be downgraded but still receive a quality grade (i.e. downgraded from Choice to Select). It is commonly believed that the discounts on these carcasses are smaller than B4 discounts producers see in Canada. The consequences for a producer of having B4's show up in a load of cattle can be significant. *Reducing the incidence of dark cutters to 2000 levels is estimated that it would save the Canadian beef industry $3.1 million annually*[13].

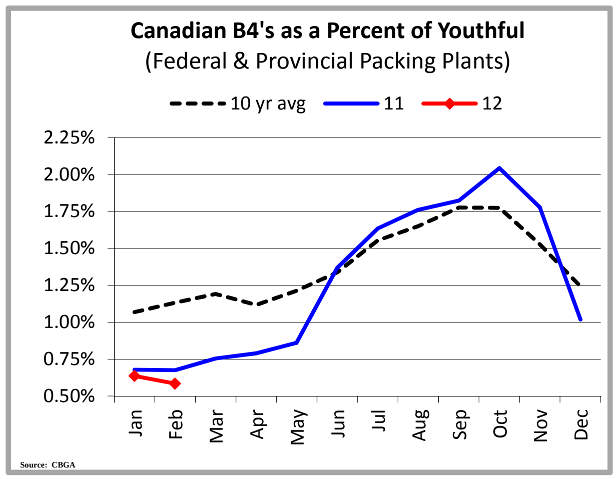
From 97-02 B4's as a percentage of youthful slaughter averaged 0.9% annually in Canadian Federal and Provincial Slaughter plants. From 03-10 this increased to 1.4% annually. The proportion of B4's increased steadily after breaking through the 1% barrier in 2003 to peak in 2007 at 2.1%, which is over double the previous average. In 2008 this number decreased to 1.4% and has remained steady since. In the first quarter of 2011 the proportion is down to 0.7%, which is the lowest first quarter average since 2001.

[13] Reducing the incidence level from 1.3% in 2011 to 0.9% seen in 2000 assuming B4s are discounted by $0.40/lb on an 820 lb heifer carcass





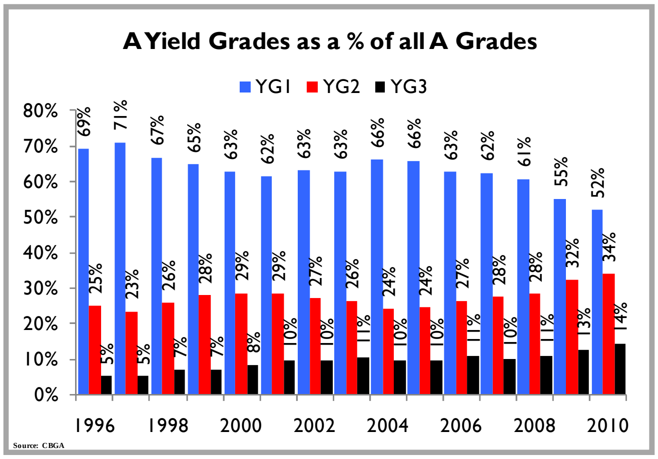
Regionally these numbers look quite different. Historically the percentage of B4's has been higher in the East at 1.86% from 98-06, while the West averaged 0.87% during this same time period. The proportion of B4's has declined in the East since 2005 to average 1.25% annually between 2007 and 2010. In contrast, the percentage of B4's in the West has increased to average 1.6% from 2007-10. In 2011, the difference narrowed with the percentage in the East increasing to 1.3% while the Western percentage declined to 1.28%.



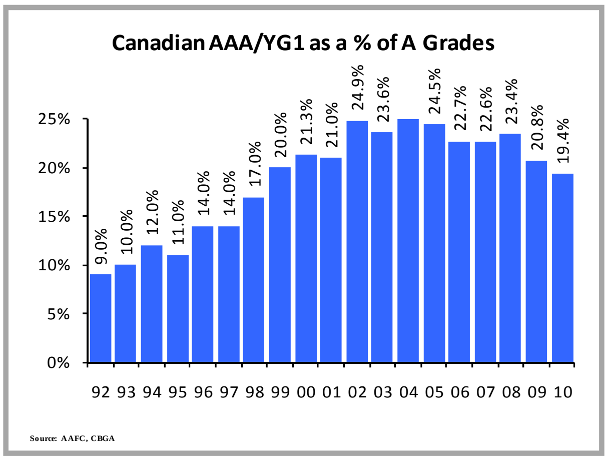
A seasonal trend is apparent, with the highest incidence of B4's in August and September when temperatures are the highest and heat stress increases. The ten year average for these two months is 1.6% for August and 1.7% for September. Last year, the monthly peak was seen in August at 2%. Large swings in temperature, either up or down have been found to increase the incidence of dark cutters. While feeding electrolytes has been found to reduce the incidence of B4's, it must be fed to all cattle to reduce the incidene in a small proportion of the population making it a questionable economic investment at lower incidence levels.

YIELD GRADES

It can be the case that two carcasses, which are both 800 lbs will vary significantly in terms of the amount of meat they yield. If one carcasses is a YG1 (62%) and the other is a YG2 (58%) there is a difference of 32 lbs of fat, which a feedlot has paid to put on and then a packer, processor, or retailer is paying someone to cut off and find a use elsewhere for it. While yield does not influence the consumers eating experience it does fall within the overarching question of beef quality and what is being produced. It should be noted that U.S. consumer feedback indicates high external fat is a concern/complain.

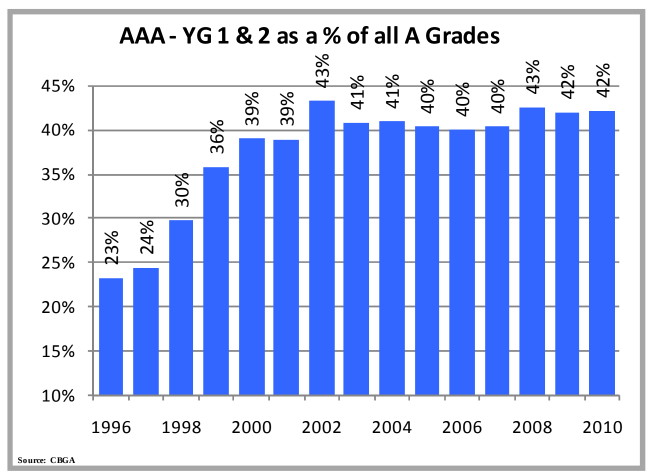


The ideal carcass is a quality grade of AAA/Prime that is yield grade 1. AAA and Prime product that yield grades 1 as a percentage of total A grades increased from 10% in 1993 to peak at 25% in 2002. Since then it has fallen to 19.5% in 2010. The percentage of A grades which are yield grade 1 increased from 67% in 1993 to peak at 71% in 1997 before falling to 52% in 2010. Yield grade 2 has increased from 23% in 1997 to 32% in 2009 and yield grade 3 has increased from 5% to 14% in 2010.

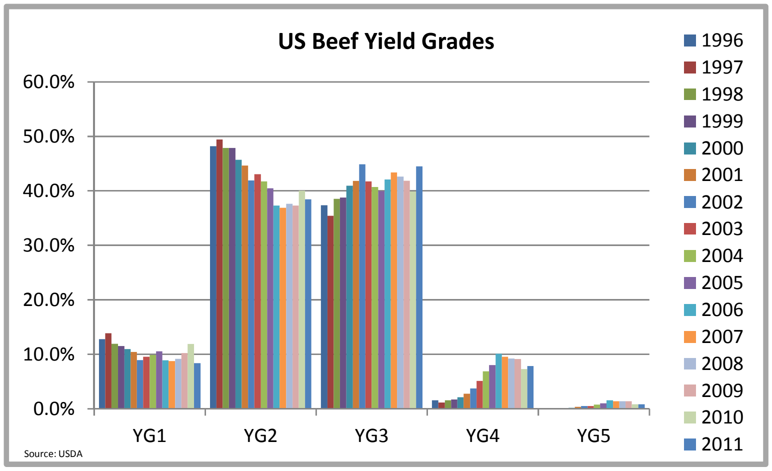


There are several reasons for varying yield grades. First is the age of cattle at slaughter. In 2003 there was a switch to more backgrounding and grazing programs as a build-up of fed cattle supplies were required to go through Canadian only packing plants. This decreased the number of calves directly entering the feedlot. In addition, calving dates were pushed back to a certain degree changing when these cattle would actually enter the feedlot and be ready for slaughter. Second, the practice of holding cattle even for a couple of weeks resulted in more back fat increasing the number of animals yielding 2. Third, over these years there has been increased influence of Angus and British breeds within the national mix, with fewer exotics. This breed influence can also be seen in the difference in carcass weights between Ontario and Alberta.

There is very little price difference between yield 1 and 2 on grids with packers not discounting or providing any incentive to produce Y1 cattle over Y2 cattle. When combined, AAA product with yield grade 1 and 2 as a percent of all A grades increased steadily from 23% in 1996 to 43% in 2002. Since then it has fluctuated between 40% and 43%. In 2010 the average was 42%. This trend differs from the yield 1 only data in that it is relatively stable around 40% from 2003-2007, indicating that animals have shifted from yield grade 1 to yield grade 2. With limited discounts on yield grade 2 animals versus yield grade 1, producers will continue to put the pounds on the carcass, as they are paid for the additional pounds.



Due to differences in the yield algorithm we are unable to compare yield grades in Canada to the U.S. However, by examining the Canadian data we can see that improvements have been made in both quality and yield grades since the current system was put in place in 1992. However, those improvements appear to have largely plateaued under the current price incentives.



In the U.S. the yield and quality grades are de-coupled and only a small percentage of cattle are yield graded. Over the last three years 34% of fed cattle slaughtered were yield graded, as compared to 63% in the late '90s. Similar to the Canadian trend, in the U.S. higher yielding cattle have declined as a percentage of the total over the last 15 years. Over time YG1 has been steady at 10.5%; but YG2 has decreased from 47% in the late '90s to 38% from 2009 to 2011. The decline in YG2 has shown up in slightly higher YG3 at 42% over the last 3 years compared to 37% in the late '90s; as well as higher YG4 at 8% over the last 3 years compared to 1.6% in the late '90s. YG5 continues to be less than to 1% of all cattle yield graded.

MOVING FORWARD WITH BEEF QUALITY

Beef Quality in Canada lags behind the U.S. in terms of production of AAA and prime beef. In addition, per capita consumption is lower in Canada; although Canadian consumers are willing to pay more for beef. Improvements in yield have plateaued and actually reversed in some cases, with current market signals encouraging heavier weights and offsetting the penalty for YG2 or YG3 animals. Furthermore the incidence of dark cutters has increased since 2004; particularly in the West. While overall numbers have declined since 2008, levels are still above the historic average.

Maintaining beef demand requires careful, clear and concise information directed at the consumer in order to educate them around the health benefits of beef and dispose of common consumer myths. There is a role for industry research to advance these messages; p*articularly around food safety; consistency and tenderness of the product; nutritional attributes of beef; and the development of new cuts to utilize and increase the value of the overall cutout.*

A lack of consistency in tenderness has plagued the beef industry for years. While marbling is related to juiciness it has little correlation with tenderness. The ability to measure tenderness would be of significant value to the industry. A significant transformation that has been led by research is the movement towards CVS grading. This will also allow for more accurate measurement of quality attributes beyond marbling. For example, there is the potential of measuring light reflectance as an indicator of tenderness. Once tenderness can be measured, new ways of providing a consistently tender product can be pursued through processes such as aging and enzyme technology.

FOOD SAFETY

Food Safety is of critical importance to maintaining consumer confidence. The objective of research in the area of food safety is to maintain domestic and international consumer demand for beef by developing improved food safety interventions, methods to quantify the effectiveness of food safety interventions, and develop food safety intervention strategies that counteract multiple pathogens.

Private industry takes this risk seriously with a number of measures in place, as their company reputations are detrimentally impacted by any product recall. Meat companies are introducing video surveillance cameras in an effort to reduce *E.coli* and other contamination inside processing plants. Remote auditors can watch whether plant workers follow safety protocols. JBS reported a 60% decline in the level of *E.coli* found by company inspectors after it installed the monitoring cameras. A pilot program was introduced in the Souderton, PA plant after a recall of 380,000 lbs of beef that resulted in 23 sick in 9 states in 2009. Immediate improvement resulted in the program being adopted in other plants. Cargill introduced monitoring cameras to ensure cattle were treated humanely before slaughter. They are now considering expanding that program into food safety. These private monitoring cameras do not replace current inspection systems but provide companies with information to ensure staff is appropriately handling the product.

Measuring progress made on food safety is difficult. Reported outbreaks only represent the tip of the iceberg, with only a portion of those reported actually having a source found (e.g. beef). In addition this data is published on a significant lag. Expert elicitation which may provide a better idea of the scope of the problem has significant variance from one report to another, with no consistent reporting over time that would provide an indication of how foodborne disease has progressed (improved or worsened) over time. Human illness attribution data has been recognized as an important tool to better inform food safety decisions. It should be recognized that the data referenced below is more complementary than comparable.

Greig and Ravel (2008) analyzed foodborne outbreak data reported internationally from 1988-2007 and found that of the 4,093 foodborne outbreaks that had an identified source, almost 70% were attributed to *Salmonella* (46.9%), Norovirus (13.5%) and *E.coli* (9.5%). The most frequently reported source was multiple ingredient foods (17%), eggs (14.3%), produce (12.2%) and beef (12.2%). Internationally the most common pathogen reported in beef is *E.coli* (34.6%), with the majority of reporting in the US (63%) followed by Canada (27%) and the EU (10%)[xviii].

Greig and Ravel (2008) showed three interesting subsets or clustering which highlights a specific association between the categories (1) EU, *S. Enteritidis* and Eggs; (2) *S.Typhimurium*, Australia and New Zealand; and (3) *E.coli*, Canada, Beef. The association between beef and *E.coli* was expected as cattle are a reservoir of human pathogenic *E.coli* strains. However, the relative proportion of beef as the source of *E.coli* was higher in Canada (34/55 outbreaks or 62%) than in the EU (12/41 or 29%) or U.S. (79/189 or 42%). No biological explanation has been provided for the difference in Canada versus other countries.

INCIDENCE

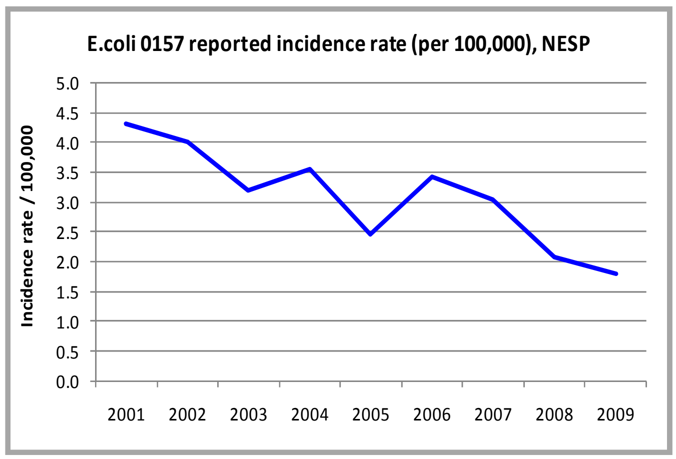
The Public Health Agency of Canada (PHAC) maintains a database of foodborne disease outbreaks from Canadian and international sources. A foodborne disease outbreak is defined as two or more individuals with a similar illness resulting from consuming common food or water source. This information by no means represents all outbreaks as foodborne disease is under-reported for a variety of reasons including no treatment sought, doctor did not report, misdiagnosis, and no further exploration of source if diagnosed. While the overall value is under-reported, the overall trend is valuable in knowing if the industry is making progress in this area or not. Table 10 provides the Canadian outbreaks associated with beef and *E.coli* from 1995-2010.

Table 10. Canadian Outbreaks Associated with Beef and Escherichia coli

1995	1999	2000	2001	2002	2003	2004	2005	2006	2007	2009	2010
1	6	5	3	7	1	7	4	2	2	1	2

Source: Science to Policy Division, Laboratory of Foodborne Zoonoses, Public Health Agency of Canada

Since 2000, there have been 13 outbreaks where the source of contamination was confirmed as beef. The number of cases associated with each outbreak varied from few to several. Since 2000 there have been 11 outbreaks where the source of contamination was suspected to be beef but was not confirmed and no food recall occurred. These 11 suspect outbreaks are counted as one outbreak in Table 1. From 2005 to 2011 there were 16 outbreaks documented where the source of contamination was unknown or a source other than beef was confirmed.



The above data only includes incidence of national investigations which cross provincial borders. The National Enteric Surveillance Program (NESP) collects data on laboratory confirmed isolations of pathogens from provincial laboratories. The incidence rate of *E.coli* 0157 VTEC has declined from 3.41 cases per 100,000 in 2006 to 1.82 cases per 100,000 in 2009.

Table 11. Cases and Rate of *E.coli* 0157 per 100,000 Population by Province, NESP 2009

E.coli	BC	AB	SK	MB	ON	QC	NB	NS	PE	NT	YK	National
# Cases ǂ	165	99	16	45	154	107	13	3	9	1	1	613
Rate (per 100,000)*	3.70	4.47	1.55	3.68	1.18	1.37	1.73	0.32	6.38	-	2.97	1.82

ǂ Includes both verotocigenic (606 cases) and non-verotoxigenic (7 casess from MB)
**Only verotoxigenic cases included (606 cases)*

A large outbreak can spike incident rates in a single province in a single year making historical comparisons difficult. Provincially, PEI had the highest incident rate in 2009 at 6.38 per 100,000 followed by Alberta (4.47), British Colombia (3.70) and Manitoba (3.68). As with the national trend, declines have been seen in all the provinces. *However, the question remains if the reduction in the* *number of outbreaks has been due to an overall reduction in the amount of E.coli present or if the adoption of test and hold has resulted in this product being removed from the supply chain. While protecting the consumer is of the utmost priority, if the actual amount of E.coli present in beef has not been reduced than there is still a cost to industry to dispose of the product safely.*

E.coli incidence is the highest in the spring and fall which corresponds with seasonal shedding of *E.coli* in cattle. Science has shown a connection between the level of *E.coli* found in cattle (on hides) to the level found on carcasses (potentially through cross-contamination with other carcasses). This implies there is a place for controlling *E.coli* levels at the feedlot level. Recent studies have explored the potential of an *E.coli* vaccine for cattle. The challenge is how to create an immune response because *E.coli* is a good bug and present in a healthy rumen. The question left, if the vaccine is effective then, "is this a viable economic alternative for the industry to adopt wide-scale?"

While irradiation has been available to the industry for a number of years adoption of this technology is low due to uncertainty by consumers and delays in regulatory approval. The potential benefits from irradiation if it performs as advertised to reduce *E.coli* and other food pathogens is large. The literature has likened the adoption of irradiation to that of pasteurization in dairy products.

DETECTION

There has been a significant improvement in the sensitivity/detection limits of *E.coli* tests (specifically for 0157:H7). The classical culturing and enrichment methods from the early '90s list detection limits of 10-100 colony forming units or bacteria per gram (CFU/g) with levels less than 100 CFU/g not being consistently detected. In 1994 a new method introduced increased the sensitivity of detection by 100 fold. The new limit for detection is 1 CFU/25 g or 0.04 CFU/g with commercially available assays confidently detecting at that level. New research assays (introduced in 2011 and not on the market yet) are less than 1 CFU/25 g at about 0.04 CFU/g.

Product testing and surveillance of *E.coli* have been mainly focused on *E.coli 0157:H7,* with the detection of other serotypes of *Shigatoxin-producing E.coli (STEC)* largely neglected. In May 2011 Derzelle et al. presented a new PCR assay designed to detect all known *stx* gene subtypes in a single reaction; including the most distant variant *stx*2f[xix]. The new assay was shown to be 100% specific and had sensitivity at industry standards of less than 1 CFU/25 g or 0.04 CFU/g.

In September 2011, the USDA's Food Safety and Inspection Service (FSIS) announced it would declare six non-0157 *E.coli* serogroups as adulterants in raw non-intact beef products, with testing on beef trim starting in March 2012. However, industry groups using the rapid test kits for the six non-0157 serogroups are experiencing higher rates (up to 20%) of possible positives than occur with the test kits for *E.coli 0157:H7*. While many of these turn out to be false positives, it extends the total time product must be held to about six or seven days while confirmation testing is done. The Canadian government is working to ensure that Canadian companies meet the same standards under the USDA proposal. The CFIA is expected to direct companies to plan for equivalent compliance in January 2012.

Another factor for detection is the time needed to perform the test. Traditional culture takes 24-48 hours in most cases for identification. The newer assays are running at about 9-24 hours to enrich and screen for E.coli 0157:H7 with the goal of being completed in one 8 hour work shift. This time difference makes a big difference with the adoption of test and hold. The longer test time means product may have already been shipped to market versus still being in storage and avoiding a recall completely. The future goal is to detect early enough to avoid shipping contaminated food altogether.

Rapid screening methods that provide initial results within 6.5 – 8 hours are now commercially available, but do not provide the sensitivity (miss true positives) that standard procedures used by regulatory agencies use for confirmation. Therefore, they may yield conflicting data.

ANTIMICROBIAL RESISTANCE

Antimicrobial resistance raises two concerns for cattle producers.

1) The animal health concern: if cattle pathogens are resistant, then the antimicrobial will no longer effectively treat cattle diseases.
2) The other is in maintaining consumer confidence: there are concerns that resistant bacteria may be able to transfer resistant genes to other bacteria that cause disease in humans. Ultimately the concern is that this could decrease the effectiveness of important antimicrobials used to treat human illness.

Improper antimicrobial use in the livestock sectors has been identified as a potential risk factor, which may contribute to the development of human pathogens that are resistant to antimicrobials. Of particular concern are antimicrobial agents that belong to the same chemical family as antimicrobials commonly used to treats bacterial infections in humans. A number of studies have been done examining antimicrobial resistance in fecal *E.coli* and *Campylobacter* from beef cattle. Checkley et. al (2008 & 2010) found no association between antimicrobial use in the feedlot and antimicrobial resistance[xx]. Despite there being no issue currently, due to the ongoing use of antimicrobial agents in the cattle industry ongoing monitoring in this area is appropriate.

MOVING FORWARD WITH FOOD SAFETY

Food Safety is of critical importance to consumer confidence in beef. The reported incidence rate of *E.coli 0157* has been declining over the last decade. At the same time detection levels have improved significantly. It is unclear whether the reduction in the number of outbreaks has been due to an overall reduction in the amount of *E.coli* present or due to the adoption of test and hold procedures that has resulted in this product being removed from the supply chain. The use of test and hold procedures means rapid screening methods that can be completed within 6.5-8 hours and meets industry standards for sensitivity need to be developed.

Antimicrobial resistance is a concern on two fronts, that of animal health and consumer confidence. Studies in 2008 and 2010 have found no association between antimicrobial use in the Western Canadian feedlot industry and antimicrobial resistance (with no indicator organisms found between human pathogens or cattle pathogens). Despite there being no issue currently, due to the ongoing use of antimicrobial agents in the cattle industry ongoing monitoring in this area is appropriate.

APPENDIX I

Dependent Variable: F_G
Method: Least Squares
Date: 01/09/12 Time: 16:56
Sample (adjusted): 159 724
Included observations: 203 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ADG_KG	-5.481296	0.131189	-41.78176	0.0000
FEED_INTAKE_DM_KG	0.738241	0.019408	38.03830	0.0000
YEAR	0.003804	8.99E-05	42.31914	0.0000

R-squared	0.914561	Mean dependent var	7.141724
Adjusted R-squared	0.913707	S.D. dependent var	1.331291
S.E. of regression	0.391075	Akaike info criterion	0.974835
Sum squared resid	30.58799	Schwarz criterion	1.023799
Log likelihood	-95.94577	Hannan-Quinn criter.	0.994644
Durbin-Watson stat	1.038526		

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