Priority Area Review:
Forage & Grassland Productivity

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EXECUTIVE SUMMARY

In 2012, the Beef Cattle Research Council (BCRC) committed to completing an evaluation of the value of research funded in each priority area: Animal Health & Welfare, Beef Quality, Feed Efficiency, Forage and Grassland productivity, and Food Safety. The goal of these priority area reviews was to provide a cost:benefit analysis of research to identify research areas within each priority that were potentially under- or over-funded. This is intended to inform the next round of priority setting sessions by providing more in-depth background for the participants. The first review was completed in October 2013 by Dr. John Cranfield on "The Value of Research in Beef Quality and Food Safety". This second review assesses forage and grassland productivity research.

Evaluating research benefits to producers is often challenging due to unreliable or insufficient data. This is the case in measuring the benefits from research related to forage quality, stand mixtures, or ration alternatives. Recognizing this shortfall, this report evaluates benefits that can be measured through changes in productivity (Section 1. Economic Evaluation) and also summarizes the benefits to producers from various forage research areas (Section 2) including stand establishment and forage management.

Eighty percent of a beef animal's diet over its lifetime comes from forages. Tame/seeded **forages** cover 16.9 million acres in Canada. Most cow-calf producers in Canada still feed hay for a portion of the winter even if they are able to use extended grazing in the fall. Hay yields peaked in the 1980s, dropped well below historic levels in the 1990s and have rebounded in the last decade to be back at levels seen in the 1950s. In contrast, annual crops have seen significant yield improvements over the last 60 years. This puts the beef sector at a competitive disadvantage as beef production must compete with other commodities for land, labour and capital. Over the long term, improving forage productivity is crucial for future competitiveness of the cattle industry. While it may be more profitable for a producer to obtain hay or pasture from another source in the short term (i.e. buy land or purchase hay), reducing the per unit cost of production (COP) is required over the long term.

Grazing land that is unsuitable for other agriculture purposes allows it to contribute to food production in a sustainable way. This key resource also provides biodiversity, wildlife habitat, nutrient cycling and ecosystem services to society. Research into these environmental benefits help tell a more balanced story about the beef industry to consumers.

Forage is the primary input for the cow-calf producer, whether from summer pasture or winter feed. The goal of forage research is to decrease the per unit COP (defined as $/tonne of relative forage quality), making beef producers more competitive whether they are using that forage to feed livestock or sell to other producers. The COP of forages can be reduced by increasing the quantity or quality produced[1]. Becoming more competitive, productive and efficient in forages will increase the resilience of the cow-calf sector. The value of forage research is in understanding how improved yields, persistence and quality from new varieties and appropriate management reduce the COP. For producers dependent on forage, this can support the long term sustainability and viability of their operations.

Economic Evaluation

The value of forage research is evaluated by calculating the impact on productivity changes in forage and cow-calf COP. First, the ***forage COP*** was examined. Advancing ***yields*** through variety development or changes in management have the most impact on COP. However there is a diminishing return. While

[1] A crop with higher inputs may have a lower per unit cost of production if yield is proportionately higher

increasing average hay yields by 5% would reduce per unit costs by 5%, increasing average hay yields by 30% would only reduce per unit costs by 23%.

There are both productive and economic benefits to re-seeding. Understandably, many producers delay re-seeding in an attempt to minimize overall costs. By ***delaying re-seeding*** to eight or ten year intervals, average yields are lower (1.65 and 1.53 respectively) and the average cost per acre drops slightly for the eight year scenario, but increases for the ten year scenario because lower yields result in higher per unit costs in the last two years. In addition to increase per unit costs, lower yields have been shown to be strongly correlated with reduced animal performance and therefore, reduced revenue. Therefore, it is not economical to delay re-reseeding to eight or ten year intervals.

During the past two centuries, at least 40 ***droughts*** have occurred in western Canada with multi-year episodes observed in the 1890s, 1910s, 1930s, 1960s, 1980s, and early 2000s. While rarely significant in a model over a long period of time, the immediate effects can be significant for an operation, particularly if cash flow requires animals to be sold to finance the purchase of feed for those that remain.

Yield response to fertilizer is unpredictable in Canada. Therefore in higher moisture areas where response to fertilizer is more consistent may result in a lower COP, but in low moisture areas where yield response is low or inconsistent, fertilization may increase the COP. Low moisture areas may consider irrigation, if available, to address these issues. This requires weighing the cost of irrigation against the additional yield provided.

The largest impact forage research can have on forage cost of production comes from increased yields Yield increases can come from changes in management or adoption of higher yielding varieties. The advantage to changes in management is that they can impact large acres of land now, and still have an effect while producers wait to re-seed. Adoption of new varieties while critical, has not only a long investment timeframe but just as long an adoption timeframe when producers are only re-seeding every 6-10 years. Improved longevity and drought resistance do result in small reductions in COP. However, research in these areas is more about relieving the short term financial impact from needing to re-seed or purchase feed.

Second, the impact on ***cow-calf COP*** from a 5%, 10%, 20% and 30% increase in hay yield was examined. While an enterprise analysis of a cow-calf operation would value hay at market value, most producers in Canada continue to produce the majority of their winter feed. Therefore a lower cost of producing hay is expected to reduce winter feeding costs for the cow-calf operation and ultimately the per unit cost of producing a calf. It is still recommended when analyzing individual enterprises to use the market value of hay. However, that does not tell you anything about your competitiveness in producing forages.

The results vary for each farm depending on the amount of hay in the winter feed ration, days on feed, as well as the proportion of feed that is purchased versus homegrown. In general, if there is excess summer pasture available, a 30% increase in hay yields reduced long term COP (including depreciation) between 11-15%. Many production decisions are based on cash costs. By decreasing dependence on purchased feed cash expenditures are replaced with the cost of producing hay on farm (accounting for the opportunity cost of labour and machinery costs). Consequently cash costs were reduced by 10-15% with 30% higher yields.

When herd size was held constant and land use changed into the most profitable cash crop, feed costs were reduced between 3-10% and cash costs were reduced between 2-6%. Due to the small changes in land use, the overall farm profitability did not change significantly. However, this could still be a factor in long term decision making.

While yield improvements had the greatest impact on COP, the cost of poor forage quality on animal performance, particularly reproductive efficiency is unclear and maybe even greater to the beef producer. Without more data this area cannot be tested adequately.

There is a need for forage economists in Canada who understand the plant side of forage quality and can develop the economic models that will support the industry independent of beef economists who focus only on how forage as an input is utilized in calculating beef cost of production.

Forage Research Areas

A number of forage research areas contribute to the overarching goal of reducing per unit COP and increased resilience of the cow-calf sector. Many of these research areas also have animal health and environmental impacts, which are not addressed in this review.

Yield improvement has the largest impact on forage COP, providing a greater benefit than drought resistance or longevity even though these traits remain important to producers when developing new forage varieties. Developing high yielding **forage varieties** is critical to remaining competitive with other commodities. Competition for land encourages forage acres to be converted into annual crops. Yield improvements can come from variety development or management changes. Variety development (plant breeding) can take many years and must be suited to the regional soil and climate conditions. Cross regional breeder collaborations provide the opportunity to test varieties that have failed in one region to be tested and potentially adopted in another, maximizing the knowledge gained from these breeding investments. However, adopting varieties that have been produced elsewhere in the world may not necessarily sustain forage production in Canada. This development requires ongoing investment in plant breeding capacity/infrastructure and a regulatory system that supports registration and commercialization of new varieties.

Establishment of new pastures can be expensive and producers often prioritize stand life over yield. **Seeding complex mixtures** of grasses and legumes that maintain highly diverse botanical composition in pastures can contribute to increased persistence, yield stability and improved productivity. Yields benefit from including species that are highly productive as well as drought tolerant. While some species will not persist beyond the first three or four years, the presence of other species is able to fill in the gap and maintain overall yields to a degree. Species should be selected to match the environment as well as the anticipated management.

There are risks associated with re-seeding. Producers are more reluctant to re-seed and more willing to accept a poor stand for a longer period of time in dry regions where successful **establishment** of a forage stand is highly variable. Increasing the success rate of establishment through innovation in less expensive re-seeding methods and higher germination rates can assist in decreasing the COP associated with low yielding stands.

It has long been recognized that pasture and **forage management** can significantly influence **forage yield, quality, animal health and productivity**. Grasslands can benefit from appropriate grazing. Light grazing results in the development of a more varied flora with a greater total percentage basal area, while non-grazing appears to simplify the flora with a trend toward a monoculture (Johnston, 1960). Appropriate pasture management also helps ensure long-term sustainability of the grassland system. Heavy grazing pressure can jeopardize the sustainability of the ecosystem by reducing fertility and water-holding capacity. Grazing management can have a significant impact on animal productivity, which ultimately affects a producer's bottom line. Research that improves the understanding of the interconnectedness of the numerous variables at play in grazing management could have a significant impact on productivity and the cost of production on existing forage acres.

Poor forage **quality** can create problems with beef cattle that are difficult to evaluate financially. Matching forage quality to animal needs is part of cattle management as nutrient requirements of cattle change throughout the year based on the stage of the production cycle. A high quality forage can provide a lower cost ration than using a low quality forage supplemented with a concentrate when feed grain prices are high. Low quality forages that fail to meet all of the nutritional needs of a cow can have animal health and performance consequences that directly impact COP (e.g. loss of body condition, dystocia, lower milk production, and delayed returning to estrous). This can be largely avoided by feed testing and appropriate supplementation, particularly when hay is of an unknown quality. Timeliness in harvesting is not always possible due to weather (e.g. rain, frost) but is critical to producing high quality forage.

Pasture is a critical resource in the cattle industry. Effective pasture management not only ensures high forage yield and animal productivity but also benefits the pasture ecosystem. An effective management plan requires good understanding of pasture production, realistic production goals, effective grazing strategies and timely response to forage availability and environmental changes. While numerous studies have focused on production aspects such as grazing management and fertilizer use, recent studies have shed light on environmental impact and species selection.

Managing grazing lands so that they are productive and persist over time requires knowing when to graze certain species, if they can withstand multiple grazings/cuttings within a single year and how much recovery time is needed to prevent overgrazing. There have been a number of technologies that have increased the control producers have in pasture management. Technologies like electric fences and portable solar water systems have contributed to intensification of grazing that allows for the appropriate recovery time, grazing period, stocking density, nutrient transfer and reduced feed waste.

Weed control affects forage yield and quality. Weed management can be accomplished through cultural, mechanical, chemical and biological controls. An effective and sustainable weed management program should integrate two or more methods and consider long term impacts. Over 95% of the weed control in a healthy forage crop is due to the competition by the existing forage stand.

As a forage stand becomes less productive over time, producers may **rejuvenate** or renew a stand. There are a number of ways a producer can go about rejuvenating a stand but the most common way is fertilization. Recommendations for when to renew a stand vary, but as productivity declines, there comes a point when breaking and re-seeding is less expensive. The higher the establishment costs the more years a producer is willing to spread the costs over as they balance costs with the net present value of future income (yield times value). Knowing that for every additional year there is reduced yield to spread annual costs over.

Moisture and soil fertility are essential factors that affect forage productivity and management strategies. Many other countries that recommend **fertilizing** forages as part of good management practices have higher average yields, but no research indicates that the higher yields are from fertilization versus precipitation. An alternative to including inorganic N is to add a legume to the mix, which fixes nitrogen and supports yields. The proportion of tame hay with alfalfa has increased from 44% of tame hay acres in 1971 to 66% in 2011 (Census of Agriculture).

While synthetic fertilizer has not shown consistent yield responses, in-field winter feeding with manure and feed waste providing **organic fertilizer** to a pasture can be a cost-effective winter feeding option that improves forage productivity. A number of studies have shown that extended grazing can reduce winter feeding costs compared to traditional winter feeding systems, and improve soil nutrient status. However, successful winter grazing depends on proper planning and management to avoid negative environmental impacts and to maintain animal performance.

INTRODUCTION

In 2012, the Beef Cattle Research Council (BCRC) committed to completing an evaluation of the value of research funded in each priority area: Animal Health & Welfare, Beef Quality, Feed Efficiency, Forage and Grassland productivity, and Food Safety. The goal of these priority area reviews was to provide a cost:benefit analysis of research to identify research areas within each priority that were potentially under- or over-funded. This is intended to inform the next round of priority setting sessions by providing more in-depth background for the participants. The first review was completed in October 2013 by Dr. John Cranfield on "The Value of Research in Beef Quality and Food Safety". This second review assesses forage and grassland productivity research.

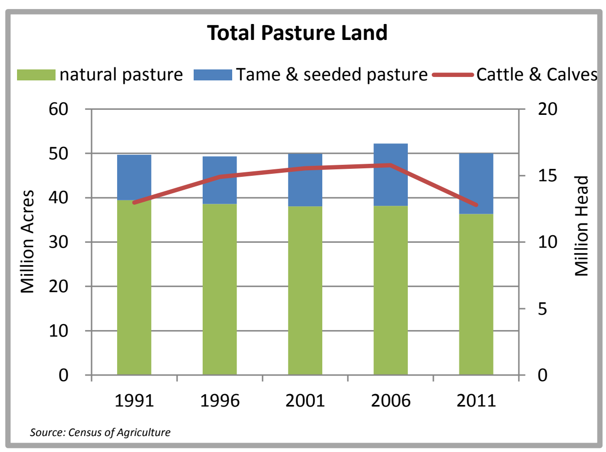
Evaluating research benefits to producers is often challenging due to unreliable or insufficient data. This is the case in measuring the benefits from research related to forage quality, stand mixtures, or ration alternatives. In addition, forages include everything from native and tame grasses to cereals, all of which can be used for hay, silage and/or grazing. This wide variety of research areas makes it difficult to compare results in a consistent way. There is also a lack of data to complete economic analysis with.

Recognizing these shortfalls, this report evaluates benefits that can be measured through changes in productivity (Section 1. Economic Evaluation) and also summarizes the benefits to producers from various forage research areas (Section 2) including stand establishment and forage management.

Why should the beef industry invest in forage and grassland productivity research?

Forages cover a large acreage in Canada, and are produced with ruminant livestock in mind. In western Canada, the prominent livestock is beef cattle. Beef cattle have the ability to convert forage (native, tame and annuals) that is unsuitable for annual cropping into a nutrient dense food for humans. Beef producers manage many of these forage acres for summer and fall grazing as well as production of winter feed. Forage acres are a viable, sustainable system on many landscapes.

Eighty percent of Canada's beef production occurs on forages. Feedlots account for only 30% of the total calories consumed in the entire beef sector, with the cow-calf and backgrounding sectors consuming large volumes of forage.[2] Feed represents between 28-34% of total costs for a cow-calf operation (*agri benchmark* 2013 data).



Pasture land accounted for 31% of Canada's total farm land in 2011. Grazing land that is unsuitable for other purposes, can still contribute to food production in a sustainable way. This key resource for the cow-calf sector also provides biodiversity, wildlife habitat, water and nutrient cycling, and ecosystem services to society. Research into these environmental benefits help tell a more balanced story about the beef industry to consumers.

While the proportion of natural versus tame pasture has been steady over the last five years, total pasture land is actually down 4% from 52.2 million acres to 50.0 million acres. The decline in pasture area is closely tied to the reduction in Canadian cattle herd which is down 19% from 15.6 million head in 2006 to 12.8 million head in 2011. As the cattle industry is currently at the bottom of the cattle cycle and is

[2] Weaber, Bob. March 21, 2014. Steps to Improve Cow Herd Efficiency. www.ag.web.com

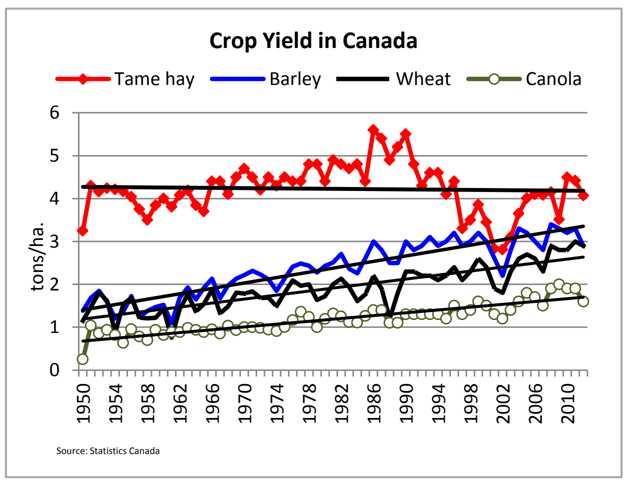
expected to expand, sufficient and high quality forage supply at a competitive cost will be increasingly critical to the profitability and sustainability of the cattle industry.

Extended grazing practices, which increase the number of days in a year that livestock remain in a pasture or open field setting, have been widely adopted over the past decade. Extending the grazing season reduces the amount of time livestock need to be fed in a confined area, which reduces costs associated with feed production, storage, delivery, and manure handling. Over the past decade, the number of producers using extended grazing techniques has increased (2011 FEMS).

Most cow-calf producers in Canada still feed hay for a portion of the winter even if they are able to use extended or swath grazing in the fall. *In all regions of Canada, hay is the most common method for extending the grazing season with 76% of beef farms using hay in 2010/11*[3] *(*Ag Census*).* The Prairie Provinces have a higher use of spring and fall forages, swaths and dormant vegetation than other regions. However in many regions of Canada, even these options are limited to only a portion of the winter due to weather (e.g. snow being too deep or crusted).

Forage Acres

The 2011 Census of Agriculture reports that 16.9 million acres or 11% of total agricultural lands are growing tame hay with 11.2 million acres or 66% of the total growing alfalfa or an alfalfa mixture. The National Forage & Grassland Assessment (Fall 2012[4]) notes that in 2011 cultivated forages for pasture, feed and seed production accounted for 33.8 million acres or 39% of crop production in Canada. The economic value of the industry at $5.09 billion was the third largest crop after wheat and canola. 'The Value of Alberta's Forage Industry' report notes that forage crops (native range, tame and seeded pasture, and silage) cover more acreage in the province than any other agricultural crop[5]. The report concluded that forages make substantial contribution to the economic and environmental sustainability of the province.



Tame hay yields in Canada have not improved over the past 60 years, while annual crops have seen significant yield improvements. Beef production must compete with other commodities for land, labour and capital. As input costs (e.g. fuel) increase, yields must increase in order to maintain the per unit cost of production, otherwise the cost of producing forages increases compared to other commodities. Internationally, beef production must be competitively priced with other major exporting countries. Tame hay yields peaked in the 1980s but declined in the 1990s eliminating any advancements made and in fact by 2001/02 yields were the lowest on record, before rebounding back to 1950 levels over the last decade. Western Canadian hay yields are lower than in eastern Canada, which are lower than in the US. Therefore more acres are required to produce winter feed for each cow in western Canada. History would suggest that

3 Hay supplements dormant season grazing, by allowing cattle to stay on pasture longer even when there is inadequate nutrition available.

4 Yungblut & Associates Inc. June 2012. National Forage and Grassland Assessment. http://www.canadianfga.ca/wp-content/uploads/2011/04/V1-Final-June-2012-Report-National-Forage-and-Grassland-Assessment-formatted.pdf

5 Kosinski, Stephanie.2012. The Value of Alberta's Forage Industry: A Multi-Level Analysis. Government of Alberta and Alberta Forage Industry Network.

varieties are available that can achieve the yields seen in the 1980s and management is a key to getting back there.

Over the long term, improving forage productivity is crucial for future competitiveness of the cattle industry. While it may be more profitable for a producer to obtain hay or pasture from another source in the short term (i.e. buy land or purchase hay), reducing the per unit cost of production (COP) is required over the long term. Current competition for land from other crops is putting further pressure on the forage industry to increase margins or be converted into a more profitable commodity.

Applications of Forage Research

It has long been recognized that pasture and forage management can significantly influence **forage yield, quality, longevity of the stand** and **animal productivity**.

Recent research has also shed light on the **environmental impact** of pasture management. McCaughey (1997) measured methane (CH_4) production by steers grazing alfalfa/grass pastures and examined the effects of grazing management strategies (grazing system and stocking rate) on methane production. The results show that methane production was greatest for steers that continuously grazed at low stocking rates and least for steers that continuously grazed at high stocking rates. Methane production by rotationally grazed steers on heavily and lightly stocked pastures was intermediate between these two values and did not differ from either. However, when methane production measurements were compared on a per-kilogram of body weight basis, no differences were found between these grazing treatments. Iwaasa (2006) found methane production by grazing cattle is lower when forage productivity and digestibility are improved. Nitrous oxide losses did not appear to be affected by legume type, but were considerably lower than Intergovernmental Panel on Climate Change (IPCC) estimates. This highlights the importance of having local research completed on topics that are of international interest.

Iwaasa (2006) also assessed changes in soil organic carbon concentration in native range that has been grazed continuously (season long) or in a short-duration rotational manner, and to evaluate the potential greenhouse gas emissions from grazed forages. The results suggest that within reason, ranchers can use continuous and deferred grazing systems on native range without altering soil carbon sequestration.

The Goal of Forage Research

The goal of forage research for the beef industry is to decrease the per unit COP (defined as $/tonne of Relative Forage Quality), making producers more competitive whether they are using that forage to feed livestock or sell to other producers[6]. Becoming more competitive, productive and efficient in forage production will increase the resilience of the cow-calf sector. Decreasing the COP of forages contributes to the overall well-being of the cow-calf industry both directly (lower COP per pound of calf weaned) and, or indirectly (producers with both enterprises decrease COP elsewhere to become more competitive). Being able to produce more pounds of beef from a fixed land base is the most effective

[6] It is not the goal of beef industry research to maximize the profitability from forages. Maximizing profitability (revenue minus input costs) implies that the goal is not only to reduced costs but maximize revenue through promotion or marketing of a commodity to support revenue generated. That is not the purpose of beef research allocated to forages. BCRC is focused on research that supports the beef industry's overarching goal to maximize beef profits, but leaves beef promotion and marketing to other industry organizations (e.g. Canada Beef Inc.). In addition, the beef industry is focused on maximizing revenues from beef cattle while minimizing input costs from products like forage by supporting improvements in productivity, quality, and reduced inputs. By reducing input costs, if revenues are constant, margins or profitability are increased.

way to decrease COP, but it is not always possible on marginal or sensitive lands. These lands still benefit from a large grazing animal that support a healthy ecosystem function.

There are multiple applications for forage research. Management practices not only influence forage yields and consequently animal productivity; but also forage quality which determines the class of cattle that can consume the forage. Pasture management can also impact animal health, ensure long term sustainability of the grassland system, and influence the environmental impact of beef production. Pasture management can increase animal performance by managing the existing yield more effectively without requiring increased yield. Some of these practices can be quantified. Others cannot. There is also cross-over between forage and grassland productivity with other BCRC priority areas (e.g. Animal health and environmental impacts) that will not be addressed in this report.

The Economic Evaluation (Section 1) provides an understanding of how improved yields, persistence and quality from new varieties and appropriate management reduce the COP. For forage dependent operations, this can support long term sustainability and viability. This is evaluated by calculating the impact on forage and cow-calf COP from changing productivity. It is recognized that forage productivity varies widely across Canada, depending on soil and climate conditions. The goal is not to provide a model that reflects a single region, but a general trend.

Forage research areas and how they contribute to the overarching goal are summarized in Section 2. These research areas are grouped into two broad sections: (1) Stand Development (variety/plant breeding development, stand mixtures, and establishment); and (2) Forage management (quality, pasture management, weed control, and rejuvenation options).

1. ECONOMIC EVALUATION

Forage, whether summer pasture or winter feed, is the primary input for the cow-calf operation. Forage research is expected to lead to management strategies and varieties that reduce the per unit cost of producing forages, and ultimately the per unit cost of the calf.

Per Unit Cost of Production

In the beef industry there are two ways to look at costs. On a per cow basis or a per hundred weight of calf. The former has limited ability to inform management; while the latter takes into account both costs and the herd's productivity. This provides the total costs divided by total units of production. Therefore both production efficiency and economic efficiency are measured simultaneously with the per unit cost of production. The lower the per unit cost of production the higher the profit margin. The advantage is that it takes into account all production costs and all units of physical production.

How can this be applied to the forage sector? What is the unit of interest?

Feed for beef cattle can come from many sources. Which source a producer chooses depends on the per unit cost of relative feed value. As noted later in the Quality section a high quality forage can result in a cheaper ration. But low grain prices may mean that supplementing with concentrate provides the cheapest ration. A high yielding forge can actually take more input costs up front, but have a lower cost in terms of ***$/tonne of relative forage quality (RFQ)*** due to the much larger yield.

The per unit cost of production for forages = $/tonne of relative forage quality

$/tonne of RFQ = all input costs / yield of nutrients or forage quality

Therefore the per unit cost of production can be reduced by (1) increasing the units of output per unit of input (in other words increasing yield); (2) increasing quality; or (3) reducing input costs.

Due to limited data around forage quality the focus in the following analysis is on changes to yield. This does not mean that quality is not important. Quality and its impact on ration costs are discussed under Section 2 Forage management.

Getting the Bigger Picture

Cost of production should always account for opportunity costs (e.g. unpaid labour, market value of forage if sold versus fed to the cow herd), in addition to cash costs. Producers should know where profits are made on the operation (enterprise analysis) as well as the opportunity cost of retaining a commodity to add value by feeding, processing or transforming. When evaluating their entire operation, a producer will consider additional reasons for retaining a commodity.

For <u>feedlots</u> if money is being made in the silage enterprise, and lost feeding cattle, specializing in silage production is not desirable because the high water content of silage makes it a non-traded product. Supply of a critical input is one example of a reason to produce a commodity regardless of how competitive production is.

A <u>cow-calf</u> operation using **risk management** by diversifying the commodities grown on the operation will utilize the cycles within agricultural commodities knowing there will be times when grain production will be profitable and cattle production is not, and vice versa. Similarly, there will be times when money is made in the haying enterprise and times when beef production is profitable. Having multiple commodities on an operation can stabilize cash flow.

Hay, unlike silage, is a traded product with a market (although thinly traded). So why would a cow-calf producer continue producing hay if production costs are high and hay can be purchased cheaper? What happens in drought years when supplies are tight? What about when the hay available on the market is poor quality? What do these **supply** and **quality** uncertainties mean for a cow-calf producer?

From a business point of view, it is frequently recommended to specialize production where one is most competitive - is that a sustainable model in a volatile agricultural market? Diversification for risk management is a legitimate reason for keeping an enterprise that is only profitable 50% of the time, particularly if it is a required input for another enterprise.

Given these diversities, the analyses cited in this report may not apply to every operation.

There is a need for forage economists in Canada who understand the plant side of forage quality and can develop the economic models that will support the industry independent of beef economists who focus only on how forage as an input is utilized in calculating beef cost of production.

A. FORAGE COST OF PRODUCTION

The largest impact forage research can have on forage cost of production comes from increased yields. Yield improvements may come from new varieties, stand mixtures or changes in management. . The advantage to changes in management is that they can impact large acres of land now, and still have an effect while producers wait to re-seed. Adoption of new varieties while critical, has not only a long investment timeframe but just as long an adoption timeframe when producers are only re-seeding every 6-10 years. Improved longevity and drought resistance do result in small reductions in cost of production. However, research in these areas is more about relieving the short-term financial impact from needing to re-seed, purchase feed or sell animals. It should be noted that more forage does not necessarily support more beef production if the quality is low.

The COP for forage applies whether producers are using the forage on farm or if they are selling it. By reducing the COP of forage, the sector will be better situated to compete for acres. A strong forage sector that has multiple markets will be able to redirect production to the domestic market when impacted by drought.

The following analysis is based on a model with the following assumptions:

1. The cost of swathing, baling and hauling hay to the feed yard is $80/acre (includes land, labour and machinery costs)[7]
2. The cost of burn-off, breaking, re-seeding and taking the first crop is $240/acre
3. Yields are assumed to decline as a stand ages, with the first year crop being 33% higher than the average. Yields by year ten are half of the first year. Yield distributions are based on literature for grass/alfalfa mixes.
4. Scenarios are all run for 30 years with average yield, and per unit ($/tonne) costs presented.
5. The average yield is based on Statistics Canada national average. Obviously there are regions with higher yields than this, particularly if multiple cuts are possible within a single growing season. However, the overall principles are going to be similar.

The base case has six years before re-seeding with an average annual yield of 1.73 tonnes per acre over the 30 year scenario with an average cost of $59.82/acre. A number of scenarios were completed with changes in yield, re-seeding interval, drought resistance and fertilizer.

I. YIELD

Advancing yields through variety development has the largest impact but there is a diminishing return. Increasing average hay yields by 5%, 10%, 20% and 30% would reduce per unit costs by 5%, 9%, 17% and

[7] Agri-Profit$ Benchmark Analysis (http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/econ10237)

23% respectively. A 30% increase in yield results in the lowest per unit COP (see Table 1). It is noted that a greater yield per acre added time and machinery costs at harvest that are not included here. ***Canadian hay yields averaged 1.92 tons/acre from 2000-10, this is 26% below the average in the 1980s and 17.6% below the average in the 1990s. This suggests that increasing yield by 20-25% is possible.***

II. LONGEVITY

Re-seeding is sometimes required when the existing stand becomes unproductive to the point that re-seeding is the best alternative to restore production. The need to re-seed is usually associated with undesirable plant species composition, even though the tolerance for inadequate species is usually greater for pasture than hay or annual crops. Higher producing forages which are better adapted to warmer, moister regions are inherently short lived; while species adapted to lower productivity and harsher environments (particularly drought) are longer lived.

Table 1. Value of Forage Research Scenarios

Scenarios based on 30 year averages

	Production *tonnes/acre*	Cost *$/acre*	Per Unit Cost *$/tonne*
Base Case - 6 yr	1.73	112.00	59.82
Variety - Yield +5%	1.82	112.00	56.97
Variety - Yield +10%	1.90	112.00	54.38
Variety - Yield +20%	2.08	112.00	49.85
Variety - Yield +30%	**2.25**	**112.00**	**46.01**
Reseed more often - 4 year	1.81	120.00	63.40
Delayed Reseeding - 8 year	1.65	104.00	59.65
Delayed Reseeding - 10 year	1.53	96.00	60.97
Longevity - 10 year (5% better)	1.60	96.00	58.56
Drought Resistance	1.75	112.00	59.25
Fertilizer with Seeding	1.73	117.00	62.83

The decision to re-establish a field must balance the cost of establishment with the Net Present Value (NPV) of future income (yield times value) less the annual maintenance costs. Knowing that for every additional year in production, there will be less yield to spread the annual costs over.

Cost of Establishment = NPV of future income – annual maintenance costs

There are both productive and economic reasons to re-seed. In the harsh prairie environment the risk of establishing a successful forage stand is higher and producers are more reluctant to re-seed and more willing to accept a poor stand longer. In addition, breaking and re-seeding a hay stand represents a significant expense. While in a normal year costs consist of swathing, baling and hauling hay home, when re-seeding there is burn-off in the fall, breaking, seeding and rolling. Hence, production costs in a re-seeding year can be three times higher than a normal year. This creates an incentive to re-seed as little as possible. However, as a stand ages yields decline and per unit costs increase. There comes a point when re-seeding is a more profitable way to increase productivity and reduce per unit costs.

The 2006 Farm Environmental Management Survey (FEMS) showed that the dominant re-seeding interval was six to ten years in the prairie provinces. Most other regions typically re-seed every three to five years.[8] Within the prairie provinces, there is a trend towards longer intervals from moist to dry regions, with an increasing percentage of farms that do not re-seed at all (Ag Canada Grazing Livestock Management FEMS summary 2006). In any given region, longer re-seeding intervals may be associated with better grazing management which enables stands to persist longer.

[8] This questions was not asked in the 2011 Ag Census

Shortening the time between re-seeding from six year intervals to four, the average yield increased 4.6% to 1.81 tonnes/acre, but the average cost increased 6% to $63.40/acre (the highest per unit cost of all the scenarios). It is understandable that many producers delay re-seeding in order to minimize overall costs. By delaying re-seeding to every eight or ten years, average yields are lower (1.65 and 1.53 respectively). The average cost per acre drops slightly for the eight year scenario, but increases for the ten year scenario as lower yields result in higher per unit costs in the last two years.

If a variety had 5% greater yield in years two through ten, with delayed seeding (every 10 years), the average yield for the entire period would be 8% lower than the base case when re-seeding every six years. But per unit COP for the entire period would be 2% lower than the base case due to reduced seeding costs. By focusing on yield improvements, producers would be able to delay re-seeding and see minimal impact on average COP. ***However, cost cannot be the only consideration as lower yields have been shown to be strongly correlated with reduced animal performance and hence revenue.***

III. DROUGHT RESISTANCE

Most regions of Canada experience drought, but the southern regions of the Canadian Prairies and interior British Columbia are the most susceptible. During the past two centuries, at least 40 droughts have occurred in western Canada with multi-year episodes observed in the 1890s, 1910s, 1930s, 1960s, 1980s, and early 2000s. Rarely has drought been as serious or extensive as the recent 1999-2004 period. This event produced the worst drought in over one hundred years in parts of the Canadian Prairies. Well below normal precipitation was reported in areas of Alberta and Saskatchewan for more than four consecutive years from autumn 1999 to spring 2004.[9]

Drought reduces forage production, increases purchase prices, and increases transport costs. While rarely significant in a model over a long period of time, the immediate effects can be significant for an operation, particularly if cash flow requires animals to be sold to finance the purchase of feed for remaining animals. Alternatively, animals may need to be sold because feed is unavailable. This can interrupt a cattle cycle or result in the cattle cycle entering a liquidation phase with implications on longer term profitability. Even in locations with high precipitation and larger yields, drought can cut hay production in half. Hence, research into drought tolerant varieties that have a smaller reduction in yield during drought years is valuable to the beef industry. However, it should be noted that these drought tolerant species may be less productive in good/normal years. Given higher yields will have the largest impact on a producers' bottom line the detrimental impact from drought must be balanced with the need for higher productive forages over time.

IV. FERTILIZER

Research has indicated that fertilization can bring the productivity of a stand back to its original level without the expense of re-seeding. Table 1 (page 13) shows that per unit cost increases when fertilizer is used, because the additional value from the yield response is smaller than the cost of applying the fertilizer. However, even when fertilizer is applied at recommended rates, the target yields are often not achieved, making it a risky proposition (see Fertilization on page 38). ***The goal of fertilizing is to decrease the per unit COP. Higher yields do not necessarily translate into lower costs or increased profits.*** Only when the value of the additional production surpasses the cost of application does it reduce the per unit COP and increase margins. The profitability of fertilizing forage crops is highly

[9] http://en.wikipedia.org/wiki/Drought_in_Canada

variable and depends on the cost of the fertilizer and hay prices. As these factors change, so will the feasibility of fertilizing. Given the high fertilizer prices and poor margins in the cattle industry in recent years, many producers are hesitant to increase input costs.

Historically the economic benefit from fertilizing forages has been measured as the additional tonnage produced valued at either market value (regardless of quality) or the value to beef producers based on a nutrient feed test. However, this disregards that the input costs are spread over more tonnage reducing the per unit cost for all the tonnage produced and ultimately the margin.

Why do producers not fertilize forages?

- Fertilizer is too expensive. Higher costs of fuel mean that it is more cost efficient to have a higher yield off less acres than drive a tractor over more acres for less tonnage.
- *Myth:* It is only worthwhile in years of high forage/beef prices. Remember that Profit margin = revenue – per unit cost of production. The price of the output is not in question here. ***The goal of fertilizing is to increase margins by decreasing the per unit cost of producing hay,*** regardless of the price recieved (forage or beef). Therefore, if the benefits of fertilizer application are to be captured on grazed lands it is important to increase the stocking rate. Fertilizer has been shown to increase the number of animal grazing days (AUM) and total livestock production. But these benefits can be negated by trampling over time if the same number of head are simply left in a field longer.
- *Myth:* It is cheaper to buy more land. Buying more land leaves the per unit COP the same and therefore does not add to one’s margin or long term sustainability. As more marginal land is converted to annual crops and land prices increase, the productivity on land becomes more critical and one can actually invest more in that land to intensify production and increase revenues from the same land base by becoming more efficient with existing resources.
- It is cheaper to buy hay. To purchase hay cheaper than a producer’s COP implies that from the seller is either selling it below cost, or has a lower COP due to a higher yield (assuming input costs of land, labour and capital are the same). Also, knowing what it would cost to produce hay determines a reasonable purchase price.
- Yield response is dependent on rain, increasing risk of adding costs with little or no benefit. Particularly where yield response diminishes in regions were moisture is more limited. Yield response in cereal crops is also dependent on rain and they are fertilized even in low rainfall areas because producers know there will be a positive economic benefit from reduced per unit costs and therefore a larger margin on all bushels produced. There is the option of top dressing later in the season when rainfall is expected.
- In pastures with a legume component, it is assumed that nitrogen, and therefore fertilizer, is not needed? However, other nutrients (P and S) can have an impact on legume productivity and longevity.

Is there an economic benefit?

There are many ways to increase the tonnage of hay on operations. The question is which of those options provides a lower per unit COP? (1) fertilizing (2) investing in a new variety & re-seeding (3) renting or buying more acres to produce more hay (4) buying hay. It is a relative cost:benefit issue There is a cash flow component to all these answers that a producer must consider in addition to the agronomic factors.

Forage fertilization must compete economically with alternative sources such as rented or purchased pasture, purchasing hay or incorporating alfalfa in the seeding mix. However, buying more land leaves your per unit COP the same and therefore does not add to one’s margin or long term sustainability. As more marginal land is converted to annual crops and land prices increase, the productivity on land becomes more critical and you can actually invest more in that land to intensify production and increase revenues from the same land base by becoming more efficient with existing resources. Also, ***knowing your per unit COP on hay ($/tonne of RFQ)*** is key to determining at what price buying hay is a good deal.

Historical Review of Research

Numerous researchers in the past forty years have studied the effectiveness of fertilization on forage production. However, the variability in response means a well-developed yield response model is not available. Without standard yield responses, economic analyses in this area are lagging behind annual crops. Within the limited amount of economic analyses, there is no strong evidence for economic benefit of fertilizing forage crops, especially on grass-legume mixtures.

At Lacombe and Eckville, Alberta Malhi *et al.* (2002)[10] found that the economic optimum rates of nitrogen for pure bromegrass were much higher than the recommended rates. However, the application of nitrogen to bromegrass:alfalfa mixtures at rates greater than 50 kg/ha seldom produced an economic benefit. The application of nitrogen on pure alfalfa was not profitable under any situation.

Khakbazan (2009) showed that application of commercial fertilizer, the addition of alfalfa or another nitrogen-fixing legume in Manitoba increased forage yields from 1994-2004. While fertilizing grass-only or alfalfa-grass pastures to full soil test recommendations improved pasture productivity, it did not improve profitability compared to unfertilized pasture as the yield gain was not large enough to justify the expense.

The above studies were all on hay fields where the additional production was harvested. In pasture situations this is more difficult to measure. But to take advantage of additional forage production, stocking rates must be adjusted and gains monitored. Kopp *et al.* (2003) [11] discusses the cost-effectiveness of using fertilizer to improve meadow bromegrass pastures in Manitoba. The study showed that fertilization on meadow bromegrass pasture and incorporating alfalfa with fertilization both improved carrying capacity of the pasture. However, the two treatments entailed significant financial risk as they were only cost-effective when precipitation was not limiting.

The residual effect of fertilizer can last for three or more years after the year of application. Therefore, economic returns from forage fertilization need to be measured over a period of several years.[12] A five year study on Dark Brown Loam at Scott, Saskatchewan and a nine year study on a Gray Luvisolic loam at Loon Lake, Saskatchewan showed high profitability from annual applications of nitrogen on bromegrass when evaluating the discounted net present value (Zentner *et al.* 1989[13]). The study found that the financial optimum rate of nitrogen were generally higher than the recommended rate and producers were typically under-fertilizing their grass crop.

Maximize Profits & Minimize Costs

Using the yield data from the three studies[14] referenced above, where soil types are representative of the highest beef cow density and alfalfa/grass areas in Alberta and Saskatchewan, the following section simulates the economic impacts of fertilization and the optimum fertilization rates under different prices scenarios.

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[10] Malhi, S. S., R. P. Zentner, and K. Heier. "Effectiveness of alfalfa in reducing fertilizer N input for optimum forage yield, protein concentration, returns and energy performance of bromegrass-alfalfa mixtures." Nutrient Cycling in Agroecosystems 62.3 (2002): 219-227.

[11] Kopp, J. C., W. P. McCaughey, and K. M. Wittenberg. "Yield, quality and cost effectiveness of using fertilizer and/or alfalfa to improve meadow bromegrass pastures." Canadian journal of animal science 83.2 (2003): 291-298.

[12] Malhi, S. S., et al. "Fertilizer management of forage crops in the Canadian Great Plains." Recent Res Dev Crop Sci 1 (2004): 237-71.

[13] Zentner R.P et al. July 1989. "The Economics of Fertilizing Bromegrass in Saskatchewan" Can J. Plant Sci 69:841-859

[14] Malhi et al. (2002) "Effectiveness of alfalfa in reducing fertilizer N input for optimum forage yield, protein concentration, returns and energy performance of bromegrass-alfalfa mixtures."; Malhi et al. (1992) "Response of alfalfa hay yield to phosphorus fertilization in two soils in central alberta."; and Lkhagvasuren et al. (2011) "Plant and soil responses to nitrogen and phosphorus fertilization of bromegrass-dominated haylands in Saskatchewan, Canada."

The simulations showed that higher yields do not necessarily translate into lower costs or higher profits. The per unit costs of pure grass were generally higher than grass-legume mixtures – reflecting the yield data with pure grass having lower base yields than grass-legume mixtures and higher yield response to fertilizer. The application of nitrogen fertilizer usually brings higher profits to pure grass stands, but not necessarily to alfalfa-grass mixtures.

The optimum fertilization rates tended to be higher in poorer soil types. Optimum phosphorus fertilization rates for alfalfa in Thin Black Chernozem soil at 40 kg/ha are generally higher than in Black Chernozem soil at 20 kg/ha. However, optimum fertilization rates vary when a longer period is taken into account. Annual application of phosphorus fertilizer on alfalfa in Thin Black soil resulted in a negative margin with a higher per unit cost in the first year. However, when 40 kg/ha of phosphorus fertilizer is applied annually, the five year average yield provides the lowest COP.

Optimum fertilization rates are also affected by economic factors such as hay, fertilizer and land costs. Changes in hay and fertilizer prices had little impact on optimum nitrogen rates for the pure grass, 2:1 bromegrass-alfafa mixture or pure alfalfa stands in black and grey soil types. However, the optimum nitrogen rates are positively related to hay prices and negatively related to fertilizer prices on 1:1 bromegrass-alfafa and 1:2 bromegrass-alfalfa mixtures**.** When hay price increased from $60/tonne ($0.06/kg) to $100/tonne ($0.10/kg), the profit maximizing fertilizer rates for a 1:2 bromegrass-alfalfa 1:2 mixture in Lacombe, Alberta increased from 50-150 kg/ha to 150-200 kg/ha. Holding hay price constant at $80/tonne ($0.08/kg), the profit maximizing nitrogen rates decreased from 150 kg/ha to 100 kg/ha when nitrogen price exceed $120/tonne ($1.20/kg).

If hay is not traded and the focus is on cost minimization the land (base) cost is the main factor contributing to per unit COP. Land and fertilizer prices influence the optimum nitrogen rates for the bromegrass-alfalfa mix in Grey Luviso soil. When land costs increase, the cost minimizing nitrogen rate tends to be higher, indicating it will be more cost efficient to reach target production by increasing yield via fertilization than increasing grazing area when fertilizer is relatively cheaper.

When hay prices are high, producers should be willing to pay more for fertilizer**.** Lkhagvasuren *et al.* 2011, implied that the optimum fertilization rate (56 kg N/ha) is relatively steady despite changes in hay prices. However, as hay prices increase the fertilizer price at which the optimum fertilization rate increases to 112 kg N/ha does change. When hay price are $60/tonne ($0.06/kg), the optimum nitrogen rate for a grass-alfalfa mixture in Vanscoy, Saskatchewan increases from 56 kg/ha to 112 kg/ha only when nitrogen prices are below $1.00/kg. Over the past ten years nitrogen prices have averaged $1.07/kg (adjusted to actual nutrient value) with a range of $0.80-1.43/kg and averaged $1.34/kg in 2013. When hay prices are $100/tonne ($0.10/kg), the optimum nitrogen rate only increases when nitrogen prices are below $1.40/kg. In the cost minimization scenario, producers with higher base production costs will be more willing to pay higher fertilization prices.

B. IMPLICATIONS OF FORAGE PRODUCTIVITY ON COW-CALF COP

While an enterprise analysis of a cow-calf operation would value hay at market value, most producers in Canada continue to produce the majority of their winter feed. Therefore, a lower cost of producing hay is expected to reduce winter feeding costs for the cow-calf operation and ultimately the per unit cost of producing a calf. It is recognized that the methodology recommended for beef producers calculating cost of production is to still use the market value of hay. However, the following analysis provides a greater understanding of the relationship between forage COP and cow/calf COP based on the cash costs which still drive many production decisions.

When forage yields were increased by 30%, reducing dependence on purchased feed and then expanding the cow herd. The long term COP (including depreciation) declined by 11-15% depending on the amount of hay in the winter ration, days on feed and the proportion of feed that is purchased versus homegrown. Many production decisions are based on cash costs. By decreasing dependence on purchased feed cash expenditures are replaced with the cost of producing hay on farm (accounting for the opportunity cost of labour and machinery costs). Consequently cash costs were reduced by 10-15% with 30% higher yields.

When herd size was held constant and land use changed into the most profitable cash crop, feed costs were reduced between 3-10% and cash costs were reduced between 2-6%. Due to the small changes in land use, the overall farm profitability did not change significantly. However, this could still be a factor in long term decision making.

agri benchmark is a global, non-profit and non-political network of agricultural economists, advisors, producers, multi-disciplined farm experts and specialists. They provide a consistent methodology to compare production systems, COP and profitability around the world. This is a challenge given the wide variety of different production practices, such as grain-finished versus grass-finished beef calves that range from less than two years to over four years to reach finished weight.

In 2012, Canfax Research Services collected Canadian data and applied it to the methodology developed by *agri benchmark.* Two sizes of 'typical' cow-calf operations were developed (200 and 800 head operations) and evaluated for Alberta and Saskatchewan. These operations incorporated data from 16 cow-calf producers in the two provinces for the 2011 production year[15]; 3-5 producers from each operation size and province contributed to each 'typical' farm developed for the analysis. While the sample size was admittedly small, the repetition of data submitted and consensus process of the panel discussions created a range in the data that reflected the range in production practices over the two provinces.

The *agri benchmark* farm model allows us to examine how changes in hay yield impact per unit COP on a cow-calf operation. Hay yields were increased by 5%, 10%, 20% and 30%. With 25% excess pasture available on each farm[16], larger hay production allowed for additional cow numbers. In some instances, the proportion of purchased feed was reduced before expanding the herd; these operations have the opportunity to expand and increase their dependence on purchased feed, however, that leaves the per unit COP unchanged with no improved ability to compete for acres against cash crops.

There is substantial variety in winter feeding conditions across Western Canada. Days on feed varied from 135 to 210 days depending on location; more southern locations had fewer days on feed. Access to different feeding options (i.e. swath grazing) are weather related, and dependent on snow cover in some locations. ***The results vary for each farm depending on the amount of hay in the winter feed ration, days on feed, as well as the proportion of feed that is purchased versus homegrown***.

200 AB – located in the irrigation region of central Alberta. The winter feeding ration included swath grazing in the fall followed by 120 days on 33 lbs/day of silage then 33 lbs/day of hay for 60 days for a total feeding period of 180 days. There was no mineral supplement. Labour and machinery costs were divided between the two enterprises of cow-calf and cropping based on profitability of each sector.

The base yield on this farm (3.5 tonnes per hectare or 1.43 tonnes/acre) was higher than the other farms due to irrigation, with 100% of feed grown on the farm. This meant each incremental increase in

[15] This is a point in time with costs varying from year to year in each country. However, as a general trend for comparison this does provide a snapshot for comparison.

[16] The Canadian beef cow herd declined by 26% from 2006 to 2014 (Statistics Canada). The Agriculture Census shows that 400,000 acres of tame pasture, 1.8 million acres of native pasture, and 2.75 million acres of tame hay were converted to other land uses (e.g. annual crops, city expansion) between 2006 and 2011 (4.9 million acres in all).

yield allowed it to increase carrying capacity. Increasing hay yields allowed the herd to grow by 40-95 head (20-48%) and reduced long term COP (including depreciation) by 7-15%.

200 SK – a mixed (cow-calf and grain) farm in Northern Saskatchewan. Feeding alternatives include silage and swath grazing when weather permits. Typical ration is swath grazing for one month in the fall followed by 35 lbs/day of hay (95% homegrown) with 2 lbs of barley/pellets (60% purchased) for 180 days followed by 35 lbs/day of silage for 30 days during calving (100% homegrown), for a total feeding period of 210 days with mineral supplement of 1.5 oz/day year round.

As yields increased, dependence on purchased hay was reduced before the herd was expanded. Expansion occurred after yields increased 10% and increased by 5-45 head (2-23%) reducing long term COP (including depreciation) by 1-15%.

Table 2. Herd Changes with Yield Increases				
Forage Yield	**200 AB**	**200 SK**	**800 AB**	**800 SK**
Control	200	200	800	800
+5%	240	200	800	840
+10%	250	205	800	880
+20%	270	220	855	930
+30%	295	245	900	980
	% change in Herd Size from control			
+5%	20%	0%	0%	5%
+10%	25%	2%	0%	10%
+20%	35%	10%	7%	16%
+30%	48%	23%	13%	23%

800 AB – located in central Alberta along the Rocky Mountains. This region has access to mountain range for summer grazing, but has limited alternative winter feeding options due to snow conditions (i.e. no swath grazing, etc.). A winter feed ration included 26 lbs/day of hay supplemented with 3 lbs/day of greenfeed or pellets for 180 days. Located in the hay belt, this operation grows 78% of their hay and purchases the other 22% along with mineral supplement of 1 oz/day for the feeding period of 180 days. Pressure from urban expansion keeps land prices high.

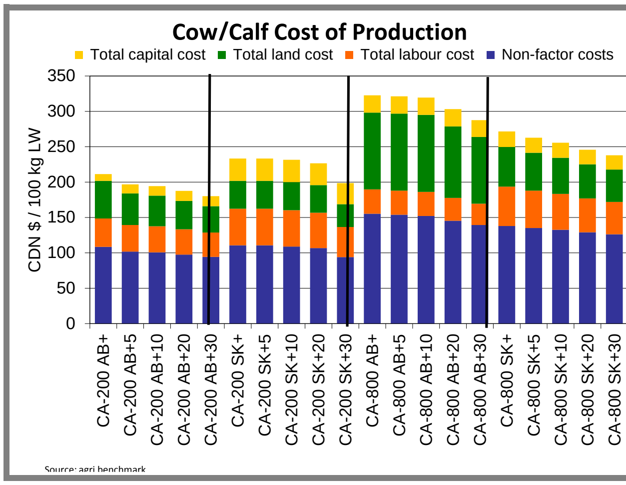
Higher hay yields initially reduced dependence on purchased hay. A 10% increase in hay yield made this operation 100% homegrown, but did not allow for expansion of the herd. At 20% and 30% increases in yield, the herd was able to expand by 55-100 head (7-13%) and reduced long term COP (including depreciation) by 6-11%

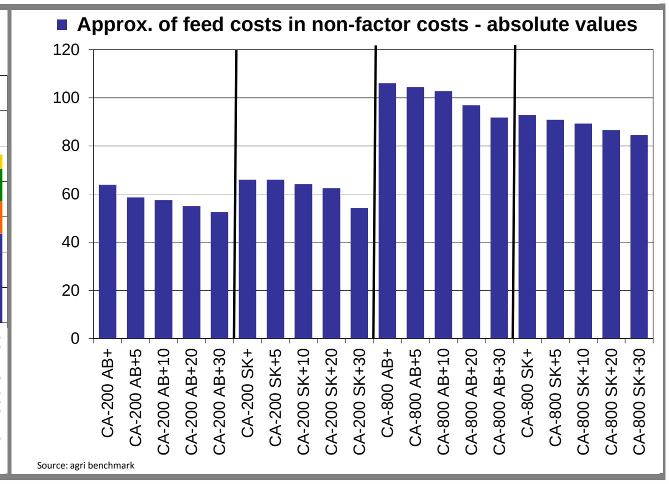
800 SK – located in west-central Saskatchewan a mixed grain and beef farm with stubble grazing in the fall followed by 4.5 months (135 days) on 15 lbs/day hay (20% purchased, 80% homegrown), 6 lbs/day barley/pellets (100% purchased), and 1 oz/day mineral during the feeding period. Yield increases allowed this farm to add 40-180 cows (5-23%) and reduced long term COP (including depreciation) by 3-12%.

Table 3. Long term costs incl. depreciation					Cash Costs Only ($/100 kg LW)				
Forage Yield	**200 AB**	**200 SK**	**800 AB**	**800 SK**		**200 AB**	**200 SK**	**800 AB**	**800 SK**
Control	211	233	323	272	Control	116	101	226	167
+5%	197	233	321	263	+5%	111	101	224	163
+10%	194	231	319	256	+10%	110	99	223	159
+20%	187	227	303	246	+20%	106	97	211	154
+30%	180	198	288	238	+30%	103	86	201	150
	% change in LT costs from control					**% change in cash costs from control**			
+5%	-7%	0%	-1%	-3%	+5%	-5%	0%	-1%	-3%
+10%	-8%	-1%	-1%	-6%	+10%	-5%	-2%	-1%	-5%
+20%	-11%	-3%	-6%	-10%	+20%	-8%	-4%	-7%	-8%
+30%	-15%	-15%	-11%	-12%	+30%	-12%	-15%	-11%	-10%

When forage yields were increased by 30%, reducing dependence on purchased feed and then expanding the cow herd (there is excess summer pasture available). ***The long term COP (including***

depreciation) declined by 11-15% depending on the amount of hay in the winter ration, days on feed and the proportion of feed that is purchased versus homegrown. Many production decisions are based on cash costs. By decreasing dependence on purchased feed cash expenditures are replaced with the cost of producing hay on farm (accounting for the opportunity cost of labour and machinery costs). ***Consequently cash costs were reduced by 10-15% with 30% higher yields*** (see Table 3).





Feed costs in absolute values declined on all operations with increased yields (see chart). Despite the differences in base yields, percentage homegrown hay and therefore the amount of expansion that could take place, feed costs on both the 200 AB and 200 SK farm declined by 18% when yields were increased by 30%. The majority of the change on the 200 SK farm occurred in the change from a 20% yield increase to a 30% increase; while the 200 AB farm saw costs incrementally decline with each yield improvement.

The 800 AB and 800 SK farms also saw incremental declines in feed costs as herd size increased; however neither of the larger farms saw an 18% decline in costs like the smaller 200 head operations. This could be because of the lower reliance on hay in the ration at 15-26 lbs per day with more concentrates (barley or pellets) compared to 33-35 lbs per day on the smaller farms.

Silage vs. Hay

The two smaller farms have notably lower COP compared to the larger farms that should have the advantage of economies of scale. One of the major differences between these small and large farms is the use of silage on the smaller operations. Even though, input costs are higher the significantly larger yield (particularly on irrigated acres) results in a lower forage COP and consequently calf COP. Even the 200 SK farm with only 30 days on silage during calving has an advantage over the larger farms using hay, greenfeed, pellets or concentrate in their rations. For more on the limitations and advantages of silage versus hay see page 30.

Changing Land Use

While the price signal is there to expand the national herd, many producers are looking at other commodities that have brought a greater return to land, labour and capital in recent years, primarily grain. In order for cow-calf production to expand, producers need to be attracted by competitive margins and forages must compete with other crops for acres. Stronger prices for certain field crops have made the move to annual crops an attractive option over the past five years. As the cattle industry is currently at the bottom of the cattle cycle and is expected to expand, a sufficient and high-quality forage supply at a competitive cost will be increasingly critical to the profitability and sustainability of the cattle industry. While extended grazing practices have changed over the past ten years, weather (temperature, wind, snow crust and depth) dictates that winter feeding is required in most locations across the country for at least a portion of the year.

Increased forage productivity can make more land available to be converted to cash crops, supporting whole farm income although not necessarily changing per unit COP for the cow-calf enterprise. As hay yields increased, the dependence on purchased hay was kept relatively constant by changing land use to the cash crop with the highest price grown in the region.

- The **200 AB farm** was able to increase canola acres by reducing the acres of land used for feed production by 4%. This reduced the feed costs by 4%, but cash costs only decreased by 2%.
- On the **200 SK farm** there were no cash crops in the base scenario, but additional acres of barley for sale were added (3%). This reduced feed costs by 10% but cash costs by only 6%.
- The **800 AB farm** was able to reduce the acres of land used for feed by 3%. This reduced feed costs by 7% but cash costs by only 4%.
- On the **800 SK farm** there were no cash crops in the base scenario, but additional acres of barley for sale were added. This reduced feed costs by 3%, but cash costs by only 2%.

Feed costs were reduced between 3-10% and cash costs were reduced between 2-6%. Due to the small changes in land use, the overall farm profitability did not change significantly. However, this could still be a factor in long term decision making.

2. FORAGE RESEARCH AREAS

Forages provide nutrients for cattle. There are multiple ways to reduce the per unit cost of producing forages:

1. Increase productivity – through improved yield, drought resistance, and longevity
2. Increase quality – through weed control, stand mixture, and management so that less forage is needed to meet the nutritional needs of the cow
3. Reduce input costs – by finding cheaper ways to re-seed and harvest forages

Forage research focuses on two main areas:

A. Developing a Stand - variety development, stand mixtures and establishment
B. Forage management - forage quality, pasture management, weed control, and rejuvenation options

Forage and pasture establishment starts with choosing a variety and stand mixture appropriate to the region and intended management practices. Different management practices can optimize forage quality, productivity, animal health, longevity, and environmental indicators. Management of time grazing/cutting to maximize forage quality while maintaining plant health may harvest more *pounds of protein per acre*.[17] Management practices will vary across Canada with soil, species, and climatic conditions. This makes regional research and extension critical to ensure management recommendations and environmental impact estimates are regionally appropriate.

While forage research has historically focused on production aspects such as grazing management and fertilizer use; recent studies have shed light on environmental impact and species selection. This social conversation highlights the importance of beef producers as stewards of the land which provides valuable ecosystem services in terms of biodiversity, water filtration, and wildlife habitat. How beef production supports healthy ecosystem function, while outside of the scope of this review, involves many inter-related topics including how forage management works within a complex ecosystem.

A. DEVELOPING A STAND

I. VARIETY DEVELOPMENT

As seen above improve yield and yield stability (i.e. drought resistance, stand longevity) have the largest impact on forage COP. Developing high-yielding forage varieties is critical to remaining competitive with other commodities as competition for land pressures producers to convert forage acres into annual crops. Variety development (plant breeding) can take many years and must be suited to the regional soil and climate conditions. Cross regional breeder collaborations provide the opportunity to test varieties that have failed in one region to be tested and potentially adopted in another; maximizing the knowledge gained from these breeding investments. However, adopting varieties that have been produced elsewhere in the world may not necessarily sustain forage production in Canada.

Over the long term, improving forage productivity is crucial for future competitiveness of the cattle industry. While it may be more profitable for a producer to obtain hay or pasture from another source in the short term (buy land or purchase hay), reducing the per unit COP is required (through improvements in yield and quality). Current competition for land from other crops is putting further

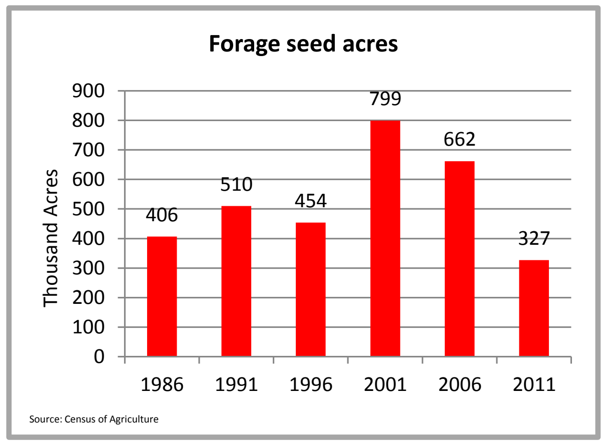
[17] Saskatchewan Agriculture. Rejuvenation of Tame Forages. http://www.agriculture.gov.sk.ca/Default.aspx?DN=f58e4b48-b268-4da1-9ac2-961f01b252a8

pressure on the forage industry to increase margins or be converted into a more profitable commodity. This makes forage breeding a key piece to the long term health of the beef industry.

Forage breeding is a long term investment. It can take up to ten years to develop a market ready variety. Continual investment in breeding programs can provide a rich source of new varieties suited to the local environment with incremental improvements in yield, longevity, disease and drought resistance. This requires (1) an ongoing investment in research capacity (both human capital and infrastructure) with varieties developed for the different Canadian soils and climate conditions; (2) Collaboration among regional breeding programs to identify varieties that perform well in other environments; and (3) a regulatory system that supports registration and commercialization of new varieties.

Maintenance of a regional testing system with at least major regions represented is important to support adoption as it provides producers with an indication of how varieties will perform in their area. Collaboration by breeders to test each other's varieties is a part of this, but there are more regions than breeders currently in Canada. Therefore, additional testing sights are required.

Having a new variety available is only step one. Seed must also be propagated for commercial use. This can be a bottleneck in the system if there are not enough registered growers willing to do this, in which case the investment in breeding never results in varieties that are available to producers. Forage seed acres have declined from close to 800,000 acres in 2001 to 326,500 acres in 2011. This is below the 1986-1996 average of 457,000 acres. While historically forage seed acres have represented 3-4% of total forage acres, they are now under 2%.



Finally, new forage varieties must be adopted by industry. This is a question of tech transfer and a variety gaining a reputation of performing well under typical production systems. Connecting breeding programs with forage specialists to provide seed recommendations can provide breeders with valuable feedback on what characteristics producers are looking for in their region, and what the most popular variety is.

The return on this investment takes equally long when longer periods between re-seeding are considered. Adoption of new varieties in some regions can take decades.

II. STAND MIXTURES

Establishing new pastures can be expensive and producers often prioritize stand life over yield. Seeding complex mixtures of grasses and legumes that maintain highly diverse botanical composition in pastures can contribute to increased persistence, yield stability and improved productivity. Yields benefit from including highly productive as well as drought-tolerant species. While some species will not persist beyond the first three or four years, other species in the mix can fill in the gap to maintain overall yields, to a degree.

Schellenberg (2013) [18] assessed the productivity and crude protein content of forage stands to determine if species show complementarity in Swift Current, Saskatchewan. The fast growing and highly competitive species dominated biomass production in the early establishment phase. Including less

[18] Schellenberg, Michael P. 2013. http://www.beefresearch.ca/factsheet.cfm/drought-tolerant-forage-mixtures-55

productive species in the forage sward had minimal impact on pasture productivity or nutritional value under good growing conditions. However, less productive species should be included in pasture mixes when they bring beneficial traits (i.e. increasing nitrogen availability, drought resistance) to the forage stand that provide 'insurance' for less optimal years.

There is a wide range of grasses and legumes available. Each species has its own particular plant and seed characteristics that make it more or less suitable for a producer's purpose. Thus, selecting or formulating a seed mix is as critical as selecting the best variety.

Many factors have to be taken into account when making a forage selection. Stand mixtures should be appropriate for the soil, acclimatized to the region, able to withstand management intentions and pressures (haying/grazing). It is necessary to match forage species to the characteristics of the soil, considering characteristics such as drainage, fertility, and pH. Soil maps and information that describe the limitations of a particular soil are helpful, especially with land the producer has not previously farmed.

How the forage will be managed (for haying or grazing) and how intensively will also influence the stand mixture decision.[19] McCartney *et al.* (2004)[20] evaluated how eight tame grass species[21] respond to different management systems in northeast Saskatchewan. Meadow bromegrass showed the most uniform seasonal distribution of yield among the high-yielding grasses under all management systems, offering the most late season yield. It also had the lowest protein concentrations throughout the growing season, making it the most suitable for grazing cattle as their protein requirements are low. Crested wheatgrass had significantly more first cut production than all other grasses, making it ideal for early spring grazing allowing producers to stop expensive winter feeding. The high yield of green needlegrass under multiple harvests suggests good potential for pasture use.

Yousef Papadopoulos (2013)[22] conducted a study on forage seed mixtures for different regions of Canada in order to determine the best combination of a single grass species with one legume species (white clover, birdsfoot trefoil, or grazing-type alfalfa), and to compare four grass mixtures combined with two forage legumes (trefoil and grazing-type alfalfa) that form a set of 12 distinct mixtures. Results from the first two years indicate that mixture selection can be used to optimize the energy:protein ratio with forage yield and animal gain. However, results to date have not identified complex mixtures that simultaneously provide high yield, nutritive value, and animal performance. This trial will be continued for five more years to gather additional yield, nutrient content and grazing performance data as the pasture compositions stabilize.

A mixture of a grass and an inoculated legume can be advantageous over a pure grass or legume stand for the following reasons:

1. Eliminates the need for nitrogen fertilizer on pure grass stands because the legume in the mixture will provide nitrogen for grass growth.

[19] http://www.agry.purdue.edu/ext/forages/publications/ay253.htm
[20] McCartney, D. H., Bittman, S. and Nuttall, W. F. 2004. The influence of harvest management and fertilizer application on seasonal yield, crude protein concentration and N offtake of grasses in northeast Saskatchewan. Can. J. Plant Sci. 84: 205–212. http://www1.foragebeef.ca/$foragebeef/frgebeef.nsf/all/frg90/$FILE/harvestfertilizersofftake.pdf
[21] The grasses used in this study were Altai wildrye [Leymus angustus (Trin.) Pilger], creeping red fescue (Festuca rubra L. var. rubra), meadow bromegrass [Bromus riparius (Rehmann)], Russian wildrye [Psathyrostachys juncea (Fisch.) Nevski], smooth bromegrass (Bromus inermis Leyss.), crested wheatgrass (Agropyron cristatum L. Gaertn.), intermediate wheatgrass [Elytrigia intermedia (Host) Nevski] and green needlegrass [Nassella viridula (Trin.) Barkworth].
[22] Papadopoulos, Yousef. 2013. http://www.beefresearch.ca/factsheet.cfm/forage-seed-mixtures-for-different-regions-of-canada-108

2. Lengthens the life of the pasture or hayland because the grass will remain after the legume stand is reduced. If desired, a legume can be reintroduced by pasture renovation.
3. Reduces the problem of legumes "heaving", in which legumes are raised from the soil surface by freeze-thaw action in the late winter and early spring, resulting in plant damage. The grasses hold the legume plants in place.
4. Reduces soil erosion on steep slopes. Grasses have a more massive root system and are better for soil conservation purposes than pure legume stands.
5. Improves livestock performance. A grass-legume mixture can improve animal gain and cattle breeding performance over a pure grass stand. A grass mixture can also reduce animal performance problems associated with bloating on alfalfa.

To get N fixation from a legume, the legume seed must be inoculated. Inoculants are currently very hard to source, which may be discouraging re-seeding of alfalfa-grass mix hayfields at historic levels.

A pure grass stand or a pure legume stand can be advantageous over a grass-legume mixture for the following reasons:

1. Eases the management associated with trying to keep all species in a mixture competitive.
2. Increases the number of herbicides that can be used for weed control. Weed control options are more limited with a grass-legume mixture.
3. Forage quality. A pure legume stand is usually higher in forage quality than a pure grass stand or a grass-legume mixture.

III. ESTABLISHMENT

The risks associated with re-seeding have already been noted (see Longevity). In dry regions where establishment of a forage stand is highly variable, producers are more reluctant to re-seed and more willing to accept a poor stand for a longer period of time. Increasing the success rate of establishment through innovation is less expensive re-seeding methods and higher germination rates can assist in decreasing the COP associated with low yielding stands.

Re-seeding a forage stand typically includes herbicide burn-off in the fall, breaking, seeding and rolling, but there are alternative methods that can reduce re-seeding costs.

Frost seeding or overseeding legumes and grasses can be used as a means to improve pasture yields or change forage species composition within the pasture. Frost seeding is simply broadcasting legume or grass seed on existing pastures in late winter or very early spring when the ground is still frozen. Freezing, thawing and early spring rain provides the only seed cover.

Frost seeding offers several potential advantages including: (1) the ability to establish forage in an undisturbed sod; (2) a reduced need for labor and energy compared to conventional seeding methods; (3) the ability to establish forages with minimum equipment investment; (4) a shortened "non-grazing" period; and (5) maintenance of stands at productive levels with both grasses and legumes.[23]

Regardless of how re-seeding takes place, the keys to success include: (1) seed-soil contact, (2) low plant competition for new seedlings, (3) species selection and seeding rates, and (4) seeding time and method.

[23] http://www.uwex.edu/ces/crops/frostsd.htm

B. FORAGE MANAGEMENT

Management decisions affect **forage quality, quantity and longevity**. These in turn, impact **animal performance** and consequently the cost of producing a pound of weaned calf. Increasing forage yields back to levels seen historically is a realistic goal, as the performance in the past indicates that there are varieties available to reach these levels with management. The question is what management practices have changed. Forage research has proven to have many interconnected variables. This complex system does not always provide straightforward answers.

I. FORAGE QUALITY

Matching forage quality to animal needs is part of cattle management as nutrient requirements of cattle change throughout the year based on the stage of the production cycle. When feed grain prices are high, a high-quality forage can provide a lower cost ration than a low quality forage supplemented with a concentrate. Failing to provide all the nutrition a cow needs due to low quality forage can have animal health and performance consequences that directly impact COP (e.g. loss of body condition, dystocia, lower milk production, and delayed returning to estrous). This can be largely avoided by feed testing, particularly when hay is of an unknown quality.

Forage quality is determined by the stage cut, fertilization and grazing intensity.

Forage quality refers to the plant's ability to provide digestible, absorbable, essential nutrients at levels that meet the animals physiologic needs. Forage quality is a function of voluntary intake and nutritive value (nutrient content and digestibility).[24] Forage quality is typically determined by crude protein (CP), neutral detergent fiber (NDP), and acid detergent fiber (ADF) (Kerley 2004).[25]

Proteins and energy are the most essential nutrients in cattle's diet. Crude protein (CP); calculated from total nitrogen content, is an important indicator of the total protein content in a forage crop. A higher CP level typically indicates higher forage quality, but it is not the ultimate measure. In fact, the energy value of forage is often the most limiting attribute for meeting an animal's requirements in most forage-based feeding.[26] However, energy content (usually expressed as Total Digestible Nutrients; TDN) is more difficult to measure and depends on the digestibility of various chemical fractions of forage. The most common method of predicting forage energy content is based on amount of fiber (Newman et al. 2009).[27]

Neutral detergent fiber (NDF) and acid detergent fiber (ADF) are measures of the fiber in forage and are both negatively related to forage quality. NDF measures the amount of cellulose, hemi-cellulose, lignin and insoluble ash in a plant and provides an indication of the potential voluntary intake of the animal. As the NDF increases, animals will be able to consume less forage. ADF measures the amount of cellulose, lignin and insoluble ash and is a good indicator of digestibility and thus energy intake. As ADF increases, digestible energy levels decrease.[28]

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[24] Saha, Uttam. *et al*. 2010. Common terms used in animal feeding and nutrition. The University of Georgia Cooperative Extension. http://athenaeum.libs.uga.edu/bitstream/handle/10724/12196/B1367.pdf?sequence=1

[25] Kerley, Monty S. 2004. Matching Forage Quality with Production http://livestocktrail.illinois.edu/pasturenet/paperDisplay.cfm?ContentID=6620

[26] Saha, Uttam. *et al*. 2010. Common terms used in animal feeding and nutrition. The University of Georgia Cooperative Extension. http://athenaeum.libs.uga.edu/bitstream/handle/10724/12196/B1367.pdf?sequence=1

[27] Newman, Yoana C., Barry Lambert, and James P. Muir. 2009. Defining Forage Quality. SS-AGR-322. University of Florida IFAS Extension. http://edis.ifas.ufl.edu/ag332

[28] Saha, Uttam. *et al*. 2010. Common terms used in animal feeding and nutrition. The University of Georgia Cooperative Extension. http://athenaeum.libs.uga.edu/bitstream/handle/10724/12196/B1367.pdf?sequence=1

The Importance of Forage Quality

Forage quality has direct effects on animal performance and, ultimately, profitability. A common belief is that cows can simply eat more low quality forage to meet their energy demands. This is not true in most cases since the higher fiber content in low-quality forage decreases voluntary intake.[29] Forage with low protein content (7% or less), high acid detergent fiber (ADF) and neutral detergent fiber (NDF) cannot meet the nutritional needs of many, if any, classes of livestock without supplementation. Sometimes making hay of this quality cannot be avoided due to weather, but often times it can through proper management, as outlined below. In contrast, feeding high quality forage typically means no supplementation is needed other than minerals to meet nutrient requirements for most cattle. Harvesting and feeding high quality forage, may avoid many programs (e.g. loss of body condition, dystocia, lower milk production, and delayed returning estrous) that are hard to economically quantify.

Factors Affecting Forage Quality

Forage quality varies among different species. Legumes generally produce higher quality forage than grasses as they usually have less fiber and favor higher intake than grasses.[30] A study conducted by Kopp et al. (2003) in Manitoba shows that alfalfa-meadow bromegrass pastures often had higher CP than grass-only pastures during the experiment period. On average, alfalfa-grass mixture has 13.3% CP in the first cut compared to 8.3% in pure grass. The alfalfa-grass mixture also has lower NDF and ADF levels compared to pure grass which is important to maximize voluntary forage intake by grazing animals. Studies also show that cool-season species are generally higher in quality than warm-season grasses; while annual grasses are often higher in quality than perennials (Collins *et al*. 2001).

Maturity at harvest is one of the most important factors determining forage quality of a given species. As one would expect, quality values were highest while the forage was young and declined as it matured. Studies show that cool season grasses often have dry matter digestibility above 80% during the first two to three weeks after growth initiation in spring. Thereafter, digestibility declines by one-third to one-half percentage units per day until it reaches a level below 50% (Collins *et al*. 2001).[31] A one week delay in harvesting alfalfa (*Medicago sativa L.*) decreased digestibility and crude protein concentration by 2% and increased cell-wall concentration by 3% (Buxton, 1996).[32] Similar results were also found in studies conducted in eastern Canada on cereal forages.

Table 4. Cereal forage quality (2 year average from New Liskeard)

Oats			Barley			Oats + Peas			Barley + Peas		
CP *	ADF ǂ	NDF ◊	CP	ADF	NDF	CP	ADF	NDF	CP	ADF	NDF
16.4	35.2	53.7	16.6	35.5	56.1	18.2	37.2	52.6	18.6	36.4	53.3
13.5	40.9	60.1	13.3	39.8	61	15.4	41	57.7	15.9	38.9	57.5
10.1	43.5	61.2	10	40.1	58.8	12.2	42.1	57.8	14	38.7	54.3
8.4	43.3	62.4	6.9	45.8	68.8	10.3	43.5	59.8	11.3	42.5	60.3

*Crude protein as a percent of dry matter, ǂ ADF as a percent of dry matter, ◊ NDF as a percent of dry matter
Source: Ontario Agriculture, Fact Sheet: Forage Production from Spring Cereals and Cereal-Pea Mixtures [33]

[29] Saskatchewan Agriculture. 2012. Forage Quality. http://www.agriculture.gov.sk.ca/Default.aspx?DN=c81b8c84-8abc-4685-8efb-cbc9c593bd4e
[30] Collins, Mike, et al. 2001. Understanding Forage Quality. Park Ridge, IL: American Farm Bureau Federation.
[31] Collins, Mike, et al. 2001. Understanding Forage Quality. Park Ridge, IL: American Farm Bureau Federation
[32] Buxton, Dwayne R. 1996. Quality-related characteristics of forages as influenced by plant environment and agronomic factors. Animal Feed Science and Technology 59(1):37-49.
[33] *http://www.omafra.gov.on.ca/english/crops/facts/98-041.htm#harvest*

Table 4 shows how ADF and NDF increase as crude protein decreases. ***Therefore, timely harvest of forage is critical to maintain high quality feeds.*** Waiting until tonnage increases, to harvest more hay per acre, may result in low quality feed that does not meet livestock's nutritional needs. To meet nutrient requirements of these animals, a concentrate supplement should be fed. Other factors affecting forage quality include harvest and storage condition, fertilization, and weather.

Forage Quality & Ration costs

Matching forage quality to animal needs is also an important aspect of cattle management as nutrient requirements of cattle change throughout the year based on the stage of the production cycle. For example, the average cow requires 55% TDN and 7% CP during mid-pregnancy, 60% TDN and 9% CP during late pregnancy and 65% TDN and 11% CP after calving. If the cow's diet is completely made up of forage, her energy requirement must be met by the forage as well.[34]

Forage quality affects the nutrient content of the diet and ultimately feeding costs. Table 5 shows results from a study (R.E. James 2013) using good and poor quality corn silage and how it impacted ration costs. Good quality corn silage resulted in less corn, barley and concentrate required and ultimately a lower cost ration. There will be times when feed grain is cheap compared to good quality forage and it will be desirable to increase the amount of concentrate in the diet while using a poor quality forage. But growing good quality forage can eliminate the need to supplement is some situations.

Table 5. Rations and Costs with High and Poor-quality Corn Silage

Feed	As fed lb.		DM lb.		NEI%		CP%		NDF%		Cost/ton $	
	GQ*	PQ*	GQ	PQ	GQ	PQ	GQ	PQ	GQ	PQ	GQ	PQ
Barley straw	0.5	1.0	0.45	0.9	0.55	0.55	4.4	4.4	71	71	100	100
Corn silage	**75**	**56**	**26.8**	**12.9**	**0.75**	**0.60**	**7.5**	**9.6**	**38.5**	**57.5**	**65**	**60**
Small grain silage	9	32	2.48	11.1	0.66	0.69	11	7.2	62.8	52.5	50	50
Brewer grain	14	14	4.2	4.2	0.7		32.8		44.1		88	
Ground corn	2	6.5	1.8	5.7	0.91		9.3		9.5		200	
Ground barley	3	6.5	2.6	5.7	0.88		12.9		18.9		150	
Concentrate mix	13.5	17	12.4	15.7	0.81	0.81	32.4	23	15.2	23	396	380
Total			50.6	56	38.9	40	16.2	15	32.7	37	**$6.40**	**$7.74**

* GQ= Good Quality; PQ = Poor Quality
DM=Dry Matter, NEI = Net Energy Intake, CP=Crude protein, NDF= Neutral detergent fiber[35]

Measuring Forage Quality

A sound theoretical definition for forage or feed quality is animal performance. Voluntary intake and nutrient digestibility have been used to form indices of forage quality, and most feeding standards and models are based on the assumption that animal performance is related closely to intake of available nutrients. Due to variation in measurements of intake, digestibility, and animal performance, however, relationships used to develop prediction equations for animal performance from intake and digestibility are often less accurate than desired. To be useful in livestock feeding, forage quality information must be available before feeding. Therefore, prediction of forage quality from feed attributes taken from small samples is necessary (Coleman and Moore, 2003[36]).

[34] Saskatchewan Agriculture. Forage Quality. http://www.agriculture.gov.sk.ca/Default.aspx?DN=c81b8c84-8abc-4685-8efb-cbc9c593bd4e
[35] James, R.E. June 2013. The Impact of Forage Quality on Ration Cost on Feed Inventory. Virginia Cooperative Extension. *http://pubs.ext.vt.edu/DASC/DASC-23/article_1_dasc-23.html*
[36] Coleman Sam W. and John E. Moore. October-November 2003. Feed quality and animal performance. Field Crops Research 84(1-2):17-29.

The Relative Feed Value (RFV) was developed by the Hay Marketing Task Force of the American Forage and Grassland Council (Rohweder et al. 1978[37]). As early as 1982 (Turnbull et. al.[38]) it was noted that Relative Feed Value (RFV) was a better gauge of alfalfa hay instead of quality grade when animal performance was examined.

Relative Feed Value

Buyers and sellers require an accurate and effective way of communicating the quality of hay using a method that best describes the feed value to livestock. Protein content has been used as a measure of hay quality. However, other factors, such as fibre content, which influences digestibility and intake, also need to be taken into account when determining forage quality. Relative Feed Value (RFV) attempts to use a single value to describe forage quality, and has become a common tool for determining hay quality (intake and energy value) and in pricing hay. Relative Feed Value can also be used to determine the quality of standing alfalfa hay. This allows producers to determine the appropriate harvest date of their alfalfa to suit their feed needs.

Limitations

Although RFV provides a convenient way of comparing alfalfa hay quality and predicting feed value in the field, the concept does have some limitations. It is only useful for comparing alfalfa forage. It cannot be used for comparing grass or alfalfa-grass forage due to the fact that grass does not have the same developmental stages of alfalfa and the nature of grass fibre is different than that of alfalfa.

ADF and NDF are the only laboratory values used in the calculation. Crude protein concentration of forage is not used. The RFV of the forage must be balanced with the fibre requirements of the type of animal being fed. Therefore, RFV cannot be used in ration formulation or evaluation. Since RFV was developed using legume forages and intake responses of lactating dairy cows, it works best when applied to that situation.

Calculating the Relative Feed Value

RFV = (DDM x DMI) / 1.29

DDM = Digestible Dry Matter (% of DM) = 88.9 - 0.779 x (ADF, % of DM)
DMI = Dry Matter Intake (% of BW) = 120 / (NDF, % of DM)

The numerator 120, in the DMI calculation indicates maximum feed intake in alfalfa based dairy rations when NDF is 1.2 lbs per 100 lbs of body weight. The divisor 1.29 in the RFV calculation provides an RFV index of 100 when alfalfa is in full bloom. A method of predicting Relative Feed Value can be found at http://www.agriculture.gov.sk.ca/Default.aspx?DN=1b3ff05b-e399-48cc-a1ba-2ae03cbfc7be

Relative Forage Quality

As new technology and information becomes available with Near Infrared Reflectance Spectroscopy (NIRS) and in vitro digestion in forage testing there have been recommendations on how to improve forage quality measurement. Differences in digestibility of the fiber fraction can result in a difference in animal performance when forages with a similar RFV index are fed. The Relative Forage Quality (RFQ) index was developed to overcome this difference (Jeranyama and Garcia 2004) and provide a methodology that could be used in calculating rations (Moore and Undersander, 2002[39]).

[37] Rohweder, D.A., R.F. Barnes, and N. Jorgensen. 1978. Proposed hay grading standards based on laboratory analyses for evaluating quality. J. Anim. Sci. 47:747-759.
38 Turnbull G.W., D. W. Claypool and E.G. Dudley. July 1982. Performance of Lactating Cows Fed Alfalfa Hays Graded by Relative Feed Value System. Journal of Dairy Science 65(7):1205-1211.
[39] Moore John E. and Daniel J. Undersander. 2002. Relative Forage Quality: An Alternative to Relative Feed Value and Quality Index. Proceedings 13th Annual Florida Ruminant Nutrition Symposium, pp. 16-32 http://dairy.ifas.ufl.edu/RNS/2002/moore.pdf

Fiber from grass and legumes naturally differs in digestibility, as it also does when grown under different ambient temperatures. RFV of first-cutting alfalfa will be similar to that of second and third cuttings harvested at similar stages of maturity. However, fiber digestibility from each cutting will be different, as this is influenced by ambient temperatures at the time of growth and development. Therefore, differences in fiber digestibility are not taken into account in the RFV calculation and cows may perform differently when fed forages from different cuttings. The RFQ takes these differences in fiber digestibility into account as well as differentiating legumes from grasses. The inclusion of Neutral detergent fiber in grasses makes RFQ a better predictor of forage quality than RFV[40]. However, there are challenges with implementation. Forage testing laboratories must match the type of forage being tested with the appropriate equations for DMI and TDN as well as communicating what RFQ is and how it can be used must be done to laboratories, producers, and extension specialists.

Calculating the Relative Forage Quality

RFQ = (DMI, % of BW) * (TDN, % of DM) / 1.23

TDN = (NFC*.98) + (CP*.93) + (FA*.97*2.25) + (NDFn * (NDFD/100) – 7

Where: CP = crude protein (% of DM)
EE = ether extract (% of DM)
FA = fatty acids (% of DM) = ether extract - 1
NDF = neutral detergent fiber (% of DM)
NDFCP = neutral detergent fiber crude protein
NDFn = nitrogen free NDF = NDF – NDFCP, else estimated as NDFn = NDF*.93
NDFD = 48-hour in vitro NDF digestibility (% of NDF)
NFC = non fibrous carbohydrate (% of DM) = 100 – (NDFn + CP + EE + ash).

DMI = 120/NDF + (NDFD – 45) * .374 / 1350 * 100

Where: DMI is expressed as % of body weight (BW)
NDF as % of DM
NDFD as % of NDF
45 = average value for fiber digestibility of alfalfa and alfalfa/grass mixtures.

The divisor of 1.23 ensures the equation has a mean and range similar to that of RFV.

STORING FORAGES: SILAGE OR HAY

It is essential to harvest forage at the best time, from the point of view of nutritional quality, quantity available and climatic conditions, and then to store it properly to reduce losses. The objective of harvesting forage for storage is to preserve forage produced in the summer months in order to ensure winter feed for livestock, when grazing is not feasible or accessible.

Hay uses dessication or dry storage containing less than 15% water to prevent spoilage. **Silage** or wet storage uses the acidifying power of lactic bacteria, which reduces the pH to around 4, below which all chemical reaction and fermentation ceases. **Haylage** usually refers to a crop that is wilted to 60% moisture and is stored in oxygen limited structures or plastic bags. Limited haylage is produced in North America due to material handling problems; however it is very popular in Europe.

Hay baled at a high moisture content will spoil and mold; while silage must be firmly packed to minimize the oxygen content or it will spoil. Silage can be successfully made from any green crop that has sufficient water-soluble carbohydrates and appropriate moisture content.[41] In regions where frequent rain has a high risk of reducing hay quality, silage is a better option for storing forage nutrients. In

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[40] Jeranyama, Peter and Alvaro D. Garcia. August 2004. Understanding Relative Feed Value (RFV) and Relative Forage Quality (RFQ). Extension Extra 8149. South Dakota State University. http://pubstorage.sdstate.edu/AgBio_Publications/articles/ExEx8149.pdf

[41] Crops for Silage production. Saskatchewan Ministry of Agriculture. http://www.agriculture.gov.sk.ca/Default.aspx?DN=cce79134-cefe-4e7c-a64e-08ea52f8ff99

regions that are dry and have challenges with targeting 68-70% moisture in silage after wilting due to high evapotranspiration; hay is preferred assuming the same forage is used with comparable quality and yield.

The advantages of silage as animal feed include:

- Silage is harvested at relatively high moisture content and is wilted in the field for short periods of time, reducing field losses compared to hay production.
- Preservative: During fermentation, the silage bacteria act on the cellulose and carbohydrates in the forage to produce volatile fatty acids (VFAs), such as acetic,propionic, lactic, and butyric acids. By lowering pH, these create a hostile environment for competing bacteria that might cause spoilage. The VFAs thus act as natural preservative, during winter in temperate regions, when green forage is unavailable. The fermentation process that produces VFA also yields energy that the bacteria use: some of the energy is released as heat. Silage is thus modestly lower in caloric content than the original forage. However, this loss of energy is offset by the preservation characteristics and improved digestibility of silage.
- Palatability: When silage is prepared under optimal conditions, the modest acidity also has the effect of improving palatability and provides a dietary contrast for the animal. It should be noted that excessive production of acetic and butyric acids can reduce palatability.
- Several of the fermenting organisms produce vitamins (e.g. lactobacillus species produce folic acid and vitamin B12).
- Consistency: Feedlot rations need to be consistent. Erratic ingredient quality can affect feed intake and animal performance. Alfalfa silage tends to be more consistent than alfalfa hay in cattle rations when wilted to 68-70% moisture, then packed properly[42]. However, the highly variable energy content of corn silage makes it challenging to maintain animal growth rate when cattle are fed high forage diets.

The choice of how forages are stored will depend on the region, climate but a producer must also consider that while silaging may have higher input costs the per unit COP may be lower when taking into account that yield loss after wilting is only about 95% compared to hay which can be 70-85% depending on weather. Further losses occur during storage with silage dropping to around 85% and hay to 65-80%.[43] Differences in feed quality must also be considered.

II. PASTURE MANAGEMENT

Effective pasture management not only ensures high forage yield, sustainability, animal health and productivity - all of which impact COP - but also benefits the pasture ecosystem. Innovations in pasture management that give producers greater control support the environment (e.g. biodiversity) but also utilize this resource for food production.

Pasture is a critical resource in the cattle industry. Managing grazing lands so that they are productive and persist over time requires knowing when to graze certain species, if they can withstand multiple grazings/cuttings within a single year and how much recovery time is needed to prevent overgrazing (which is a matter of time not intensity).

Effective pasture management not only ensures high forage yield and animal productivity but also benefits the pasture ecosystem. An effective management plan requires good understanding of pasture

[42] Sprague, Dr. James I. September/October 1999. Alfalfa Silage vs. Alfalfa Hay. Feedlot VII (5) http://feedlotmagazine.com/archive/archive/issues/199909/alfalfa_pg52.html

[43] Switch to hay could be a false economy. April 2011. Farmers Guardian. http://www.farmersguardian.com/home/livestock/profit-from-grass/switch-to-hay-could-be-a-false-economy/38277.article

production, realistic production goals, effective grazing strategies and timely response to forage availability and environmental changes.

Pasture management can affect **animal health**. For example, some rapidly growing pastures lack certain dietary inputs, such as roughage, dry matter and various minerals that are important for good rumen function and maximum production. This can lead to animal health issues associated with mineral deficiencies, as well as scouring and bloat, which limit weight gain and in extreme cases can cause death.[44] Iwaasa (2006)[45] showed that selection of genetically improved sainfoin varieties could produce a bloat safe legume that is more productive and better able to compete and persist in pastures. Legume persistence would also benefit from the development of grazing strategies that consider the critical growing periods of legume species. This would help to improve forage and soil quality, allow safer grazing of legume pastures, and improve animal performance.

Forage productivity has a direct impact on **animal performance**. A study by Doran *et al*. (1963)[46] conducted in central Alberta measured forage productivity and yearling steer weight gain of three pastures under three levels of fertility. The results show that under appropriate grazing management, rather heavy applications of nitrogen and phosphorus fertilizers will lead to substantial improvements in measured increments of animal productivity. Various studies have also showed that an annual yield of 1,365 kg (3,000 lbs) dry matter per acre can be achieved on a well-managed pasture. These same pastures can produce 225-275 kgs (500-600 lbs) of gain per acre in growing cattle. However, a lack of fertilizer and moisture combined with severe overgrazing can easily reduce the availability of dry matter to less than 454 kg (1,000 lbs) per acre.[47]

Pasture management has long term effects, as it can take years to recover from overgrazing. Grazing will favor the forage species that are most capable of withstanding grazing pressures. Overgrazing can make a stand vulnerable to invasive species and weeds (inedible, noxious or poisonous).

Appropriate pasture management helps ensure **long-term sustainability** of the grassland system. A study by Johnston (1961)[48] compared the changes of vegetation character between lightly grazed and non-grazed treatments during a twelve-year period. Light grazing resulted in the development of a more varied flora with a greater total percentage basal area while non-grazing appeared to simplify the flora with a trend toward a cover consisting largely of *rough fescue*. A varied cover could conceivably be of value to the ecosystem especially during times of climatic stress. A twelve-year study by Schuman *et al.* (1999)[49] found that continuous season-long grazing results in a significant increase in the masses of soil carbon (C) and nitrogen (N) in the root zone of the soil profile and simulates C and N cycling from above-ground plant component to the soil. However, plant longevity can be reduced if the plants are re-grazed before they have sufficiently recovered from a previous grazing or cutting. If this process is continually repeated, a thinning or loss of the most desirable species occurs – providing openings in the ground

[44] Meat and Livestock Australia. Nutrition. http://www.mla.com.au/Livestock-production/Feeding-finishing-and-nutrition/Pasture-finishing/Nutrition

[45] Iwaasa, Alan. 2006. Pasture management and productivity. BCRC Fact Sheet. http://www.beefresearch.ca/factsheet.cfm/pasture-management-and-productivity-56

[46] Doran, W. J. , G. H. Bowman, D. R. Walker. 1963. The Productivity of Fertilized Pastures in Central Alberta. Canadian Journal of Plant Science 43(2):188-194 http://pubs.aic.ca/doi/abs/10.4141/cjps63-032

[47] Alberta Agriculture. Grazing tame Pastures effectively. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex113?opendocument

[48] Johnston, Alexander. 1961. Comparison of lightly grazed and ungrazed range in the fescue grassland of southwestern Alberta. Canadian Journal of Plant Science 41(3):615-622 http://pubs.aic.ca/doi/abs/10.4141/cjps61-090

[49] Schuman, G. E., *et al*. 1999. Impact of grazing management on the carbon and nitrogen balance of a mixed-grass rangeland. Ecological applications 9(1):65-71.

cover for invasion of weeds or less desirable plant species (Jensen *et. al*).[50] A forty-four year study (Dormaar *et al.* 1998)[51] of grazing on fescue grassland soil in Southern Alberta showed that heavy grazing pressure jeopardized the sustainability of the ecosystem by reducing fertility and water-holding capacity.

There have been a number of technologies that have increased the control producers have in pasture management. Technologies like electric fences and portable solar water systems have made it cost effective for producers to create smaller fields that allow for more frequent moves and a more consistent clip throughout the pasture. New products and management techniques give producers greater confidence in grazing alfalfa while controlling the risk of bloat and maximizing productivity.

Timing and COP

Grazing cattle too early in the spring on pasture will lead to poorer pasture conditions later on in the grazing season. It is estimated that grazing cattle one week too early on pasture in the spring will sacrifice three weeks of grazing in the fall.[52] A study by Llewellyn L. Manske (2001)[53] shows that grazing native range before the grass plants reach the third-leaf stage causes reductions in herbage biomass production and subsequent reductions in stocking rate (2.86 acres/AUM vs. 4.04 acres/AUM) and animal performance (calf ADG 2.09 lb vs. 1.80 lb). These reductions result in lower economic returns ($7.02/acre vs. $0.75/acre) for a livestock operation. Herbage biomass production can be increased, along with stocking rate, animal performance, and net returns, when grazing is started after the third-leaf stage. Herbage production can be further increased when grazing started after the third-leaf stage is coordinated with grass phenological growth to meet the biological requirements of the grass plants. With such management, stocking rate, calf average daily gain, calf gain per acre, net returns per cow-calf pair, and net returns per acre will also increase.

A grazing **plan** that matches animal numbers to forage yield is important in optimizing pasture and animal productivity. Stocking rate should be calculated based on soil and climatic conditions as well as the condition of forage stands of a specific pasture. ***In setting production goals, it is important to consider the economic return per acre rather than production per animal, and compare production per acre or per dollar invested into the pasture***.[54]

A **grazing system** should balance livestock demand with forage availability, promote rapid pasture re-growth during grazing season as well as long-term pasture persistence.[55] Grazing systems will vary with the climate, species and soil types. Grazing systems that are commonly used in Canada include: continuous grazing, rotational grazing, forward grazing, creep grazing, strip grazing, limit grazing, stockpile grazing and extended grazing.

A study by Bailey *et al.* (2006)[56] in West Virginia, US showed that grazing systems (continuous stocking versus rotational stocking of paddocks) had an effect on forage quality by influencing plant height and maturity. Continuously grazed pastures were shorter than rotationally grazed pastures and had lower

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[50] Jensen, Scott. *et.al.* Improved pastures. http://extension.oregonstate.edu/coos/agriculture/ImprovedPastures

[51] Dormaar, Johan F. and Walter D. Willms. Jan 1998. Effect of Forty-Four Years of Grazing on Fescue Grassland Soils. *Journal of Range Management* 51(1):122-126 http://www.jstor.org/stable/4003574

[52] Ontario Agriculture. Grazing Management. http://www.omafra.gov.on.ca/english/crops/pub19/4grazman.htm

[53] Manske, Llewellyn L. 2001. Grazing Before Grass Is Ready Report. Dickinson Research Extension Center. http://www1.foragebeef.ca/$Foragebeef/frgebeef.nsf/all/frg39/$FILE/Pasturegrazingbeforegrassready.htm

[54] Foragebeef.ca. Pasture Management. http://www1.foragebeef.ca/$foragebeef/frgebeef.nsf/all/frg39

[55] Ontario Agriculture. Grazing Management. http://www.omafra.gov.on.ca/english/crops/pub19/4grazman.htm

[56] Bailey, B. *et al*. December 2003. Pasture Forage Quality in West Virginia. West Virginia Extension Service Fact Sheet http://webdev.wvu.edu/~Agexten/forglvst/foragequal.pdf

Acid Detergent Fiber (ADF) and Calcium (Ca). The most important factor was herbage maturity, and therefore time of harvest is an important aspect in pasture management.

Pasture management that adjusts for **drought conditions** will impact production. Plants that are healthy because of good soil fertility programs and good rest periods that preserve root reserves will respond quickly once the rains return following a drought.[57]

AGRONOMY

In order to manage forages there are a number of agronomic areas that research needs to support producer decisions including: optimal irrigation time, water use efficiency, plant growth regulators, inoculants, fertility of legumes, leaf diseases, tolerance of new herbicides, soil health, understanding the role of carbon capture, root bound issues and supporting higher yields on long lived stands (>40 years old).

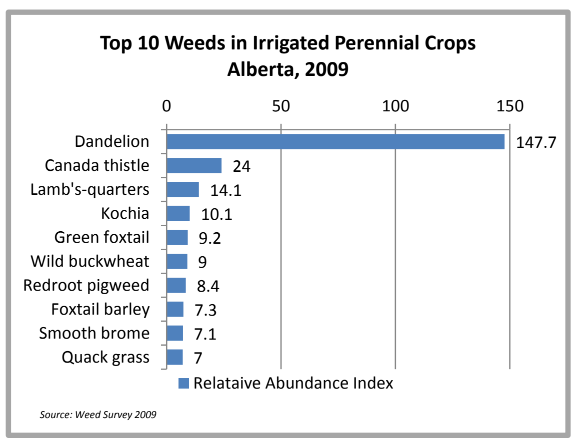
III. WEED CONTROL

Weed control is an important aspect in forage and cattle production as it affects forage yield and quality. Weed management can be accomplished through cultural, mechanical, chemical and biological controls. A more effective and sustainable weed management program should integrate two or more of these methods and consider long term impacts. Over 95% of the weed control in a healthy forage crop comes from the competition provided by the existing forage stand.

In 2009, a survey that focused on weeds was conducted of common irrigated crops including annual cereals (spring wheat, barley, corn), annual broad-leaved crops (canola, sugar beets, dry beans, potatoes) and perennial crops (alfalfa, grass hay) in Alberta. For the 135 fields of irrigated perennial crops, the top 10 most abundant weeds were reported as: Dandelion, Canada thistle, Lamb's-quarters, Kochia, Green foxtail, Wild buckwheat, Redroot pigweed, Foxtail barley, Smooth brome, and Quack grass.

Other than plants that are poisonous to livestock, individual plants growing on a pasture are rarely a problem. However when large populations of a single species spread over a wide area, choking out and replacing the pasture grasses that provide nutrition to livestock, weeds become an economic issue.[58]

If weeds become a problem, they can compete or interfere for light, nutrients, water and space, directly influencing forage yield. A study by Chad and Bork (2004)[59] assessed herbage yield losses within eight central Alberta pastures due to Canada thistle from 1999 to 2001. The study shows that yield losses due to Canadian thistle can be substantial, peaking at 2 kg/ha for each kilogram of standing thistle biomass and 4.3 kg/ha with each additional thistle stem per square meter. Demonstrated yield losses were variable among sites, likely due to factors such as heterogeneity in soils,



[57] Ontario Agriculture. Conserving Pasture Production During Dry Conditions. http://www.omafra.gov.on.ca/english/crops/facts/pasture.htm

[58] Crozier, Stephen. 2006. Rearing, Release and Distribution of Insects for Biological Control of Pasture Weeds. http://www.beefresearch.ca/factsheet.cfm/insects-for-weed-control-59 accessed on May 26, 2014

[59] Chad W. Grekul and Edward W. Bork (2004) Herbage Yield Losses in Perennial Pasture Due to Canada Thistle (Cirsium arvense)1. Weed Technology: July 2004, Vol. 18, No. 3, pp. 784-794.

available moisture, and variation in disturbance history or pasture vegetation composition. Research also shows that if enough weeds are present to cause a reduction in forage production, there is a gain of at least 1 pound of grass for each pound of weeds controlled. Some work shows a return of up to 7 pounds of grass for 1 pound of weed controlled (Donald *et al.*2011).[60]

Since weeds are often harvested along with the forage crop, it can reduce forage quality by resulting in lower protein content and feed digestibility. Dandelions have nearly equal amounts of protein and total digestible nutrients as alfalfa, so control of dandelion may not improve the quality of hay, but it may increase the time necessary to dry the hay, since dandelion dries more slowly than alfalfa. Increased drying time may mean greater harvest losses due to untimely rainfall. Grassy weed quality can be similar to that of the forage. In general, weedy grasses have about 75% of the quality of alfalfa. However, controlling quackgrass in alfalfa can increase forage protein levels 4% to 7%. Weeds with woody stems or flower stalks, such as yellow rocket, white cockle, rough fleabane, curly dock, and broadleaved dock, have lower protein levels (about 50% of the quality of alfalfa), so controlling them is even more important.[61]

While most studies focus on weed control and its economic impact during the current growing season, K.G. Beck[62] pointed out that weed management must be applied and evaluated over an extended time to be successful. It is important to develop a comprehensive weed management plan and incorporate that plan into a long-term land management program.

Weed control can be accomplished by cultural, mechanical, chemical and biological methods. **Cultural controls** are methods that suppress weed growth and production, while promoting the development of the desired plant, such as proper grazing management, irrigation, and seeding vigorously growing, competitive, desirable plant species. **Mechanical controls** manage weed populations through physical methods that remove, injure, kill, or make the growing conditions unfavorable, and include such methods as tillage, mowing, mulching and burning. **Chemical controls** are the use of herbicides. **Biological controls** are the use of an organism to disrupt weed growth. Classical biological control uses natural enemies of weeds, such as insects or disease organisms. Biological control also may include use of sheep, cattle, goats, or other large herbivores to control weeds. *A good weed-management plan integrates two or more control measures into a management system*.[63]

Cultural controls

Over 95% of the weed control in a healthy forage crop comes from the competition provided by the existing forage stand.[64] A good weed management strategy should focus first on cultural practices. According to Green *et al.* (2003)[65] weed control is more critical during the first year than any other period of forage production as forage seedlings grow slowly and are easily overcome by rapidly growing weeds. The timing of seeding is also important. As a general rule, the summer complex of weeds tends

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60 Donald J. Dorsett, 2011, Pasture Management for Beef Cattle Production, http://agrilifecdn.tamu.edu/coastalbend/files/2011/10/PASTURE-MANAGEMENTFORBEEFCATTLEPRODUCTION_3.pdf accessed on May 26, 2014

61 Penn State Extension, Managing Weeds in Legumes http://www.forages.psu.edu/topics/species_variety_trials/species/alfalfa/weeds.html accessed on May 26, 2014

62 K.G. Beck Range, Pasture and Natural Area Weed Management, Colorado State University Extension Fact Sheet, 2014 http://www.ext.colostate.edu/pubs/natres/03105.html accessed on May 26, 2014

63 Olson, B.E., 1999. Grazing and weeds. In: Sheley, R.L., PetroV, J.K. (Eds.), Biology and Management of Noxious Rangeland Weeds. Oregon State University Press, Corvallis, OR, pp. 85–96.

64 Stephen Crozier, Rearing, Release and Distribution of Insects for Biological Control of Pasture Weeds, BCRC project 2006, http://www.beefresearch.ca/factsheet.cfm/insects-for-weed-control-59 accessed on May 26, 2014

65 Green, J. D., MV Marshall, and J. R. Martin. Weed Control of Alfalfa and Other Forage Legume Crops. University of Kentucky, US, Cooperative Extension Service, AGR-148, 2003. http://www. ca. uky. edu/agc/pubs/agr/agr148/agr148. pdf accessed on May 26, 2014

to overcome spring seedings; whereas, the winter weed complex tends to outcompete forages seeded in the fall. Therefore, for optimum establishment of most forage crops, one should consider fall seedings in fields that have a history with such weeds as large crabgrass, foxtails, or lambs quarters. Spring seeding should be considered in fields that are potentially infested with common chickweed, henbit, and yellow rocket. In addition, using weed-free seeds will also prevent weeds in the first step. Proper fertility during the establishment phase and throughout the life of the forage stand is important to achieve a competitive forage stand that can suppress weed emergence and growth (Green *et al.* 2003). Nevertheless, increasing forage species diversity in pastures could also be an effective cultural control. A study by Tracy *et al.* (2004) [66] found consistent negative relationships between forage species diversity and weed abundance. The results suggest that maintaining both productive pasture communities (>150 g m−2 of above ground biomass) and an evenly distributed array of forage species should be combined to effectively reduce weed invasion.

Mechanical controls

Mowing or clipping can be an effective option for controlling some weeds. This removes leaves and lateral buds that develop new growth and helps to stop seed production. Annual broadleaf weeds have buds that develop above the soil surface; they are more easily controlled with clipping or mowing than grasses, which have crown buds near the soil surface (Green *et al.* 2003). Undesirable annual grasses should be mowed after the seed stalk has elongated, but prior to seed formation. Mowing perennial weeds once usually reduces seed production; repeated mowing reduces vigor and slows spread (Lemus & Weirich. 2010)[67]. In grazed forages, livestock often selectively graze and may leave particular weed species. Mowing soon after livestock have been removed from the field can help control these weeds and prevent seed production and further spread of infestations (Green *et al.* 2003).

Chemical controls

Herbicides control many annual, biennial, or perennial broadleaved weeds and woody plants in grass pasture. Chemical control costs may be lower than mechanical methods. Clary *et al*. 2008 compared the costs of mowing pastures with a 40-horsepower tractor and 6-foot rotary mower versus spraying pastures with the same 40-horsepower tractor pulling a 30-foot boom sprayer applying herbicide. The results show that herbicide and application totaled $11.57 per acre compared with $15.24 per acre for one mowing. However, it is important to note that once the weed has begun to flower, herbicide applications are much less effective. Therefore it is important to spray at the right time with the right rate. Generally speaking, the best time to spray weeds in new pasture is 4 - 8 weeks after sowing, prior to the first full grazing when the weeds are still small and there is about 70% or more ground cover. The herbicides should not damage the newly established clover while providing effective weed control. For established pasture, the best time to use herbicides is during fall, early winter or early spring when weeds are actively growing. The approach will depend on the targeted weeds species and sometimes different applications throughout the year might be necessary. (Information on herbicide control on specific weed species can be found at Saskatchewan Agriculture's website). A producer should consider price, method of application (spot spraying vs. broadcast), rates, and time of application. (A comparisons of herbicides used in forage legumes can be found in Green *et al.* 2003.)

[66] Tracy, Benjamin F., and Matt A. Sanderson. "Forage productivity, species evenness and weed invasion in pasture communities." *Agriculture, ecosystems & environment* 102.2 (2004): 175-183.

[67] Rocky Lemus and Jason Weirich, Making Pasture Weed Control Decisions, Mississippi State University Extension Service, 2010. http://msucares.com/crops/forages/newsletters/10/3.pdf accessed on May 26, 2014

Biological controls

Previous studies on weed control have generally focused on herbicides and mechanical methods. However, grazing can be a key cultural component to weed control within the forage stand. Olson (1999)[68] described three grazing strategies for managing weeds: (1) moderate grazing to minimize the physiological impact on desirable plants and reduce soil disturbance; (2) intensive grazing to counteract inherent dietary preferences of cattle such that the physical impact on weeds and desirable species is equal; and (3) multi-species livestock grazing that distributes the impact of grazing more uniformly among all plant species.

Recent work shows that a high intensity, low frequency (HILF) grazing system can be used as a weed control tool. A study conducted by Sue *et al.* (2006) tested three cattle grazing systems - (1) continuous or season-long grazing (SL), (2) short duration (SD) (or low intensity-high frequency) rotational grazing, and (3) high intensity-low frequency (HILF) rotational grazing - for their ability to reduce Canadian thistle (CT) and release non-thistle herbage within permanent pastures of central Alberta, Canada. The results showed that season-long grazing maintained or increased severe CT infestations and reduced forage yield. In contrast, the HILF rotational system reduced CT shoot density and biomass, as well as flowering, and resulted in greater weed suppression than the short duration system. The implication is that prescribed grazing with an HILF system can be an effective biological control tool for CT, particularly in areas where other control options, including the use of herbicides, are not possible due to environmental restrictions or inaccessibility to equipment.

Bork *et al*. (2008) compared the HILF and continuous grazing systems' effectiveness in reducing Canada thistle in the Aspen Parkland.[69] Over a three-year test period of short duration, heavy grazing, the paddocks in the HILF grazing system had Canada thistle reduced to nearly zero, while under continuous grazing the Canada thistle continued to grow vigorously. However, it is not recommended that such intense heavy grazing treatments be applied every year because heavy spring grazing of the same field each year for many years will reduce the health and forage production of the desirable perennial species, the amount of forage will decline, and other weeds will invade the fields.

For classical biological weed control, a growing range of beneficial insects are becoming commercially available to control thistles and some other perennial weeds. A study by Stephen Crozier (2006) assessed the current effectiveness of biological control insects that had previously been introduced in Canada, focusing on field studies in Nova Scotia. Following up on insect biocontrol introductions carried out in the 1980s and 1990s, the study surveys of 18 insects on 10 target weed species. The five insects showing the greatest potential to control weeds were: *Hadroplontus litura* (a European weevil) for Canada thistle control; *Urophora stylata* (a gall fly) for bull thistle control; *Longitarsus jacobaeae* (a flea beetle) for Tansy ragwort control; *Deloya guttata* (a leaf beetle) for bindweed control and *Galerucella calmariensis* (a European beetle) for purple loosestrife control.[70]

Studies on using of fungus as a biological herbicide have also been conducted. Examples include using *Phoma macrostoma* to control for several broadleaved weeds and *Colletotrichum truncatum* for scentless chamomile. While biological controls can be effective in weed management, it is not always

[68] Olson, B.E., 1999. Grazing and weeds. In: Sheley, R.L., PetroV, J.K. (Eds.), Biology and Management of Noxious Rangeland Weeds. Oregon State University Press, Corvallis, OR, pp. 85–96.

[69] Bailey, Arthur W., Duane McCartney, and Michael Peter Schellenberg. *Management of Canadian prairie rangeland*. Ottawa, Canada: Agriculture and Agri-Food Canada, 2010. Page 36 http://www.beefresearch.ca/files/pdf/fact-sheets/991_2010_02_TB_RangeMgmnt_E_WEB_2_.pdf

[70] Stephen Crozier, Rearing, Release and Distribution of Insects for Biological Control of Pasture Weeds, BCRC project 2006, http://www.beefresearch.ca/factsheet.cfm/insects-for-weed-control-59 accessed on May 26, 2014

easy for producers to adopt these new technologies. It requires changing their current weed control plans and potentially an investment that has not historically been a part of their operation. However, significant advancements have been made in the selection of biological control agents, their mass-production and method of delivery that could make these options more attractive in the future (Boyetchko *et al.* 2009). [71]

IV. FORAGE REJUVENATION OPTIONS

As a forage stand becomes less productive over time, producers may rejuvenate a stand (fertilize) or renew a stand (break and re-seed). There are a number of ways a producer can go about rejuvenating a stand. The most common way is organic or inorganic fertilizer.

Moisture and soil fertility are essential factors affecting forage productivity and management strategies. Higher moisture areas where response to fertilizer is more consistent may result in a lower COP, but in low moisture areas where yield response is low or inconsistent may actually increase the COP. There are other low cost alternatives including adding a legume to the mix, which fixes nitrogen and supports yield or having cattle spread manure with in-field winter feeding when weather permits.

FERTILIZATION

Forage response to fertilizer as a management strategy vary widely based on soil fertility, moisture conditions throughout the growing season with timing of moisture being more important than quantity, and the stand composition. Due to this wide variety, longer term studies have provided different results than short term studies.

The goal of fertilizing is to decrease the per unit cost of producing forage. However, higher yields do not necessarily translate into lower costs or increased profits due to fertilizer and application costs. Optimal fertilizer costs are affected by hay prices, fertilizer prices and the base land cost. As hay prices increase the willingness to pay for fertilizer should increase. As land costs increase the willingness to pay for fertilizer should increase. Therefore, it is important for producers to know their COP and adjust their strategy based on the current price situation.

Soil Fertility

Nutrient deficiency in soil is one of the important factors limiting forage productivity in Canada. Forages are generally grown on marginal land and their production can be increased with fertilization (Malhi *et al.* 2004). Forages remove more nutrients from the soil than other crops, as more biomass is removed. However, the application of fertilizer on forages in Canada is minimal. It is estimated that only 25% of the improved pasture and hay is fertilized and only 15% of alfalfa hay fields (Lickacz and Johnston 2001[72]). Given the level of nutrient removal by forages and these low levels of fertilization, it is little wonder that forage stands are only maintained for 3-5 years in high moisture regions of western Canada and 6-9 years in semiarid regions. A low forage yield is the most commonly cited reason for terminating a stand. Rather than terminating the stand through tillage and reseeding, rejuvenation by fertilization may be the most economic and practical method to improve production and quality in some situations

[71] Boyetchko, Susan M., Karen L. Bailey, and Rosemarie A. De Clerck-Floate. "Current biological weed control agents-their adoption and future prospects." *Prairie soils and crops scientific: perspectives for innovative management* 2009 (2009).

[72] Jerome Lickacz, Alberta Agriculture, Food and Rural Development and Adrian Johnston, Potash & Phosphate Institute Canada. "Forage Rejuvenation – Alternatives to Stand Termination" Prairie Steward Issue 33, Summer 2001. Published by the Saskatchewan Soil Conservation Association. http://www.ssca.ca/newsletters/issue33/johnston.html

(Lardner *et al.* 2002).[73] Optimum levels of forage production require adequate level of soil nitrogen (N), phosphorus (P), potassium (K), and sulphur (S) as well as micronutrients. Soil testing to determine what nutrients are limiting is recommended.

Moisture

Uncertainty about moisture conditions discourages fertilizer use as dry conditions can result in volatilization (i.e. evaporation of Nitrogen) and a limited production response, while wet conditions can result in nutrient runoff, creating environmental concerns. Studies show that forage response to fertilizer application is directly related to the amount and distribution of growing season precipitation and the ability of the soil to store water. This has resulted in wide variability in yield responses to recommended fertilizer rates.

A 10-year study in Manitoba shows adding fertilizer increased productivity of grass pastures.[74] However, the target forage yield was often not achieved, even though fertilizer was applied to full soil test recommendation, due to moisture limitations. Soil can have a significant impact, as very low water holding capacity (as found on sandy loam soil) limits moisture availability and severely reduces plant growth, forage quality, stocking rate, and animal gain as well as reducing the benefit of fertilizer.

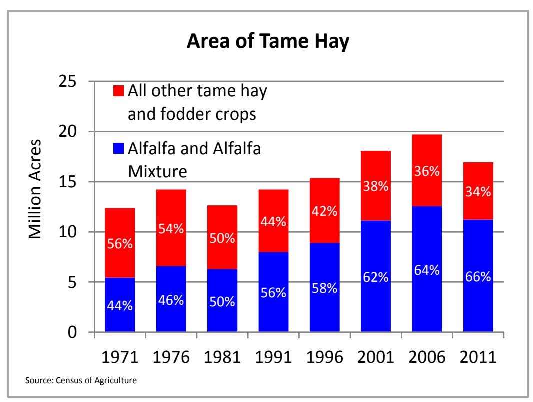
Malhi (2004) showed that the timeliness of rainfall during the growing season can significantly affect productivity. A 19 year study on thin Black Chernozemic soil at Crossfield, Alberta had lower dry matter yield and limited response to applied N in many years. This appeared to be at least partially associated with a lack of timely rainfall. [75]

Producers make decisions each fall or spring on the fertilizer needed for their crops. In deciding the economically optimal rates of fertilizer to apply, costs and price information must be combined with expected yield response, forage quality data and other management factors. See Fertilizer section in the Economic Evaluation section.

LEGUME-GRASS MIX

Forage productivity and carrying capacity can also be improved by incorporating legumes. This represents less financial risk as it is less affected by weather and input prices but may increase the risk of bloat slightly. Alfalfa has been widely adopted across Canada with 66% of tame hay acres being an alfalfa or an alfalfa mixture. Adoption has been supported by innovation and grazing management that controls the risk of bloat.

Grasses are often seeded in mixture with legume. Properly inoculated alfalfa can fix large amounts of N from the atmosphere and consequently, additional N is not normally required to obtain increases in dry matter yield and protein content. While grass:alfalfa mixes may not require N, other nutrients (P & K) can influence stand productivity and longevity. Responses are affected by soil and climatic conditions.



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[73] Alberta Agriculture and Rural Development, Fertilizing Grass for Hay and Pasture, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex10473 (Last accessed: August 29,2013)

[74] Khakbazan, M., et al. "Economic effects and energy use efficiency of incorporating alfalfa and fertilizer into grass-based pasture systems." World Academy of Science, Engineering and Technology 49 (2009): 79-84.

[75] Malhi, S. S., et al. "Fertilizer management of forage crops in the Canadian Great Plains." Recent Res Dev Crop Sci 1 (2004): 237-71.

According to Kopp et al. (2003),[76] on sandy soils in Manitoba, incorporation of alfalfa into grass pastures improved carrying capacity by 28% compared to meadow bromegrass alone. Incorporating alfalfa with fertilization (N,P,K,S) improved carrying capacity by 57%. The alfalfa with fertilization treatment entailed significant financial risk as it was only cost-effective when precipitation was not limiting. The alfalfa without fertilization treatment did not entail financial risk and was always a cost-effective approach.

Research has recommended that due to the high variability in response to fertilizer on tame grass, the most cost-effective way to increase forage yields is to add alfalfa to the mix, as it increases productivity without annual application costs.[77] This has been widely adopted across the prairies over the last decade as management experience and products have reduced death losses from alfalfa related bloat. Over the past 30 years, the area alfalfa and alfalfa mixtures as a percentage of total tame hay production steadily increased from 44% in 1971 to 66% in 2011.

Products to decrease the incidence of bloat on alfalfa have not been widely adopted as pasture management is the critical success factor for controlling bloat even when using them (see Pasture Management).

ORGANIC FERTILIZER

In-field winter feeding, with manure and feed waste providing organic fertilizer to a pasture can be a cost-effective winter feeding option that improves forage productivity. A number of studies have shown that extended grazing can reduce winter feeding cost compared to traditional winter feeding systems and improve soil nutrients. However, successful winter grazing depends on proper planning and management to avoid negative environmental impacts and maintain animal performance.

Extended grazing practices, increase the number of days in a year that livestock remain in a pasture or open field setting. By feeding in open field into the winter months using perennial pastures held in reserve, annual crops, crop residues and bales, producers can significantly reduce winter feeding costs associated with feed and manure handling. In addition, manure spread on the pasture during the extended grazing period, returning nutrients to the land, instead of concentrating them in one area and being lost to runoff or leaching.

Extended grazing has quickly gained popularity as new research informs management practices with optimum results. The 2006 and 2011 Farm Environmental Management Survey (FEMS) reported that 27.8% of farms in 2006 used extended grazing; this increased to 59.6% in 2011. The number of farms using <u>hay bales in an open field setting (76%</u> in ’11 vs. 47% in ’06), swaths (14% in ’11 vs. 15.3% in ’06), and <u>dormant growth (45.3% in ’11</u> vs. 17.7% in ’06) have all been steady to higher.[78] According to 2011 Agriculture Census 30,260 farms use in-field winter grazing or feeding practices; 11,118 in Alberta, 5,963 in Saskatchewan, 4,584 in Ontario and 4,004 in BC.

While there are a number of options for extended grazing system, all of them require proper planning and management to achieve cost efficiency without sacrificing cattle health and productivity. The following sections provide brief descriptions of each extended grazing system, recent studies and related resources, followed by information on animal care.

Bale Grazing

[76] Kopp, J. C., W. P. McCaughey, and K. M. Wittenberg. "Yield, quality and cost effectiveness of using fertilizer and/or alfalfa to improve meadow bromegrass pastures." Canadian journal of animal science 83.2 (2003): 291-298.

[77] M. Khakbazan et. al. 2009. “Economic effects and Energy Use Efficiency of incorporating Alfalfa and Fertilizer into Grass-based Pasture Systems”. Proceeding of World Academy of Science, Engineering and Technology Volume 37 January 2009 ISSN 2070-3740.

[78] Unpublished data

Bale grazing is the practice of allowing livestock to graze bales on pastures and hayfields, rather than feeding intensively in confinement. When bales are grazed where they are dropped from the baler, the need to stack and move the bales in the winter is eliminated.

An experiment[79] conducted in Biggar/Herschel area, Saskatchewan on a smooth bromegrass-alfalfa field during 2009-2011 showed that bale grazing has positive impacts on soil and plant nutrients. Forage yield for the two year period following bale grazing was higher than an ungrazed site, with the land profitable for the two year following post-bale grazing on the area. Other experiments conducted in the Peace Region of Alberta[80] and in Clearwater, Manitoba[81] also showed improvement in soil fertility, forage yield and quality following bale grazing.

Jungnitsch *et al*. 2008[82] conducted a study in Saskatchewan on an old Russian wildrye grass pasture to examine the effects of cattle winter feeding systems (bale processing or bale grazing) on soil nutrients, forage growth, animal performance and its economic implications. Results of this study show that both in-field bale grazing and bale processing greatly increased nutrient retention and recycling efficiency in the pasture compared to drylot systems, with reduced equipment and fuel input costs and little difference in cattle performance.

Site selection, bale placement and nutrient management of the grazing field are important management aspects for a bale grazing system. When bale grazing, producers should consider animal density and bale placement to ensure the optimum deposit rate of nutrients from manure, urine and leftover material and avoid excessive nutrient build up. Bale grazing should also be avoided on environmentally sensitive sites such as in riparian zones where runoff will flow directly into surface water, on high water tables or on sandy soil.

Stockpile Grazing

In a stockpile grazing system, perennial pasture is grazed early in the season and saved for late-season or early spring grazing. Typically, the first cut is used for grazing or is cut as hay, and then the stand is left so that sufficient re-growth takes place before dormancy. The pasture is then left to rest until it is needed in the fall or in the early spring. Depending on forage characteristics, it can be grazed as a standing crop, or swathed and grazed from the swath.[83]

The most important management factor in stockpile grazing is determining when to remove the animals from pasture so that it can re-grow and be stockpiled for use in the fall and winter. The yield and quality of forages will be influenced by the amount of rest the pasture is given. However, the longer the stockpile is allowed to regrow and mature, the more the quality is reduced.

A number of studies[84] in Canada have examined the effects of nitrogen application, harvest date, grass species in a stockpile grazing system on cattle performance, forage yield and quality.

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79 Saskatchewan forage Council, Nutrient and Yield Effect of Bale Grazing on Hay Fields Project final report http://www.saskforage.ca/Coy%20Folder/Projects/ADOPT/Bale_Grazing_(ADOPT)-Final_Report.pdf (Last accessed: Nov 25, 2013)

80 Omokanye, A. T. "Soil Nutrient Trends and Forage Production Following Years of Bale Grazing in Parts of the Peace Region of Alberta, Canada." (2013).

81 Réjean Picard "Nutrient cycling in winter grazing cattle on pasture; three years following bale grazing", http://umanitoba.ca/faculties/afs/agronomists_conf/media/Rejean_Picard_bale_grazing.pdf (Last accessed: Nov 25, 2013)

82 Paul F. Jungnitsch, 2008, M.Sc Thesis, The effect of cattle winter feeding systems on soil nutrients, forage growth, animal performance, and economics, http://ecommons.usask.ca/bitstream/handle/10388/etd-05202008-212947/Jungnitsch.pdf

83 Manitoba Agriculture, A Quick Guide to Extended Grazing, http://www1.foragebeef.ca/$foragebeef/frgebeef.nsf/all/frg8/$FILE/manitobaextendedgrazing.pdf

84 Ontario Agriculture, Stockpiled Pasture series 1-5, http://www.omafra.gov.on.ca/english/crops/facts/yieldsp1.htm

Swath Grazing

Swath grazing is the practice of allowing livestock to graze annual cereals in the swath during the winter months. Crops that are typically used for swath grazing are barley and oats. Corn and triticale are also shown to be good options. [85]

Research indicates that swath grazing can reduce total daily feeding cost per cow by 41% to 48%. This is based on a 78% reduction in yardage costs and a 25% reduction in feed costs. However, daily feed costs range from $0.61 to $1.80 per cow, largely due to variability in the number of grazing days per acre.[1] To identify the cost-efficient crop combinations for swath grazing, ongoing studies by Baron *et al.* have focused on comparing daily feeding costs per cow, carrying capacity, utilization and cow performance in swath grazed corn, spring triticale and barley compared to drylot feeding.[86]

In the first Beef Cattle Industry Science Cluster, seeding dates and alternative annual forages were compared for swath grazing to reduce winter feeding costs of the cow herd. Research suggests that swath grazing triticale can reduce winter feeding costs by over $100 per cow compared to wintering cows for 100 days in a corral. Savings were lower for swath grazed barley ($89) due to lower yields, and for corn ($83) due to higher input costs. Triticale had the lowest production cost, higher yields, and a lower daily feeding cost compared to barley and corn. High-yielding crops which utilize a greater portion of the season than barley have the potential to reduce the cost of wintering cows further than previously envisioned.[87] In the second Beef Cluster, research focuses on evaluating the suitability of new annual forage varieties for swath grazing and developing management strategies with improved forage quality that is maintained throughout the swath grazing season.[88]

During swath grazing, animal health and body condition score should be closely monitored. Feed, fencing, water sources and shelter are all important elements that need to be carefully planned.

Animal Care in Extended Grazing

Animal care is an important factor in extended grazing, no matter which method is used. It is important for producers to consider the nutritional requirements of different types of cattle in late fall or winter. In cooler temperatures, cattle need more feed to maintain good body condition while replacement heifers, young cows and mature animals all have different nutritional requirements.[89] Feed testing is recommended to ensure nutritional needs of the cattle are met while supplemental nutrients such as protein may need to be added.[90] Electric fences can be used in reducing feed wastage by controlling access to the swaths or bales. Ensuring adequate clean water supply and sufficient protection from wind are also important in extended grazing.

[85] BCRC, Extended Grazing, http://www.beefresearch.ca/research-topic.cfm/extended-grazing-45

[86] BCRC projects by Vern S. Baron et al., Reducing Swath Grazing Costs, Part 1 and 2 http://www.beefresearch.ca/factsheet.cfm/reducing-swath-grazing-costs-part-2-48

[87] 2009-2013 Canadian Beef Cattle Industry Science Cluster http://www.cattlemen.bc.ca/docs/beef_science_cluster_exeutive_summary.pdf

[88] Research funded by the Beef Cattle Industry Science Cluster http://www.beefresearch.ca/files/pdf/beef_science_cluster_2_research_project_details.pdf

[89] BCRC, Tips for Successful Extended Grazing to Reduce Winter Feeding Costs, http://www.beefresearch.ca/blog/extended-grazing-tips/

[90] Tory Smith, Supplementing Winter Grazing, http://www.feedingandfeedstuffs.info/articles/feeding_management/winter_feeding/0203aj_extendedgrazing.pdf

EXTENSION

Extension to producers is critical for adoption of technology and research. There are several existing resources and producer decision making tools available to help producers identify the optimal seed mixtures for their region, fertilizer and weed control methods, winter feeding and nutrition strategies. These are listed below for each research area. This is not an exhaustive listing as there are no tools listed for stand establishment methods.

A. Developing a Stand

I. Variety Development

II. Stand Mixtures

- Forage Species Selection Tool, Sask Forage Council

III. Establishment

- Forage Seed Mixture Calculator, Alberta Agriculture
- Improving Pasture by Frost seeding, Iowa State University

B. Forage management

I. Forage Quality

Factors affecting forage quality:

- Understanding Forage Quality, University of Kentucky
- How to Maintain Forage Quality during Harvest and Storage, Alberta Agriculture
- Decision making tools:
    - Feed value calculator, Saskatchewan Agriculture
    - Forage and Crop Nutrient Calculator, Saskatchewan Agriculture

Forage rations and ration costs:

- Beef Ration Rules of Thumb, Alberta Agriculture
- Beef Cow Ration and Winter Feeding Guidelines, Saskatchewan Agriculture
- Decision making tool:
    - FeedPlan, Manitoba Agriculture
    - Silage value, Kansas State University

Measuring Forage Quality

- Forage Quality, Saskatchewan Agriculture.
- The Impact of Forage Quality on Ration Cost on Feed Inventory, Virginia Cooperative Extension.

Storing Forages

- Crops for silage production, Saskatchewan Ministry of Agriculture
- Challenges for Growing Corn Silage in a Northern Climate, AAFC

II. Pasture Management

More information can be found at:

- Pasture Management, Foragebeef.ca
- Pasture Management for Beef Cows, by Dennis Lunn and Shur-Gain
- Grasslands Beneficial Management Practices

Forage yield assessment and grazing rate calculation:

- Estimating Available Pasture Forage, Iowa State University
- Budgeting Feed Requirements of Beef Cattle on Pasture, Foragebeef.ca
- Decision making tool:
    - Grains, Forage and Straw Nutrient Use Calculator, Alberta Agriculture
    - Pasture Yield Calculation, PennState

Detailed descriptions and comparison of various grazing systems can be found at:

- Pasture Management, Manitoba Agriculture
- Grazing Management, Ontario Agriculture

III. Weed Control

- Management of Canadian Prairie Rangeland, Agriculture Canada
- Weed Control In Forage Crops, Manitoba Agriculture
- Control of Select Weeds on Pastures and Hay Land In Saskatchewan, Saskatchewan Agriculture
- Biological Control of Weeds on the Prairies, Saskatchewan Agriculture
- Insects for Weed Control, BCRC
- Current biological weed control agents - their adoption and future prospects
- Weed Control in Alfalfa and Other Forage Legume Crops, J.D. Green University of Kentucky Cooperative Extension Services
- Decision making tool: Noxious Weed Control, Montana State University Extension

IV. Rejuvenation Options

Extended grazing:

- Research summary, fact sheets and links to more resources, BeefResearch.ca
- Year Round Grazing 365 Days handbook, Agriculture Research and Extension Council of Alberta (ARECA)
- Extended Grazing Season, ForageBeef.ca
- Feed Testing, BCRC Blog
- Decision making tools:
    - Cow Wintering Costs, Kansas State University
    - Nutrient Loading Calculator, Alberta Agriculture
    - Manure management application rate calculator, Manitoba Agriculture
    - Feed Systems Cost Evaluator, Alberta Agriculture
    - Crop Residue Calculator, Saskatchewan Agriculture
    - Barley Silage Calculator, Alberta Agriculture

Bale grazing management and cost/benefit analysis:

- Beef Cattle Research Council
- Bale Grazing by Foragebeef.ca
- Bale Grazing by Saskatchewan Agriculture
- Decision making tool:
    - Bale Grazing Calculator, Saskatchewan Agriculture

Stockpiling:

- Stockpiled Pasture by Ontario Agriculture
- Using Stockpiled Forages by Foragebeef.ca

Swath grazing:

- Swath Grazing in Western Canada: An Introduction by Alberta Agriculture
- Extended Grazing by Beef Cattle Research Council
- Decision making tool:
    - Swath Grazing Calculator, Alberta Agriculture

Animal care in extended grazing:

- Tips for Successful Extended Grazing to Reduce Winter Feeding Costs, BCRC

Partnering researchers with producers

Forage and grassland productivity takes place in a complex ecosystem with many factors that are interconnected. Infrastructure is available but researchers are not being trained in whole system approaches which require collaboration across disciplines. In addition, whole systems research is extremely expensive. There is potential to have researchers partner with producers to complete studies on private land that is done on a larger scale. This comes with difficulties for creating controls and duplication of results. Producer decisions do not always work for the researcher. Documentation of data needs to be done on the farm and can be prohibitive. While this may not work for primary research, it could work for demonstrations. This raises the question of how can funding programs support these kind of endeavors. Many funding programs have a dollar cap and a limited time frame of one to two years.

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