Agricultural Feed Options For Northern Livestock

Investigating feed options and feed management systems for Yukon livestock

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Acknowledgements and Project Partners

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- The local producers who participated
- Yukon Research Centre
- Yukon Agricultural Research Committee
- Growing Forward II
- Yukon Agriculture Branch

Executive Summary

This report outlines and discusses new and existing research pertaining to livestock feeding systems and livestock feeds pertinent to Yukon producers. This report does not make specific recommendations per se; instead, it provides arguments and evidence supporting certain management systems and feed types for each of the livestock species identified by the Agricultural Research Committee.

This project was managed by the Yukon Research Centre, funding was provided by Growing Froward II, and oversight was provided by the Yukon Agriculture Branch. The concept for the project was brought forward as an area of concern, requiring further study, by the Yukon Agriculture Research Committee in the winter of 2013-2014. Work began on the project in May of 2014 and was completed January 31 2015.

In livestock production, feed costs are, in most cases, the single largest expense. These expenses can be reduced through on-farm forage production and preserving forages for winter feeding. Expenses can be further reduced by optimizing feed management systems, comprehensive management of pastures and by selecting forages that will provide a highly nutritious feed for the duration of the growing season. Feeds and feed management, is relatively simple for ruminant animals whose primary feed source comes from grass-based forages. Finding local feed options for monogastric livestock, on the other hand, can be more difficult and sometimes complicated.

One of the key reasons for this reports commissioning, is due to a growing interest in pork and poultry production in the Territory (State of the Industry, 2010-

2012). Pork and poultry have more complex nutritional requirements which traditional local forages are unable to meet. Local feed producers have, in recent years, begun meeting the demand for high energy crops by growing barley, oats, peas and rye; when combined with a premix, these grains are able to meet the nutritional requirements in most cases.

Availability of organic livestock feed is another area of concern. Many local producers are working towards, or are already certified organic, including many of the poultry, pork and dairy producers. The costs of organic feed is considerable, and the cost of importing it makes it even more expensive. Locally available organic feed options are commonly limited to hay bales, and even these are only temporarily available. The ability to produce on farm high protein and high energy crops, suitable for pork and poultry forage, is an important first step in reducing those costs and making production more affordable and sustainable.

For our purposes we will define forages as plant materials (mainly plant leaves, stems and seeds/grains) eaten by livestock either as a green forage (i.e., pasture forages) or as preserved forages. Traditionally, the term forage is used to define the plants eaten by the animals directly as pasture or crop residue, however, it is more recently used to include crops that are harvested, preserved and delivered to the animals as hay or silage. In this report we will also be including grains and grain legumes in our definition of forages.

The main relationship that will be investigated throughout this study is between growing conditions and the feed type that can be successfully grown within it. If the climate is not right the feed type will not grow or mature. However, it should be noted that not all forages need to "mature", in order to be good feed options.

There are many crops that can be harvested prior to maturity, and when turned into silage, or fed as green feed, make excellent feed for most ruminants. These crops can produce high yields and high grade feed when compared to traditionally cultivated crops.

Alternative forages can have a new learning curve associated with production, harvest and storage, additionally, local availability for equipment and expertise can be limited. These factors are important to consider when planning what to grow on your farm. In many instances planting crops with lower yields and lower nutritional value must be done in order to ensure a successful harvest. This is especially true of cereal crops which take a long season to mature and are highly susceptible to lodging. Cool, wet falls can create challenging conditions for harvest. Grass hay, on the other hand, is harvested in midsummer when there is a higher probability of having good weather for harvesting.

The number of farms raising livestock in the Yukon has been increasing, more farmers are growing poultry and pork, which has increased the demand for high protein and high energy feeds. Some producers have stepped in to meet these needs, however, as of this writing, there are no reliable sources for organic feed options; which is what many producers are choosing to feed.

This project was initiated to provide new information about potential forages, both fresh and preserved, and new ways of providing those forages to livestock animals. The livestock animals that were chosen to be included in this project were: cattle, pigs, poultry, sheep, goats, elk and bison. In the following chapters, forage options will be discussed as they pertain to each livestock species as will feed management options and strategies.

The recommendations outlined in this project were made with consideration of the scale of Yukon agriculture, the ethical ideals of local livestock producers and with attention to organic production methods. While the production systems discussed are generally smaller scale, they are scalable and adaptable to larger production systems. This report focused primarily on discussing methods and feeds that are currently available to producers with a secondary effort on discussing methods and feeds that are still requiring further study and research.

Finally, this report identifies and discusses research gaps relevant to Yukon forage and livestock production, and proposes potential research projects that could help to fill these gaps.

This project found that many of the forages grown locally meet or exceed the nutritional requirements for most ruminant livestock under most conditions. Many of the common forages (bromegrass, timothy etc.) provide good yields in most soil types, in most regions, and in most years. That said, there were exceptions, for a variety of reasons, some forage samples that were tested did not meet these requirements.

This project found that Yukon grown grains can supply most of the nutritional needs for pork and poultry production. Northern hardy varieties of oats, barley and rye can all be grown to maturity (in most years) and make an excellent feed base for these livestock. Nutrition of these grains is comparable to those grown in other regions and yields (assuming adequate irrigation and nutrition are applied to the soil) are comparable as well.

A source of high protein supplementation is as yet unavailable from local producers, however, recent investigations into early maturing pulse crops may soon be able to change this. Recent research by the Agriculture Branch has found several varieties of field pea (Agassiz, Meadow, Peace River etc.) that can produce mature seed under irrigated and (to a lesser extent) dryland production. Research conducted for this report also found several varieties of field pea, Lupin, and faba bean that have been developed for Northern European growing regions. These crops may also be used as a high protein supplement for monogastric livestock. Continued research into variety testing, yields and hardiness will likely expedite adoption and integration of these crops.

Introduction

The Yukon Agriculture Research Committee (YARC), with the Yukon Agriculture Branch and Yukon Research Centre (the proponent) requested a research project be conducted to investigate feed and feed management options for Yukon livestock production. This project aims to identify best forages and best feed management options for livestock species which are currently being raised for the local market.

The proponent set four main objectives for the project:

1. Identify jurisdictions with similar agriculture conditions to those in the Yukon.
2. Build a reference resource, from the identified jurisdictions, which compiles successful feed management options for the livestock species of interest.
3. Summarize and rank the most suitable agronomic crops and native feed options that would successfully grow in Yukon.
    i. Factors included in the ranking system include: agronomic success, availability of seed, ease of use, equipment needs, benefits to Yukon, skills required, management decisions (including organic, synthetic, and closed system), and cost analysis.
4. Summarize the most appropriate feeding patterns to optimize production (quantity and quality) of each Yukon livestock species listed.

i. How can we adapt our current production to meet these feed management options?
ii. Determine the cost of production for the most appropriate options.
iii. Analyze the production strengths, weaknesses, opportunities and constraints for each livestock species taking into account the regional differences in the Yukon.

Forage production, either as hay or pasture, is the largest crop, in both land mass and revenue for Yukon farmers. Forage production forms the basis of the Yukon's agriculture industry, supporting: livestock producers, hobby farmers, outfitters and horse owners.

The Yukon is recently undergoing a shift in livestock production, from a predominantly cattle based sector, to a sector diversifying into poultry (eggs and meat), pork, and small ruminants. This diversification in livestock requires a corresponding diversification in available feedstuffs.

Feed represents the single largest cost associated with production of livestock which makes it an important area to analyze when trying to reduce production costs. Fresh forages from pasture are typically the cheapest source of livestock feed making investigations into new and improved feeds and feeding techniques an important area for research. This research project came about due to the needs for increased information into these topics.

The Agricultural Feed Options for Northern Livestock project was prepared by Treharne Drury, oversight conducted by Yukon Agriculture Branch, the Yukon Research Centre managed the project, and Yukon Agriculture Research Committee developed the project idea.

Summary of Yukon Agronomic Conditions

Agronomy: the science and technology of producing and using plants for food, fuel, fibre, and land reclamation. Agronomy encompasses work in the areas of plant genetics, plant physiology, meteorology, and soil science. Agronomy is the application of a combination of sciences like biology, chemistry, economics, ecology, earth science, and genetics. Agronomic practices are steps farmers incorporate into their farm management systems to improve soil quality, enhance water use, manage crop residue and improve the environment through better fertilizer manage-

Climate and Land Class Suitability:

The Yukon's climate is characterized by long cold winters and warm short summers (Scudder, 1997). The Yukon holds the record for having the coldest recorded temperature below freezing (-62.8°C in Snag) and the most variable climate in North America (Scudder, 1997).

Climate is just one of the many of the agronomic conditions of the Yukon that can effect growing conditions. Other significant agronomic parameters are precipitation and soils. Temperature, rainfall and soil fertility, have been mapped, studied and are reasonably well understood in the Territory. These three parameters largely dictate the types of crops that can be successfully grown in our region. There are other agronomic factors to consider as well, however, many can be remediated using soil improvement strategies, herbicides, pesticides and fungicides, these factors will constitute a lesser focus. For this report, we will be mostly concerned with summer temperatures and to a lesser degree moisture and fertility. These agronomic conditions will be discussed and evaluated for two purposes:

1. To better understand livestock feed management options, systems and potential forages based on the environmental limitations of the area.
2. To build a comparative profile so that analogous jurisdictions can be identified and researched for new methods of feed management and forage options.

The main conditions we will focus on are climate and soils. With this information we can classify agricultural lands throughout the Yukon and determine crop suitability.

For northern growing regions climate is commonly the determining factor of agricultural potential. Precipitation can be mediated through irrigation; however, there is no solution for cool growing temperatures or untimely killing frosts. When evaluating Yukon weather data (using plant hardiness maps and the Land Class Suitability Ratings system), the Yukon appears lacking in necessary heat units, moisture, and frost free days. However, many regions possess the microclimate needed to grow a diversity of crops (like apples in Dawson). In the 1987 report by Delloitte et al., "A Study of the Feasibility of Establishing a Forage and Dairy Operation in the Yukon", the authors note that:

> In reality the Yukon consists of numerous micro-climatic areas that are site-specific and it could be erroneous to extrapolate data from one site to another even if they were separated by less than a kilometre".

The aforementioned quote is an accurate descriptor of many regions of the territory; careful evaluation of the climate, specific to an individual farm, is needed to make the most informed management decisions.

This project will be utilizing Yukon weather data recorded by Environment Canada and Yukon Government Community Services, to assess climate suitability for the crops investigated.

Agroclimatic Regions

Overall, the Yukon climate can be considered continental in nature, consisting of warm brief summers and long cold winters (Deloitte et al., 1998, Maurer, 1989). The Yukon receives relatively little annual moisture (239-415mm) and has an average annual temperature of -1.4°C in southern regions (Maurer, 1989). The number of frost free days varies with region, however, southeast areas can average 90 with a few areas getting around 20 (Maurer, 1989).

The territory is conventionally defined by four agroclimatic regions, these include:

1. Whitehorse region, mainly in the Takhini and Yukon River valleys.
2. Central Yukon, this area generally includes the areas between Carmacks, Mayo and Dawson.
3. South West Yukon, Takhini River and Haines Junction regions.
4. South East Yukon, Watson Lake area.

These regions differ geographically, climatically and in agricultural potential. Agricultural potential can be described in a number of ways, one of which is the Land Suitability Rating System for Agricultural Crops. (Agriculture and Agri-Food Canada, Technical Bulletin 1995-6E). This evaluation system uses climate data (and other data) to loosely describe the crops that will successfully grow in a specific region. These Land classes are accorded based on growing capability, class 1 being the best growing conditions and class 7 the worst (Table 1).

Table 1. Land class suitability ratings for Canada

Class	EGDD °C	Key Traits
Class 1	1400-1600	These lands have no significant limitations that restrict the production of the full range of common Canadian Agricultural crops.
Class 2	1200-1400	These lands have slight limitations that restrict the range of some crops but still allows the grain and warm season vegetables.
Class 3	1050-1200	These lands have moderate limitations that restrict the range of crops to small grain cereals and vegetables.
Class 4	900-1050	These lands have severe limitations that restrict the range of crops to forage production, marginal grain production and cold-hardy vegetables.
Class 5	700-900	These lands have very severe limitations that restrict the range of crops to forages, improved pastures and cold-hardy vegetables.
Class 6	<700	These lands have such severe limitations for cultivated agriculture that cropping is not feasible. These lands may be suitable for native grazing.
Class 7		These lands have no capability for cultivated agriculture or range for domestic animals.
SOURCE: State of the industry, 2005-2007		

With these land class designations in mind, we can assess the productive capacity of the 4 agroclimatic regions in the territory. Weather data from Environment Canada was used to calculate growing degree days (GDD), a day length factor (based on latitude) was then used to calculate the effective GDD or EGDD (Land Suitability Rating System for Agricultural Crops 1995). From the EGDD the land class designation can then be calculated. Table 2 shows weather data and land class designations averaged over a 30 year period from 1981 to 2010.

Table 2. 30 years of weather data and land class designation for various Yukon sites.

1981-2010	Whitehorse Region	Central Yukon	South West Yukon	South East Yukon
GDD	936.4	1016.4	863.1	1015
Day Factor	1.16	1.18	1.16	1.14
EDGG	1086.2	1248.38	1001.2	1157.1
Land Class	Class 3	Class 2	Class 4	Class 3

SOURCE: Environment Canada

The land class designation for each region can vary significantly from growing season to growing season. For example, at the Whitehorse airport in 2004, the land class designation was Class 2, in 1996 it was designated Class 6. This variation in growing seasons has significant impacts on crop success/failure and is important to consider when choosing crops. As there is no way to predict the growing potential of a particular season, most producers tend to plant crops that will succeed in even the worst of growing years.

Moisture

The two main climate factors limiting agricultural potential are temperature and moisture. In all agroclimatic regions of the Yukon precipitation is considered low (semi-arid) which results in it limiting growth (Maurer, 1989). To maximize yields, most agricultural operations in the Yukon find it necessary to irrigate (this may not be required for perennial grass pastures, however, is a good management decision for fields intended to be harvested). There is some debate regarding the effectiveness of irrigation without the use of fertilizers, however, in all instances crop yields are higher when a combination of fertilizer and irrigation is used (Deloitte, 1987). It is recommended that some form of nutrient be added to soils when irrigating in order to maximize the usage of the additional water.

Rainfall in the Yukon is variable from region to region and from year to year. Over the last 30 years the South East Yukon has had the highest annual precipitation (snow plus rain 416mm) and rainfall (262mm) and the South West Yukon has had the lowest (228mm and 156mm)(Table 3).

Table 3. Average precipitation for agroclimatic sites around Yukon, 1981-2010

Region	Rainfall (mm)	Total Precip. (mm)
South West Yukon	156	228
Whitehorse	161	262
Central Yukon	202	319
South East Yukon	262	416

SOURCE: Environment Canada

Variability in annual precipitation affects the yields of forage crops grown in the absence of irrigation. This is especially problematic for annual crops which rely on spring rains to germinate seed. Evidence of this can be seen in the dryland forage trials that take place at the Yukon Research Farm (Table 4). Dryland plots have consistently lower rates of germination and lower yields.

Table 4. Average dry biomass of oat varieties over three years (t/ha)

Location	Management	Variety	2010	2011	2012
Research Farm	Dryland	Local Oats	-	-	6.4
		AC Lu	2.7	-	4.3
		AC Murphy	3.2	-	4.3
		AC Mustang	2.5	10.7	4.0
		Triactor	2.9	9.8	-
	Irrigated	Local Oats	-	-	13.9
		AC Lu	11.4	9.2	15.4
		AC Murphy	13.2	9.2	15.5
		AC Mustang	11.8	9.0	14.1
		Triactor	13.8	8.2	-

Source: 2012 Research and Demonstration Report, Ag Branch.

Agricultural Soils

Yukon soils have been broadly surveyed, mapped and described in the recent past by: Acton and Pringle (1975), Rostad et al. (1977), Hughes et al. (1983), White et al. (1992), and Tarnocai et al. (1993). Soil classification for agricultural purposes was conducted by the Agriculture Canada Expert Committee on Soil Survey in 1987; the committee produced the following map (Figure 1) outlining the general distribution of dominant soil types found throughout the Yukon. As this map illustrates, the bulk of agricultural activity takes place in the Eutric Brunisolic soils of the Southern and Central Yukon.

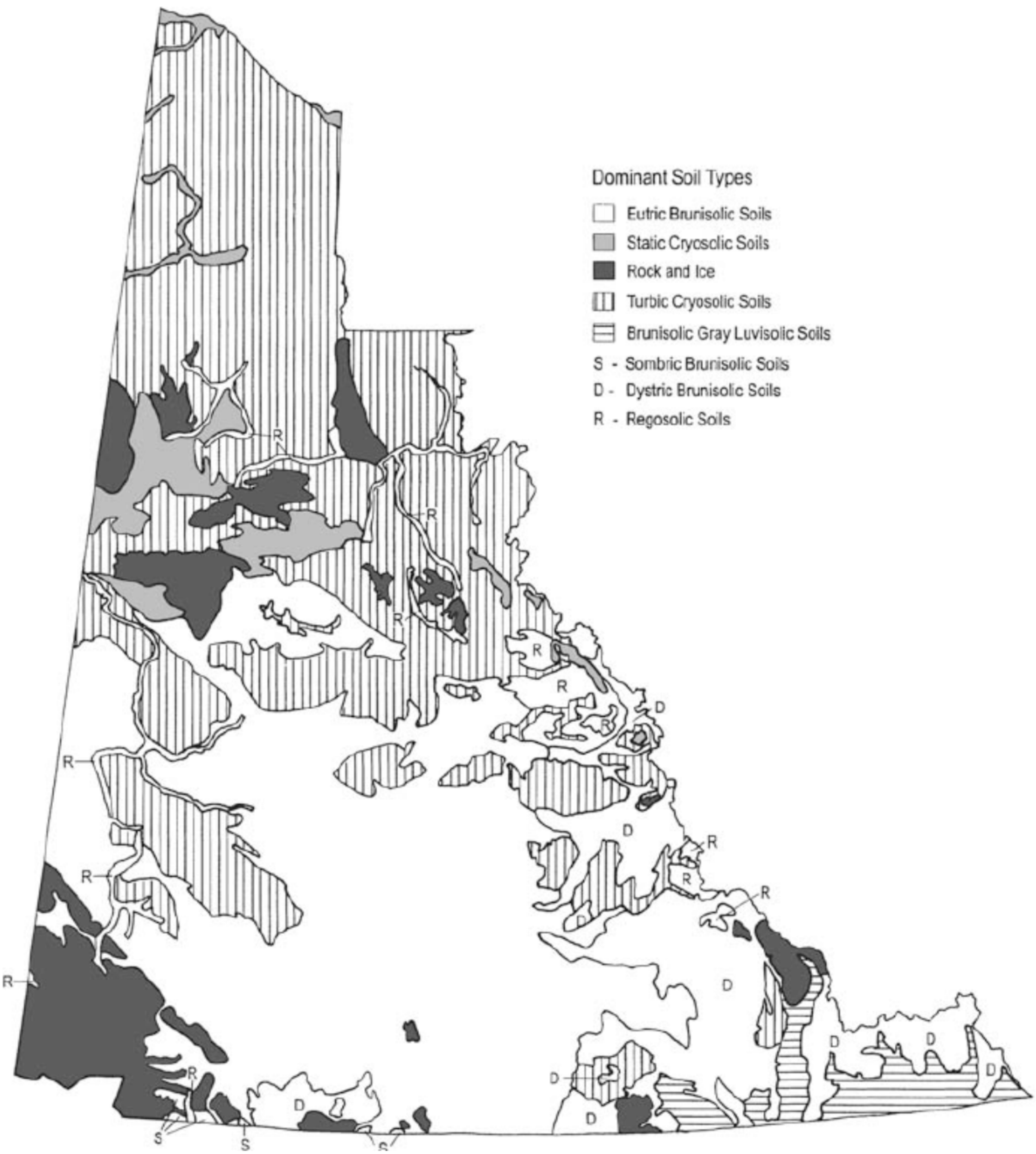


Figure 1. General distribution of soil types in the Yukon (from Agriculture Canada Expert Committee on Soil Survey 1987

The work done by the Agriculture Canada Expert Committee on Soil Survey (1987) built upon the work conducted by Rostad et al. in 1977. During his survey, Rostad et al. (1977) calculated the regional extent of agriculture land and classified it according to Agricultural Capability Class. The results are as follows:

Table 5. Areal extent of Agricultural Capability Class in area surveyed by Rostad et al. (1977)

	Agricultural Land Class (ha)				
Region of the Yukon	Class 3-4	Class 5	Class 6	Class 7	Total
Dawson-Stewart-Mayo	24,380	166,912	17,238	133,613	342,143
Pelly Cross. Carmacks	27,730	143,721	17,127	67,691	256,269
Watson Lake	10,447	209,267	267	97,737	317,718
Faro – Ross River	644	31,912	67,235	12,768	112,559
Whitehorse	--	73,240	17,472	79,278	169,990
Takhini – Dezadeash	--	126,215	14,887	26,178	167,280
Snag	--	35,821	2018	17,766	55,605
Total	63,201	787,088	136,244	435,031	
Grand Total					**1,421,564**

Source: Rostad et al. (1977)

In his report, Rostad et al. (1977), included Class 7 lands in the total calculation of total agriculture lands, however, Class 7 lands are generally considered non-agricultural so can reasonably be excluded. This leaves approximately 986,533 hectares of land with some form of agricultural potential. Of this area, approximately 10,646 hectares are currently in production (2011 Census of Yukon Agriculture, Statistics Canada). It is currently unknown how much of the agriculture land is in what Class designation, however, the majority of Yukon farms are located in the Whitehorse area which consist of land Classes 5 and 6.

In the 1970's, Yukon soils were broadly surveyed to assess agricultural potential; the areas selected to be assessed were chosen based on current land use (at that time), native vegetation types, and areas where agricultural leases were being applied for (Rostad et al. 1977). The survey classified and mapped soils into groups with similar properties and created a set of aerial photographs and interpretive maps with the data. These resources were created for the use and interpretations of:

1. Soil capability for agriculture
2. Grazing capability
3. Suitability for irrigation
4. Suitability as a source for topsoil
5. Surface texture
6. Soil drainage and permafrost

These surveys found that the majority of soils were composed of either sand or gravel and were formed in deposits of fluvial (soils associated with rivers and streams) origin. Most of these soils had surface layers of finer textured material, sandy loam and silt loam, between 10 and 50 cm thick (Rostad, et al., 1977). Much of the agricultural land surveyed was near major rivers (Yukon, Takhini, Pelly, Stewart and Liard) where mixed organic and mineral soils were found throughout the profile. Most of these soils were found to be neutral to alkaline pH.

This survey further classified all glaciated soils as Brunisols or Regosols. Both these soil types are considered young, poorly developed and common to fluvial deposits.

Table 6. Description and agricultural potential of various soils throughout the Yukon

Location	Description	Agricultural Potential
Takhini Valley Various sites	Orthic and degraded Eutric Brunisols can be found in this region, weakly developed Dark Grey and Grey Luvisols and low lying areas were observed to be saline and alkaline	Low
Pelly River Farm	Soils were sampled at the Pelly River Ranch, these soils were described as Cumulic Regosols with a surface moderately high in organic matter.	Rated as low but it has been demonstrated to be otherwise
Sunnydale	Soils here were classified as gleyed Rego Dark Grey Chernozemic with a 6 inch thick surface layer or organic matter. This was overlying varved or bedded non-calcarious very fine sandy to silty sediments.	Agriculture potential in this region is considered limited, however good yields of vegetables and forages has been demonstrated
Carmacks area	Soils are classed as Orthic and Degraded Eutric Brunisols blanketed by a thin layer of volcanic ash. Soils have low moisture	Agricultural potential is considered limited

	holding capacity and low fertility

Source: Acton and Pringle, 1975

Research on Yukon agricultural soils was also conducted by the Department of Indian and Northern Affairs in 1975, by Acton and Pringle, and soils were assessed and described regionally. Table 6 provides a general overview of the regions surveyed.

Soil Fertility

Following the analysis of the 1977 soil surveys conducted by Rostad et al., (1977) the general conclusion on soil fertility in the Yukon was stated thusly:

> It can be generally concluded that the soils in the study areas are not highly fertile and will present some problems with respect to plant nutrients. In many areas it is likely that fertilizer use will markedly increase production……The most serious limitation is likely that of nitrogen for continued grass production and of potassium on selected soils.

Rostad (1977) further advises that phosphorus fertilizer will be needed for most crops and for most soils under continued cultivation or production practices.

The structure of agricultural soils in the Yukon are not likely to limit the growth and yield of forage crops. Acton and Pringle (1975), note that the structural conditions of the Brunisolic and Luvisolic soils will not markedly interfere with the production of perennial forage crops. They further remark that Luvisolic soils may develop surface structural conditions that restrict cereal crop production.

For a detailed analysis of the 1977 study areas and more specific recommendations refer to "Soil Survey and Land Evaluation of the Yukon Territory" by Rostad et al., 1977. EMR library call number S599.Y2C.5. Soil samples can also be taken to the Yukon Agriculture Branch where they will be sent out for analysis. The branch can also help with interpreting the results and determining ideal application rates of nutrients.

Soil pH

Soil pH was found to be near neutral in all regions except for: Dawson, Stewart Crossing, and the Mayo areas; these areas were found to be on the acidic side and liming is recommended for optimal yields and productivity in these areas (Rostad, et al., 1977).

Soil Salinity

Most of the soils in the 1977 survey did not have salinity problems except for some soils in the Pelly Crossing Association, these had moderate salinity. Rostad et al., (1977) advised that these levels of salts could have serious effects on the production of many crops. Rostad further advises that areas of moderate salinity should be avoided and not used for cultivation; as salinity levels frequently increase under cultivation, agricultural production will become increasingly difficult.

Soil Nitrogen

Nitrate nitrogen levels were found to be low in all the soil profile samples obtained and tested in the 1977 soil analysis conducted by Rostad et al. In almost all instances, nitrogen (in some form) needs to be added to soils in order to obtain reasonable levels of productivity.

Soil Phosphorus

Soil phosphorus measurements were found to be highly variable depending on where the samples were taken, higher levels were found in poorly drained alluvial soils or from garden plots which had been fertilized to some degree. The results of the 1977 soil analysis recommends that some amount of P is used for most crops grown in Yukon soils. Yield increases will make the increased input cost worthwhile for most producers and production systems (Rostad et al., 1977).

Soil Potassium

Yukon soils were found to have a rather high incidence of very low potassium levels with some areas being classified as "potassium deserts" for certain crops (Rostad et al., 1977). Potassium application is recommended for most Yukon soils and for most crops.

Soil Sulphur

Rostad et al., (1977) found most agricultural soils in the Yukon to be sufficient in sulphur levels and suggests that most soils would be fine with usage of a sulphur containing nitrogen or sulphur containing phosphorus fertilizer.

Soil Organic Matter

Soil organic matter is a very important component of agricultural soils especially in regions with low or intermittent precipitation (Patriquin, 2003). The presence of organic matter can influence the water holding capacity of the soil and increase the efficiency of water capture and utilization (Patriquin, 2003). Research conducted by Hudson (1994) found that when soil organic matter is increased from 1% to 3%, the water holding capacity of the soil approximately doubles; Hudson also found that when soil organic matter is increased to 4% it accounts for upwards of 60% of the total available water holding capacity. Patriquin (2003) further attributes increased soil organic matter with: better infiltration, better drainage, increased aeration, as well as improved soil nutrition and soil life. Conservation of existing organic matter in the soil is an important management strategy as building organic material in the soil is time consuming and can be expensive. Patriquin (2003) suggest several ways to build soil organics:

- Return crop residues to the soil
- Cover crop techniques can build organic material
- Minimize tillage as this accelerates breakdown of organic material
- Add compost to the soil

Building or maintaining soil organics can be especially important in areas like the Yukon where unirrigated crop lands rely on snowmelt and spring rains as their main source of annual precipitation. The Yukon's agricultural regions have a varying degree of soil organic matter which range from highs of 13.7 (as calculated based on organic carbon content), to nearly none (Acton and Pringle,

About Soil Carbon

Soil organic matter (SOM) is an important part of soil health. SOM is made up primarily of organic carbon (OC), around 56%. If you need to determine the organic matter content of soil from OC the formula is this:

% organic matter = % organic carbon x 1.78

From Cannon, 2001.

1975). In 1975, Acton and Pringle surveyed a variety of developed and un-developed sites throughout the territory, sites were sampled for a variety of variables, one of which was soil organic carbon, results are displayed in Table 7.

Table 7. Soil carbon (%) for agricultural soils throughout the Yukon

Site Location	Soil carbon at depth		
	0-15 cm	15-30 cm	30-45 cm
Mile 10 Mayo Rd.	1.1-2.8	0.6	0.5
Pelly River Ranch	3.6	1.7	1.6
Swede Creek	3.6		2.7
Sunnydale	5.5	2.4	n/a
Soil carbon (%) for non-agriculture soils throughout the Yukon			
Mile 154 Klondike Hwy	1.0 (0-10 cm)	0.6 (10-20 cm)	1.7 (20-30 cm)
Mile 28 Mayo Rd.	2.3 (0-10 cm)	1.0 (10-25 cm)	1.0 (25-100 cm)
Lorne Crossing	3.9-5.4	0.6-2.5	n/a
Takhini River	7.1	4.5	n/a

Developed soils in the Whitehorse area, such as the Yukon Grain Farm and the Yukon Research Farm, have soil organic matter between 2 and 3% (Ball and Barton, 2010).

Summary Table of Yukon Agricultural Conditions:

Table 8. Summary table of Yukon Agricultural Conditions.

Temperature	The summer temperature in the Yukon is typified by being warm and short, effective growing degree days at most farming regions range from 900-1300 with corresponding land class designations of class 3 to class 6.
Precipitation	Precipitation in the Yukon is fairly low, the 30 year average is between 156mm to 262mm (depending on the region) of rain annually and total precipitation ranges from 228mm to 416mm. Most cropping systems require irrigation to maximize production.
Soils	Soils in the Yukon are generally considered young, nutrient poor, and low in organic matter, Rostad (1977) among others, recommend that most soils will require some form of additional nutrient to ensure good yields and productivity.

Identifying Comparable Jurisdictions

One of the key goals of this project is to identify alternative forages and feed management practices that could be implemented in the Yukon to increase feed quality and livestock productivity. Identifying comparative agronomic jurisdictions is the first step towards a more in depth investigation into potential forages and feed management alternatives. Armed with the information discussed in the preceding chapter (Summary of Yukon Agronomic Conditions) we can look for comparable global regions from which we can gather information.

Outlined below is the list of criteria that jurisdictions should be comparable with. Obviously, it will be difficult to find agronomic regions that compare identically with those found throughout the Yukon, however, several regions have been identified as meeting many of the criteria.

Variables of comparison between jurisdictions:

In order to accurately identify comparable agronomic regions to the Yukon, a list of "factors for comparison" was assembled so that regions of interest (other countries, provinces, etc.) could be compared to areas of the Yukon. This was done so that potential crops and feeds could be rapidly screened for suitability depending on their region of origin. If the region of origin did not meet some minimum agro-climatic thresholds, then crops and feeds from these areas was generally overlooked. Some of these variables included:

- Climate should be similar
    - Cold frozen winters (-30°C)
    - Warm dry summers (800-1200 EGDD)
    - Rainfall should be in the range of 150-400mm/year

- soils should be comparable
    - low organic component
    - young, silt and sandy loam
    - relatively low in fertility
- Latitude should be similar, photo period, solar exposure etc.
    - Between 60 and 65 degrees north (or farther north in Scandinavia)
- Winters should be comparable
    - Limited coastal influence, must reach cold temperatures of at least -30 C for perennials or biennials
- Other factors: Location to markets and proximity to service and supply
    - This does not affect what can be grown but it may affect what is grown.
    - This is difficult to duplicate as very few places are as remote and sparsely populated as the Yukon.
- Proximity to services and suppliers?
    - Proximity to services and suppliers can impact the types and sizes of agricultural machines that are typically used on a farm, large complex agricultural machines require specialized maintenance and servicing, without infrastructure in place to undertake these tasks, farm managers are less compelled to own and operate these equipment types. This can impact the types and volumes of forage crops (more likely grain and legume crops) that are able to be efficiently harvested and therefore grown.

Jurisdiction for comparison

Growing Degree Days, a Starting Point

One of the easiest and quickest ways to make climate comparisons between jurisdictions is by comparing growing degree days (GDD) (explained in section "Climate and Land Class Suitability"). Comparing GDD allows regions to be assessed based on the types of crops that can grow and mature there. Finding agricultural regions that have a similar GDD profile to those found throughout the Yukon allows them to be identified for further investigation.

In order to gather GDD information an online GDD calculator was used, this was

Table 9. Comparative GDD's of various northern ag. Regions.

Location	°N	GDD	Yr. Average	Day length factor	EGDD
Whitehorse	60.4	1506	30	1.16	1747
Watson Lake	60	1672	30	1.14	1906
Dawson City	64	2000	7	1.18	2360
Haines Jnct.	60	1191	30	1.16	1381
Fairbanks	64.5	2110	30	1.18	2489
Ft. Smith NWT	60.0	1961	30	1.16	2274
Reykyavik IS	64	1065	30	1.18	1256
Murmansk RU	68	1350	7	1.18	1593
Rovaniemi FI	66.5	2000	7	1.18	2360
Source: www.weather.com					

found at, http://www.weather.com/outdoors/agriculture/growing-degree-days/FIXX4094%3A1 . Potential northern regions were identified (using a map and information available online) and cities in those areas were selected and entered into the GDD calculator, these figures were recorded and compared in table (Table 9).

The GDD calculator used a base temperature of 40°F, this is 4.44°C which is lower than the standard base temperature used in Canada and Europe of 5°C. For this reason the GDD numbers appeared higher than conventionally published figures as a base 40°F formula captures more heat units than the base 5°C. This is inconsequential for our purposes as we are using these numbers to simply compare the climate between regions.

Based on the data presented in Table 9, we can gain a very general understanding of how regions in the Yukon stack up compared to other northern growing regions based on GDD.

Soils, a Deeper Degree of Comparison

To gain a fuller understanding of the agronomic regions identified assessing GDD's, an analysis of soils was also conducted. As covered in the previous section, the agricultural soils of the Yukon are: geologically young and poorly developed, low in fertility, lacking in organic matter and were formed through a combination of glacial and fluvial processes.

Many of the soils found in the regions identified by looking at GDD's have some similarities in soil properties to Yukon soils. Alaska, for example, is proximal to Yukon and shares much of the same geological history, this has contributed to similar soil types being found in the central growing regions of Alaska (Scudder, 1997). In a technical note from the Natural Resources Conservation Service (2008) called "Making Fertilizer Recommendations from Soil Test Reports", the authors comment that additions of nitrogen, phosphorus and potassium (in some cases) are required in most cases.

Regions in central Alaska, like the north Yukon, were not glaciated during the last ice age, this has resulted in some areas containing higher natural levels of soil organic matter than are typically found in the post glacial soils in the southern Yukon. Some regions have levels as high as 12% soil organic matter (NRCS Technical Note 16, 2008).

Scandinavian soils on the other hand are also post-glacial (35,000-40,000 years ago) but have had a much longer developmental period than most soils found in the Yukon. This has resulted in higher natural levels of nutrients and soil organic matter (Landenberger et al. 2012). High levels of naturally occurring phosphorus are found in the soils of Norway, Sweden and Finland due to the fact that the bedrock is high in apatite which enriches the soil (Landenberger et al. 2012).

Levels of soil organic matter in Finland, Norway and Sweden can be much higher than those found in the Yukon. Levels approaching 50% can be found in cool wet areas, however, the range is 0.8% to 49% (Landenberger et al. 2012)

Soils in Iceland are quite different from the soil types described thus far. Soils in Iceland are formed from the weathering of volcanic materials and volcanic ash (Arnalds, 1999). These soils are generally classified as Andisols, and have a range of unique characteristics. These soils tend to be susceptible to erosion, have low cohesive properties and have high water absorbing capacity. The vast majority of the soils are classified as Brown Andisols, these have 2-10% organic matter and a slightly acidic pH (5.5-6.5%) (Arnalds, 1999). Andisol soils in Iceland are considered fertile, however, due to certain characteristics they immobilize P, this creates a P deficiency for most crops (Arnalds, 2008).

Precipitation

In many regions forage crops are grown without the use of irrigation. Seasonal rains and spring snowmelt are sufficient sources of moisture to grow perennial and even annual grasses, grains and other forages. Most of the agriculture regions in the Yukon are moisture limited (135-239mm rainfall) and irrigation is generally required for good yields (Maurer, 1989). Compounding this moisture deficit is the periodicity of when that moisture occurs. For best growth, germination and yields, precipitation in the spring is most valuable, however, for several areas of the Yukon, the bulk of the rain events occur in July, August and September (Environment Canada). Table 10 below shows summer precipitation events from 1981-2010.

Table 10. Summer rainfall at various locations in Yukon, 1981-2010.

Location	May	June	July	Aug.	Sept.
Whitehorse	14.3	32.4	38.1	35.5	29.0
Dawson	28.4	38.2	49.0	43.1	29.7
Watson Lk.	33.6	54.9	59.5	47.4	41.1
Tahk.Riv.Rch	14.1	30.6	39.6	37.3	24.5

Source: Environment Canada, Climate Normals 1981-2010

Precipitation in the interior growing regions of Alaska is higher than those found in the Yukon. Between 1981 and 2010, Fairbanks receives and average of 275mm of rainfall per year and the Tanana Valley receives around 300mm (acclimate.org/climate/normal). This is nearly double the rainfall the Whitehorse area has received on average throughout the same period.

The Nordic countries also receive on average more precipitation than Yukon, Finland averages 578mm of precipitation annually, slightly more than half of which falls as rain during the growing season (www.finland.climatemps.com). Sweden averages about the same and Norway averages around 860mm (www.climatemps.com). Like Yukon, the Nordic countries receive a good deal of their rainfall during mid and late summer, this has led to innovations in silage harvest and storage technologies in order to harvest and store forages more rapidly.

Alaska: Delta Junction and Fairbanks

Fairbanks and Delta Junction regions of Alaska have comparable soils and growing conditions to those found in central Yukon. Over the years there has been considerable information sharing between the Alaskan agriculturalists and those in the Yukon. In the 1970's considerable work was done on forage and grain trials in Alaska and the results of which benefited both Yukon and the State. Most growing regions in central Alaska have more GDD’s as well as more summer precipitation than Yukon.

North West Territories

Growing conditions in the NWT are comparable to those found in central Yukon, however, NWT receives slightly more GDD’s and precipitation than Yukon.

Nordic Regions, Finland, Norway, Sweden

There was a considerable amount of good agricultural information available from Finland, growing conditions were somewhat comparable and good forage variety trials were found. Finland also has an extensive forage based beef and dairy industry and performance information was available from this region. Finland, Norway and Sweden receives more precipitation than Yukon, most areas have more GDD's and these areas have more developed, fertile soils.

Iceland

Iceland has very a different geological history than the other regions discussed so far, Iceland has somewhat fertile soils that are young with relatively high organic matter. Iceland has les GDD's than Yukon but gets much more moisture.

Northern Russia and Siberia

Both northern Russia and Siberia would make excellent comparative models for Yukon agriculture as they have the largest expanse of comparable land in the world. After considerable effort attempting to gather (in English as I do not speak Russian) agricultural and climate information and attempts in contacting Russian agriculture scientists, no inroads were made and no information was found.

Crops and Native Feed Options for Yukon

For any livestock operation relying on the production of all, or some of, their own feed, the land base needs to appropriately complement the needs of the animals throughout their development. A cattle operation will have differing needs than a pork or sheep farm and these factors need to be considered when tailoring your forage crops. Conversely, not all forage crops will be suitable for a particular soil type adding further complexity to forage selection.

Several key elements need to be seriously considered when planning your live-stock operation. By assessing the capabilities of your local climate and land, a list of appropriate forages can be generated. The types of forages that can be grown may dictate the types of livestock you chose to raise. As foraging is typically the most cost effective method of feeding livestock these decisions can significantly affect the profitability and sustainability of an operation. Some questions to consider that can help when planning are:

- What forages will the local climate allow me to grow on my farm?
- What forages will my farms soil support?
- Can I irrigate/do I want to irrigate?
- Do I have sufficient land to support summer foraging and forage harvesting?
- Will the forages capable of being grown on my land meet the nutritional requirements of my livestock?
- What supplemental feed (if any) do I need to use/grow?

Answering these questions will help farm managers identify crop types and feed options that are suitable for their livestock and help to identify the limitations of farm capacity.

The following sections will assess the forage types and varieties that can be successfully grown in the Yukon specific to each livestock type. It will discuss nutritional and energy concentrations, palatability and digestibility and provide a crude ranking of the most suitable crops/forages for the livestock animals: cattle, bison, elk, sheep/goats, pigs and poultry.

Traditional Crops and Forages

The Yukon has had some degree of agriculture taking place since the mid eighteen hundreds. Hudson's Bay traders began growing small garden plots in 1840 (Se-recon, 2007) and by the time of the gold rush it is estimated that upwards of several thousand acres were in production in the Klondike area (Deloitte, 1987). Demand for meat and produce during this time pushed food prices to record highs making food production a lucrative business.

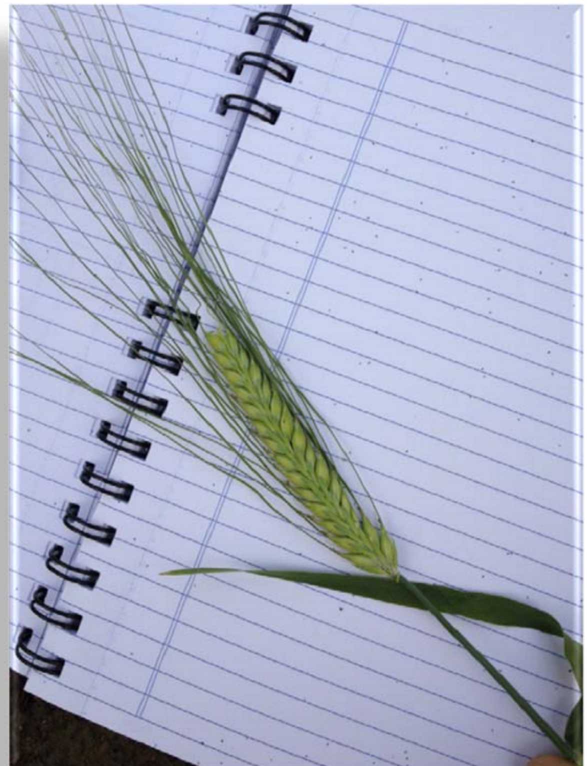
As the gold rush declined and miners left the territory, demand for produce and meat declined as well. Most of the farms in the Klondike stopped producing. Small farms throughout the territory continued to produce, however, by 1971 there were only 12 farms left and only three of them reported more than 2500$ in sales annually (Rostad, et al., 1977). As transportation costs decreased with the introduction of the Alaska Highway, Yukon farmers were never again able to compete with continually lowering food prices.

Today, grass hay is the largest single agricultural crop produced in the territory (2012, State of the Industry Report). It accounts for nearly 50% of total agriculture production both by area and value. Most of the grass hay produced is smooth brome (Bromus inermis) or a brome mix (State of the Industry, 2007). Grass hay is produced for the local market and is fed primarily to horses and cows.

Historically, forage crops were grown to support the horse industry: outfitters, individual owners and horse boarding being the largest consumers. Today forage crops are being diversified to meet the needs of the many small farms in Yukon which are raising an ever expanding variety of livestock animals. In 1987 it was estimated that only 40% of the required forages for Yukon livestock was produced locally (Deloitte, 1987). In 2007 that figure was increased to 75% (Serecon, 2007). Locally produced feed grains roughly meet the demand of the non-organic livestock producers, however, there is still a lack of high protein feed for pork and poultry producers (Serecon, 2007). In both feed grains and grass hay, there is a large and increasing demand for local organic options.

As we will see in the proceeding chapters, the feed requirements of livestock varies considerably between animal groups; the most notable difference being between the ruminants and the non-ruminants. With increases in pork and poultry production, forage producers have begun to diversify their crops to include high energy grains for these animals. Pasturing also plays an important role in livestock production both in terms of animal health and cost of production; high quality forages are typically fed to cattle, sheep and bison etc., but they can also be tailored to meet the needs of poultry and pork. The specific needs of these livestock animals will be dealt with in the following chapters.

Northern Crop Development, Past, Present and Future



Yukon New Crop Development (1985-1987)

In 1985 the government of Yukon began field trials for grain and forage crops at various locations throughout the territory. This was a 3 year study and was called the "Yukon New Crop Development Project". This project investigated the adaptability of agricultural crops throughout the Yukon's varied climatic zones. Amongst other crops, grasses, cereals and legumes were tested. These trials represent one of the more comprehensive field scale forage tests conducted in the Yukon and findings are summarized as follows.

Testing sites were diversely located throughout the Yukon and included: Sunnydale, Minto Bridge (2sites), Pelly Farms, Firth Farms, Bjorkman, Toole, and Tait farm (sites are identified on Figure 2).

Figure 2. Location of variety trials and research sites during the 1985-1987 New Crop Development Project

Cereal, legume and grass varieties tested at the eight sites are displayed in Table 11 below.

Table 11. Cereal, legume and grass varieties tested during the New Crop Development Project, 1985-1987

	Barley	Oats	Grass	Legume
Variety				
	Otal	Foothills	Green Needlegrass - Lodrom	Beaver
	Lidal	Toral	Crested Wheatgrass - Fairway	Peace
	Datal	Cascade	Crested Wheatgrass - Nordan	Drylander
	Datal	Grizzly	Timothy - Climax	BL-1019
	Johnston	Cavell	Orchardgrass - Kay	NRG-84-4
	Gateway		Tall Fescue Kentucky 31	NRG-84-2
	Scout		Creeping Red Fescue - Boreal	S-7312
	Calibre		Meadow Fescue - Miner	
	Tupper		Smooth Bromegrass - Carlton	
	Diamond			

Results from the first seasons (1985) grain trials showed that yields and maturity were highly dependent on the soil and climate conditions of each farm. Barley yields were highly variable depending on testing sites while the oat yields were consistently high (except for Firth Farms). Table 12 presents the highest yielding and best maturing varieties. Toral oats exhibited best maturity at all sites and had consistently high yields.

Table 12. Maturity and estimated yields of oat trial 1985

Grain (Oats)				
Site	Best Maturing (bu/acre)		Highest Yielding (bu/acre	
Stewart Crossing	Toral	145.6	Grizzly	210.8
			Cascade	210.8
Pelly Farm	Toral	201.5	Toral	201.5
Minto	Toral	201.5	Toral	201.5
Firth Farms	Toral	19.	Cascade	30.9
SOURCE: Adapted from Yukon New Crop Development Project, 1985				

Table 13. Maturity and estimated yields of barley trials 1985

Grain (Barley)				
Site	Best Maturing (bu/acre)		Highest Yielding (bu/acre)	
Sunnydale	Scout	57.8	Johnstone	100.6
Stewart Crossing	Lidal	66.8	Calibre	103.1
Pelly Farm	Otal	83	Tupper	85.8
Minto Bridge	Otal	52	Lidal	77.5
Firth Farms	Datal	12.8	Diamond	14.9
SOURCE: Adapted from Yukon New Crop Development Project, 1985				

Barley had lower yields compared to oats; best maturing varieties had noticeably lower yields than highest yielding varieties Table 13. More than anything, these results indicate the importance of choosing the correct crop variety for your specific location as this choice can have large implications on success of maturity and yields. Tailoring the crop type to end usage is also important; if the crop is to be used as silage, grain maturity is less of an issue.

Forage yields of oats and barley also showed variability between testing sites, (Table 14), however, yields were high for most varieties at most locations.

Table 14. Estimated yields of oat and barley forages, 1985

Oats/Barley Forage Yields				
Site	Barley (t/acre)		Oats (t/acre)	
Sunnydale	Gateway	6.65		
Stewart Crossing	Scout	6.97	Cascade	7.40
Pelly Farms	Scout	5.35	Foothills	6.61
Minto Bridge	Tupper	5.35	Cascade	7.40
Firth Farms	Lidal	1.45	Foothills	2.99
SOURCE: Adapted from Yukon New Crop Development Project, 1985				

Testing results for the 1986 season were somewhat different to the previous season; this may illustrate how climate variability can affect results. Results were more variable between sites with many sites showing vastly lower yields compared to the previous season (Table 15). In part, poor results were attributed to killing frosts at some locations in early summer.

Forage yields of oats and barley were equally variable between sites for the 1986 trials. Gateway and Lidal barley showed the best results while Cascade and Toral oats had highest yields.

Table 15. Estimated grain yields at all sites, 1986

Grain Yields 1986				
Site	Barley (bu/acre)		Oats (bu/acre)	
Pelly Farm	Thual	49	Toral	71
Stewart Crossing	Datal	11	Toral, Cascade	15
Minto Bridge	Gateway	5	Cascade	7
Dawson	Otal	18	Toral	65
Sunnydale	Datal	14	Cascade	39
Firth Farms	Datal	51	Cascade	39
Drury Farm	Lidal	40	Cascade	17
SOURCE: Adapted from Yukon New Crop Development Project, 1985				

Grass and alfalfa forages were planted in 1985 and yields were analysed in 1986. Summary of highest rated varieties are outlined in Table 16, (results were only presented as "best rated", no yield weights are given).

Table 16. Highest rated grass and Alfalfa forage results, 1986

Site	Grass	Alfalfa
Pelly Farm	Brome	BL 1019
Stewart Crossing	Smooth Brome	BL 1019
Minto Bridge	Brome	n/a
Dawson-Heydorf	Timothy	Peace
Sunnydale	Brome	Anik
Firth Farm	Brome	Peace
Drury Farm	Brome	n/a
SOURCE: Adapted from Yukon New Crop Development Project, 1985		

The "Yukon New Crop Development Project" study assessed the protein content and bushel weight of the best maturing grain varieties. Results are shown in Table 17. Bushel weights are lower than standard, however, protein content is average or above-average. In "Nutrition and Feeding of Organic Pigs", Blair gives the standard range of protein content for barley as between 9 and 16%. Protein analysis from 1985 showed that Yukon barley had protein content as high as 17.5%. Oats also had low bushel weights and average protein content. Again from Blair (2007), oat protein ranges from 11% to 17%; Yukon oats had protein levels of between 11 and 14 % (Table 17).

Table 17. Protein content and bushel weight of barley and oat testing, 1986

		Barley			Oats		
Site	Ag. Capa. Class (1985)	Variety	Bu Wt (kg)	Protein content (%)	Variety	Bu Wt (kg)	Protein Content (%)
Sunnydale	4	Scout	24.8	17.5	n/a	n/a	n/a
Stewart X	4	Lidal	20	13.7	Toral	16.5	14.4
Pelly Farm	4	Otal	21.9	17.3	Toral	15.8	14.4
Minto	5	Otal	16.6	16.3	Toral	11.5	11.8
Firth Farm	5	Detal	13.9	11.6	Toral	8.2	12.4

SOURCE: Adapted from Yukon New Crop Development Project, 1986

Yukon Crop Development (1988-1990)

1988 was the first year of another 3 year research project called the "Yukon Crop Development Program". This research project was designed to investigate varieties and management techniques to aid in the commercial production of vegetables and forages in Yukon.

Forages chosen for this trail were based on the success of the preceding trials the year before. Included were new forage varieties from Alaska and Alberta. This set of trials not only investigated crop yields but also had forages analysed for a range of nutritional values including: protein, acid detergent fibre, and total digestible nutrients (Bisset, 1988).

Cereal trial feed analysis for 1988 included: Toral oats, Cascade oats and Weal barley. The grain and straw were tested by the lab separately and the results were promising yet variable. Haydorf farms had whole plant oat protein levels of 14% and oat grain protein of 17%, these are high protein levels and would make excellent feed (Table 18).

Table 18. Haydorf Farm cereal forage trial results, 1988

Variety	Protein (%)	ADF (%)	TDN (%)
Weal Barley			
Straw (DM)	6.19	34.4	61.0
Grain (DM)	12.10		
Whole Plant	7.45		
Toral Oats			
Straw (DM)	13.6	35.4	60.5
Grain (DM)	17.4		
Whole Plant	14.1		

SOURCE: Bisset, 1988. Yukon Crop Development

Firth farms, near Whitehorse, tested the same oat and wheat varieties as Haydorf, however nutrient content was not as high at Firth farms, this is likely due to difference in time of harvest and perhaps management practices. Table 19 displays the protein nutrient analysis of the tested forages.

Table 19. Firth Farms cereal forage trial results, 1988

Variety	Protein (%)	ADF (%)	TDN (%)
Weal Barley			
Whole Plant (DM)	9.66	34.1	61.1
Toral Oats			
Straw (DM)	10.6	33.8	61.3
Grain (DM)	12.2		
Whole Plant (DM)	10.78		
Cascade Oats			
Straw (DM)	10.6	38.4	59.0
Grain (DM)	11.6		
Whole Plant	10.68		

SOURCE: Bisset, 1988. Yukon Crop Development

The 1988 seasons testing of barley resulted in disappointing grain development results; no grain matured at any of the sites. It was determined that barley from this seasons testing would have made sufficient green feed for most ruminants.

Oat trials for this season were limited to Toral and Cascade, and were planted at three sites. Oat yields were high and protein levels in the grain were found to be much higher than in the barley. Cascade performed the best at all sites, producing the largest amount of grain and having the highest bushel weights.

The 1989 season saw the first harvest of the grass forage trials planted in 1988. Forages were assessed for yields and for feed analysis. This forage trial represents one of the larger scale forage studies that has taken place in the territory and the results are seen in the following tables (Table 20, Table 21, Table 22, Table 23).

Table 20. Mease Farms forage trial results, harvested July 19 1989.

Variety	Yield (est.) t/ha	Protein (%)	ADF (%)	TDN (%)
Timothy-Climax	4.62	7.21	38.9	58.7
Brome-Polar	3.31	6.84	35.4	60.5
Hannas Hay Mix	2.99	4.64	36.2	60.1
Fosters Hay Mix	2.99	6.26	35.7	60.3
Meadow Foxtail	2.86	9.74	35.7	60.3
Brome-Carlton	2.86	8.93	33.8	61.3
Peace/Carlton Mix	2.63			
YCDP Mix	2.36			
Fosters Stock Mix	1.86			
Red Clover	1.09			
Alsike Clover	0.63			
Alfalfa-Peace	0.41			
Hannas High Tech	0.36			
Brome-Regar Mead.	0.50			
Sainfoin Clover	0.32	11.70	34.6	60.9
SOURCE: Bisset, 1989. Yukon Crop Development.				

Table 21. Heydorf forage Trial results, harvested July 17 1989.

Variety	Yield (est.) t/ha	Protein (%)	ADF (%)	TDN (%)
Brome-Carlton	6.48	14.4	42.2	57.1
Brome-Polar	6.48	9.66	41.7	57.3
YCDP Mix	6.03	12.8	38.5	58.9
Fosters Stock Mix	5.44	11.2	45.4	55.5
Hannas Hay Mix	5.40	18.1	38.0	59.2
Timothy-Climax	5.35	12.0	40.5	58.0
Peace/Carlton	5.35	16.0	36.3	60.0
Fosters High Hay	4.44	14.6	39.5	58.4
Red Clover	4.40	13.1	41.1	57.6
Meadow Foxtail	4.04	11.5	39.4	58.5
Alsike Clover	3.13	19.6	33.5	61.4
Kent Blue Nug-get	1.18	17.1	35.6	60.4
Alfalfa-Peace	1.09			
Hannas High Tech	1.04	18.9	34.4	61.0
SOURCE: Bisset, 1989. Yukon Crop Development				

Table 22. Firth Farms forage trial results, harvested 1989

Variety	Yield (est.) t/ha	Protein (%)	ADF (%)	TDN (%)
Hannas Hay Mix	3.72	6.15	38.7	58.8
Fosters Stock Mix	3.63	6.33	40.6	57.9
Brome-Carlton	3.17	7.35	37.6	59.4
Fosters High Hay	3.04	7.30	41.3	57.5
Peace/Carlton	2.90	6.29	40.4	58.0
Alfalfa-Peace	2.77	15.2	39.7	58.3
Timothy-Climax	2.49	6.16	30.7	62.8
Brome-Polar	2.40	5.13	38.2	59.1
YCDP Mix	2.27	6.74	38.5	58.9
Brome-Mead-Reg.	1.09	12.9	35.8	60.3
Hannas High Tech	0.82	16.4	27.6	64.4
Red Clover	0.45			
Alsike Clover	0.32			
Sainfoin Clover	0.27			
SOURCE: Bisset, 1989. Yukon Crop Development				

Table 23. Toole forage trials, Watson Lake, harvested July 11-12 1989.

Variety	Yield (est.) t/ha	Protein (%)	ADF (%)	TDN (%)
Meadow Foxtail	4.35	20.0	37.4	59.5
Timothy-Climax	4.04	16.7	37.8	59.3
Timothy-Engmo	3.40	12.6	40.0	58.2
Fosters Hay Mix	2.81	18.5	31.3	62.6
Fosters Stock Mix	2.09	23.4	32.3	62.0
Polargrass-Aleyea.	1.72	17.2	33.9	61.2
YCDP mix 2	1.72	25.9	33.0	61.7
Brome-Carlton	1.72	21.5	34.0	61.2
Brome-Polar	1.45	26.6	31.6	62.4
Hannas Hay Mix.	1.31			
Peace-Carlton	1.09			
SOURCE: Bisset, 1989. Yukon Crop Development				

Protein levels for each forage variety tested were higher at the Toole site (Table 24) than any other site for the 1989 season. Reasons for this are postulated by the author and are thought to be due to lower degree of maturity at this site compared to the other sites. Samples were harvested on July 11-12 at the Toole site, July 19 at the Mease site, Haydorf was harvested on July 17th.

1990 was the final year of the Yukon Crop Development Project and forage data was collected at 4 sites: Pelly Farm, Mease Farm, Heydorf Farm and Firth Farm.

Forage yield and nutrition data is as follows (Table 24, Table 25, Table 26, Table 27).

Table 24. Pelly Farms forage trials, harvested July 28, 1990.

Variety	Yield (est.) t/ha	Protein (%)	ADF (%)	TDN (%)
Brome-Carlton	7.30	10.1	39.6	58.4
Brome-Polar	6.80	13.0	36.1	60.1
Fosters Stock Mix	4.76	9.2	37.8	59.3
Hannas Hay Mix	4.49	11.5	36.9	59.7
Mead.Brome-Reg.	4.44	11.1	36.8	59.8
Timothy-Engmo	3.94			
Timothy-Climax	3.17			
Hannas High Tech	1.95	15.3	30.0	63.2
SOURCE: Bisset, 1990. Yukon Crop Development				
No Survival: Meadow Foxtail				

Table 25. Mease Farm forage trial, harvested July 18-19 1990.

Variety	Yield (est.) t/ha	Protein (%)	ADF (%)	TDN (%)
Peace/Carlton	3.67			
Brome-Carlton	3.13	9.85	37.9	59.2
Timothy-Climax	2.90	9.15	36.5	59.9
Hannas Hay Mix	2.77			
Timothy-Engmo	2.54	10.6	35.5	60.4
Brome-Polar	2.31	9.26	38.2	59.1
Fosters Hay Mix	2.22			
Fosters Stock Mix	2.09			
Alsike Clover	1.99	14.3	44.0	56.2
YCDP Mix 2	1.95			
Meadow Foxtail	1.68			
Mead.Brome-Reg.	1.41			
SOURCE: Bisset, 1990. Yukon Crop Development				
No survival of: Alfalfa-Peace, Red Colver, Sainfoin, Hannas High Tech Blend				

Table 26. Heydorf Farm forage trial, harvested July 26 1990.

Variety	Yield (est.) t/ha	Protein (%)	ADF (%)	TDN (%)
Brome-Carlton	9.93	13.2	38.7	58.8
Peace/Carlton	8.34			
Fosters Hay Mix	8.30	13.3	41.2	57.6
Hannas Hay Mix	7.84	11.3	39.6	58.4
YCDP Mix 1	7.03			
Fosters Stock Mix	6.76			
Brome-Polar	6.53	12.7	40.2	58.1
Timothy-Engmo	5.67	7.4	36.3	60.0
Meadow Foxtail	5.58	13.3	48.7	53.8
Timothy-Climax	3.81			
Mead-Brome-Reg.	2.31			
Kent.blue.Nugget	1.68			
Alsike Clover	0.27			
Red Clover	0.18			
SOURCE: Bisset, 1990. Yukon Crop Development				
No survival of: Alfalfa-Peace, Sainfoin, Hannas High Tech Blend				

Table 27. Firth Farms forage trial, harvested July 16 1990.

Variety	Yield (est.) t/ha	Protein (%)	ADF (%)	TDN (%)
Peace/Carlton	5.12	8.0	42.1	57.1
Brome-Carlton	4.17	7.27	41.2	57.6
Brome-Polar	4.17	10.1	37.0	59.7
Fosters Stock Mix	3.81	7.45	34.3	61.0
Fosters Hay Mix	3.54	4.76	38.0	59.2
Hannas Hay Mix	2.86			
YCDP Mix 1	2.77	8.45	39.9	58.2
Timothy-Climax	1.72			
Meadow Foxtail	1.54			
Mead-Brome-Reg.	0.86			
SOURCE: Bisset, 1990. Yukon Crop Development				
No survival of: Alfalfa-Peace, Sainfoin, Hannas High Tech Blend, Red Clover, Alsike Clover, Timothy-Engmo				

The Yukon Crop Development Project represents one of the more comprehensive agricultural research projects to take place in the Yukon. This project assessed a wide variety of crops in a diverse set of locations. While there was a wide range of yield and nutritional variability within species, within years, and based on location, several forage varieties were routinely found as top producers in terms of yield and protein.

The forage data from the 1989 and 1990 Yukon Crop Development Project was input into excel and re-analyzed in order to look for trends. Crop yields were grouped by location and year and average yields for each forage species were determined. Unsurprisingly the top three producers in terms of yields (t/ha) were brome grass or brome grass mixes. Carlton Smooth Brome was the top producer averaging 4.85 t/ha (range, 1.72-9.93 t/ha) between 5 sites and over the two year test period. Polar Smooth Brome was the second highest producer averaging 4.18 t/ha (range, 1.45-6.8 t/ha). The complete breakdown of yield data is shown in Table 28 below.

Table 28. Yukon Crop Development Project Average Crop Yields 1989-1990

Forage Species	Average (t/ha)
Brome-Carlton	4.85
Brome-Polar	4.18
Peace/Carlton Mix	4.16
YCDP Mix	4.09
Hannas Hay Mix	3.92
Fosters Hay Mix	3.91
Timothy-Engmo	3.89
Fosters Stockmans	3.81
Timothy-Climax	3.51
Meadow Foxtail	3.34
Brome-Regar	1.77
Red Clover	1.53
Kent-Blue-Nugget	1.43
Alfalfa-Peace	1.42
Alsike Clover	1.27
Hannas High Tech	1.04

Sainfoin Clover	0.30
SOURCE: Bisset, 1990. Yukon Crop Development	

Protein analysis for the forages tested were also highly variable between years and locations. The data was again input into excel and analysed for average protein (%) across the sampled forages. The highest average protein was found in Kentucky blue nugget, however, this was a single sample with no replicate which decreases the degree of confidence in this figure.

Table 29. Yukon Crop Development Project Average Protein (%) 1989-1990

Forage Species	Protein Avg. (%)
Kent-Blue-Nugget	17.10
Alsike Clover	16.95
Hannas High Tech	16.87
Alfalfa-Peace	15.20
Meadow Foxtail	13.64
Red Clover	13.10
Brome-Regar	12.00
Sainfoin Clover	11.70
Brome-Polar	11.66
Brome-Carlton	11.58
Fosters Stockmans	11.52
Fosters Hay Mix	10.79
Hannas Hay Mix	10.34
Timothy-Climax	10.24
Timothy-Engmo	10.20
Peace/Carlton Mix	10.10
YCDP Mix	9.33

SOURCE: Bisset, 1990. Yukon Crop Development

Protein, as expected, was higher in the legumes and less in the grasses, however, most of the grasses tested performed well. Table 29 displays the protein (%) of the forges tested, forages are listed highest to lowest.

One interesting method of looking at this forage data is to assess forage yields vs. protein content. This technique can aid producers to choose the forage crop that will deliver the best combination of tonnage and nutrition. When plotting the yield data against the protein data from the 1989-1990 Yukon Crop Development projects we get an interesting result, (Relationship between yield and protein concentration in Yukon forages tested.). As crop yields decrease (blue line) average protein levels tend to increase (red line). Interestingly the brome species show a slight reversal of this trend showing the highest yields and a relatively high protein concentration.

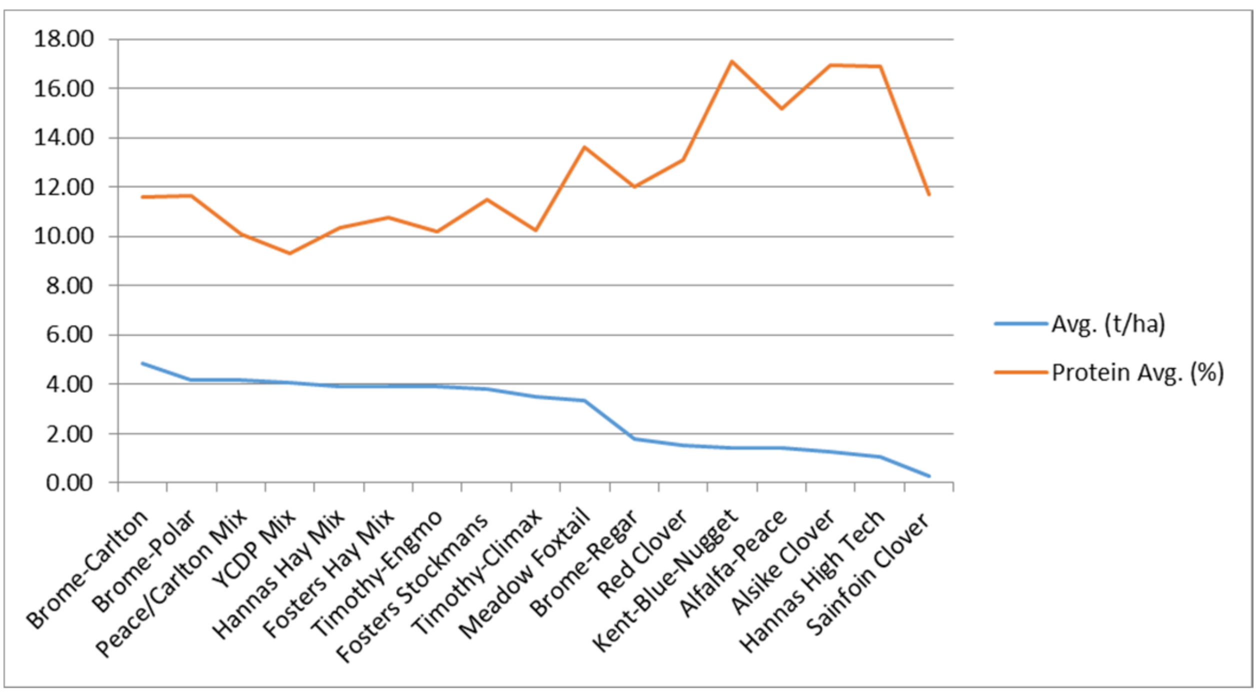


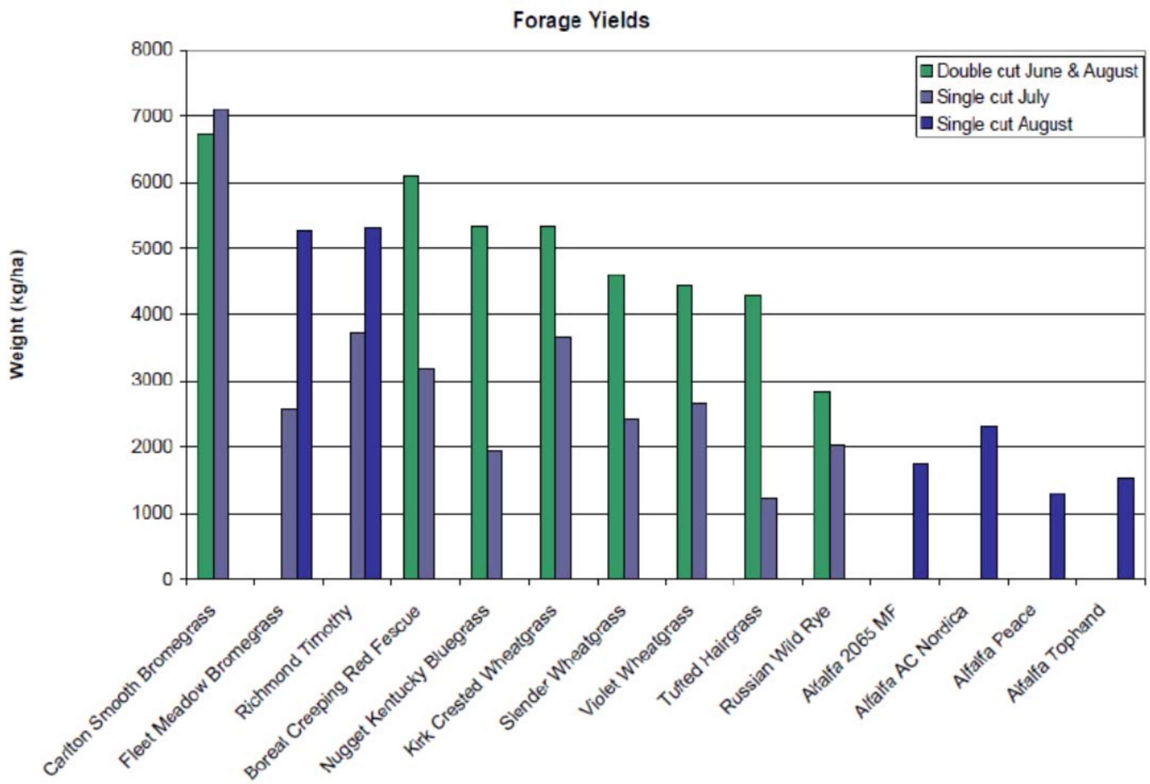
Figure 3. Relationship between yield and protein concentration in Yukon forages tested.

Yukon Forage and Grain Trials, Research Farm (1989-Present)

The majority of contemporary Yukon agriculture research has been conducted at the Agricultural Research Farm located at the Gunnar Nilsson Mickey Lammers Research Forest near the confluence of the Takhini and Yukon Rivers. Research at this site is commonly industry driven; crop trials and nutrient management trials reflect concerns and management scenarios pertinent to local producers. Amongst many other trials, the research farm conducts research into dryland and irrigated forage crops.

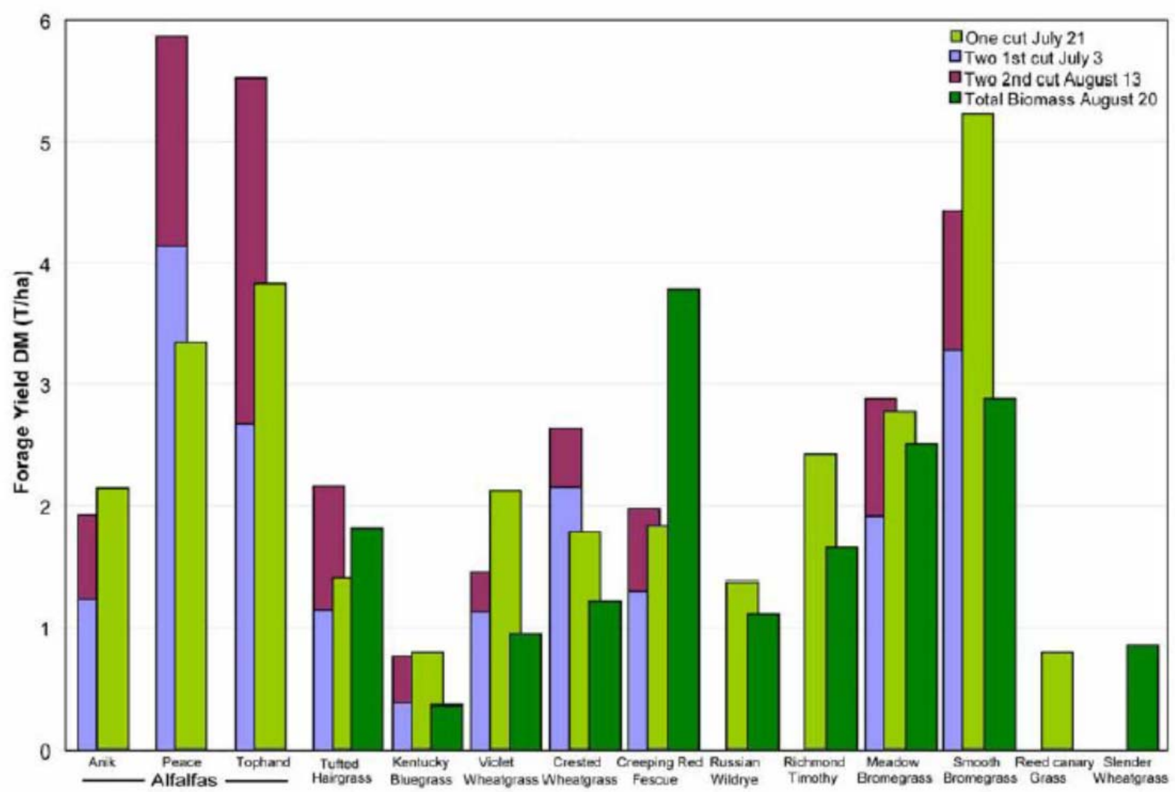
Forage trials were initiated at the research farm in 2005; 4 varieties of legumes and 12 types of grasses were planted. Germination and establishment were observed to be successful by fall of that year; overwinter success was poor with only 5 of the grasses surviving and none of the legumes. Winterkilled varieties were reseeded in 2006 and in 2007 some usable crop data was available. 14 forage species survived the winter and yields were calculated and presented in Figure 4.

Figure 4. Grass and legume forage yields, from 2007 Ag. Research and Demonstration Report.



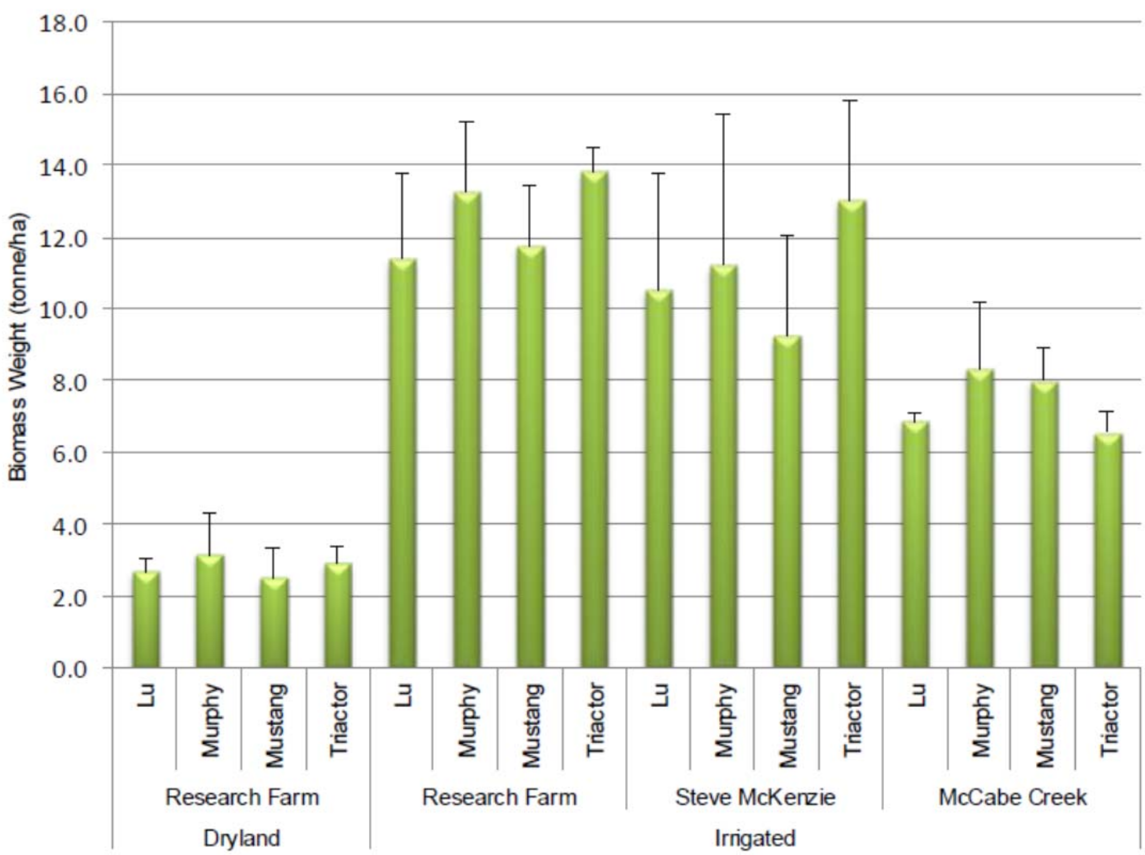
Of the forage species assessed, Carlton Smooth Brome produced the most forage in both the double and single cut trials. This was again the case in 2008 and 2009. 2008 saw the introduction of new alfalfa varieties which successfully overwintered; in 2009 two of the alfalfa varieties, Peace and Tophand, out produced the Carlton Smooth Brome (Figure **5**).

Figure 5 Single and double cut forage management yields, 2009, research and demonstration report.



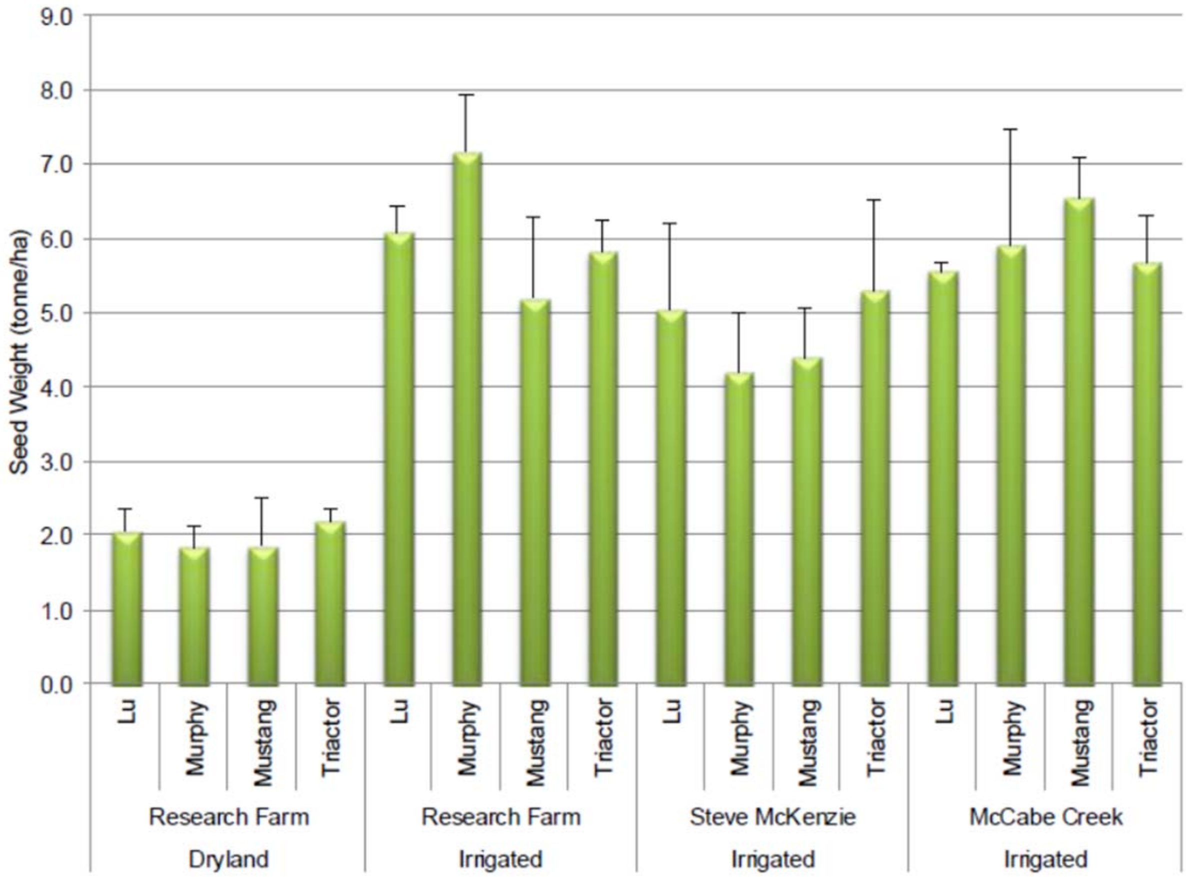
In 2010 oats and wheat were trialed at the research farm and at McCabe Creek in central Yukon. Wheat varieties were selected for hardiness and rapid growth and included: ACS Intrepid, Alvena and CDC Osler. Wheat grown in central Yukon performed better than wheat grown at the Research Farm (this was expected); RF wheat failed to mature and was adversely effected by early frosts. Wheat planted in the Central Yukon did mature and under irrigation had yields comparable to the Canadian prairies outlook reports (R&D progress report 2010). Yields and grain maturity were found to vary significantly depending on heat units for a particular summer; although maturity is possible, it might not be advised to depend on a wheat crop as a reliable feed source in Yukon.

Figure 6 Biomass of whole crop oats at three sites around the Yukon, 2010



New oat varieties were tested in 2010 at the Research Farm, Yukon Grain Farm and McCabe Creek. Oats were tested for gross biomass yields (as forage) and for seed production. AC Mustang, a commonly grown oat variety used in the Yukon, was planted as well and used as a control to measure against at each site. New varieties tested (upon recommendations from prairie seed companies) included: Triactor, Lu and Murphy. Results of this testing revealed no clear advantage with the new varieties, in some cases they performed better than AC Mustang oats and in others they did not. One thing this research does highlight nicely is the yield increases associated with irrigation, notably LU having almost 10 t/ha in yield difference (Figure 6).

Figure 7. Seed weights of oats tested at three sites around the Yukon, 2010.



Grain yields were again lower, as seen in Figure 7, in the dryland production system than the irrigated system, the grain yields showed less variability between sites, however, the variability was still too great to confidently state that one variety was better than another. More testing would need to be done to make this case.

Oat variety forage trials were continued for the next 2 years at the McCabe Creek and Research Farm sites. The yield results continued to vary depending on location and seasonal weather fluctuations, in 2011 oats at the Research Farm did not reach maturity and significantly lower yields were produced at the McCabe Creek site. These oat trials discovered that oat variety AC Murphy yielded the highest dry biomass each year and at each site under both dryland and irrigated management systems. Yields can be expected to range between 4 and 12 t/ha (Table 30).

Table 30. Average dry biomass of oat varieties over three years (t/ha), from 2012 Research and Demonstration Progress Report

Average Dry Biomass (t/ha)				**Year**	
Location	**Management**	**Variety**	2010	2011	2012
McCabe Creek	**Dryland**	Local Oats	-	-	8.2
		AC Lu	4.8	5.5	6.5
		AC Murphy	6.3	7.6	7.9
		AC Mustang	7.7	5.1	5.4
		Triactor	4.5	6.0	-
	Irrigated	Local Oats	-	-	8.2
		AC Lu	6.5	8.0	10.2
		AC Murphy	8.3	12.1	13.2
		AC Mustang	8.0	11.0	8.4
		Triactor	6.6	7.3	-
Research Farm	**Dryland**	Local Oats	-	-	6.4
		AC Lu	2.7	-	4.3
		AC Murphy	3.2	12.9	5.4
		AC Mustang	2.5	10.7	4.0
		Triactor	2.9	9.8	-
	Irrigated	Local Oats	-	-	13.9
		AC Lu	11.4	9.2	15.4
		AC Murphy	13.2	9.2	15.5
		AC Mustang	11.8	9.0	14.1
		Triactor	13.8	8.2	-

Grain production from these oat trials was more difficult assess due to high variability and low sampling numbers. No yield trends were found between the varieties tested over the three year period. Results can be seen in Table 31.

Table 31. Average grain yields of oat varieties tested, 2010-2012 (t/ha), from 2012 Research and Demonstration Progress Report

Average Oat Seed Yield (t/ha)			**Average Yield (t/ha)**		
Site	**Management**	**Variety**	**2010**	**2011**	**2012**
McCabe Creek	Dryland	Local Oats	-	-	2.4
		AC Lu	4.5	1.6	3.8
		AC Murphy	5.2	1.3	3.0
		AC Mustang	6.9	0.3	3.3
		Triactor	4.2	1.4	-
	Irrigated	Local Oats	-	-	5.4
		AC Lu	6.7	1.9	5.2
		AC Murphy	7.1	2.4	5.2
		AC Mustang	7.9	2.0	5.2
		Triactor	6.8	4.7	-
Research Farm	Dryland	Local Oats	-	n.m.	1.3
		AC Lu	2.1	n.m.	1.3
		AC Murphy	1.8	n.m.	1.3
		AC Mustang	1.9	n.m.	1.5
		Triactor	2.2	n.m.	-
	Irrigated	Local Oats	-	n.m.	4.2
		AC Lu	6.1	n.m.	3.8
		AC Murphy	7.2	n.m.	2.9
		AC Mustang	5.2	n.m.	4.8
		Triactor	5.8	n.m.	-

*n.m. indicates seed did not reach maturity

**(-) indicates variety was not tested

Interestingly but perhaps not surprisingly, the oat yields over the three year trial period was directly correlated to the number of Effective Growing Degree Days (EGDD) pertaining to that season. Years with warm summers correlated with high grain yields and, in extreme cases, cool summers resulted in an immature crop (2012 Research and Demonstration Progress Report).

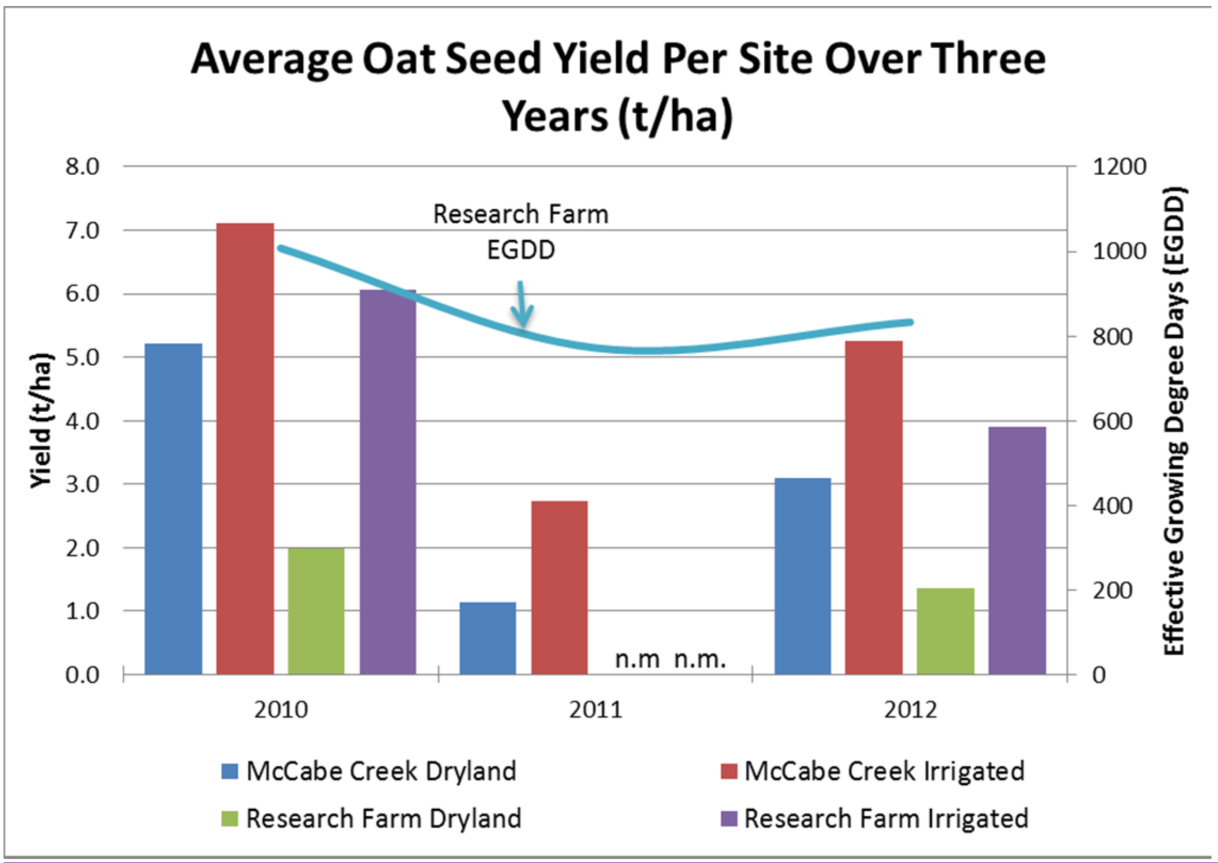


Figure 8. Relationship between EGDD and oat maturity at the Research Farm and McCabe Creek, 2010-2012, from 2012 Research and Demonstration Progress Report.

Field Pea Trials, Yukon Research Farm 2010-2012

Between 2010 and 2012 the Yukon Research Farm was engaged in field pea forage trials. These trials were initiated following an industry request to look into high protein forages for livestock such as pork and poultry. Monogastrics require a higher concentration of dietary protein than ruminants and, with an increase in the number of pork and poultry producers in recent years, a local source of high protein feed is being sought after.

Field peas have been trialed in the Yukon before and have had limited success, new varieties of short season field peas are being developed in northern BC and some of these were used for this trial. Peas can be used in a number of ways in livestock feed, as mature dried peas, whole crop silage, mixed with other forages in silage, or as green feed.

The field pea varieties selected for this trial included: Agassiz, APCM 397107, Meadow, Polstead, CDC Golden and Peace River.

Whole plant forage results for these trials was quite varied and yields ranged between 2 and 11 t/ha. As with the oat trials, the peas were also affected by the seasonal differences between 2011 and 2012, with 2012 results having much lower yields. CDC Golden was the top producer of the irrigated plots averaging 4.4 t/ha of dry biomass, the full yield results are displayed in Table 32.

Table 32. Dry biomass yields of yellow field peas from 2010-2012, from 2012 Research and Demonstration Progress Report

Average of Dry biomass (tonnes/hectare)			Year		
Location	**Management**	**Variety**	**2010**	**2011**	**2012**
McCabe Creek	Dryland	APCM397107	-	4.2	-
		Meadow	-	4.9	-
		Polstead	-	4.7	-
	Irrigated	Agassiz	-	-	11.9
		APCM397107	-	6.7	5.5
		CDC Golden	-	-	4.8
		Meadow	-	11.2	3.6
		Peace River	-	-	3.4
		Polstead	-	7.5	4.3
Research Farm	Dryland	Agassiz	4.2	5.1	1.8
		APCM397107	-	6.4	3.9
		CDC Golden	-	-	2.6
		Meadow	3.7	4.6	2.5
		Peace River	-	-	2.5
		Polstead	3.3	5.6	2.4
	Irrigated	Agassiz	6.1	6.4	2.4
		APCM397107	-	5.5	3.7
		CDC Golden	-	-	4.4
		Meadow	5.4	6.5	3.7
		Peace River	-	-	2.8
		Polstead	3.6	4.7	2.1

*(-) indicates vareity not sampled or tested

Field pea seed maturity had mixed results at the Research farm and maturity only occurred there in 2010. 2010 saw about 156 more growing degree days than the 10 year average and this is likely the reason for successful maturation. In 2010 seed yields ranged from 1.7 t/ha to 2.8 t/ha.

At McCabe Creek, seed matured in all years and yields ranged from 0.6 t/ha in the dryland plots to 4.9 t/ha in the irrigated plots. Table 33, shows the average yields for the three trial years. The variety "Polstead" was found to be a consistent top performer, however, due to small sample size and variability this was not found to be statistically significant, more research would need to be conducted to verify this trend (Yukon Agriculture Research & Demonstration 2012 Progress Report).

Table 33. Average yellow pea seed production between 2010 and 2012 at McCabe Creek and the Research Farm. From 2012 Research and Demonstration Report.

Average Yellow Pea Seed Yield (t/ha)			Year		
Site	**Management**	**Variety**	**2010**	**2011**	**2012**
McCabe Creek	Dryland	Meadow	n.m.	0.6	n.m.
		Polstead	n.m.	1.1	n.m.
		APCM397107	n.m.	1.0	n.m.
	Irrigated	Meadow	2.5	2.0	3.1
		Polstead	3.7	2.9	4.9
		Agassiz	3.0	-	1.5
		APCM397107	-	1.7	3.0
		Peace River	-	-	3.0
		CDC Golden	-	-	4.2
Research Farm	Dryland	Meadow	1.7	n.m.	n.m.
		Polstead	1.7	n.m.	n.m.
		Agassiz	1.7	n.m.	n.m.
	Irrigated	Meadow	2.5	n.m.	n.m.
		Polstead	1.9	n.m.	n.m.
		Agassiz	2.8	n.m.	n.m.

*n.m. indicates variety did not mature

**(-) indicates variety was not tested

The field pea research conducted by the branch also turned up some interesting management challenges. They found that the field peas attracted both livestock and wildlife which a) contributed to some of the sampling variability and b) wildlife management would need to be considered if seed peas were to remain unmolested throughout the growing season.

The conclusion of the field pea trials suggest that they would make an excellent forage and seed crop for the central Yukon. In the Whitehorse area, however, the cooler growing conditions and subsequent immaturity of the seed may limit field peas to a green forage or silage crop for this region. It is possible that maturation of the seed could be expedited by top-killing the plants and forcing earlier maturity, however, this needs to be investigated further.

Again it is important to note that the research farm (the Whitehorse location where this research took place) is one of the cooler sites in the area and more favourable results can be expected in other locations. For instance, when comparing the average growing conditions between Whitehorse and the research farm, 2003 and 2012, the research farm averaged about 200 EGDD less than the EGDD measured at the Whitehorse airport (these sites are less than 20km apart). This example illustrates the variability of local micro climates in the region and reminds us to understand these variables during crop selection.

Yukon Forage Sample Analysis

Over the years the Yukon Agriculture Branch has conducted testing on a variety of feeds produced throughout the Yukon. This testing analyzed feed for: moisture, crude protein (CP), % dry matter and total digestible nutrients (TDN). The results of this testing is presented in Table 34.

It needs to be stated that the information presented in Table 34 is by no means a complete picture of the quality of forages available in the Yukon it is merely a snapshot of feeds that were tested over the years.

Due to the manner in which the samples were taken, sample locations, time of sampling and some forage species specifics were not recorded. While this limits the comparative and informative value of the data, some interpretation can be made. It is also important to note that there are very few (sometimes one) replicate of these samples which further reduces the relevance of the data.

As can be seen in Table 34, feeds can have a wide range of nutritional value, Yukon grown "Grass Hay" for example, has a crude protein range of 21.1 - 2.5%. This range is most likely attributed to "time of harvest"; earlier hay having the most protein and late hay the least. Rain during the curing process can also leach nutrients from the crop reducing CP and TDN. The results of these feed analysis tests exemplify the importance of procuring good quality feed for livestock animals as variability can be quite significant.

Table 34. Yukon Ag Branch forage testing, 2003-2005

Samples	Sample Type	Avg. Protein (%)	Protein Range (%)	Avg. ADF (%)	Avg. TDN (%)
8	Brome Hay	9.95	14.4 - 6.1	39.2	61.6
19	Grass Hay	10.8	21.1 - 2.5	35.3	61.8
15	Native Grass	15.7	18.7 - 11.9	35.4	61.3
2	Brome + Alfalfa	12.45	15.8 - 9.1	27.9	72.8
1	Barley/Oat Ration	11.3	11.3	n/a	80.8
1	Grass/Legume	17.1	17.1	35.8	58.9
1	Oat Straw	4.4	4.4	46.1	53.0
1	Rye Grass Hay	4.8	4.8	31.8	67.0
2	Timothy Hay	7.25	10.5 - 4	36.15	61.1
2	Timothy/Brome	6.8	7.6 - 6	29.5	66.7

SOURCE: Adapted from Yukon Agriculture Branch dataset

The data in Table 34 also illustrates that there are a wide range of Yukon grown feeds that meet and exceed acceptable protein and nutrient levels required by most ruminants. Of the forages tested, all but a few meet minimum levels for acceptable growth and production. This data also stresses the importance of purchasing local hay with care and attention; purchasing and feeding a lower quality hay could result in poor performance and animal health issues. Visiting the farm and inspecting the hay prior to purchasing is a good way to ensure you are getting acceptable feed quality.

Alaska Forage and Grain Trials (1970's)

During the 70's, considerable agronomic research was conducted in the Delta Junction and Fairbanks regions of Alaska. This research investigated varieties of feed-barley and oats for maturation and yield. Fairbanks and Delta Junction share similar climate and growing conditions as central Yukon; crops which perform well in these Alaskan locations should do well in central Yukon.

Alaskan researchers chose barley and oats because of their ability to grow to maturity in cool temperatures and short growing seasons. Barley was considered the most highly adapted to northern environments with oats being a close second (Deloitte, 1987). Several varieties were even able to mature when planted as late as the second week of June (Deloitte, 1987).

Results from oat and barley yield research in the Fairbanks areas are as follows (Table 35):

Table 35. Average yields of oat and barley varieties, Fairbanks Alaska, 1971-1979

Crop and Variety	Avg. Yield (bu/acre)	Range of Yield (bu/acre)
Barley		
Galt	87	59-117
Otra	71	50-99
Weal	70	43-101
Lidal	64	46-97
Oats		
Toral	124	67-179
Pendek	117	50-167
Nip	118	52-159
Rodney	130	63-178

SOURCE: Adapted from Deloitte, 1987.

In 1980 further oat and barley research was conducted in the Tanana River Valley (Fairbanks region) and more varieties were tested. Results of these studies complemented the anecdotal results of the producers in the region; varieties tested included: Galt, Otra, Weal, Lidal (barley) and oat varieties Nip, Pendek, Rodney and Toral, all varieties were found to have good yields and maturity.

In 1980 grass research was also conducted; highest yielding introduced grasses tested were smooth brome (Manchar and Polar) and timothy (Engma) with yields exceeding 4 tons per acre for the brome and 3 tons per acre for timothy. These reports also concluded that the nutritive value of the introduced (brome and timothy) as well as the native grasses was sufficient to sustain ruminant growth and development (Deloitte, 1987).

Finland Variety Trials 2005-2012

Northern Finland has similar growing conditions as the Whitehorse area. Growing degree days in this region are low (exact comparable numbers were not available, however, using the "Weather Network" GDD calculator for both Rovaniemi Finland, lowest land class region for Finland and most northerly ag research station, and Whitehorse Yukon, both regions had GDD of between 500 and 900 degree days) and researchers have spent considerable effort optimizing the productivity of forages and forage based feed management systems. Researchers have conducted extensive variety trials on grains, legumes and perennial grasses and most of the data is available on the web.

www.mtt.fi/mttraportti/pdf/mttraportti75.pdf

Some of the higher yielding perennial grasses that have been tested in Finland may be good candidates for similar trials in the Yukon. Several high yielding cultivars of Timothy are being used with good success in Finland and include: Grindstad, Rakel, Lidar, Switch and Nuutti. Even in the most northerly zones in Finland (zone 5), these varieties yielded: 11117, 11523, 10813, 11532 kg/ha respectively. These yields are based off a 2 cut system.

Meadow and tall fescue are also high yielding forage crops in northern Finland. The varieties: Kasper, Retu, Swaj, Karolina and BOR20603 all produce between 9600 and 10317 kg/ha, these harvest numbers are based off a 3 cut system.

Other forage crops tested in Finland during these trials include: perennial rye-grass, Italian rye-grass, red clover and white clover. The red clover did poorly in the zone 5 trials with low yields and high winterkill. Yields were around 1500-1700 kg/ha and winterkill was around 20%. White clover did even worse with around 75% winterkill and equally poor yields.

Finish researchers have also conducted variety trials on oats in zone 4 regions. Some of the higher yielding varieties include, Haga (6326 kg/ha), Ringsaker (6205 kg/ha), Roope (5782 kg/ha), and Akseli (5780 kg/ha). These yields are about on par with some of the oat varieties trialed in the territory.

Legume trials, Finland

Domesticated lupins (not wild lupins) are another seed producing legumous crop that could have benefits for Yukon livestock producers. Like field peas, lupins are high in protein, have a decent amino acid profile (low in sulphur containing AA) are high in energy, and improve soil health by fixing nitrogen (Lizarazo *et. Al.,* 2010). Lupin seed would make an excellent addition to poultry, pork and ruminant diets, and new cultivars are becoming lower in toxic alkaloids and no longer require processing prior to consumption (Lizarazo *et. Al.*, 2010). Lupins can be grown, stored and used on farm without complicated processing which makes it an attractive option for local producers. Lupin seed also stores well for long periods of time (Blair, 2011).

There are two types of lupin that would be suitable for cultivation in the Yukon, these are: blue lupins (*Lupinus angustifolius* L.) and the perennial lupin (*Lupinus polyphyllus*) (Nwokolo and Smartt, 1996). These two lupin species possess great adaptability to the cold, require moderately high moisture conditions and are tolerant to many soil types and fertility conditions. Blue lupins have a high day light requirements and do well in northern regions where day length is long (Nwokolo and Smartt, 1996).

Of the lupin varieties, the blue lupin family has the lowest productivity, however, in good conditions, dry matter yields can be as high as 4720 kg/ha. Protein content can be as high as 40%, fat 13%, and blue lupins contain high levesl of digestible energy (Nwokolo and Smartt, 1996). According to Nwokolo and Smartt, (1996), lupin seed inclusion rates into livestock diets are as follows (Table 36):

Table 36. Inclusion rates of lupin forage for livestock classes.

Livestock	Feed	Inclusion rate
Bulls	Lupin seed	1.5-2.0 kg/day
Dairy cows	Lupin seed	2.0-2.5 kg/day
Horse	Lupin seed	2.0-2.5 kg/day
Adult pigs	Lupin Seed	0.5-0.7 kg/day
Growing pigs	Lupin seed	0.3-0.4 kg/day
Young pigs	Lupin seed	0.5 kg/day
Poultry	Lupin seed	11-20 %/day
Cows	Lupin green feed	20-25 kg/day
Adult pigs	Lupin green feed	10-11 kg/day
Young pigs	Lupin green feed	4 kg/day

Source: adapted from Nwokolo and Smartt, 1996.

Lupin seed varies in protein content depending on the variety, these ranges can be lower in the blue lupin, 31-38% and higher in the Yellow lupin family, 39-47% (Nwokolo and Smartt, 1996). Lupin seed has a good amino acid profile for many livestock groups, with high content of aginine (4.1-11.2%), leucine (7.5-9.4%), lysine (4.3-5.2%), and phenylalanine (3.0-6.8%). The sulphur containing amino acid groups are relatively poor, however, and normally need to be supplemented.

Research carried out on blue lupins in Finland (Lizarazo et al., 2010), showed good results; maturity dates ranged from mid to late August and yielded 3.3 - 4.8 t/ha. The lupin cultivars were selected for high yields, fast maturity, high nutrition and cool season tolerance, the varieties included: Haags Blaue, Boruta, Boregine and Sandabor. The earliest of these varieties to mature was Haags Blaue and needed only 981 growing degree days (calculated using 5°C as the base temperature) to reach maturity (Table 37). Whitehorse has a 30 year average GDD of 936.4 (and an EGDD of 1086.2) which means that there is potential for this variety to reach maturity in our growing region.

Table 37. Blue Lupin flowering and maturity dates, growing degree days and yields.

Cultivar	Flowering date (10%)	Maturity Date (90%)	GDD from sowing to maturity (base 5°C)	Yield (t/ha)	Total dry matter (t/ha)
Haags Blaue	23 June	14 Aug.	982	3.28	7.7
Boruta	28 June	27 Aug.	1107	3.94	9.4
Boregine	26 June	13 Sept.	1284	4.08	10.0
Sanabor	27 June	23 Sept.	1364	4.82	10.8

Source: Lizarazo et al., 2010.

Blue lupins tested in the Finnish trials had high protein content and low starch content which is consistent with other literature reports (less than 1% starch), Table 38.

Table 38. Blue lupin proximate analysis (dry weight basis)

Cultivar	Moisture (%)	Ash (%)	Protein (%)	Starch (%)
Haggs Blaue	6.1	3.7	30.9	0.63
Boruta	6.2	3.5	32.4	0.66
Boregine	6.6	3.7	29.4	0.68
Sanabor	6.2	3.9	36.2	0.66

Source: Lizarazo et al., 2010.

Lupin seed can be used in all types of livestock feed, ruminants and non-ruminants. However, because of the lack of available inclusion rates and the relative newness of this feed stuff, seed should be tested for nutritional information (especially for pigs and chickens) to ensure essential amino acids are not neglected in the diet.

Faba beans (fave, horse bean, borad bean are other names for the faba bean) are another cool season legumous crop which are widely used in horse and ruminant feed throughout much of the world (Blair, 2008). In Northern Europe, where high protein feeds are predominantly imported, faba beans are receiving particular attention as a potential crop for poultry (Blair, 2008).

In 2010, Lazarazo et al., conducted variety trials on four northern hardy faba bean varieties in Finland. The faba beans trailed required more heat units than the lupin, however they yielded much more per ha than the lupin trials. Trialed varieties and yields are presented in Table 39.

Table 39. Faba bean flowering and maturity dates, growing degree days and yields.

Clutivar	Flowering (10%)	Maturity (90%)	GDD sowing to maturity (base 5)	Yield (t/ha)	Total dry matter (t/ha)
Kontu	22 June	22 Aug.	1055	6.29	10.4
Jogeva	19 June	25 Aug.	1082	6.04	10.2
Aurora	29 June	5 Sept	1208	7.33	12.8
Melodie	30 June	14 Sept.	1271	6.30	10.9

Source: Lizarazo et al., 2010.

While it is unlikely that there is sufficient heat units in the Whitehorse area to mature faba beans (although they may mature, the ten year average for Whitehorse is 1097 EGDD and some faba beans were able to mature in less than that), it is probable that bean maturity would be possible in central and possibly South East Yukon.

Alaskans have also had good results with fava bean cultivation, in an article titled "Twelve Underappreciated Herbs, Fruits and Vegetables for Alaskan Kitchen Gardens", published by UAF, fave beans are said to be:

> "a hardy, bushy, cool season, annual legume, often used as a cover crop, since they have one of the highest rates of nitrogen fixing of any cover crop, and produce a very high rate of compostable organic matter per square foot. They can help to loosen highly compacted soils. Unlike many other bean varieties, favas thrive in Alaskan conditions, and can be heavy pro-

ducers, even after a few light frosts. Favas are high in protein and many other nutrients."

There is also anecdotal evidence found on the internet expressing successful cultivation of fava beans in a variety of coastal and inland locations in Alaska. No information on scientific trials or field scale cultivation was found for fava beans in Alaska and more research is needed to identify the most applicable varieties for the north.

Table 40. Summary of grain crops, varieties and their requirements commonly grown in Yukon

Grain Crop	Variety	Min. GDD	Min. Precip (MM)	Preferred Soil Type	Optimal pH	Yield (t/ha) Whole crop	Market
Barley	Wheal, Otal, Datal, Thual	>900 Est.	460	Loams, clay loams, silt clay loams	>6	Up to 7	Pigs, poultry, most ruminants
Oats	Toral, Cascade, Grizzley, Athabasca, Mustang, AC Lu, Murphy, Triactor	>900 Est.	430	Most	5-6.5	Up to 15	All livestock
Rye	Kodiak	>900 Est.	Unk.	Sandy soils	5-7.0	Unk.	Pigs, most Ruminants

Source: Kangas et al (2012), Alberta ARD barley fact sheet (accessed 2014), 2012 Research and Demonstration report (Ball and Barton 2012), McKenzie and Dunn (1997), Bisset (1994)

Table 41. Summary of pulse crops, varieties and their requirements that show potential for Yukon production.

Pulse	Variety	Min. GDD or DTM	Min. Precip (mm)	Preferred toil type	Optimal pH	Yield (t/ha)	Market
Pea	Agassiz	>900	410	Unk.	Near 7	11.9	Pigs/poultry
	APCM 397107					5.5	
	CDC Golden					4.8	
	Meadow					11.2	
	Peace River					3.4	
	Polstead					7.5	
Blue Lupin	Haags Blaue	982	Unk.			7.7	Pigs/poultry
	Boruta	1107				9.4	
	Boregine	1284				10	
	Sanabor	1364				10.8	
Faba Bean	Kontu	1055	560			10.4	Pigs/poultry
	Jogeva	1082				10.2	
	Aurora	1208				12.8	
	Melodie	1271				10.9	

Source: Kangas et al (2012), 2012 Research and Demonstration report (Ball and Barton 2012), McKenzie and Dunn (1997), Willy and Langois (2006)

Table 42. Summary of grass crops, varieties and their requirements commonly grown in Yukon.

Grass type	Variety	Min. GDD	Min Precip. (mm)	Preferred Soil Type	Optimal pH	Yield (t/ha)	Livestock type
Brome	Meadow	375	350	All	6.0-7.5	Up to 5	All ruminants
	Smooth	375	350	All	6.0-7.5	Up to 10	All ruminants
Timothy	Richmond		400	All	>4.5	5.2	All ruminants
	Engmo		400	All	>4.5	3.9	All ruminants
Red Fescue	Boreal Creeping	Unk.	400	All	As low as 4.5	Up to 6.1	Ruminants at low requirements
Bluegrass	Kentucky	Unk.	350	All	5.5-7.5	5.2	Ruminants
Wheatgrass	Kirk Crested	290	200	All	Tolerates acidity	3.0	All ruminants in early stages
	Slender	Unk.	350	Fine-medium	>5.6	Up to 5.1	Ruminants
Hairgrass	Tufted	Unk.	400	Most	Tolerates acid and alkaline soils	Up to 4.1	Ruminants
Rye	Russian Wild	Unk.	200	Loamy to heavy clay	>6.5	2.9	Most ruminants

Source: BC Forage Manual, Fraser 2006,

1. Future Research, Forages

Based on the results of the 1988-1989 forage trials at various locations throughout the Yukon, further research should be conducted regarding maximizing protein and nutrient content in harvested and preserved forages. The 1989 season saw a massive variation between nutrition levels of forages harvested on July 11-12 in the Watson Lake area compared with the same forage samples harvested a week later in Dawson and Minto. For example, there was a massive difference between Polar brome grown in Minto and that grown in Watson Lake. Minto Polar brome had 6.84% protein (DM) while the Polar brome grown in Watson Lake had 26.6% protein (DM). Similar research has been conducted in Alberta on a variety of forages. Results from Alberta show a protein decrease of about 50% over a 7 week harvest period (Table 43) (no author, 2013).

Table 43. Crude protein and ADF of brome grass cut at weekly intervals starting June 1

Week		1	2	3	4	5	6	7
Brome	%CP	26.1	23.4	20.3	17.8	15.4	12.3	12.4
	%ADF	18.2	20.4	25.6	28.3	31.6	32.5	31.3

SOURCE: Adapted from Alberta Ag and Rural Development 2013

This research could investigate the nutrient profile change of the 5 most commonly grown forage crops in the Yukon over a one month period. The project could begin taking samples in early July and end in early August. Samples could be taken on a weekly basis and analysed for crude protein, ADF and TDN. This could be then used to determine the most appropriate time to harvest based on changing nutritive values. The resulting data would produce a graph depicting a rise in nutrition followed by a short peak and plateaux and ending in a declining nutritional value. This information could be plotted with yield data to provide the producer with a better understanding of the best time to harvest which would both maximize yields and nutrition.

2. *Legume Grains for the North*

Grain legumes make an excellent feed for a range of livestock; these products can be fed to ruminants and non-ruminants and are typically high in protein and energy. Most commercial poultry and swine feeds utilize grain legumes (soybeans) to increase the protein content of the feed.

Typical broiler feeds can have between 18-25% protein in them. Layer feeds have around 12-20% depending on age. Grains cannot typically provide this high of a protein level and are commonly lacking in essential AA. Swine diets have a high protein range as well which is commonly met using a combination of legume grains and traditional grains.

In northern growing regions soybeans do not grow well, however, there are several varieties of grain legumes that do. These include: faba beans, field peas, and lupins. There is currently research investigating field pea varieties which has yielded promising results. Continued research into early-maturing varieties of peas and will be needed to increase probabilities of obtaining mature seed. Initiating investigation into northern hardy and early maturing varieties of faba bean and lupin would also be of value. These legumes mature quite early and yield good AA profiles.

The aforementioned areas of research stood out as perhaps the most important areas to further investigate in order to help producers provide good quality/consistent forages/feed for their livestock. Most Yukon forages can make excellent feed and under good management they will produce high yields. For ruminants and horses, the forage needs are being met with traditional grass forages; local grains can be used for animals with higher energy demands. Engaging in research designed to maximize the nutrition of established and existing forage crops would help to ensure a consistent supply of nutritious livestock feeds.

For monogastric livestock, pigs and chickens, the needs are more complex. To ensure good yields, higher protein and higher energy feeds are needed. While there is a local source for grains, there is currently no local source of high protein feed. Grain legumes would fill this gap nicely. Engaging in research designed to find early maturing and high yielding grain legumes would do well to help develop the monogastric livestock industry.

3. *Rotational/intensive grazing trials*

There is much information about the benefits of rotational/intensive grazing as a way to provide forage for livestock. Rotational grazing can maximize the utilization of available forage within a paddock, reduce livestock selectivity of favoured plants, reduce weeds, and maximize health and vitality of the paddock. This system has been used in other regions; however, the effectiveness of this style of livestock management has not been evaluated in the Yukon, with Yukon forages and our short season. Conducting experimentation into rotational grazing and its impacts and benefits may provide valuable knowledge for livestock producers.

4. *Multispecies grazing trials*

Multispecies grazing is another method of forage maximization. This method utilizes the feeding preferences of two or more different livestock species to utilize all (or at least more) of the forage species available. In pastures and paddocks which are not monocultures, livestock will preferentially graze certain forage species while ignoring non-preferred species. This can lead to overutilization of one plant type and the underutilization of another. Using browsers can also help to reduce tree and shrub encroachment onto your pastures as well.

5. *Develop management guidelines for successful production of alfalfa crops in the north*

There has been limited success with establishment and long term viability of alfalfa crops in most of the Yukon. One of the hurdles is that the Yukon is at the northernmost extreme of the viable range of these plants so cultivation is going to be challenging at best. Specially developed northern varieties are also not commonly available. A secondary complication is how the crops are introduced and subsequently managed. Alfalfa is easily out competed by more aggressive plants such as smooth brome. When planting alfalfa alongside a grass, it is best to select a less vigorous grass species. Alfalfa is also susceptible to over fertilization. A fertilizer regime designed for grass will hinder alfalfa growth. Alfalfa is also sensitive to overharvesting, it is important to allow sufficient time in the spring for initial growth and time in the fall for regrowth prior to senescence. A management routine where alfalfa is cropped and then allowed to be grazed contributes significantly to alfalfa being outcompeted. Most literature stipulates either cropping or grazing but not both.

Conducting research into alfalfa cultivation for Yukon producers could be quite valuable. Developing guidelines for planting and management would be helpful for producers looking at incorporating alfalfa into their production system.

Feed Management and Feed options for Yukon Livestock

Ruminants

Livestock animals are digestively described in two ways, ruminants and non-ruminants (monogastrics). The monogastrics are considered to have a "simple" digestive tract and include: pigs, chickens, horses, etc. Ruminants, comparatively, have a complex digestive system where multiple stomachs ferment feed prior to digestion. The digestive systems of livestock animals will dictate the feed management system needed for optimal nutrition and growth. Regardless of the digestive system, all animals require five dietary components from which to source their nutrients: energy, protein, minerals, vitamins and water (Blair, 2011).

Ruminants, (cows, sheep, goats, bison, elk) utilize an assortment of bacteria, protozoa and yeasts in their rumen to breakdown fibrous plant matter into a digestible form. This microbial population allows ruminants to digest lower quality fibrous feeds efficiently. One notable benefit to ruminant digestion is its ability to synthesize most essential vitamins; except for A, D, and E, ruminants are not dependant on dietary sources for vitamins (Church, 1991). The advantage to this form of digestion is that ruminants can thrive on low quality, fibrous feeds that other livestock cannot utilize. The downside (if you have a cheap source of high energy feed) is that ruminants have a rather poor feed conversion rate. They need nearly twice the amount of feed as monogastrics to produce the same weight gain (Church, 1991).

Grazing vs. harvested feeds

In any livestock management operation feed is typically the single biggest cost and important component to consider for management of a successful herd. Feed cost, feed quality and feed availability are key variables, if these three variables are correctly balanced, a healthy, productive and economically profitable herd can be managed. Livestock managers must balance the cost of feed with the quality of feed, and quality often is reflective of availability. In order to keep feeding costs to a minimum while keeping feed quality to a maximum, a combination of grazing and supplemental feeding is often employed.

Grazing has specific advantages over supplemental feeding: It requires less labour, it is less expensive, less management intensive, and animals usually are able to preferentially graze higher quality forage. This allows animals to have higher yields while keeping costs to a minimum. Drawbacks to this management system are: the need for large areas of grazing lands, and in the north, supplemental feeding is still required throughout the winter/shoulder seasons. In some instances, forages cannot supply a livestock animal with optimal nutrition regardless of the volumes or quality. Highly productive milk-producing cows, for example, require supplementation even under optimal forage conditions (Church 1991).

Feeds and Forages

In the face of an assemblage of hurdles to northern agriculture, a short passage in "Livestock Feed and Feeding" by D.C., Church stands out as a bright light:

> "Grasses that grow in warmer climates tend to produce higher quantities and lower quality of forage, while those that grow in cooler climates tend to produce less quantity but higher quality of forage".

Forage plays an important role in all ruminant livestock operations and if Church has it right, local forages should provide all the necessary nutrients and energy that ruminants need. Feed management for most ruminant operations can be summed up rather simply: "…grazing to the extent possible and supplemental feeding of harvested feeds when necessary" (Church, 1991).

The following sections will discuss the most appropriate feeds and feeding patterns specific to each livestock type; this will include some background on nutrition, digestion and feeding. Focus will be directed toward methods practical and practiced in the north. Local and non-local management techniques will be discussed where appropriate.

Cattle

Nutritional Considerations for Cattle

Cattle, like all animals, need five basic components of nutrition in order to live. These include: an energy source (carbohydrate or starch), a protein source, vitamins, minerals and water. These elements of nutrition need to be supplied and consumed in a balanced and readily digestible form in order for animals to be productive and healthy.

Understanding Fibre:
There are three main fibrous components in plant material. Cellulose, hemicellulose and lignin. Cellulose is a linked form of glucose, is readily digestible and is a main source of carbohydrate in feed. Hemicellulose are polysaccharides that have more complex structures and are less digestible than cellulose. Lignin are structural components and are rarely utilized. (Durant, 2002, Van Soest, 1982)

Energy:

Energy for cattle comes primarily from the ingestion and conversion of fibrous plant tissues called cellulose. Cellulose is broken down through the combined action of cud chewing (rumination which creates smaller particle size) and microbial fermentation in the rumen. In the rumen about 60% of starches are degraded and 100% of sugars are digested (Blair, 2011).

This fibrous component of cattle diets is very important for several reasons: the energy it contains is used for maintenance, growth and meat/milk production, as well, it maintains healthy ruminal function and it provides important body heat in the winter. Should cattle consume surplus energy, it is converted into fat and stored (Blair, 2011).

Proteins:

Proteins are also converted by rumenal microbes into a usable product for cattle. Protein is provided to the cow via two sources, protein directly from the feed and proteins that are produced by the microorganisms in the gut. Rumen microbes are able to convert the fermented protein products of the feed, i.e., ammonia and organic acids, and convert them into amino acids that can be absorbed by the cow. The amino acids (AA) are used for building muscle tissue, milk products, foetal development, etc., (Blair, 2011).

Minerals:

Like all livestock animals, minerals are an essential element for growth and production for cattle herds. Minerals are typically broken down into two groups, those that are needed in large quantities "macro-minerals" and those that are needed in small quantities, "micro-minerals". The macro-minerals for cattle include:

- Calcium (Ca)
- Phosphorus (P)
- Sodium (Na)
- Chlorine (Cl)
- Potassium (K)
- Magnesium (Mg)
- Sulfur (S)

Macro-minerals are important for several reasons: they are components of body tissue, body fluids and bone. The micro-minerals or trace minerals needed by cattle are:

- Iron (Fe)
- Iodine (I)
- Manganese (Mn)
- Copper (Cu)
- Cobalt (Co)
- Zinc (Zn)
- Selenium (Se)

There is a wide range of disease associated with deficiencies of any of the above mentioned minerals, Table 44, lists the more common mineral deficiency diseases, however, for more information related to mineral deficiency disease refer to a veterinary manual.

Table 44. Signs of mineral deficiency in cattle

Mineral	Deficiency Signs
Calcium	Rickets, slow growth, weak bones, milk fever, reduced yields
Phosphorus	Weak, fragile bones, poor growth, reduced appetite, impaired reproduction
Sodium	Craving salt, reduced appetite, impaired growth, incoordination, weakness, shivering
Potassium	Decreased feed intake, loos of hair condition, impaired growth, emaciation, inability to coordinate muscle movement
Magnesium	Irritability, nervousness, tetany - increased excitability, muscular twitching, convulsions
Sulfur	Slow growth, reduced milk production, reduced feed efficiency
Copper	Severe diarrhoea, abnormal appetite, poor growth, bleached hair coat
Cobalt	Failure of appetite, anaemia, decreased milk production, rough hair coat, wasting
Iodine	Goitre "big neck" in calves, goitrogenic substances in diet may cause deficiency
Iron	Nutritional anaemia, pale mucous membranes, poor growth, listlessness, enlarged heart, enlarged fatty liver
Manganese	Delayed or decreased signs of oestrus, poor conception, abnormal skeletal growth
Selenium	White muscle disease, retained placenta, impaired reproduction, unthriftiness (failure to grow and put on weight), reduced immunity
Zinc	Decreased weight gains, lowered feed efficiency, mastitis, skin/wound problems
SOURCE: adapted from Merck Veterinary Manual, 2011.	

Common sources of minerals are from feedstuff, supplements, and mineral/salt licks. Many of the essential minerals will be readily available from pasture forages and preserved forages (this is the best and most bio-available source), however, it may be necessary to test forages to ensure adequate levels are present. Table 45 lists the suggested macro-mineral allowance for beef cattle which can be compared with Table 46 listing the average macro-mineral analysis results of common beef feedstuffs. Mineral licks and salt licks are another good option; however, most cattle prefer salt licks to mineral licks which makes providing a combined lick a good idea. This will force the cattle to eat the mixture in order to get the salts (Corbett, no date).

Table 45. Suggested macro-mineral allowance for beef cattle

	Calcium (% DM)	Phosphorus (% DM)	Magnesium (% DM)	Potassium (% DM)
Pregnant Cows	0.38	0.25	0.16	0.80
Lactating Cows	0.34	0.23	0.20	0.80
400 lbs Steer				
1.5lb daily gain	0.42	0.23	0.16	0.80

SOURCE: adapted from Corbett, no date.

Table 46. Average macro mineral analysis for common cattle feeds (BC sourced)

	Calcium (%)	Phosphorus (%)	Magnesium (%)	Potassium (%)
Grass Hay				
Average	0.46	0.25	0.19	1.8
Range	0.07-1.24	0.05-0.62	0.04-0.61	0.30-6.50
Grass Legume Hay				
Average	0.93	0.24	0.23	2.05
Range	0.22-2.44	0.05-0.73	0.01-0.66	0.62-3.85
Barley Grain				

Average	0.08	0.37	0.16	0.44
Range	0.01-0.29	0.10-0.52	0.05-0.37	0.30-0.70
SOURCE: Corbett, no date.				

As can be seen from the above tables, average grass hay (BC analysis) is able to meet the daily macro-mineral requirements of most stages of beef cattle.

Vitamins:

Vitamins are key organic molecules that are needed to sustain animal life, maintenance and normal growth. Cattle get their vitamins either by direct consumption or through ruminal synthesis. Deficiency of most vitamins in cattle is fairly rare, especially cattle fed on good pasture or high quality preserved forages (Blair, 2011).

There are two basic types of vitamins to be aware of when feeding cattle, the water soluble and the fat soluble vitamins. Fat soluble vitamins are the D, E, and K vitamins; these are taken in to the body along with dietary fats and are stored in large quantities in the fatty tissue of the animal. Water soluble vitamins are the B group vitamins; these are not absorbed with fats and are not stored in any quantity. Excess of vitamins in this group are excreted in the urine. For more information on cattle vitamin requirements refer to a veterinary manual or "Nutrition and Feeding of organic Cattle" by Robert Blair (2011).

Feed Management of Cattle

The energy and protein requirements of a cattle herd vary depending on many factors; the main variables dictating requirements are life stage and output. Steers have a different nutritional and energy requirement than lactating cows resulting in the need to consume less or more feed accordingly. High performing dairy herds also need higher quality and higher protein feed for optimal production.

Pasturing

All nutritional requirements can, for the most part, be met with either fresh or preserved forages. Foraging and grazing is the most cost effective method of feeding cattle (assuming access to lands capable of growing forages is available) and should be capitalized upon whenever possible. Not only is pasture the most cost effective method of feeding, it is also the most natural feeding method of both dairy and beef cattle (Blair, 2011). In organic agriculture, forages, either fresh or preserved, must make up at least 60% of the diets of organically raised cattle; in many smaller scale operation, forages make up nearly 100% of cattle diets (Blair, 2011).

When planning how and what to feed beef cattle it can be difficult to find good information comparing and contrasting natural feeding methods. Understanding how the feeding and finishing method you choose will impact the: growth rate, expected yields, and taste of your animals is important and should be considered when planning your beef operation. These factors will also vary depending on the cattle breed you choose to raise, this is discussed later in the chapter.

In 1997 an Irish study (Keane, 1998) set about trying to understand how pasture based feeding systems changed the yields and economics of a beef operation compared to more conventional systems. This research looked at three feeding methods: intensive, conventional and extensive (slow). The intensive method fed young animal's silage and concentrates till 19 months of age, the conventional method fed silage and concentrates and slaughtered at 24 months age, and the extensive method raised and finished the animals on pasture till 29 months of age. As would be expected the intensive and conventional systems produced higher weight gains and less days till slaughter weight was reached. Animals on the intensive system gained 1.18 kg/day and reached slaughter weight at approximately 398 days. Animals raised conventionally gained 0.83 kg/day and reached slaughter weight at 556 days and extensively raised animals gained 0.7 kg/day and reached slaughter weight at 684 days. The table below (Table 47) shows the live weight gains for the three production systems.

Table 47. Live-weights and live-weight gains of cattle in three production systems

	No. Days	Intensive	Conventional	Extensive
Live-weights (kg) at				
End of 1st winter	141	438	358	357
End of 2nd grazing	194		546	547
Slaughter		677	669	684
Days to slaughter		398	556	684
Live-weight gain (kg/day)				
1st winter		1.18	0.73	0.72
2nd grazing season		1.18	0.97	0.97

2nd winter	1.18	0.88	0.15
3rd grazing season	1.18	0.88	0.88
At slaughter	1.18	0.83	0.70
Source: adapted from Keane and Allen, 1998.			

One of the more interesting comparative elements of this study was the weight gain difference between the conventionally raised steers and the extensively raised steers; daily gains are almost identical up until the second winter, at this time steers in the conventional group are being fed preserved forages (silage) and concentrates, while the extensive steers are only fed the silage. Up until this point they had both been on a pasture based diet. The addition of the concentrate allows the steers to maintain a high level of weight gain throughout the winter season while the steers on silage-only diets gained significantly less. This is a good example of the differences that feeding methods can have on beef production.

This study also assessed the costs associated with intensive production systems vs. extensive systems. They found that, in Ireland, the extensively raised steers had a higher profit margin than the conventional and intensively raised steers. Most of this difference came from the high cost of concentrates vs. the lower cost of forages. Table 48 summarises the input and outputs of the three systems and the associated costs.

Table 48. Summary of concentrate inputs and market value of the three systems.

	Intensive	Conventional	Extensive
Stocking rate (ha/animal)	0.25	0.48	0.68
Per animal inputs and outputs			
Concentrates (kg)	1705	1218	256

Carcass weight (kg)	384	363	366
Market Gross Margin (ECU)	54	34	156
Source: adapted from Keane and Allen, 1998.			

The authors of the study also conducted extensive testing of the quality and composition of meat from the three treatments. They found that all three systems were capable of producing acceptable commercial grades of meat. They found that carcasses from the intensive group had, on average, higher conformation and fat scores than the other two groups, however, when the meat was consumed and rated by a tasting panel, no significant differences were detected between meats from the three systems.

In a recent Canadian study conducted by Berthiaume et al., (2006) evaluation of five different beef cattle management systems were carried out to assess their effects on growth, performance, carcass quality and cost of production. The five production systems are displayed in the table below (Table 49):

Table 49. Feed management regimes and treatments for the five systems

Growing Phase (0-98 days)	
GS	Grass silage only
GS/GP	Grass silage fed with growth promotants
GS/LCON	Grass silage + 4% soybean meal
GS/HCON	Grass silage + 8% soybean meal
GS/GP+HCON	Grass silage + 8% soybean meal + growth promotants
Finishing Phase (99 day-slaughter)	
GS	Grass silage only
GS/GP	Grass silage fed with growth promotants

GS/LCON	Grass silage + 40% rolled barley
GS/HCON	Grass silage + 70% rolled barley
GS/GP+HCON	Grass silage + 70% rolled barley + growth promotants
Source: Berthiaume et al., 2006.	

The results of these trials indicated that, of the five methods of production, forage feeding was a more economical production method than forage + concentrate feeding. The authors estimated that forage-fed, non-implanted beef would cost 31% less to produce than grain-fed, implanted beef. However, because of the lower grades (31% lower) and weights (16% lower) of the forage-fed beef the authors suggest natural beef farmers need to charge a 16% premium to be as economically competitive as conventionally finished cattle, Table 50 has the detailed analysis of the production numbers.

Table 50. Animal performance during growth and finishing of experiment

	Management Regimes				
	GS	GS/GP	GS+LCON	GS+HCON	GS/GP+HCON
Growing Phase					
Avg. daily/gain (kg)	1.03	1.16	1.05	1.05	1.19
Dry Mat. Intake (kg)	6.49	6.66	7.38	7.31	6.89
Dry Mat. Int. % body weight	2.05	2.00	2.30	2.28	2.08
Finishing Phase					
Avg. daily/gain (kg)	0.74	1.18	1.07	1.13	1.44
Dry Mat. Intake (kg)	7.87	8.26	9.42	8.77	9.20
Dry Mat. Int. % body weight	1.92	1.82	2.18	2.08	2.01
Overall					
Avg. daily/gain (kg)	0.85	1.17	1.06	1.08	1.31

Dry Mat. Intake (kg)	7.32	7.50	8.41	8.12	8.05
Dry Mat. Int. % body weight	2.02	1.89	2.22	2.20	2.02
Gain to Feed ratio	0.12	0.16	0.13	0.13	0.16
Source: Berthiaume et al., 2006.					

The authors address the issue of varying feed cost, acknowledging that production costs and associated economics will vary depending upon regional feed costs. In regions like the Yukon, grain costs are significantly higher than in the south which would result in an even greater economic reason to operate a forage-fed production model. The costs associated with this experiment are displayed in the table below (Table 51).

Table 51. Cost of production and cost of gain for five treatments ($ CND.)

	Management regime				
Item	GS	GS/GP	GS+LCON	GS+HCON	GS/GP+HCON
Initial BW (kg)	266	273	269	272	273
Day 98 BW (kg)	367	387	373	374	390
Final BW (kg)	461	513	487	473	530
Days on feed	234	210	208	186	197
Cost/Steer ($)					
Feed	168.41	175.94	238.15	227.59	250.02
Overhead cost	106.96	113.16	103.12	99.84	110.84
Total cost/steer	275.39	288.91	341.46	327.43	360.87
Cost/kg of gain ($)					
Feed cost	0.86	0.73	1.10	1.14	1.00
Overhead cost	0.55	0.47	0.48	0.50	0.44
Total cost per kg gain	1.42	1.20	1.58	1.65	1.44
Source: Berthiaume et al., 2006.					

For most Yukon beef producers a feed management system based on grass feed, either as fresh forage, silage, hay, or a combination of these, is most likely going to produce the best results at the least amount of cost. Not only is this method the most cost effective but it is also requires the least amount of infrastructure, labour and the feed can easily be produced on-farm.

Pasture Management Considerations

There are two basic management systems to consider when pasturing livestock, continuous grazing and rotational grazing (Sollenberger & Newman 2007). Rotational grazing comes in numerous forms and intensity levels and can range from daily movement of livestock (mob grazing) to weekly or longer durations between moves.

A continuous grazing system exists when livestock graze the same paddock continuously for as long as sufficient pasture forages persist.

Regardless of the details of either system, the management goals are the same; to maximize the utilization of available pastures without damaging forages or the range.

Anyone who has researched this subject will know that there are proponents of both management systems with outspoken advocates on either side. Proponents of intensive management, claim that higher weight gains and improved pasture condition are the benefits of rotational grazing, while proponents of non-intensive management claim the same gains and pasture condition without the fuss and hassle of moving livestock.

Rotational grazing exists when alternating periods of grazing and rest occur among several paddocks. This can range in rotational intensity from every few days to weeks.

Interestingly, the science agrees with both sides (or neither side) but for different reasons. In 2008, Briske, et al., researched and synthesized the published literature intensive vs. continuous grazing techniques. They summarized the findings of decades of researchers going back to the 1960's. What they found was that there is almost no difference, in either grass productivity, livestock productivity or pasture health, between the two systems. It turned out that the system of management was inconsequential compared to weather management was taking place or not. They found that, because many continuously grazed systems are overstocked and mismanaged (undermanaged/not managed) animals do poorly and range suffers. In intensive systems the likelihood of overstocking is far less, resulting in better animal condition and performance, and a healthier pasture.

Under research conditions, when stocking rates are assessed and adhered to (or adjusted according to conditional change) the two pasturing systems perform very closely. In fact, Briske et al., (2008) found that in 87% (20 of 23) of studies, plant production on continuously grazed systems was found to be equal to or greater than that of rotational systems. In 92% of the studies (35 of 38) animal production, per head, on continuous grazing systems were equal to or greater than those on rotational systems.

Briske et al., (2008), sum up the confusion regarding these two systems like this:

> "To emphasize the importance of management as a confounding variable, consider that a well-managed rotational system will very likely achieve desired production goals more effectively than poorly managed continuous grazing. A visual inspection could lead to the conclusion that rotational grazing is more beneficial than continuous grazing, but this is not a legitimate comparison of these two grazing regimes because it is confounded by tremendous managerial variability. In oth-

> er words, the reverse is also true that well-managed continuous grazing would be more effective than poorly managed rotational grazing."

In short, this means that committing to a grazing system and managing it with purpose and consistency will result in increased productivity and sustainability. If adopting rotational grazing is the method that will enable better management of animals and pastures on your farm then it is an effective tool to accomplish those goals. However, as the aforementioned studies indicate, rotational grazing is not necessary for optimal production and sustainability.

New research is indicating that pasture management technique may have implications on beef carcass characteristics and meat fatty acid profiles. In a recent study by Schmutz et. Al., (2014), the relationship between breed, grazing system (rotational vs. continuous) and concentrate supplementation on the carcass characteristics and fatty acid profiles was researched.

This study looked at 96 steers (German Simmental and German Holstein) over a 9 month period and found that "grazing system" had significant impact on a number of parameters. Most notably, steers on the continuous grazing system (CGS) were found to have higher fatty acid values than steers on rotational grazing (RGS), as well the CGS steers had healthier ratios of n-3 to n-6 and had higher carcass weights compared to the RGS steers. However, the paper was unclear as to the reasons why the CGS animals performed better than the RGS animals, the paper was unable to definitively state that is was the pasture management system that was responsible as opposed to some other factors.

In a study investigating the productivity and quality of smooth brome pastures under three grazing regimes, continuous grazing, rotational grazing and mob grazing, the researcher (Humerickhouse, 2014) found that forage quality was poorest in the mob treatments and that season-long total biomass accumulation of all treatments were similar. Based on her evaluation of the three types of grazing systems there are no advantages to mob grazing over the more conventional grazing systems. Figure 9, shows the forage disappearance rates for the three treatments in this study.

Mob grazing differs from rotational grazing in that it involves much higher stocking densities for much shorter periods of time. Pasture biomass accumulation is normally much greater in mob grazing and is allowed to be reduced much more than the other systems.

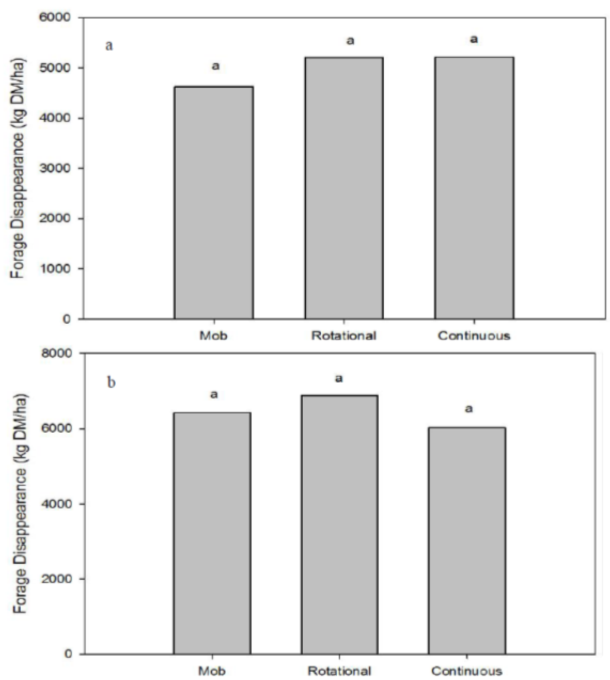


Figure 9. Forage disappearance in kg DM/ha for all treatments in 2012 and 2013

Humerickhouse (2014) also discovered that forage quality was lover in the mob grazing treatment compared to the rotational and continuous grazing treatments. Because the non-grazed paddocks in the mob-grazing treatment are not being continually grazed, (i.e., keeping them in a growing state) they become stemmy and later in the season develop seed heads. As these paddocks mature, nutritional value decreases. The rotational and continuously grazed systems on the other hand, are kept in a continually growing state resulting in more nutritious forage for a longer duration.

It should be noted that all of the studies mentioned took place over relatively short time periods, one or two seasons. If there is a benefit to rotational or mob grazing (as many livestock managers state) it is likely that these time periods are insufficiently long to see any meaningful change in the productivity of the system. For example, if a degraded pasture is used for the experiment, and no inputs are added to the system, it will remain a degraded pasture under any form of management until given sufficient time to rebuild and become productive, this could take many years. Conversely, if highly productive pastures with healthy soils are used in these experiments, it is likely that neither technique will show significant differences in quality and productivity over the course of a single seasons field trials. Pasture condition prior to experimentation was not well discussed in any of the papers reviewed.

To fully understand the implications of rotational and intensive pasture management, long term monitoring studies will need to be undertaken. I was unable to find any such study (within conventional published materials) to include in this report.

Feed management for dairy cows

Cattle with high nutritional demands such as dairy cows have been found to produce well on a forage dominant diet. German researchers (Haas et al. 2007), analysing the feeding patterns on 26 organic farms, found that under organic conditions, (pasture with some supplements) milk yields were around 7000kg/ha (0.96 ha/cow) with a calculated 73% of that yield coming from the pasture and 26% coming from concentrates and spent grains.

New Zealand dairy farms (non-organic system) were found to have even higher rates of forages in their diets. Verkerk and Tervit (2003) conducted a broad survey of dairy farms and found that the average New Zealand dairy cow obtained 83% of dry matter intake from grazed pastures.

Providing pasture as the only source of feed for dairy cows typically results in a reduction of milk yields and a number of experiments have been done to show this. In 1998, Kolver and Muller fed high performance dairy cows either a pasture only diet or a conventional diet containing concentrates and grains. The cows on the conventional diet produced 40 l/cow/day while the pastured cows produced 30 l/cow/day.

In an experiment by Stockdale, (1999) dairy cows were fed diets of pasture-only or pasture and one of three supplements. Supplements included: cereal grain, lupine seed + cereal grain, and hay. Results showed that cows on "pasture only" produced less milk (18.2 kg/cow/day) compared with cows fed grain and lupine supplements (24 kg/cow/day). All cows fed supplements were found to produce more milk than cows on pasture only. It was not discussed whether the increase in feed cost was offset by the increase in yields.

While pasturing represents the most cost effective method of feeding dairy cows it is not the highest yielding. The reduction in yield, however, is often negated by the higher market value of pastured dairy products. A recent study by the Department of Agricultural Economics and Agribusiness in the United States (Gillespie, et al., 2009), investigate the profitability of pasture-based vs. conventional dairies. This study found that pasture-based dairy systems were able to demand a higher market price which offset the decrease in milk yields. Based on this higher market price, pasture-based dairies were found to be equally profitable to conventional systems.

Feed Management and Consumer Acceptance of Dairy Products

Feed management choice can have implications on the consumer perception and assessment of dairy products as well. In a 2007 study by Valverde, consumers were asked to rate the milk of cows on three different feed systems: organic, pasture based and conventional. The results were interesting; milk from pasture based farms had the best mouth feel and appearance while milk from conventional dairies had the highest overall liking (Table 52).

Table 52. Average consumer assessment of milk from cows fed using 3 different systems.

	Overall liking	Overall flavour	Overall appearance	Overall mouth-feel
Organic	4.67	4.48	5.34	4.92
Pasture	5.72	5.71	5.87	5.91
Conventional	5.81	5.94	5.67	5.82
On a scale of 1-9: 1, extreme dislike and 9, extreme like				
SOURCE: adapted from Valverde, 2007)				

The above findings illustrate the subtle importance that feed type and feed management systems play in the quality of dairy products. While the Valverde (2007) study was not large or broad in scope, it does indicate that consumers are sensitive to product consistency and predictability. Producers should be cognisant of these findings when marketing product to a broad consumer base.

Feed Management for Beef Cows

Beef cattle have simpler requirements than dairy cattle and most of their nutritional requirements can be met by rangeland, pastures and preserved forages (Blair, 2011). In breeding herds it is important to try and match the peak nutritional requirements (calving and lactation) with spring flush and the availability of the highest quality forages (Blair, 2011). By synchronizing these two seasonal cycles there can be significant production advantages. Younie (2001) lists these advantages:

- Cows meet spring grass peak growth rates at their lowest body condition and an increasing demand for milk from the calf. This makes them very biologically efficient.
- A peak milk yield on grass alone is achieved at peak grass productivity, thus maximizing annual lactation yield.
- Fertility is maximized by a rising plane of nutrition.
- Calves begin grazing when grass productivity, quality and palatability are high.

If cattle can bounce back from parturition and lactation quickly (by getting on high quality pastures when nutritional demands are at their peak) they will be in good shape to lay down significant body reserves during the latter part of the grazing season. This can assist with winter body heat insulation and in reducing winter feed requirements. Grazing cattle should also be provided with a salt/mineral block to ensure deficiency does not occur.

The post calving period is the most nutritionally demanding period for a beef herd, cows are recovering from parturition (giving birth), they are producing large volumes of milk (5-12 kg/day), and they are likely recovering from overwintering condition loss. During this period feed intake (of nursing cows is around 35-50% higher than in non-lactating animals (Blair, 2011). This is a very important time to provide either high quality pastures or your highest quality preserved forages. It is important to maintain healthy cows and heifers during this period in order to ensure successful calving and subsequent rebreeding. Crude protein for animals during this stage should be around 70g/kg dry matter (Blair, 2011).

Calves not destined to be replacement beef herd animals are typically grown for the meat market. These animals have the simplest dietary needs and the simplest feeding regime. Typically market calves are grazed on pasture and range throughout the shoulder and summer seasons and fed preserved forages throughout the winter (Blair, 2011). Rotational/intensive grazing is a good methods of maximizing weight gain and grass production while also reducing infection from parasites (Blair, 2011). Throughout the winter feeding period it is also common to supplement preserved forages with some type of grain, oats or barley. Grain is typically supplied at rates of 0.5-1.0 kg/head/day in organic beef production (Blair, 2011).

Research has been conducted to evaluate the weight gain rates and meat quality differences of beef cattle fed differing diets. In 2001, French et al., investigated how feeding an all grass diet compared to feeding a concentrate based diet impacted the growth rate and meat quality of Limousin, Charolais crossed steers. Six different levels of concentrate were fed to the steers ranging from no concentrate to an all concentrate diet. The results (Table 52) showed that weight gain and fat content were significantly impacted by diet. Steers on the "grass-only" diet were found to have average daily gains of 360 g/day while "concentrate-only" steers were found to have average daily gains of 809 g/day. Fat content was also found to be significantly higher in the concentrate-only group.

Table 53. Effect of diet on carcass weight and meat quality of steers (95 day period)

	Dietary Allowances					
	18kg grass DM	18kg grass DM + 2.5kg concentrate	18kg grass DM + 5kg concentrate	6kg grass DM + 5kg concentrate	12kg grass DM + 2.5kg concentrate	Concentrate To Appetite
Carcass Weight (kg)	330	355	363	352	348	371
Carcass Gain/day (g)	360	631	727	617	551	809
Fat score	4.03	3.97	4.14	3.79	4.15	4.64
Intra. Musc. Fat (g/kg muscle)	23	24	29	23	25	44
Meat quality after aging for 2 days						
Tenderness[A]	3.5	4.2	4.5	4.0	4.8	4.4
Flavour[B]	3.5	3.6	3.7	3.8	3.6	3.7
Juiciness[C]	4.8	5.2	5.3	5.2	4.7	5.2
Chewiness[D]	4.2	3.7	3.7	4.0	3.6	3.9
Acceptability[E]	3.2	3.1	3.4	2.8	3.2	3.3

A, 1=extremely tough, 8 extremely tender. B, 1=very poor, 6= very good. C, 1= very dry, 8= very juicy.
D, 1= not chewy, 6= very chewy. E, 1= not acceptable, 6= very acceptable.
SOURCE: Adapted from French et al., 2001.

These findings are interesting, however, they did not show that similar weights and scores can be obtained in grass-fed-beef if they are given slightly longer to mature.

Feed Management and Meat Quality

Feed management practice can impact the quality and consumer acceptance of beef products. Meat quality is typically assessed using two evaluation criteria: grade and taste (eating quality). Beef grades are prescribed based on estimates of lean meat to fat content ratio. Higher meat grades are given to beef with higher marbling and lower grades given to meat with a lower marbling content. This grading system does not consider other quantitative criteria such as color, flavour, tenderness or fatty acid composition (Blair, 2011). In studies designed to assess feeding programs and their effects on taste, pastured beef normally fall behind conventionally raised beef in most categories. As illustrated in the above table, French (2001) found that pastured beef fell slightly behind conventional beef in: tenderness, flavour, juiciness and chewiness. In a more comprehensive study conducted by Russo and Preziuso (2005), reviewing the scientific literature on qualitative carcass characteristics of beef cattle raised organically. They found that organically raised (high degree of pasturing) beef were found to have poorer muscle development and reduced fat content when compared with conventionally raised beef of the same type.

One of the main health benefits and selling features, of pastured beef is its altered fatty acid profile. It is generally well recognized (through recent studies) that pasture raised beef is higher in n-3 PUFAs (poly unsaturated fatty acids or omega 3 fatty acids) due to the presence of C18:3 in grass; this is a compound not found in grains (Blair, 2011. Daley, et al, 2010. Razminowicz et al., 2006). Beef cows fed a forage based diet were also found to have a healthier ratio of omega-6 to omega-3 fatty acids compared to concentrate fed animals (Nuernberg et al., 2005).

Another health benefit, and marketing advantage, of pastured beef products are the elevated presence of conjugated linoleic acid (CLA). These compounds have been found to have anti-carcinogenic, anti-diabetic and anti-atherogenic properties; they have also been found to benefit the immune system, bone metabolism and body composition (Blair, 2011). CLA compounds and CLA precursors are produced by the action of rumen microorganisms and can be found in the milk and meat of pastured cows (Blair, 2011). In 2000, French et al., found that CLA levels were increased in beef cows following a switch from a concentrate based diet to a pasture based diet. CLA levels were found to more than double in pastured steers during this experiment, increasing from 3.7 mg/g to as high as 10.8 mg/g. In 2004, more research was conducted into CLA levels and diet; Poulson, et al., found that CLA was 6.6 times higher in steers raised on forage compared to steers from a feedlot diet (13.1 vs. 2.0 mg/g).

Case Study, Yukon Beef Production

Circle D Ranch

In order to gain some perspective regarding current beef production systems in the Yukon, Bill Drury of Circle D Ranch, was interviewed for his knowledge and experience in beef production. Mr. Drury has been raising beef cattle on his family farm, 30km west of Whitehorse, for the past 25 years. This is a small scale (by outside standards) cattle operation that relies on both imported yearlings and calves produced on-farm to make up its market animals. The number of animals harvested and sold each year varies between 10 and 15; of these animals about ten are imported and the rest come from the on-farm cow-calf operation.

Imported animals come from Alberta where they have gone through their first winter; they are purchased and trucked up the highway in the spring just in time to be placed onto pastures with the resident heard. All the animals are pastured from about the middle of May until the end of September; in good years the animals can remain on pasture until the middle of October.

The calves born on farm are delivered around the middle of April, cows are still on preserved feed at this point which consists solely of brome hay (or a brome mix or haylage). When oat bundles are available these may be fed as well. The cows, calves and yearlings are moved out onto pastures as early as possible, this is normally around mid-May; a small pasture is chosen for early season grazing so as not to damage the larger pastures, this enables the larger paddocks to obtain sufficient growth prior to grazing pressures. All the cattle are grazed until late September or early October, this date is determined by the cows themselves and is explained by Mr. Drury;

> "I know when it's time to let the cows into the overwintering pasture because the old cows will lead the heard to the gate and wait there till I let them in. They know when it's time to come off pasture and get fed."

The calves born on the farm are separated from their mothers in the fall and are overwintered in a small paddock with access to water, shelter and grass hay (or oat bundles). In the spring they (now yearlings) head out to pasture with the rest of the heard, they will put on weight all summer and be slaughtered in mid-September. Slaughtering weights are around 450 kg live weight and hanging sides (hot carcass weight sometimes expressed as HCW) are around 280 kg combined. Mr. Drury estimates that there is about a 40% loss in guts, hide, head and hooves.

The calves that are brought up from Alberta weigh about 320 kg when they arrive on the farm, they are fed on pasture all summer and reach a slaughter weight of about 450 kg. They are able to put on around 100kg of weight in the 4 months they spend on pasture. This equates to an average daily gain (over the summer) of

0.83 kg/day/animal. These gains are consistent with those found by Berthiaume et al., (2006) for beef cattle fed grass silage (0.85 kg/day/animal).

Interestingly, the beef yields (live weights are estimates) on Drury's farm are very similar to the yields found by Berthiaume et al., (2006). Hot carcass weights of the animals in Berthiaume's study ranged from 265 to 306.9 kg while average HCW weights at Circle D Ranch average 280 kg.

Cattle breed selection for northern production

Cattle production in northern environments such as the Yukon make selection of breed important. Research conducted in northern Europe (Younie, 2001) indicated that small breeds, particularly Angus, are an excellent choice for smaller northern farms. Younie explains that cows of small to medium mature size are better able to maintain themselves on grass alone and better cope with short growing seasons. He goes on to comment on other benefits of the Angus breed,

> "Ease of calving, satisfactory temperament, proportionate milk production and the production of a premium beef animal are also significantly attractive traits, as is natural polling, particularly in a low-labour situation".

Highland cattle also are said to do well in cold climates and snow. They require little in the way of shelter, they perform well on rough forages and do not require supplements or grains to remain healthy (although better yields are observed when supplementation is provided).

In agriculturally remote areas such as Yukon, talking with neighbouring ranchers and farmers and finding out what breeds they have tried and what breeds do well for them is often the most helpful method in narrowing down what breed to raise. Local farmers may also be able to provide breeding stock and management tips to make starting a cattle operation easier.

Shelters and performance of overwintering cattle

When livestock animals ingest feed, the calories are utilized for a number of tasks. Most calories are allocated to maintenance and metabolic functions, while surplus calories are used for growth, fat storage and reproductive tasks. During the winter months, much of the feeds calories are being utilized for maintenance and the production of body heat resulting in an increased requirement of feed.

Research has been conducted in northern Finland which investigated the relationship between feed intake, type of shelter provided (insulated barn vs. uninsulated barn vs. no shelter) and beef cattle weight gains. This research, carried out by Huuskonen et al., (2009), took place in northern Finland at latitudes of 64.44N and winter temperatures dropping below 25°C.

This experiment took place at the North Ostrobothnia Research Station of MTT Agrifood Research Finland in Ruukki. The project went from November 1999 to October 2000 and studied 30 Hereford bulls that had been born in the spring of 1999. The bulls were separated into 3 treatments, insulated barn, uninsulated barn and forested paddock. All bulls were fed the same daily ration which consisted of 50% grass silage and 50% rolled barley. The ration also included a mineral and vitamin mixture.

The results of this research proved contrary to conventional wisdom and several previous studies; cattle provided with an uninsulated barn had the highest live weights, highest live weight gain, and highest carcass weights compared to the cattle with an insulated barn and cattle with no barn. The complete results are displayed in Table 54.

Table 54. Growth, energy and carcass characteristics for beef cattle housed in 3 treatments

	Insulated barn	Uninsulated barn	Forested paddock
Initial live weight (kg)	285	284	287
Final live weight (kg)	753	785	780
Carcass weight (kg)	405	425	412
Weight gain (g/day)			
Winter	1314	1466	1356
Summer	1364	1406	1472
Carcass gain (g/day)	751	812	771
EUROP conformation	6.2	6.9	7.6
Energy Intake MJ ME (kg W)			
Winter	83.2	87.4	87.2
Summer	78.6	84.8	84.1
EUROP Conf. (1=poorest, 15=excellent)			
Source: Adapted from Huuskonen et al., 2009.			

This study was able to show that by providing some shelter was better than no shelter and that providing a feed that met all the developmental needs of the calves, adequate growth could be achieved even without shelter. What was also interesting about this study is that it did not measure a huge variation in daily energy requirements between the three treatments (Table 54) as might have been expected. The authors attributed this to winter weather (in Finland) having little effect the energy requirements of growing bulls. In the discussion the authors caution against unsheltered overwintering in areas with more extreme and longer winters.

Some Canadian research exists on this topic and several articles from the 60's and 70's were found. The results from these studies differed from the aforementioned finish study in several ways. In 1972, Lister et al., investigated how housing and forage effected the overwintering of pregnant cows in Ontario. Beef cows were studied for a three year period and were divided into three treatments and two feed types. The treatments were: in cows (cows overwintered indoors with insulated barn), in-out cows (cows with access to outside and an uninsulated barn), and out cows (cows with no indoor access just a windbreak). The forage types included hay-fed cows and silage fed cows. The results of the study are displayed in Table 55.

Table 55. Daily digestible energy intake and gain of beef cows

	Hay-fed cows			Silage-fed cows		
Housing type	DE intake (Mcal/100kg LW	Daily gain (g)	Adjusted gain (g)	DE intake (Mcal/100kg LW	Daily gain (g)	Adjusted gain (g)
In	3.47	273	131	2.86	196	59
In-out	3.52	257	125	2.90	132	-5
Out	3.81	-31	-159	3.22	-185	-311
Adjusted gain is adjusted for uterine growth associated with foetal development.						
Source: adapted from Lister et al., 1972.						

In the Lister study, cows housed without shelter showed loses in weight and condition following overwintering. The out group also had higher feed requirements of both grass hay and silage. Feed requirements when fed silage were also found to be lower in all treatment groups which indicates a higher efficiency use of silage over grass hay. Cows with access to, or confined in, shelters had significantly higher weight gains than cows without access to shelter.

One of the main differences between this study and the Huuskonen study is the use of grains, minerals and supplementary vitamins within the ration. There is no mention of these products in the Lister study and this could be a significant factor contributing to winter weight gains. Another variable between these studies is the gender and life stage of the animals; in the Finish study bulls were used and in the Canadian study pregnant cows, it is likely that the higher nutrient demands of pregnant cows combined with a lower energy feed contributed to their lower production numbers.

Effects of shelter on performance are unknown for cattle overwintering in the Yukon, however, based on this research conducted in other regions it is safe to assume that providing bedding and a covered, wind free, shelter will not only improve the wellbeing of the cows but also increase winter weight gains.

Types of Forages for Cattle Production

Forages for cows are as diverse as the regions which cows are raised in; regions with abundant crop residues will utilize it as feed, whereas regions without will rely more heavily on pasture grasses, legumes and native range. Cattle are highly adapted to converting fibrous feedstuffs into meat, milk and calves and will perform well on a wide range of feeds and native vegetation.

In Yukon, we have a well-established grass hay industry and a large amount of pasture land and grazing leases. Of the agricultural land in the territory (10,646 ha) 63% is being used for either pasture, green-feed or preserved forages (Ball et al., 2013). 1030 ha are seeded pastures, 3413 ha is natural pasture lands, 1867 ha is used for hay production and 414 ha is used for green feed production. As illustrated in previous chapters, most of the feed produced locally makes excellent cattle feed.

Most seeded and natural pastures are mixed grass pastures; bromegrass is commonly the dominant species with a number of other grasses or legumes accompanying. Pasture grasses are usually selected and planted based on local soil condition, available heat and moisture and potential yield. Smooth and meadow bromegrass is commonly a first choice as it is unsurpassed locally in yield, competitiveness and nutritional value, however, it does not do well in all conditions (See Table 42 for local yield results for common grasses). Selecting the pasture grasses that do best in a particular location will need to be determined in order to optimize forage production.

Planting a legume along with perennial grasses can have several beneficial effects; legumes are able to fix nitrogen from the atmosphere which improves soil performance, legumes also improve the nutritive quality of the forage as they are easily digestible and high in protein. Some legumes can fix a significant amount of nitrogen which can reduce the amount that needs to be applied. In a study in north Saskatchewan (Bowren, et. al., 1968) researchers found that in sub-optimal conditions, a conservative estimate of the N fixing capacity of sweet clover, alfalfa and red clover were 70- 90, 60- 95, and 50- 75 kg N/ha respectively. In optimal conditions (not Yukon) some clovers can add up to 240 kg N/ha/year to soils; some of this N can be used by other forage species for growth (Bowren, et al., 1968).

Regardless of the forage species chosen, research has shown that irrigation and fertilizer are necessary for optimal yields. Irrigation and fertilizer rates will be determined by analysing soil and natural precipitation rates in your area. (The Yukon agriculture branch can help in soil analysis and interpretation of the results)

Forages for Pasturing Cattle

Feed is the single largest expense in any livestock operation and cattle farming, either beef or dairy, is no different (Blair, 2011). Minimizing feed costs and maximizing nutrition are of utmost importance in maintaining a profitable enterprise and pastures play a key role in this balance. Providing quality pasture for your herd will pay dividends by reducing feed and handling costs while optimizing nutritional intake. Beef cattle have a fairly high tolerance for a range of pasture qualities and dairy cows require a fairly high quality pasture to maintain decent production of milk.

Ranking one pasture grass or assemblage of grasses against another can be a difficult exercise and may be of little value. Because cattle are ruminants, the grass type becomes less important than the volume of grass and the stage of growth at consumption. Even forages with the highest feed values become less nutritionally valuable with age and, if they are in too low a quantity, their higher nutritive value cannot make up for their lack of volume.

When deciding what forages to cultivate, for a specific herd in a specific region, there are a few important factors to consider. It is important to plant forages that will produce large volumes of vegetative growth, begin production early in the season, and maintain production for a long duration. This will ensure that the animals will have sufficient feed for recovery from parturition, be able to sustain high milk yields, and gain condition for the winter season.

The Alaska Forage Manual (Dinkel and Czapla, 2012), describes some of the characteristics to assess during the process of selecting forages thusly: “desirable species characteristics include site adaptation, palatability, resistance to grazing pressure, nutritional value, production of high yields and the ability to withstand competition”.

As we learned from the Yukon and Alaska variety trials, the success of a given forage species may be highly variable depending on soil type, regional climate, pasture management and a range of other factors. For this reason, it is important to consider the growing limitations/opportunities that are specific to your microclimate before choosing what forages to plant.

This stated, however, recent research conducted at the Yukon Government Research Farm and local industry experience has shown that there are a number of crops that grow and produce well throughout the Yukon. The Yukon crop trials of the 80's showed that brome grass was amongst the highest yielding forage crop of the dozen or so tested; this proved to be the case at all locations where forage testing has been conducted in the Yukon.

At the research farm, Brome has consistently been one of the highest yielding forages that the site has tested. Brome grass also produces high protein and digestibility numbers depending on time of harvest and other management factors. When under a managed grazing system, forages like brome, should be kept in a vegetative state for the bulk of the grazing season, this will provide an excellent source of nutrition for ruminants.

The research farm has also had good yield results from a range of other forages (see section *Yukon Forage and Grain Trials, Research Farm (199?-Present)* in both single cut (Carlton Smooth Brome, Meadow Bromegrass, Richmond Timothy) and double cut systems (Boreal Creeping Red Fescue, Nugget Kentucky Bluegrass and Kirk Crested Wheatgrass).

Planting perennial grass pastures with a legume will increase the nutritional value of the pasture as well provide a natural source of N for the grass (Blair, 2011). Unfortunately, in Yukon, there has been little success integrating traditional legumes like clover and alfalfa into pastures. There are a number of reasons for this, but mainly, these legumes are right on the northern edge of their range, any significant grazing/harvesting pressure late in the season seems to significantly reduce their overwintering capabilities.

Finding a pasture management system that would allow legumes like alfalfa and clover to successfully overwinter is something that could benefit farmers in the Yukon. Lowering the grazing pressure of mixed grass and legume pasture in the early spring and late summer might be an effective strategy. Legumes, being more susceptible to overgrazing than grasses, need more time to store nutrients prior to senescence. When grazing pressure persists into the late summer and fall, legumes are not able to store sufficient amounts of energy in the roots for successful overwintering. Legume success can be further increased by choosing the right grass species to plant it with. When planting legumes with brome grass for instance, it is better to use a meadow brome as opposed to a smooth brome. Meadow brome is not rhizomatous (meadow brome is a bunch grass) and less competitive giving the legume a greater chance to establish and thrive (Kyle, 2006). Fertilizer application to a grass/legume pasture also inhibits the legume growth and favours the production of grass. In a study conducted by Matt Ball, (2006) an N application rate of 25kg/ha reduced the nitrogen fixation rate of the legume (alfalfa in this case) by around 50%.

Clovers and other legumes not only make good pasture, they are able to fix nitrogen from the atmosphere which improves the soil health of the health of the companion plants. Legumes have a symbiotic relationship with a nitrogen fixing bacteria (Rhizobium) that allow this process to take place (Blair, 2011). In ideal conditions legumes are able to fix a large amount of nitrogen in to the soil. Jennings (2005), was able to show fixation rates of up to 240 kg N /ha/year, while these rates are unlikely to occur in Yukon conditions, research has shown nitrogen fixation rates as high as 90 kg/ha/year (Ball, 2006).

While legumes make for a higher quality pasture they are not essential for a healthy cattle diet. Many grasses, in the growing state, are considered good/excellent forage for cattle. In a study on the nutritional value and stage of harvest/consumption of fescue hay, Lacefield et al., (1996) found that there were significant reductions in protein and digestibility of late hay compared to early hay. Table 56 shows the results of the study. As can be seen in the table below, grasses harvested in the seed-formation stage are lower in protein, harder to digest, and cattle require higher feed volumes in order to extract the same energy.

Table 56. Effect of stage of harvest of fescue hay forage quality and live weight gain in Holstein heifers

Stage of Harvest	Crude protein (g/kg)	Digestibility %	Dry matter intake (kg/day)	Liveweight gain (kg/day)	Ratio of hay to gain (kg/kg)	Hay (1st cutting)(t/ha)
Late boot to head	138	68	5.9	0.63	10.1	1.494
Early bloom stage	102	66	5.31	0.44	13.5	2.058
Early milk stage-seed formation	76	56	3.9	0.19	22.5	3.162
Source: Lacefield et al., 1996.						

Preserved Forages for Cattle

Most types of grass forage can be made into hay for cattle feed. Obviously some forages are more nutritious than others and some have higher yields than others, these considerations should be taken into account when planting forages intended for preservation. Preservation technique will also need to be considered when deciding what forages to cultivate as not all forages can be preserved in the same manner.

As was stated in the previous section, time of harvest is equally important as type of forage being harvested. As we will see in future chapters, the forages stage of maturity at harvest can mean the difference between a high quality feed and a low quality feed. As feed quality has implications on overwintering weight gains and performance, time of harvest can have significant implications on the economics of an operation.

Many of the forage crops tested in the Yukon and Alaska (discussed in the section reviewing local research), meet the minimum requirements for most beef cattle operations. Preserved forages are typically fed to cattle when natural pastures are not available. This happens in the fall, winter and spring or in the summer if sufficient pasture is not available or pastures stop growing due to heat or moisture stress. Ideally, feeding of preserved forages coincides with when animals require less nutrients, i.e., when cows are no longer nursing and producing milk.

When livestock are consuming only preserved forages it is a good idea to have the forage tested to ensure it is meeting the minimum nutritional requirements. Forage testing is the most accurate way to ensure adequate nutrition and production, however, if this is not feasible, careful monitoring of animal condition and performance can also be indicative of feed quality. This method, however, is less precise and requires the condition of the animal to decline in order to become aware of feed deficiencies. Conversely, nutritional content of forages could be just as easily underestimated and expensive supplementation could be provided when unnecessary.

When storing preserved forages, they should be sorted and stored according to their nutritional values. This will allow livestock managers to provide the right feed at the right time. Mature cows in the early stages of pregnancy require a lower quality feed than during later stages of pregnancy. In a fact sheet called “Tips on Overwintering Beef Cattle” by the Saskatchewan Ministry of Agriculture, the total digestible nutrients (TDN) requirements for an average pregnant beef cow is: 55% during mid pregnancy, 60% during late pregnancy and 65% after calving. By sorting preserved forages according to nutritional content, high quality feed can be kept till spring and used when requirements are highest (Bruynooghe and Feist, no date).

One misconception with ruminant digestion is the idea that if the livestock need more energy, protein or nutrients (i.e., during times of cold weather) they will simply eat more feed. This will work to a point, however, there is an upper limit on the volume of feed a cow can digest in a given time. Because many low quality forages are high in fibre and low in nutrients, the rate of digestion is reduced and the feed residence time (the length of time feed stays in the digestive tract) is increased. The result is that cows cannot ingest and process enough feed to meet their minimum requirements (Bruynooghe and Feist, no date)

Overwintering steers and pregnant cows will require a minimum amount of nutrition and comprehensive nutrition tables are available from the NRC website for cattle nutrition. These can be used in conjunction with feed analysis results to develop a feeding regime that works with requirements of your animals and the feeds available on your farm.

Stage of Growth and Feed Value

For cattle to best utilize the nutrients available in forages, either preserved or fresh, forages should be harvested at the correct stage of growth. Optimal stage of growth will vary depending on forage species and growing conditions, however, plants that are young, tender and quickly growing are good indicators of high quality forage. Quality forges will provide high levels of digestible nutrients, be capable of being ingested in high volume and maintain good ruminal health (Blair, 2011).

Feeds that are harvested or grazed when they have reached or passed maturity become increasingly indigestible to cattle. As plants get older the relative proportion of cell contents (100% digestible) to lignin (100% indigestible) decreases. This decreases the plant's capacity to be digested in the rumen by microorganisms. Compounding this digestibility issue is reduced feed intake due to older plants being more fibrous. Older plants contain less protein which further reduces nutritive value.

Pastures kept in a growing state are often more productive and higher in feed value than mature pastures. Grazing research in Ireland (Dillon, 2010) indicated that production of grasses is maximized when grazed to 3.5-4.0 cm residual height. This research found that by keeping the pasture in a growing state and not allowing it to go to seed, the pastures produced high quality leafy green forage that was not overly fibrous. The researchers recommended that pre-grazing heights be around 9 cm in height and then grazed down to 3.5-4.0 cm. This would be followed by a resting/growing phase prior to another round of grazing. The research found that yields of 16t/ha could be achieved in this manner. Pastures should also be allowed to have a rest phase prior to winter, this allows nutrients to be stored in the roots resulting in better overwintering performance and more vigorous spring growth.

Hay, Haylage and Silage

Preserved forages are normally stored as hay or silage. Unlike hay, silage is harvested and stored with high moisture content and, through fermentation, is able to maintain a preserved state. While silage can be made from any green crop, it is conventionally made from annual cereal crops and legumes (barley, wheat, oats, corn, rye, alfalfa and clover).

For maximum yield and quality, silage should be harvested prior to maturity, just before the hard dough stage for cereals (Saskatchewan Ag. Fact Sheet). In northern climates, where maturity in cereals is difficult to attain, this is a convenient aspect of silage production. Silage can have high nutrient concentrations without suffering some of the typical loses that grass hay experiences (rain, mould, dust, etc.). Table 57 shows average nutrient contents of silages from Saskatchewan.

Table 57. Average nutrient content of silages (%)

Crop	CP	TDN	Calcium	Phosphorus	ADF	NDF
Barley	14.1	53.0	0.46	0.32	37.7	56.7
Wheat	12.5	57.8	0.30	0.27	38.7	58.4
Oats	12.5	49	0.37	0.26	38.7	58.5
Alfalfa	26.1	58.6	1.54	0.24	26.1	33.5
Clover	16.2	58.1	1.28	0.22	36.1	43.6
Corn	8.34	68.2	0.20	0.23	28.6	50.5

Source: University of Saskatchewan and Sask. Ministry of Agriculture

http://www.agriculture.gov.sk.ca/Default.aspx?DN=cce79134-cefe-4e7c-a64e-08ea52f8ff99

In this silage production fact sheet produced by the Saskatchewan Ministry of Agriculture, barley silage is rated as being "higher in quality than other cereals and the quality compensates for lower yields in many locations where other cereals may have greater yields". For good yields, high rates of N fertilizer are recommended (up to 185 kg/ha), and attention must be paid to selecting a barley variety with higher lodging resistance.

Oats are also highly recommended as a good northern silage crop, they have some of the highest total dry matter and total energy yields of all the cereals. While less digestible than barley they make an excellent silage. Maximum energy and digestibility of whole plant oat silage is highest when harvested at the milk stage.

There can be some complications with feeding a silage based diet to cattle. Due to the highly degradable nature of the nitrogen in most silage, adequate supplementation of carbohydrate is necessary so that rumen microbes can cope with the rapid influx of ammonia following silage ingestion (McDonald et al., 1995). This serves to maximize the synthesis of microbial protein while minimizing the loss of energy and nitrogen from the feed. Therefore, for optimal utilization of the silage, it is recommended that silage be fed with a grain based supplement (Blair, 2011).

Baled Silage- Advantages

- *Uses same harvest machines as dry hay*
- *Less labour and energy compared with chopped silage*
- *production not limited to silo size*
- *Up to half the drying time compared with dry hay bales*
- *can be used effectively in small scale farms*
- *allows more flexible harvest schedule than dry hay*
- *Lower leaf loss in the field*
- *can be fed and handled using same equipment as dry round bales*

Disadvantages

- *Costs can be higher (depending on plastic wrap*
- *Plastic must be disposed of*
- *Easily spoils if exposed to air due to puncture*
- *Storage life shorter than chopped silage*
- *High moisture bales can freeze in very cold weather*

Adapted from: Baled Silage Production Manitoba. Ag. http://hayandforage.com/hay/the-benefits-of-baleage-0201

Planting pulses such as peas along with cereals is a good way to increase the protein concentration of silage. Pea and barley silage can have up to 3% higher protein than barley alone (Saskatchewan Ag. Fact Sheet).

Grass silage is commonly called haylage, or when baled called baleage. The products are virtually the same, a grass forage preserved through fermentation. There are some advantages with preserving hay in a wrapped bale (compared with bulk storage) which include: ease of handling, less specialized equipment, higher marketability, bales can be stacked and transported, and they do not require a structure to be housed within/under (Holin, 2011). Wrapped bales use more wrapping material than tubes, 50% more, however wrapped bales are stackable resulting in lower space needs.

Choosing a silage production system

Choosing to feed silage/haylage can increase the complexity and costs of a feed management system. Silage requires specialized storage facilities (silo, wrap/bags or pits) and handling equipment in order to efficiently ensile forages. These systems can become more economical as production levels increase, however for the average Yukon cattle operation, most of these options are likely too costly to consider. One method of ensiling has been adopted by forage producers in the Whitehorse area, and that is the bale wrapping method. This method involves tightly wrapping round bales in plastic wrap to keep out air. The wrap creates an anaerobic environment in which the bale ferments, preserving the bale.

Feeding Benefits of Baled Silage

There are nutritional and utilization advantages to consider when choosing to feed baled silage over dry hay. Baled silage has a softer texture than dry hay which makes it more palatable for cattle; this is especially true for calves that are less able to process fibrous feedstuffs. Higher palatability results in higher intake which can increase productivity. Once in the feeder, utilization of baled silage is increased by upwards of 25% due to less wastage and sorting of the feed (Baled Silage Production Manitoba Extension, no year, *http://hayandforage.com/hay/the-benefits-of-baleage-0201*).

It should be added that ensiling round bales is not a method of increasing the nutritive quality of the baled forage. If poor quality forage is baled and wrapped, the resulting product will be poor quality silage. In one animal performance study researching the relative feed value (RFV) of baled silage, the University of Manitoba found that there was substantial performance variability between animals fed high quality feeds vs. lower quality feeds, results are displayed in the table below (Table 58).

Table 58. Animal performance on baled silage of various relative feed values (RVF).

	Low (RFV 78)	Medium (RFV 112)	High (RFV 155)
Initial Weight (lb)	729	727	727
Final Weight (lb)	828	867	898
Gain/day (lb)	1.96	2.81	3.63
Feed (lb)/gain (lb)	8.53	6.80	5.39

Source: University of Manitoba (*http://hayandforage.com/hay/the-benefits-of-baleage-0201)*

The performance variability was attributed to: type of forage, stage of growth at time of harvest and degree of fermentation.

One of the reasons that feedlots heavily rely on silage as opposed to hay, is that they find silage feed value is more consistent than with hay. Hay quality can vary greatly between farms, years, grass type and storage conditions. Once ensiled and assuming proper storage conditions, silage can be preserved for a long time without losing feed value.

Finland; Grass Silage Systems

Investigation into the optimization of grass based feed management systems, for dairy and beef cattle, has been the subject of ongoing research in Finland. Finland has focused on grass based systems due to the climate limitations which preclude high (and reliable) yields from cereal grains. The Yukon experiences some of the same climate challenges as northern Finland and some valuable comparisons can be made between these regions.

Due to the growing limitations of the region, Finish researchers (early on) have focussed on maximizing the nutritive, storage and yield potential of grass crops as opposed to trying to adapt cereal crops to an unfavourable climate. One of the major limitations of trying to grow cereal crops in northern regions is the unpredictability of fall and spring weather along with unfavourably high precipitation during harvest. Even "northern hardy" varieties of barley, oats and rye can be devastated by inclement weather at the wrong stage of the growing season. This unreliability in the weather makes growing these crops a risky endeavour; early frosts and cool weather can kill plants prior to grain maturity and late season rains (common in Yukon) can cause severe lodging making harvesting more difficult. For farmers in Finland, these risks prompted research focus to be invested in improving grassland productivity and forge preservation technology (Huhtanen, et al., 2013).

The research carried out in Finland has focused around: ensiling technique, silage evaluation, predicting nutrient supply from grass silage diets, and the effects of forage quality and concentrate supplements on milk production (Huhtanen, et al., 2013). One of the key components to ensiling in Finland (and northern Europe) is the use of silage additives such as formic acid; these additives artificially lower the pH of ensiled forages that lack the necessary sugars to self-ensile. Because the growing conditions of Finland do not favour easily ensiled crops like perennial ryegrass and maize, these additives have made ensiling hardy grasses possible (Huhtanen, et al., 2013).

Hay production

Grass hay is probably the most widely utilized preserved forage for cattle feed in the Yukon. There exists a long tradition of grass hay making in the territory and it is available as small square bales, large round bales and round wrapped bales. Most of the grass hay made in the Yukon is a brome grass or brome grass mix.

Grass hay is simply a forage crop that is cut down, allowed to dry to an acceptable storage moisture content (this can vary depending on regions and species) and then packaged (baling is most common) and stored. The key to making high quality grass hay is to reduce the moisture content of the forage as quickly as possible so as to avoid excess nutrient leaching and cellular respiration. If drying takes a long time, due to wet conditions, losses of forage dry matter can range between 5% and 50% (Blair, 2011).

Rainfall during cutting and drying can cause significant leaching of plant protein, phosphorus, potassium, carotene and digestible energy components (Blair, 2011). Most producers look for windows of good weather in the forecast in order to minimize the risks of rainfall on drying hay. In some years this can be tricky.

Dry hay has a number of advantages over silage or baleage which make it the most commonly used form of preserved forage on small and medium sized farms (Lacefield et al., 1996). Some of these advantages include (from Lacefield et al., 1996):

- It requires standard harvesting and bailing equipment (much of which is common in the territory)
- It is more easily transported and stacked than baleage and silage
- It can be stored for long periods of time assuming protected from weather
- There is a larger local market for the product
- Many different types of forage crops can be harvested and used as hay
- It has very little nutrient losses once baled and placed in storage
- It is economical to produce in small and medium sized amounts
- It can be hand or mechanically fed depending on scale

Dry hay also has some disadvantages associated with it as well which make some producers favour silage or baleage. These disadvantages include:

- It requires longer drying time in the field than baleage or silage increasing the risks of rain damage
- It requires lower moisture content to bale
- It suffers from nutrient losses due to handling procedures as well as nutrient leaching

Handling loses can be quite significant with some types of hay. Some of these losses have been studied and the results of one such study are displayed in Table 59. While this study looked at Lucerne hay, more difficult and sensitive to handle than brome grass, local forage grasses can suffer similar loses due to handling practices (Lacefield et al., 1996).

Table 59. Effects of handling procedure on yield in Lucerne hay

		Losses			
	Raked and baled correctly Kg/ha	Raked to dry Kg/ha	Baled to dry Kg/ha	Raked and baled to dry (kg/ha)	Raked and baled to dry Total loss %
Dry Hay	3306	798	114	1140	34
Crude Protein	752	239	68	331	44
Total digestible nutrient	1949	547	103	787	40

Source: Lacefield et al., 1996.

Once hay is baled, loses can still occur if bales are not adequately sheltered from the elements. Depending on the storage system, losses can be as low as 6%, for inside storage, or as high as 35% for outside storage of twine wrapped bales on the ground. Lacefield et al., (1996) researched the dry matter losses and the depth of weathering of bales stored in different manners and the results are displayed in the figure below.

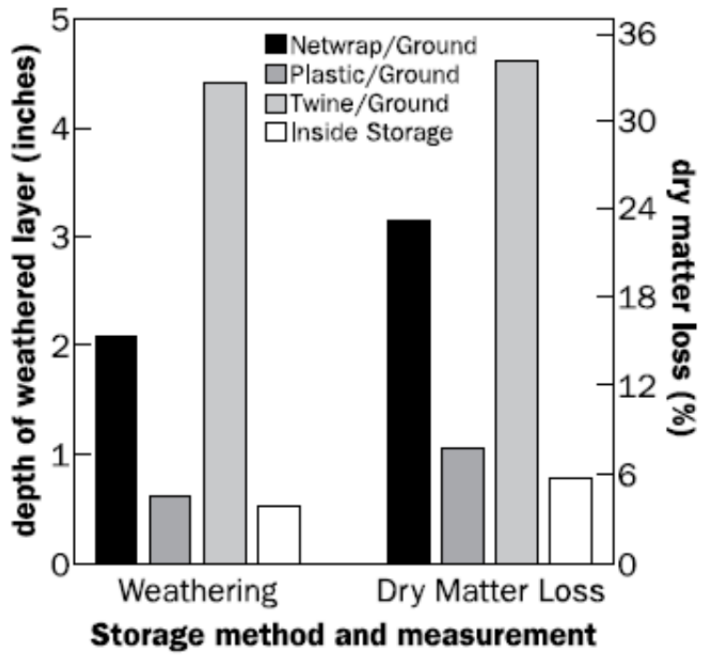


Figure 10. Weathering and DM losses during storage of tall fescue round bales bound using twine, plastic mesh netting or solid plastic wrap.

Through his research, Lacefield et al., (1996) developed 10 recommendations for harvesting and storing hay to ensure quality and preservation of the product. These include:

1. Harvest at the proper stage of plant maturity
2. Legumes alone usually have higher rates of spoilage from inside storage than grasses. This loss can be excessive
3. Make a tight uniform package at 18-20 % moisture content or below
4. Store the hay in a well-drained site

5. Break direct contact between damp soil and hay using pallets or some form of dry floor
6. Top stacks properly to shed water
7. Store hay of similar quality together
8. Leave at least two feed between stacks; round bales can be stored end to end in rows with about two feet between rows
9. Multiple storage lots will minimize risk of fire los and excessive mud
10. High quality hay should be stored inside or should be protected from the weather and raised off the ground on poles or pallets

Sampling feeds for analysis

Feed analysis is very important to ensure minimum nutritional levels are being met in the feed of livestock. Preserved forages can vary significantly in nutritional value due to a range of reasons: time of harvest, crop management regime, post-harvest handling and storage, type of forage, etc. and if feeds are being sourced from multiple suppliers, ideally, feed from each supplier should be tested.

Table 60. Recommended sampling procedure for common feeds

Sample	Procedure
Grains	1. 3 samples/truck load 2. 10-12 probes per bin
Silage	1. Probe 15-20 locations in silo/pit 2. Grab sample: 5-6/feeding for 3 feedings. Collected samples should be kept in refrigerated or frozen in air tight bags
Hay	1. 15-20 locations in stack 2. Greater than 20 bales: sample 10% of number of bales 3. Less than 20 bales: sample all bales 4. Combine all samples into a final sample volume the size of bread and submit for testing
Source: Bruynooghe and Feist, no date	

Analysing feed is the most accurate and reliable way to assess forage quality and nutritional content and there are different ways to sample different feeds. Bruynooghe and Feist, (no date) list recommended sampling procedures in Table 60.

Summary of suitable forage crops for cattle

It is difficult for this report to make specific recommendations, or rankings, of forage crops specific to cattle for Yukon producers. Due to the extensive variability in weather, soils, management practice and location of Yukon farms, specific recommendations would be impossible. This report has, within the constraints of time and budget, provided the reader with the tools and information necessary to make informed choices about forage options, nutritional requirements of livestock and the associated risks and benefits.

There are a number of tried, tested and reliable forage options that have been used by cattle producers throughout the territory for decades. These forages are typically hardy grasses, both native and non-native, and provide a balance of yield and nutrition. As stated previously, the importance of grass species, on nutrition, is often less critical than the importance of time of harvest and general management practices.

Past forage studies conducted in the Yukon and Alaska provide a relatively comprehensive list of common forages used in our region. Yield and nutrition results of these particular forages will vary between farms, between years and between management regimes. Trial and error/success will be a key determinate in which forages grow and produce well on your farm; nutrition testing/analysis will provide a good idea of the forage quality and suitability for livestock.

Alternative forages for cattle are vast and largely untested in regions comparable to the Whitehorse region and the South West Yukon. These areas are colder and drier than the South East and North Central Yukon and risks associated with testing alternative forages are higher.

There is considerable research being done on northern hardy forage varieties in areas of Northern Europe and Iceland. These forages are mostly perennial grasses and legumes and are used in pastures and silage for cattle production. Some of these species, including new varieties of Timothy, Fescue and several types of clover would likely do well in Yukon. However, without some degree of testing it is difficult to recommend these varieties to producers. Continued forage variety trials and production analysis by the agriculture branch or Yukon College will likely play a vital role in determining the suitability of these alternative crops.

Iceland has had considerable success with cultivars of Timothy developed in Norway and Denmark. Timothy is so ubiquitous in Icelandic agriculture that it is considered the most important forage grass in the country and is unmatched for yield, feed quality, palatability and persistence (Helgadottir and Sveinsson, 2006). However, the same cultivars that have so benefited Icelandic agriculture, when tested locally, were not able to out produce our local brome crops (in both yield and nutrition). This is not to say that Timothy would not make an excellent forage crop, it does, this example serves to illustrate the complexity of importing a "forage success" into a new region.

Here are some helpful steps to consider that can help determine the "best" forage crop for your cattle operation:

- Find out what has grown well on your farm in the past, if this is not known, ask neighbouring farmers what success/failures they have experienced with forage crops

- Consult with the Agriculture Branch, they can provide assistance and services such as soils testing and interpretation
- Find historical weather data for your region, this can give you a good idea of what to expect an average growing season to be like and what crops will perform well
- Try and follow "best management practices" when utilizing pastures, this will limit pasture degradation and maximize yield, nutrition and animal performance; avoid putting the animals on pasture too early and consider removing them a few weeks prior to grass senescence
- Try planting a variety of grasses in the pasture, this will have two benefits: first, if the pasture has a range of subzones, grasses with characteristics suitable to each zone will establish within them, this will limit the amount of weeds in those zones and ensure that they are productive, secondly, a range of forages will mature at different rates, this will likely provide the herd with young, tender and rapidly growing plant matter for a longer duration than a monoculture. Also, they might just appreciate the variety.
- Rotational and intensive grazing practices work well in other regions and likely work well in the Yukon. These practices have not been evaluated in our area and specific performance increases are unknown.

In 2012, authors Dinkel and Czapla compiled a list of forage species suitable for ruminant production in the north in a document called "Alaska Forage Manual". This manual discusses the common (brome and timothy) and less common forages that can be, and are, used in the north. The manual covers grasses, legumes and cereal grains, and details: forage value, distribution and adaptation, culture, uses and management and cultivars and releases. This manual outlines 24 different forages, not all of which make good livestock feed, the ones that do make good feed are included in Table 61:

Table 61. Forages and cultivars described in the Alaska Forage Manual

Grasses	**Cultivars**
Alpine Bluegrass, *Poa alpina*	Gruening, Teller
American Sloughgrass, *Beckmannia syzigachne*	Egan
Annual Ryegrass, *Lolium multiflorum*	Local cultivars when available
Kentucky Bluegrass, *Poa pratensis*	Nugget and Park
Polargras, *Arctagrostis latifolia*	Kenai, Alyeska
Red Fescue, *Festuca rubra*	Arctared, Boreal
Sleder Wheatgrass, Elymus trachycaulus	Wainwright, Revenue, Primar
Smooth Brome, *Bromus inermis*	Carlton, Manchar, Polar
Spike Trisetum, *Trisetum spicatum*	Nelchina
Timothy, *Phleum pretense*	Engmo, Climax, Champ
Tufted Hairgrass, *Deschampsia cespitosa*	Nortran
Cereal Grains	
Barley, *Hordeum vulgare*	Otal, Datal, Albright, Thual, Weal

Oats, *Avena sativa*	Toral, Nip, Ceal
Legumes	
Alfalfa, *Medicago sativa*	Denali (UAF cultivar Not available)
Alsike Clover, *Trifolium hybridum*	Aurora, Dawn
Field Peas, *Pisum sativum*	Century, Lenca, Procon
Red Clover, *Trifolium pretense*	Alaskaland (UAF release)
White Colver, *Trifolium rapens*	Ladino, Pilgrim, Merit,
Source: Dinkel and Czapla 2012.	

Based on past and ongoing research conducted in Yukon, a similar table of potential forages was compiled and is displayed in Table 42. It should be noted that not all varieties displayed in table 42 are still available.

Future Research into Cattle Pasture Development

There has been some work done in the Yukon to investigate the success of using clovers and alfalfa within pastures. Matt Ball (Agrologist with YG) conducted research at various locations throughout the Whitehorse region looking at alfalfa growth and productivity when added to existing hay stands (Ball, 2006). Results were mixed, the alfalfa overwintered successfully in the first season, however, due to late season selective grazing of the stand yields were poor and the alfalfa was not able to compete with the bromegrass. It was concluded that seeding alfalfa into an existing brome stand was not a useful technique to increase forage N content of a highly managed system (Research and Demonstration, 2006). Research has also been conducted at the research farm to investigate a range of alfalfa varieties in monoculture stands. This has had mixed results as well, some types doing well and others not.

The advantages of planting legumes within a pasture or forage crop is well understood and Yukon pastures and livestock would benefit considerably. There has been limited success with traditional legumous crops, alfalfa and some clovers, however there usage is not widespread. Interestingly a highly productive legumous crop has migrated up the Alaska Highway and established itself along ditches, gravel pits and other notoriously poor habitat.

Sweet clover seems to be highly adapted to thrive in our region and is so abundant and productive that the Yukon Department of Environment is concerned about its invasive qualities and it’s "taking over" of sensitive habitats. It can be observed in swards that are waist high along most of the ditches in southern Yukon.

Hay nutrition and maturity research: sample hay crops throughout the growing season and build a database of quality vs. quantity, see if there is an optimal time to harvest to maximize both yields and nutrition

Elk

Nutritional Considerations for Elk

In his book "Elk Farming Handbook" (Thorleifson et. Al., 2000), under the title "theory of Feeding and Nutrition Requirements, the very first sentence reads:

1. An elk is not a small cow, or a long-legged sheep, or a deer!
2. Feed production and use, and elk feed requirements, vary dramatically with the seasons.

These statements signify the importance of remembering that unlike domesticated ruminants, elk are wild animals, they have different needs and requirements than cows and sheep. Because they are now behind fence, the natural foraging ability of farmed elk is limited, this means that as a game manager it is your responsibility to provide all the essential nutrients and minerals needed to sustain a healthy herd. With a well-designed nutrition and feeding program elk will not only meet their minimum nutrient requirements but they can out-produce their wild counterparts.

Basics of Digestion

Like cows, elk are ruminants, this means that they are able to make use of fibrous feedstuffs in a way that monogastrics are not. With the help of their gut microbes, they can digest plant material that would otherwise be nutritionally unavailable to them. (For more information on ruminant digestion see the section on cattle digestion)

Elk have a faster rate of digestion than other ruminants such as cattle, this faster digestion reduces the risks associated with bloat. In southern climates where bloat-causing legumes are more common, producers are able to graze elk on these plants without issue (Klein, 2008).

Energy and Nutrient Needs

Because they are game animals, elk require a slightly more complex feeding regime than domesticated ruminants. Factors such as rutting, breeding and antler growth produce different nutritional and energy requirements in the animals, managers need to be cognisant of this when designing a feeding program.

To simplify the task of designing an elk diet, feed companies have developed custom elk pellets which are meant to meet the mineral and vitamin needs of elk at all stages of their seasonal cycle (http://wapiti.net/feed.cfm). These pellets are intended to be fed every day throughout the life of the animal. The website "wapiti.net published a list of the nutrient requirements for elk at a range of developmental stages. This is an easy to use table and gives a good idea of what to and how much to feed your elk. The table is as follows: (From wapiti.net)

PROBABLE NUTRIENT REQUIREMENTS FOR ELK (dry matter basis)									
Per Kg DM in Diet	Maint	Growth				Gestation		Lactation	
		Velvet	3-6 mo	6-9 mo	9-18 mo	12-24 wk	24-36 wk	0-6 wk	6-12 wk
DE (MCal/kg)	2.3	2.4	3.0	2.8	2.6	2.5	2.6	2.8	2.7
Crude Protein (%)	7-10	10-12	18-20	16-18	12-14	12-14	14-15	14-16	12-14
Fat (%) minimum	3	3	3	3	3	3	3	3	3
ADF (%) min-max	25-45	25-45	16-35	20-40	20-45	20-45	20-45	20-40	20-40
Calcium (%)	0.35	1.40	0.60	.55	0.50	0.50	0.60	0.70	0.60
Phosphorus (%)	0.25	0.70	0.30	0.30	0.30	0.40	0.40	0.40	0.40
Potassium (%)	0.65	1.0	0.65	0.65	0.65	0.65	0.65	1.0	1.0
Magnesium (%)	0.20	0.40	0.20	0.20	0.20	0.20	0.20	0.25	0.20
Salt (%)	0.15	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Copper (PPM)	15	15	15	15	15	15	15	15	15
Manganese (PPM)	40	40	40	40	40	40	40	40	40
Zinc (PPM)	50	50	50	50	50	50	50	50	50
Iron (PPM)	50	50	50	50	50	50	50	50	50
Iodine (PPM)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.60	0.60
Cobalt (PPM)	0.10	0.20	0.10	0.10	0.10	0.10	0.10	0.20	0.20
Selenium (PPM)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Vitamin A (IU/kg)	3000	5000	4000	4000	3000	5000	5000	5000	5000
Vitamin D (IU/kg)	600	1000	800	800	600	1000	1000	1000	1000
Vitamin E (IU/kg)	30	40	30	30	30	40	40	40	40
TDN (%)	64	70	76	72	68	64	67	76	74

DE=Digestible Energy; ADF=Acid Detergent Fiber; TDN=Total Digestible Nutrients

Figure 11. Elk nutrient requirements for a range of life stages.

For ranchers not utilizing the elk cube rations, the above table is a good starting place for determining the feed requirements of the animal and comparing it to available feedstuff. Comparing forage analysis tests with the above table will illuminate any limiting elements in the elk diets. These limiting elements can then be introduced into the diet in the form of grains, supplements and minerals.

Determining the nutritional requirements of a heard with access to a broad range of forages, such as mixed grass and forest regions, can be more difficult as there are many more variables at play. It is difficult to estimate the intake and utilization of a broad range of forage plants in this type of system, and a simpler method of evaluation might be necessary. In these cases is might be easier to “assume” that if your animals are meeting their production goals, i.e. they are gaining weight at a reasonable rate, they are reproducing and they are growing antlers, then the nutritional requirements are being met by the forages (and whatever supplements) are being made available.

Feed Management for Elk

An important consideration when developing a feeding management plan for elk is understanding that in the wild they are "intermediate feeders" (AMBOCA, 2005). This means that they forage by skimming the most nutritious parts off a diversity of plants as well as graze on grasses and forbs. Ruminants are normally divided into three categories: concentrate selectors, roughage eaters and intermediate feeders. Most intermediate feeders are highly adapted to either concentrate feeding or roughage feeding, elk, however, are highly flexible and can forage at either end of the spectrum (AMBOCA, 2005). Elk will browse on leaves, twigs, bark and shrubs and graze on grasses, legumes and forbs.

When discussing elk forages, Thorleifson (2000) stresses the importance of "**YTRG"**, this stands for young, tender and rapidly growing. Elk will eat a huge variety of plants which are YTRG and this is critical during important stages such as lactation, calf development and antler growth. Tall mature pastures are of little use to elk and are rarely eaten. Providing a forge environment rich with plant diversity is beneficial in this regard as an increased variety of plants will ensure a longer span during which those plants are in YTRG (Thorleifson *et al*., 2000).

Elk are considered moderately selective feeders; less selective than most deer species, in that they will consume and digest plants higher in fibre, however, they are known to leave plant parts that cattle, bison and sheep will eat (Thorleifson, *et. Al*., 2000).

Like other deer species, elk are highly seasonal in their eating cycle. Feed intake will vary considerably between winter and summer; summer feed intake can increase by as much as 40-60%. This can be significantly beneficial to producers with sufficient pasture as peak forage growth corresponds to peak nutritional demands (Thorleifson, et. al., 2000). Elk have also adapted their calving season to correspond to the flush of spring forage growth. Taking advantage of this seasonality is important for the health and development of the animals as well as decreasing the demand for preserved feeds and supplements (Thorleifson, et, al,. 2000).

Pastures and Grazing Management for Elk

When considering forages for elk more importance should be placed on stage of plant growth than plant species (Klein, 2008). Many studies have shown elk to prefer younger plants over mature plants of the same species, other studies have shown elk use "toughness to chew" when assessing plants for consumption, the elk seemed unconcerned with the species of plant they were eating and more concerned with whether it was tender (Klein, 2008).

Elk utilization in pastures and areas that have matured grasses is very low, these areas can be rotationally grazed with cattle on an as needed basis to maximize productivity. The cattle are able to consume the matured grass which will expose and promote new growth of younger tender grasses. This rotational system will ensure high utilization while increasing carrying capacity (Klein, 2008).

The primary objective of game managers is to prolong the vegetative state of the forage plants for as long as possible. Once matured, plants hold little in the way of nutritional value for the elk and will only be consumed when more nutritious options have been depleted (Klein, 2008). One strategy to prolong vegetative growth is to mow a growing pasture during the vegetative stage, this accomplishes two things:

1. Excess forage will be preserved in the vegetative state (highly nutritious) as windrows, this can be baled and fed later or it can be consumed in the field.
2. The cut pasture will resume growing providing quality tender forage for the elk while prolonging the maturation process.

To optimize plant growth through grazing alone, paddock size would need to be relatively small (0.2-0.5 acres/adult), however, this drastically increases fencing costs and is limited in practicality (Klein, 2008). More often paddock size is increased and plants that mature are mowed uniformly with a mowing machine. This prevents stemmy plants from dominating a pasture and stimulates new growth (Klein, 2008). Whether through multispecies grazing with cows or through mechanical harvest, stemmy mature plants should be reduced in order to promote and make available newer growth.

Stocking rates are important to consider when grazing elk on pastures and rangeland. Improperly managed lands can become degraded over time and significant losses of favoured forage species will result. If overutilization takes place for long enough desirable forage species can be eliminated altogether (Klein, 2008). Pasture management should allow for significant rest periods for paddocks that have been grazed, however, due to the high cost of fencing this is rarely done.

Proper stocking rates will vary widely depending on microclimate, soil type, forages available and annual precipitation. Working with the agriculture branch grazing coordinator and trial and error will help to properly stock a given paddock.

Careful monitoring of vegetation depletion, animal condition and rotation will be necessary for optimal management.

Rest for pastures and winter grazing

Resting a pasture after grazing is an important step in protecting from overgrazing. Klein (2008), states "forage plants cannot be overgrazed, they can only be under-rested." This means that forages can tolerate a heavy one-time use (heavy grazing) but this needs to be followed up by adequate recovery time. Forage plants under continuous grazing pressure never have time to recover, under these conditions they eventually weaken and die (Klein, 2008).

The most important period for forage species is from mid-August to late September. It is in this period when carbohydrate reserves are being stored in the roots for winter and spring flush. For best growth and overwintering success for the next season, grazing should be avoided during this time. Obviously some grazing will need to happen during this time and it should be noted that paddocks grazed from mid-August through September will exhibit slower and less productive growth the following year (Klein, 2008).

Elk will winter graze in areas where snow cover is moderate and reasonably soft. Producers have observed animals to graze in 12 inches of snow even with hay bales provided. Wildlife managers have reported that elk will switch to browse when snow is deeper than 18 inches (Klein, 2008).

Forage Species for Elk

Providing a mix of natural vegetation and planted pastures for an elk herd is an excellent management choice provided sufficient land. Natural vegetation provides a rich mixture of plant species to choose from which have a range of maturation schedules and nutrients. Planted pastures of mixed grasses, forbs and legumes will vastly increase stocking capacity and provide carbohydrates and protein.

Selecting the forage species to plant will depend on a variety of factors, several to consider are:

1. Which species have the longest palatability throughout the season?
2. Which species provide the highest forage yields for your area?
3. Which species give the best growth rates and animal yields?

There have been studies to try and determine the best forages for elk and conclusions have not been consistent (Klein, 2008). Two commonalities have been gleaned from these studies, however, and they are:

1. Because elk are mixed feeders they will consume and thrive on a vast range of plants, this goes for both natural and preserved forages.
2. Plant stage (as mentioned before) is a better predictor of palatability than plant species.

Elk will routinely select young succulent leaves of "less palatable" plants over the mature leaves of what are considered the "more desirable" plants (Klein, 2008).

Klein (2008), recommends that instead of becoming overly concerned with planting the perfect forage crop, instead choose an assemblage of forage species that exhibit good yields for your area, have adequate protein and mature at different times throughout the season. Where possible incorporate legumes to boost protein yields. Klein also presents a case for the shotgun method of seeding pastures with high topographic and soil variability. With this method plants adapted to sandy ridges will take to the sandy ridges and plants adapted to low lying areas will do well in low lying areas. This method may not be as highly productive or nutritious as a field of alfalfa and orchard grass but it will keep the weeds out and provide sufficient forage for an elk herd.

Grass Varieties for Elk Forages

Meadow Brome:

Of the grass varieties planted specifically for elk forage the most common (of the Saskatchewan producers sampled for Klein's 2008 study) was meadow brome. Both grazing trials and producer observations agree that this is a palatable species that elk readily consume. Meadow brome has a number of characteristics that make it ideal as a pasture grass:

- It is not as competitive as smooth brome, this allows other grasses and legumes to also grow within the stand
- Meadow brome performs well under grazing pressures, its leaves originate from the base of the plant near the soil and the growing point remains intact following a grazing event, this allows it to re-grow faster
- Plants remain relatively soft and tender throughout the growing season and after 3 or 4 years it produces fewer coarse seed stalks than other varieties

Meadow brome starts growth in the spring a bit later than other grasses like crested wheatgrass and Russian wild rye and it does not do well under continuous grazing conditions. It is recommended that the sward reach 8-10 inches prior to grazing (Klein, 2008).

Smooth Brome:

Smooth brome is also widely used by elk producers and it is also highly palatable and readily grazed during the growing season. Some research and observation has indicated that smooth brome stands will be grazed in winter. Smooth brome has an aggressive root system that spreads quickly and tends to outcompete other grasses and legumes.

Smooth brome is not as suitable for grazing as meadow brome for several reasons, it is slow to re-grow after grazing, and because of its upright growth is more difficult to graze, this, however, makes it highly suitable for haying (Klein, 2008).

Crested Wheatgrass:

There have been mixed results grazing elk on crested wheatgrass, some producers claim that the elk will not touch it while others claim that the elk will eat it all season. Producers who don't allow the CWG to mature (elk avoid the seed heads of CWG) have the most success, however, in winter elk have been observed to graze on mature clumps even while hay is available (Klein, 2008).

Crested wheatgrass is not an ideal elk feed and other grasses should be used instead, however, if early spring growth is needed for grazing then CWG may be a good choice as it begins growing about seven days before brome and is ready for grazing at 4 inches in height. Consider planting one paddock in CWG for early spring forage and to take pressure off of the more productive brome pastures (Klein, 2008).

Russian Wild Rye:

Although tough to chew and quite fibrous, grazing trails have found RWR is readily selected in fall as a forage by elk. RWR has advantages over other grass species in that is ungrazed plants hold their quality into late summer and early fall (Klein, 2008). Like CWG, RWR starts growing about seven days prior to most other grasses and can provide early spring forage.

Russian wild rye is not an optimal forage choice for large areas of pasture as palatability and productivity can be low in comparison to other grasses. RWR has some advantages as it is a hardy forage for harsh, dry grazing conditions (Klein, 2008).

Creeping Red Fescue:

CRF can make a good forage for winter and fall grazing, it is not preferred throughout the summer and spring, however, because it retains some nutrients even into the winter elk prefer it over other mature forage plants. CRF is not a high yielding forage plant and should not be used as a primary forage species (Klein, 2008).

Quackgrass and Kentucky Bluegrass:

In moist, wet soils QG and KBG are good forage alternatives for elk. They seem to consume it readily when in a vegetative state and can survive extreme grazing pressures. These plants are not considered good forage crops due to low productivity and high moisture needs, however, if areas of pasture support nothing else these plants make for decent forages (Klein, 2008).

Other Planted Forages

In many jurisdictions to the south elk farmers and ranchers are planting legumous crops for elk forage. These crops, alfalfa, sainfoin, alsike clover, and some vetches, are readily grazed by the elk and provide excellent gains and nutrition. While elk are less susceptible to bloat, compared with cattle, and can consume large quantities of high protein pastures, feeding 100% alfalfa (or other legumes) can cause high blood urea nitrogen levels and cause uro-genital ulcerations in males.

While success with alfalfa and other high producing legumes is limited in the Yukon, under proper management certain legume crops would likely be good producers. Research conducted by Matt Ball, (Yukon Agronomist) indicates that with sufficient recovery time post grazing and pre winter alfalfa should perform quite well. Alfalfa should be given proper time to replenish its reserves and build nutrient stores in its roots prior to the end of the growing season. This will ensure better winter survival and quicker spring growth.

Sweetclover is another possible candidate for elk forage. It grows well in Yukon, produces a large amount of forage and is winter hardy. At the time of writing this report there were no articles found in either online journals or the library on feeding sweetclover to elk. This may be an area of future research.

Native Forages and Browse

Providing elk with native forages is a good way to increase the diversity and nutrition of an elk herd's diet. Allowing the elk to select from a range of native plants is a good strategy to ensure the animals are not being limited in nutrients from a formulated or preserved feed diet. Native vegetation also provides the herd with shelter from the elements as well promotes a sense of safety to calves and cows during calving season. In the Takhini Valley wild elk herd, females and calves selected the *populus tremuloides* forest type for thermal relief and hiding cover (Chambers, 2010).

Native vegetation can also be high in crude protein and readily digestible by the elk. A recent (2010) study by Jesse Helen Sarah Chambers, looking at habitat use of elk in the Takhini Valley, found that certain native plants targeted by the elk were quite high in protein and low in ADF and NDF (Figure 12, Figure 13, Figure 14) (Chambers, 2010).

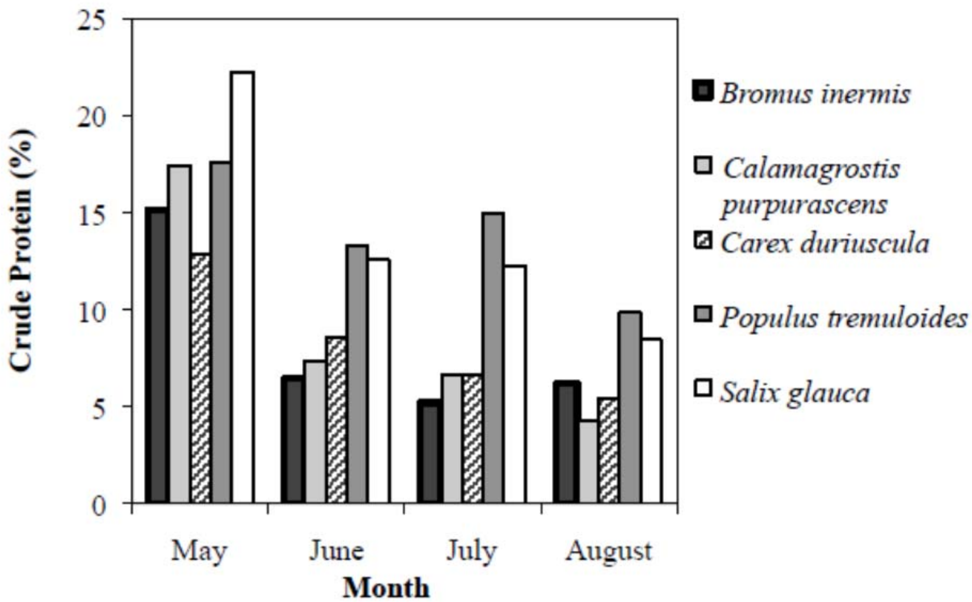


Figure 12. Percent crude protein content of five preferred elk forage species, collected monthly (May-August 2008) within the Takhini Valley study area.

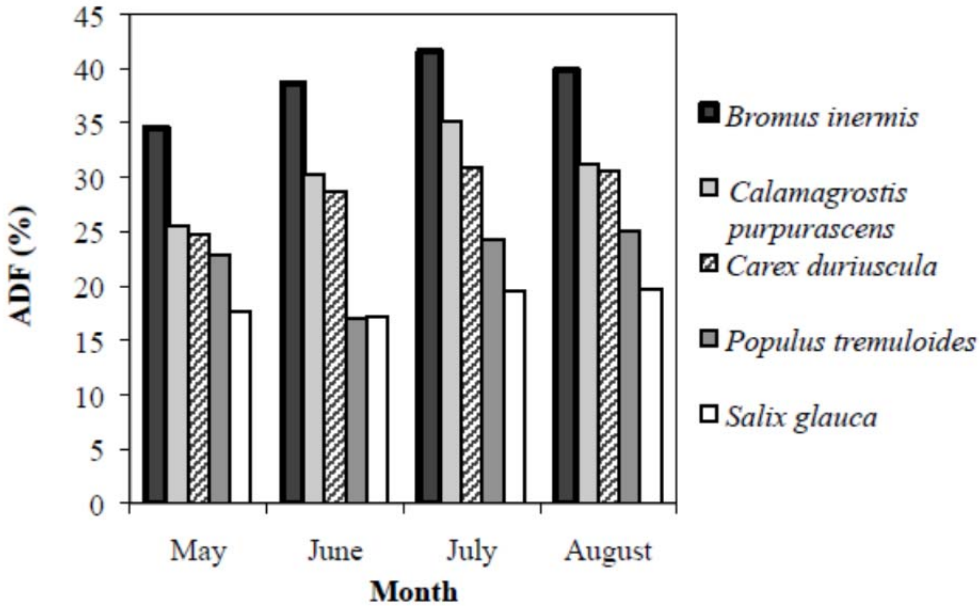


Figure 13. Percent acid detergent fibre (ADF) content of five preferred elk forage species, collected monthly (May-August 2008) within the Takhini Valley study area.

Chambers also found that at the end of the growing season native forages and browse in the Takhini Valley had higher levels of crude protein than what is considered the minimum content for animal survival (>5%). Chambers concluded that elk in the Takhini Valley were probably not limited by forage quality during the winter months.

Interestingly, Chambers found that forages and browse in the Takhini Valley were lower in the non-digestible (ADF, NDF) component than elk ranges in Colorado and Oregon indicating that the local forages were more digestible and of higher food value.

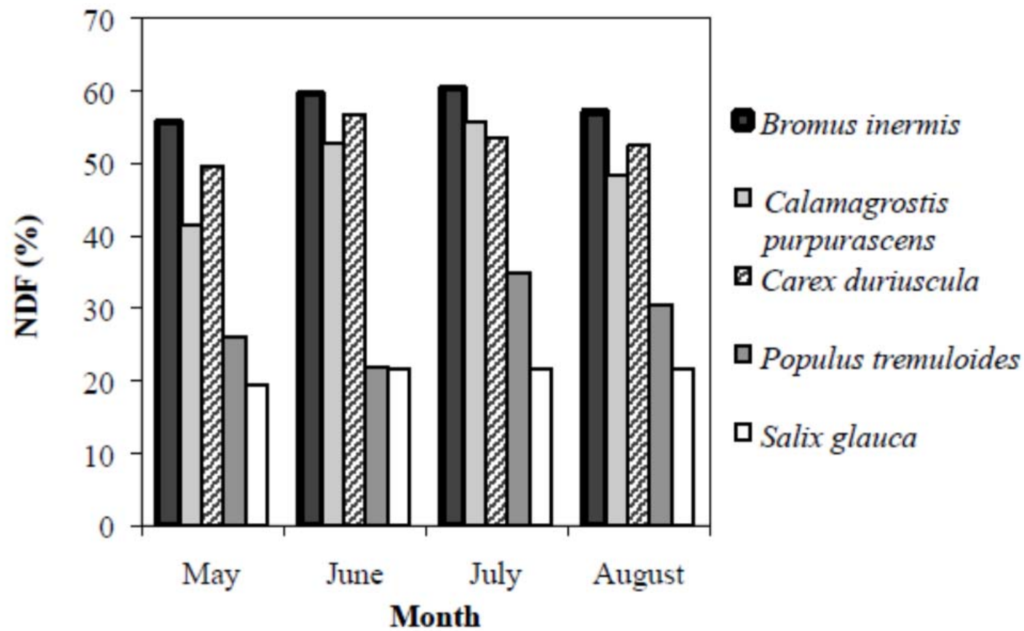


Figure 14. Percent neutral detergent fibre (NDF) content of five preferred elk forage species, collected monthly (May-August 2008) within the Takhini Valley study area.

Unfortunately, due to low overall productivity the carrying capacity of native Yukon forages and browse is very low. Due to low annual rainfall and low soil fertility native forest and range vegetation cannot offer significant quantities of foodstuffs for a given land area. In Chambers 2010 study of the Takhini Valley, she found that a sustainable elk density was between 0.76-1.52 elk/km^2. Stocking rates higher than this will begin to damage the vegetation and reduce recruitment of more targeted forage species. Higher stocking rates can be realized if supplemental feeding or seeded pastures area also incorporated.

Offering elk a mixture of seeded pastures and native rangeland is a great management technique provided you have sufficient land available and fencing is not prohibitive. Management of this system can still be quite difficult; elk with sufficient feed will still over utilize available aspen stands to the point of serious degradation if not managed correctly.

Preserved Forages, Grains and Rations

In "Elk Farming Handbook", Thorleifson (2000), covers all types of preserved forages for elk. High on his list of "best elk feed" is short-chopped silage made from grasses, cereals and legumes, piled and tarped. Thorleifson calls this the "best quality and lowest cost supplemental feed for elk if it is tested and balanced with grain, minerals and vitamins to target requirements. He also recommends high quality grass hay and alfalfa hay.

Thorleifson (2000), cautions against using large round bales or baleage as elk feed, he claims that more leaves are lost in the production of round bales lowering palatability, rounds are normally stored outdoors and exposed to the weather, this results in lower quality and sometimes mouldy hay. Baleage (individually wrapped bales) is also not recommended by Thorleifson due to the high degree of variability between bales. This can have the effect of lowering feed intake as livestock need to adjust daily to the different microbial and nutrient contents of each bale (Thorleifson, 2000).

If round bales are being fed Thorleifson (2000) suggests ways of minimizing wastage. Specially designed feeders are available for elk; these feeders allow bulls to access the hay without contacting developing antlers, animals cannot jump into these feeders and it keeps the bales off the ground. For pictures and more details refer to Thorleifsons book, Elk Farming Handbook page 161.

Supplemental grains such as oats are also an excellent choice for elk, these can be used as treat feeding and mixed with prepared rations. Thorleifson (2000), recommends mixing oats with "Elk cubes" (50:50 mix) as an easy but expensive way to ensure that your elk have the required nutrients for optimal growth and development.

Bison

The Yukon is home to several introduced wild wood bison herds and, until recently, one herd of ranched bison. Due to recent changes in government regulations pertaining to importing and exporting this species, there are no farmed bison left in the Yukon. As of 2009 there were at least 150 farmed wood bison on one ranch operating west of Whitehorse, this was a cow calf operation marketing breeding stock and farm gate meat sales (Ball et al., 2010). In the future bison may again be farmed in the territory and for this reason they are included in this report.

Basic Digestion and Physiology

Bison are ruminants and like cattle, sheep and goats, require a forage based diet for optimal ruminal function. Bison have a highly structured rumen, more so than cattle, and consequently have a longer feed retention period. Table 62 compares the total tract retention time and dry matter digestibility of forages between bison and cattle. The longer feed retention time of the bison allows it to better digest sedges and fibrous hay compared to other ruminants (Feist, 2000). When feeding on higher protein feeds such as alfalfa, the retention time typically resembles that of cattle; lower fibre feeds do not need the same time for nutrient extraction and conversion as high fibre feeds (Feist, 2000).

Table 62 . Total tract retention time comparison between bison and cattle

	Bison	Cattle
Total Tract Retention (h)	78.8	68.7
Dry Matter Digestibility (%)		
Sedge Hay	64	58
Grass Hay	74	62
Alfalfa/Brome Hay	50	52
SOURCE: Adapted from Schaefer, et. al., 1978		

As with all ruminants microorganisms within the bison gut provide the important service of braking down the feed into digestible components. These bacteria and protozoa also synthesize most of the essential amino acids and vitamins needed by the animal.

Nutritional Considerations

Bison have nutritional needs that are adapted to the seasonal environment which they inhabit. This is characterized by seasonally influenced weight changes and feed intake requirements (Feist, 2000). Once bison reach maturity (around 18 months) they will begin a lifetime cycle of winter weight loss followed by summer weight gain (Feist, 2000). Over the winter healthy mature bison can lose 10-15% of their body weight, this corresponds with a hormonally induced reduction in dry matter intake.

As day length becomes ever decreasing through fall and into winter (Table 63), the pineal gland of the bison (located at the base of the brain) secretes higher levels of the hormone melatonin. Melatonin acts to inhibit the secretion of the hormones thyroxin (controls metabolism) and growth hormone (IGF-1) which promote growth and weight gain (Feist, 2000).

Table 63 . Winter vs. summer with respect to daylength, metabolism, dry matter intake and body weight

	Daylight Hours	
	Short (winter)	**Long (summer)**
Metabolism	Slow (maintenance)	Fast (weight gain)
Dry Matter Intake	Low (1.4-1.8% body weight)	High (2.2-3.0% body weight)
Body Weight Status	Lose Weight	Maintain or Gain Weight

SOURCE: Adapted from Feist, 2000

The combination of these hormones puts the bison into a state of metabolic maintenance for the winter months, this state does not require a great deal of energy to maintain. These factors combined with a thick layer of subcutaneous fat, thick hide and a thick woolly coat allow bison to safely reduce their DM feed intake to around 1.4-1.8% of body weight (Feist, 2000). Figure 15 shows the seasonal fluctuation of mature bison cows weights and their corresponding feed intake requirements.

Mature bison bulls vary slightly from the above figure (Figure 15), bulls will be subjected to a second weight loss period in the fall breeding season. During this period they will again lose between 10-15% of their pre-breeding body weight. To ensure good condition going into winter it may be necessary to supplement bulls with extra feed post breeding (Feist, 2000). Interestingly, winter supplementation with high protein/energy grains does not eliminate winter weight loss it merely reduces its severity; animals in this state are more expensive to feed and will take longer to recover come spring (Feist, 2000).

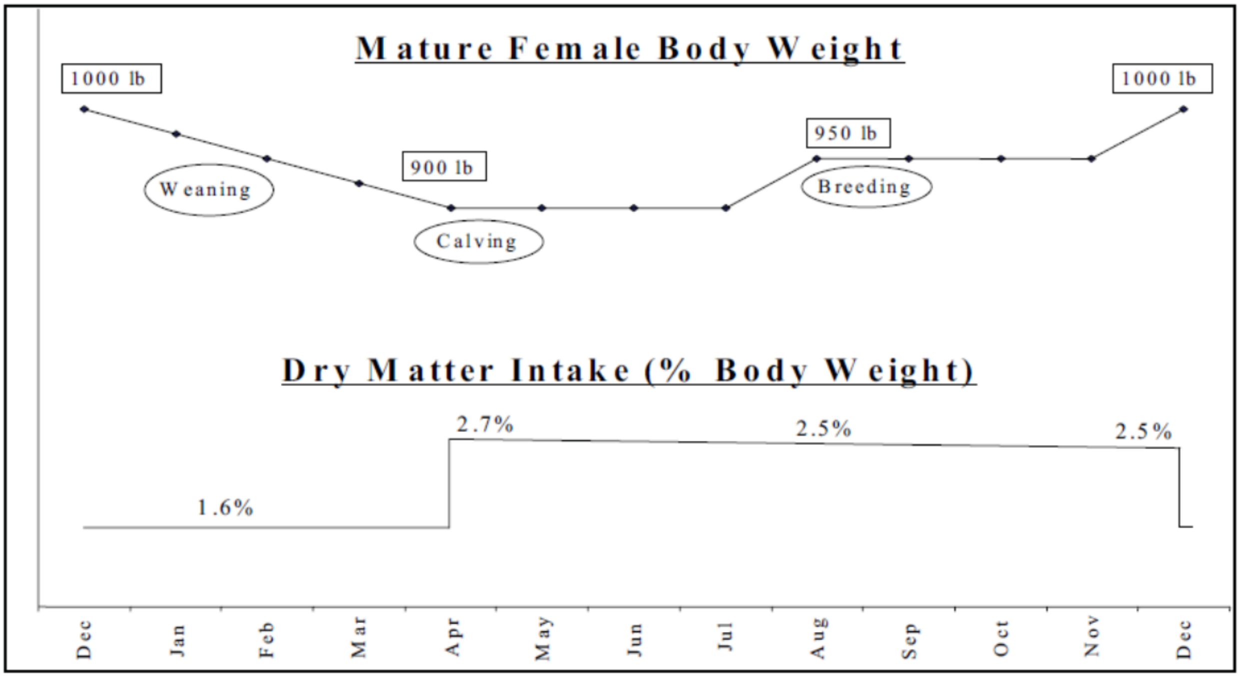


Figure 15. Seasonal weight changes of mature female bison. From Feist, 2000.

This seasonal fluctuation in feed requirements is adaptive to the seasonality of forages where bison inhabit. This seasonality in intake requirements can be advantageous for farmers with large areas of pasture; as nutritional requirements are increasing in spring, early growth will reduce feed costs and provide rapidly growing calves with highly nutritious and easily digested feedstuffs.

Energy Needs for Bison

When energy is allocated throughout the body it is hierarchically distributed to perform two tasks. The primary function of energy is to maintain the body processes of the animal, while the secondary requirement is for growth and reproduction.

Once the maintenance needs of the animal are met, excess energy is used for growth, fat storage, reproduction, etc. Energy requirements vary depending on many factors, age, sex, lactation, breeding, and energy needs estimates for bison are presented in Table 64.

Table 64. Estimated energy and crude protein requirements of bison at various ages and life stages.

Age	DMI (%BW)	TDN (%)	CP (%)
FEMALES			
6mo. - 1 year	2.0 - 3.0	55 - 63	12 - 14
1.0 year	2.0 - 2.5	55 - 63	10 - 12
1.5 year	1.8 - 2.2	50 - 55	10 - 12
2.0 year	1.6 - 2.2	53 - 60	10 - 12
2.5 year	1.6 - 2.2	48 - 50	6 - 7
Late Gestation	2.0 - 2.5	54 - 58	8 - 10
Lactation	2.5 - 3.0	54 - 58	8 - 10
Maintenance	1.6 - 1.8	48 - 50	8
MALES			
6mo. - 1 year	2.0 - 3.0	55 - 63	12 - 14
1.0 year	2.0 - 2.5	55 - 63	10 - 12
1.5 year	1.8 - 2.2	50 - 55	10 - 12
2.0 year	1.6 - 2.2	55 - 60	10 - 12
2.5 year	1.6 - 2.2	50 - 52	8
Maintenance	1.6 - 1.8	48 - 50	8

DMI = Dry Matter Intake, BW = Body Weight, TDN = Total Digestible Nutrients, CP = Crude Protein

SOURCE: Adapted from Feist, 2000.

Protein Needs for Bison

For bison, protein is considered the third limiting nutrient behind water and energy. Bison have a relatively low protein requirement and can extract sufficient quantities from most high quality forages, preserved or fresh (Feist, 2000). In his publication on bison nutrition, Feist (2000) writes that bison specific protein requirements have not been properly established, however, bison specific estimates have been made and are displayed in Table 64. Bison have a lower crude protein requirement compared with beef cattle and rancher have good success feeding bison a beef cattle diet (Feist, 2000). When dietary protein is to high excess nitrogen is passed in the urine, when to low bison have a unique ability to recycle nitrogen to the rumen through saliva (Feist, 2000).

Practical Feeding for Bison

As with all the ruminants covered thus far, the most cost effective method of feeding bison is pasturing. Adequate pasture will meet all the nutritional requirements of the animal, minimize feed costs and ensure healthy happy livestock (Feist, 2000). Pasturing should be utilized as long as possible with supplemental feeding being phased in slowly in the fall and reduced slowly in the spring.

There are two main periods of consideration when feeding bison: summer feeding and winter feeding. Summer feeding should focus on pasture management with special attention paid to lactating females and calves. In the fall producers should be looking to ensure adequate body condition prior to metabolic slowdown. Winter feeding should focus on providing a quality maintenance diet (Feist, 2000).

Winter Feeding

Careful planning and consideration must be made when bringing bison into the winter; due to the hormonally influenced seasonal weight loss, adult bison are unable to gain weight from December to April. This means that they need to be at their optimal weight prior to December. Animals entering this period in poor condition will continue to decline until spring. Cows in this state are likely to abort, furthermore, if cows are unable to regain the weight during the spring and summer they will likely not conceive in the fall (Feist, 2000).

Table 65. TDN, ADF and corresponding DMI for bison on a range of feed quality.

	TDN/Dry Matter Digestibility (%)	Percent ADF (100% DM)	Dry Matter Intake (% of Body Weight)
Excellent Quality Hay	65	29	3.0
Silage	60-65	36	2.5-3.0
Very Good Hay	60	36	2.5
Medium Quality Hay	55	39	2.0
Poor Hay/Barley Straw	45	49	1.5
Wheat Straw	35-50	54	1.0
SOURCE: Saskatchewan Feed Testing Laboratory, 1990.			

Mature bison in good condition can easily overwinter on a diet of average quality hay or a hay/straw mix; bison in this condition do not require any form of grain supplementation to maintain good condition (Feist, 2000). If the forages being consumed by the bison drops below around 50% TDN, Feist (2000) recommends grain supplementation to ensure adequate nutrition. Table 65 provides approximate TDN, ADF and dry matter intake for bison feeding on a variety of forages.

Summer Feeding

Assuming proper stocking rates, summer grazing will meet the nutrient requirements of a bison herd regardless of the life stage. If pasture quality is low or insufficient space is available for a given herd, supplementation with preserved forages may be required. Feist (2000), a Government of Saskatchewan bison nutritionist, sums up the ideal feeding regime for bison in this statement;

> When planning a year round feeding program for bison, all emphasis should be placed on forage quality and forage based diets with grain supplementation only utilized as a tool to compensate for poor pasture and forage quality.

Summer grazing corresponds with the most nutritionally important time for bison, this period will include calving, lactation, breeding and pre-winter fattening (Feist, 2000). These periods represent the highest nutritional demands for the herd and providing good pasture is in the producer's best interest. Pasture not only provides the highest possible nutrition it provides it at the least cost.

Bison are primarily grazing ruminants, this means they mostly target grass species, and have been observed through both visual observation and fistulated animals to be selective foragers (Feist, 2000, Mahoney, 2007). Providing bison with a variety of forage species on pasture will allow them to selectively feed the highest quality forages when available.

Forages for Bison

Saskatchewan bison nutritionist, Murray Feist (2000), in his document on bison nutrition, recommends these forage species as making excellent bison pasture: bluegrass, brome grasses, timothy and crested wheat grass. He mentions that alfalfa and clovers can also be used but the bison prefer the grasses. Feist also mentions native grasses as a good option although he cautions that these grasses can be more susceptible to overgrazing and are typically less productive. Larger areas are needed if grazing native forages.

Winter feeding of bison focuses on a maintenance diet, mature bison in good condition do not require high energy or high protein feed to thrive during the winter. Mature bison can do quite well on a preserved forage diet (grass hay, silage, straw etc.,) that has a protein concentration of about 8% and TDN of around 50%; this would be considered marginal hay.

Immature animals (<18 mo.) and adults in poor condition will require slightly better feed, in this case better quality grass hay and perhaps a grain (oats) supplement is required.

When selecting forage species to plant in pastures utilized by bison there are several things to consider:

1. Bison are able to utilize a wide range of forage grasses so chose a forage species that will produce well for your given soil type and climate. Providing adequate forage is more important that providing the highest energy/protein forage.
2. Try and plant a variety of forages that will provide the bison with some choices. Not all forages mature at the same time and having several species allows the animals to choose the most nutritious plants when available. This is also important if your pastures are not homogenous. Plant moisture tolerant grasses in wet areas and drought tolerant species in sandy ridges.
3. Have several pastures to rotate through, this will promote better utilization and allow pastures to recover from grazing pressures.

Small Ruminants: Goats and Sheep

Sheep are farmed for a variety of purposes including fibre and meat production, however, a combination of the two is normally practiced. The Yukon has a relatively small sheep industry and According to the 2011 Agricultural Census, there were 72 sheep and lambs on 4 reporting farms in the Territory. This is down slightly from previous census.

There is little published information regarding forage and pasture research for small-ruminant dairy, meat and fibre production and even less pertaining to the north. The majority of information relates to feeding prepared concentrates and commercial feeds. Steven P. Hart (2002),from the Institute for Goat Research Langston University, Oklahoma, sums up the state of information as such,

> "There is little published information about pastures for goats - a little from Mexico on bushy pastures with low levels of milk production and some from France which is in French".

This being the case, there are producers raising small ruminants throughout North America and some decent information is available, however, to nowhere near the degree as for pastured cattle. Much of the information being used for pasturing sheep and goats is coming from cattle pasturing research, and while these two groups are quite different in their dietary needs, there are some generalities that can be made.

Nutritional Considerations for Sheep

In industrial farming, feeds are custom formulated for the specific needs of the flock at specific stages of the productive cycle. Lactating ewes are given special high nutrient feed for maximum productivity, finishing lams are given another type of feed as are rams (Church, 1991).

In smaller scale/traditional farming, the nutrient requirements of the animal are often synched to the seasonal growth cycle of pastures, bush and scrubland. In the spring when nutrient requirements of the ewes/does and lambs/kids are greatest, forages in these areas are flushing and they are at their most nutritious and palatable. Ideally the animals should be provided with access to ample amounts of pasture during this time. In the fall and winter when nutrient requirements are reduced, mature forages and preserved feeds are typically able to meet the nutrient requirements of the animals. Meeting the necessary requirements of the animals using preserved feeds can be tricky and some calculations are provided in a later section.

The most nutritionally important time for sheep is late-gestation and lactation, these periods place high energy and protein demands on the ewes and developing lambs (Kleinschmidt, 2009).

Depending on body size and stage of annual cycle, sheep can consume between 2 and 4 % of body weight per day (dry matter) in feed. Smaller animals need a higher relative percentage than larger animals for maintenance needs.

Sheep require an increased amount of feed depending on environmental conditions and activity levels. Sheep foraging for longer hours and traveling large distances between feed, water and shelter will have higher daily nutritional needs than less active sheep. Environmental conditions also alter nutritional requirements; shorn sheep in cool environments will be most affected and need to increase feed to maintain body heat and condition (Kleinschmidt, 2009).

Sheep and Goat Digestion

Like cattle, sheep and goats are ruminants and can obtain the bulk of their energy and nutrient requirements from fibrous plant material. The rumen is filled with bacteria and protozoa which breakdown plant matter into forms which the sheep/goats are able to utilize (Kleinschmidt, 2009). As with other ruminants, sheep/goats rely on their assemblage of gut fauna for synthesis of essential nutritional elements. Research has shown that gut bacteria and protozoa are altered with changes in feed; sheep consuming high amounts of grain have lower rumen pH, this depresses protozoan populations and can lead to clinical acidosis and degrade animal health (Kleinschmidt, 2009). It is important that small ruminants get the right ratio of feeds to maintain optimal health.

Consumed plant matter is broken down in the rumen, bacteria and protozoa are responsible for the breakdown process and incorporate nitrogen into their bodies in the form of proteins. Microorganism bodies are constantly reproducing and flowing into the abomasum and small intestine of the ruminant where they are digested and absorbed. Fermentative microbes are responsible for the synthesis of all the essential amino acids required by the host. In simplistic terms, ruminants are eating microorganisms which are being fed plant matter.

Sheep have a moderate capacity within the gut for utilizing fibrous feedstuffs; of livestock animal’s sheep are similar to goats when evaluated based on GI tract to body mass ratio. The GI tract of sheep makes up around 37% of total body mass compared to around 45% for cows. This large gut allows sheep to consume a wide variety of forbs and browse. Table 66 compares the forage preferences of cattle, sheep, goats and horses and relative composition of an optimal diet.

Table 66. Forage preference by herbivores.

Forage Type	Cattle	Sheep	Goats	Horses
Grasses (Pasture)	70%	60%	20%	90%
Forbs (Weeds)	20%	30%	20%	5%
Browse (Shrubs)	10%	10%	60%	5%
Source: Adapted from Kleinschmidt, 2009.				

Sheep tend to consume more forbs than both cattle and goats and a relatively high percentage of grasses.

A key difference to note between cattle feeding and small ruminant feeding is the differences in digestive physiology. Small ruminants have a shorter and less capacious digestive tract compared to cattle or bison, which means they are less capable of consuming and processing sufficient volumes of low quality feed to extract the necessary nutrients. For proper health, nutrition, and productivity, sheep need access to a variety of highly nutritious feedstuffs, preferably as green forage in a pasture or range situation.

Forages for Sheep

Sheep, as with most grazing animals, select feedstuffs in a hierarchical manner. Preference is given to young and tender green leaves, this is followed by: mature green leaves, green stems, dry leaves and lastly dry stems. Sheep can be sensitive to, and avoid pastures that have gone to seed; grazing intensity is observed to be reduced in these conditions. Once seed stalks are removed (either by cropping or grazing other animals) sheep resume normal grazing intensity (Weisbrot, et al. 2003).

Based on available information, specific pasture species seem less important than forage diversity and stage of maturity. Rapidly growing grasses, legumes, forbs, shrubs and bushes are higher in available nutrients and lower in indigestible fibre than their mature counterparts. Preserved forages should also be harvested while immature and appropriately dried/ensiled so that nutritional value is retained.

When planting pastures for sheep or goats, high production values have been found using a legume grass mix. Legumes provide a higher amount of protein and nutrient per gram than grasses and they are an excellent pasture species. Legume incorporation into pastures in the Yukon has had mixed results and trial and error will be needed to asses this option (for more info refer to Chapter “Crops and Native Feed Options for Yukon). Pastures planted with a legume/grass mix are able to support more livestock per ha in most situations. In a fact sheet published by the Saskatchewan Department of Agriculture, on grazing management for sheep production, the grazing capacity of pastures planted with 7 different forage species is assessed. The table below (Table 67) provides some typical stocking rates for sheep grazing on these different forage types.

Table 67. Sample of initial stocking rates for sheep on pasture, seeded pastures in Saskatchewan

Forage	AUM/ac.	Five ewes grazing days/ac.
Alfalfa	1.0	28
Crested Wheatgrass	0.5	14
Meadow Brome Russian	0.5	14
Wildrye	0.5	14
Altai Wildrye	0.4	11
Smooth Brome Western	0.4	11
Wheatgrass	0.4	11
Source: Weisbrot et. Al., 2003		

The above figures represent initial stocking rates, pastures should be monitored and livestock health should be evaluated on an ongoing basis to ensure that over-stocking does not occur. Stocking rates will likely need to be adjusted throughout the season based on a range of factors, including: growing conditions and forage species assemblage.

When providing pastures and forage spaces to sheep and goats, it is important to incorporate regions of bush and forest. Because browse makes up a large part of a goats diet, and forbs make up a large part of sheep diets, providing access to bushy regions nicely complements a grass pasture in providing a full complement of nutritional elements. Anecdotal, and some limited research, has also indicated that wild browse allow small ruminants access to plants with anti-parasitic qualities.

Preserved Forages for Small Ruminants

Selection of preserved feeds for optimal small-ruminant nutrition is not as simple as a short list of grasses and legumes. As stated by Kleinschmidt, in her 2009 document, "Sheep and Goat Management in Alberta":

> Legumes are normally higher in quality than grasses, but within each group there can be a wide range of quality. When both grasses and legumes are harvested at the proper stage of plant growth, legumes are usually higher in total digestibility, rate of digestion, protein, and many minerals and vitamins. A mixture consisting of an adapted grass and legume is usually of high quality when properly managed. In addition, grasses can improve the drying rates of mixed stands compared to pure legume stands. Perennials, such as alfalfa, orchard grass, timothy, fescue, etc., are usually more economical for hay crops than annuals, although annuals, such as small grain and ryegrass, can be used effectively.

Kleinschmidt (2009) also recommends to have preserved forages tested for nutrients and digestibility in order to properly balance supplementary rations to make up any deficiency. Depending on the productivity level of your goats/sheep, the energy and protein needs will vary significantly. Table 68 shows the changes in nutritional needs throughout the developmental stages of a typical goat herd and Table 69 shows the nutritional needs of a sheep herd.

Table 68. Stage of development and nutritional requirements for goats.

Developmental stage	Body Weight (lb)	DMI (lb)	% Live weight	TDN (lb)	CP (lb)
Doe, late gest. With twins	150	3.60	2.4	2.5	0.50
Doe, early lac. With twins	150	4.14	2.76	2.24	0.55
Feeder kids, 50 days	45	1.8	4.0	1.21	0.23
Ram pre-breeding	220	5.5	2.5	2.93	0.35

Source: adapted from Kleinschmidt, 2009.

Table 69. Stage of development and nutritional requirements for sheep.

Developmental stage	Body Weight (lb)	DMI (lb)	% Live weight	TDN (lb)	CP (lb)
Ewe, Dry	175	2.8	1.6	1.6	0.27
Ewe, late gest. Twins	175	4.4	2.5	2.9	0.49
Ewe, early lac. Twins	175	6.6	3.8	4.3	0.96
Feeder lambs, 50 days	60	2.4	4.0	1.87	0.31

Source: adapted from Kleinschmidt, 2009.

One of the best methods of determining whether or not the preserved feed you are providing for your livestock is sufficient, is by observing the animal's body condition and productivity. If an animal is meeting production goals while maintaining good body condition, then the feed is likely providing the animal with sufficient protein and energy. As stated previously, testing feed quality will illuminate any nutritional deficiencies within the feed and supplements can be provided for accordingly.

Because of their limited digestive capacity, small ruminants have a lower ability to process large volumes of feed. It is important (more so than with other ruminant livestock) to provide nutritiously dense feed to avoid malnourishment. An example calculation is provided at the end of this chapter for determining if feed is meeting the daily nutritional requirements of your small ruminant.

In summary, when feeding preserved forages, know the nutritional needs of your goats/sheep, know the nutritional content of your feed, provide preserved forages with the highest feed value to the animals with the highest demand, and supplement as required.

Grass hay for small ruminants

Hay is a highly versatile and readily available preserved forage for shoulder season and winter feeding to sheep. Small bales are easy to handle and do not require specialized equipment to move or store. Properly dried hay can be stored for significant periods without suffering loss of nutrients or palata-

Vitamin and Mineral Supplement

When feeding preserved feeds it is important to include and mineral and vitamin premix. This will provide all the trace and macro minerals that your livestock require. These mixes should ideally be purchased in smaller quantities so that they are consumed within a month of purchase.

bility. Hay can also supply most of the nutrients needed by sheep (Kleinschmidt, 2009).

Hay quality can be variable from year to year and between producers, a good indication of high quality hay is animal performance. Quality of hay is considered satisfactory if animal performance can be maintained while consuming it (Kleinschmidt, 2009). Kleinschmidt outlines 3 general factors that influence animal performance while eating hay:

1. Consumption: hay must be palatable if it is to be consumed in adequate quantities
2. Digestibility and nutrient content: once hay is eaten, it must be digested to be converted into animal products
3. Toxic factors: high-quality hay must be free of components which are harmful to animals consuming it.

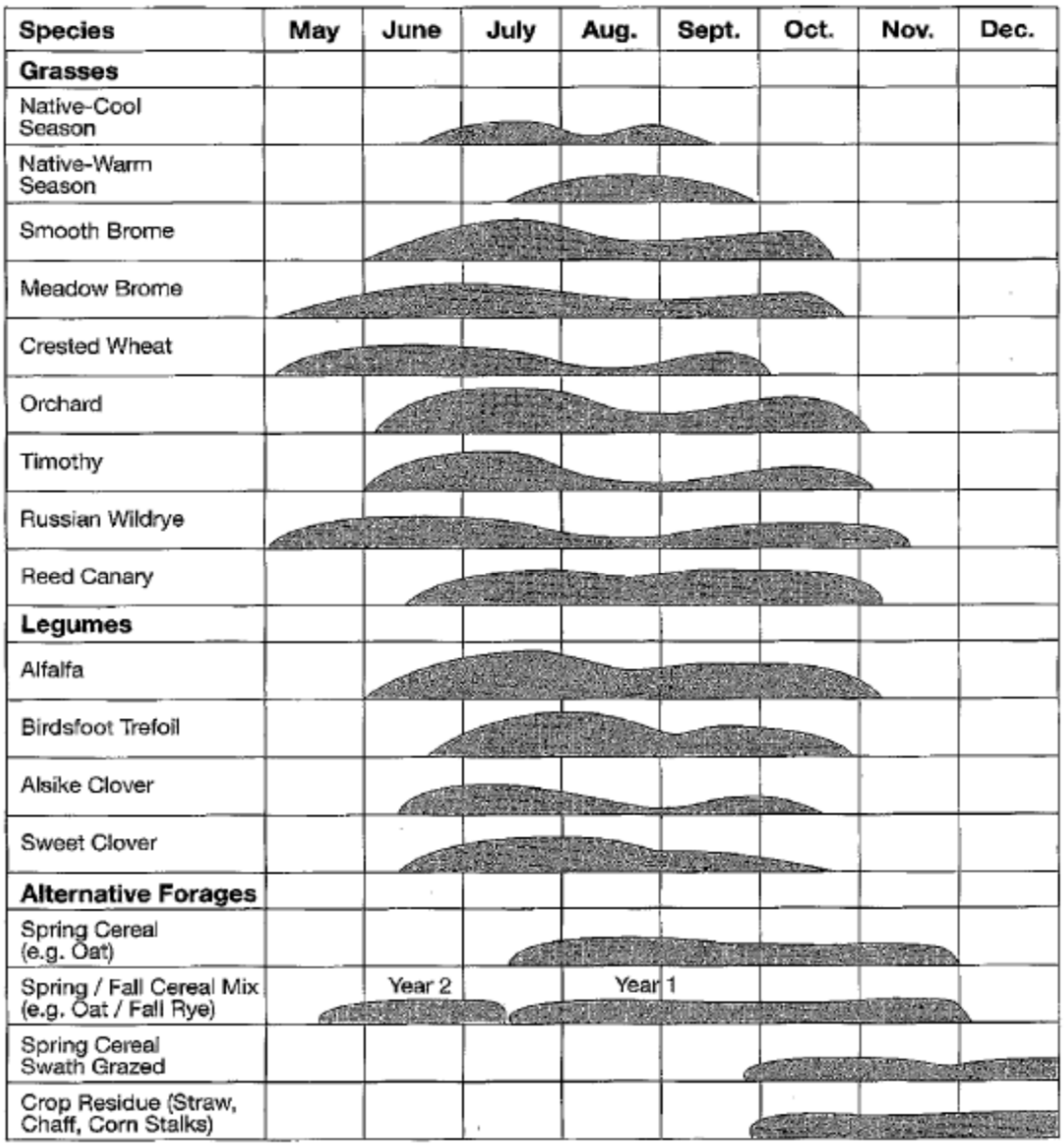
Feed Management for Sheep

It is important to consider all aspects of the sheep's needs when discussing grazing and forage. Studies have shown that sheep are highly social animals and need ample time and space for play, rumination and rest (Kastanje, 2013). These are important consideration when planning a feed management system. Sheep, as with most livestock, will need shelter (for sleep, rest and weather), a source of water, and sufficient population to meet social needs.

As with any livestock animal the feed management system chosen for sheep will be a compromise. The needs of the animal have to be met first and foremost: quality feed, access to water, shelter and browse are all necessary for the quality of life for the animal. These requirements need to be addressed within the business model of the farmer. Not all farms have the same management goals and the chosen feed management system will likely be reflective of those goals. In simple terms, if sheep are the primary income generator for your farm you will likely chose a different (and highly managed) feeding system than a farmer raising a small flock for income diversification.

Providing sheep access to pastures and rangeland will likely be the most economical source of summer and shoulder season feed. Pastures planted specifically for sheep should combine a range of forage species which can provide the longest duration of nutritious growth. Not all forages mature and produce at the same time/pattern; by having several species planted together the productive season can theoretically be extended. Table 70, shows the growth patterns and relative productivity of many common forages from Alberta. While not all of these forages grow in Yukon, many do, and it can be reasonably assumed that they would have similar productivity characteristics in the Territory. By selecting several forages

Table 70. Relative yield and period of growth of seeded pastures, Kosinski et. al., 2013.



with overlapping production peaks, extension of high value grazing can be accomplished.

Pasture Management

According to an article published by the Alberta Lamb Association, the most efficient method of pasture utilization by sheep is through rotational grazing and intensive pasture management. Because sheep are selective grazers, left to graze *ad libitum* (at liberty) they tend to graze only the most desirable plants and move on. This does two things:

1. It reduces the competiveness of the grazed plants enabling the un-grazed plants to out compete for space, moisture and nutrients, this eventually will lead to a reduction and disappearance of the more desirable species.
2. Sheep will trample or otherwise waste the less desirable plants resulting in reduced land utilization and lower effective grazing capacity.

Rotational grazing essentially confines a sheep herd (or any grazing livestock animal) to a specific area until it utilizes all pasture species equally. Equal grazing pressure allows all plants to recover at the same rate, ensuring pasture heterogeneity (Weisbrot, et al. 2003).

In summary, most native and non-native pasture grasses, forbs and shrubs can and will be utilized by both sheep and goats. The degree of utilization will depend on forage species, stocking rate and nutritional requirements of the herd. Ensuring that pastures are maintained in a growing healthy state will maximize the nutritional value of the forages while providing the herd with the necessary nutrients for development. For more information on pasture optimization, see the section on cattle management.

Calculating feed requirements for small ruminants

This sample calculation will assess the ability of a dry, non-lactating ewe to meet its daily requirements from grass hay.

The average brome grass hay, sampled in Yukon, had a crude protein content of 9.95 % and an average TDN of 61.6%.

To make these calculations we first divide the pounds of TDN needed by the amount of TDN in the hay. For a dry ewe needing 1.6lb of TDN we need to divide this by the TDN in the hay sample from above, 61.6%.

1.6 lb. of TDN ÷ (61.6%/100) = 1.6 ÷ 0.616 = 2.6 lb of hay dry matter.

Because the animal can consume 2.8lb of DM per day (this is the upper limit of digestion capability of this ewe) she is capable of consuming sufficient volumes of this hay to meet her daily energy requirements.

To calculate whether the grass hay has sufficient crude protein to meet daily needs we do another calculation. For this step we multiply the percentage of protein in the hay by the number of pounds of hay dry matter consumed. In this case it is 2.6 lb of dry matter.

(9.95%/100) X 2.6 lb = 0.26 lb of crude protein.

The protein needs of this ewe are 0.27lb of protein per day, so this amount of hay will not suffice. However, because the ewe has an upper intake limit of 2.8 lb dry matter, we can supply more hay to meet the protein needs. This will increase the daily energy requirements while providing the minimum protein requirements.

(9.95%/100) X 2.8lb dry matter = 0.28 lb crude protein

By feeding slightly more hay, savings can be realized by minimizing other supplements.

Obviously, as energy demands increase, supplements will need to be added to the diet in order to offset the deficiencies of the grass feed.

For a more detailed look at calculating rations for sheep and goats, refer to Kleinschmidt 2009.

Animal Unit and Animal Unit Month

"Animal Unit" is a term used to describe the forage supply of a given area based on the demands of a 1000 lb mature cow. An Animal Unit Month or AUM is the amount of forage required by one animal unit (a 1000 lb mature cow) for a one month period.

Animal Unit Equivalents (AUE) are used when forage demands for animals other than cows are being calculated. For example, sheep are considered to have an AUE of 0.20 for ewes and 0.26 for rams.

Essentially this means that five ewes can graze the same amount as one mature cow in the same period. (Weisbrot et al., 2003)

Goats:

Nutritional Considerations of Goats

As with other livestock operations feed is often the largest single expense in goat farming; this is the case for both dairy and meat goats with feed accounting for upwards of 60% of total production costs (Kleinschmidt, 2009). The most nutritionally important time for goats is late-gestation and lactation, these periods place high energy and protein demands on the doe and developing kid (Kleinschmidt, 2009).

Depending on body size and stage of annual cycle, goats can consume between 2 and 4 % of body weight per day (dry matter) in feed. Smaller animals need a higher relative percentage than larger animals to maintain body weight.

Goats require an increased amount of feed depending on environmental conditions and activity levels. Goats foraging for longer hours and traveling large distances between feed, water and shelter will have higher daily nutritional needs than more sedentary goats. Environmental conditions also alter nutritional requirements; shorn goats in cool environments will be most affected and need to increase feed to maintain body heat and condition (Kleinschmidt, 2009).

Feedstuffs for Goats

Goats are highly selective when foraging and their mouthparts are adapted to be dextrous and nimble while feeding. Goats consume considerably more browse than both sheep and cattle and choose tender leaves, shoots, flowers, fruits and other nutritious plant parts. Goats also consume a wide range of plants: shrubs, trees, vines, grasses, weeds, legumes and even thorny bushes. Quality and selectivity of feedstuffs will mostly be dependent on which particular feed is tender and palatable. Goats are not efficient at using the entire pasture, trampling and wastage occurs, and to maximize utilization goats should be grazed with a companion livestock animal such as cattle or sheep (Kleinschmidt, 2009).

Goats are highly adapted to grazing and browsing and this can be seen in their physiology. According to goatdairylibrary.org, an online goat resource, these physiological and behavioural advantages include:

- An innate ability to select the most nutritional plants and the most nutritional plant parts
- An ability to grasp and tear, enabling them to eat a multitude of plants other animals cannot eat
- A tolerance for bitter taste enabling them to eat plants other animals will not eat such as tannin producing plants which have natural deworming properties.
- A preference for eating forage higher than knee level (above parasite level)
- The ability to store liquid in the rumen which allows them to survive without water for up to 4 days

- Fat storage in the abdomen which allows them to survive without food for significant lengths of time

Kids have a high nutritional requirement as they are growing and should be allowed to graze new pastures ahead of older animals. Forward grazing is a management technique which accomplishes this; when high quality forage is not available for an entire flock of goats, kids can be turned out ahead of the rest of the herd and graze new growth (Kleinschmidt, 2009).

Goats have an adaptive feeding strategy which favours a diverse assemblage of plants. Goats will select young grasses when protein is high, they will switch to forbs when they become more palatable and then to browse when its nutritional value is highest (Kleinschmidt, 2009). This has several advantages over conventional grazers: goats are able to take advantage of plant growth throughout the growing season and are not resigned to consume a steadily lowering quality of feed, goats do not need to compete with other grazing animals in a paddock as they have a more diverse diet.

According to Janet Kleinschmidt (2009), a ruminant nutritional consultant, goats have been observed to:

- Select grass over clovers.
- Prefer browsing over grazing.
- Prefer foraging over rough and steep land over flat, smooth land.
- Graze along fence lines before grazing the centre of a pasture.

- Graze the top of a pasture canopy fairly uniformly before grazing close to the soil level.

Kleinschmidt (2009) also notes that goats grazing pure stands of grasses can succumb to grass tetany, this is a magnesium deficiency which results from livestock grazing an abundance of fast growing grasses especially in early spring. This can be avoided by using mixed grass pastures (legumes are great) and providing a goat specific mineral supplement. **Cattle supplements should never be used for goats as they are too high in copper**.

Pasture Management

Grazing is generally considered the most cost effective and most efficient way to supply goats with their required nutrition. Maximizing the productivity of the grazed land can be challenging with goats and requires a fairly high level of involvement and management. Most important for grazing goats is to have control of the level of defoliation that takes place on a given paddock. Due to their selective feeding nature, goats are able to quickly overgraze and damage forage species, in severe cases entire pastures. Most importantly, pastures should be allowed to recover sufficiently following a period of defoliation prior to overwintering; this will ensure that winter die-off is avoided (Kleinschmidt, 2009).

In the publication, Sheep and Goat Management in Alberta, Kleinschmidt outlines a number of management strategies to ensure a successful forage system for goats:

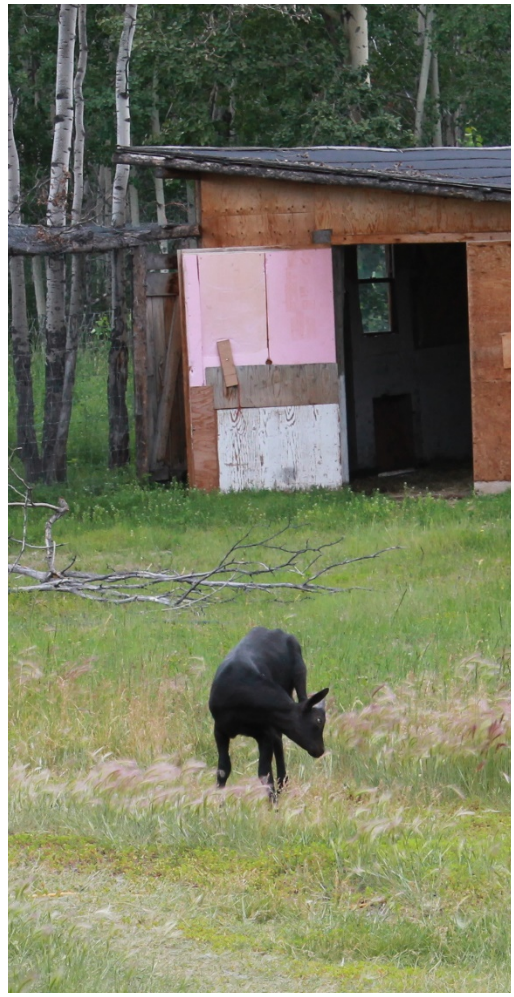
1. Adjust the number of animals grazing a certain area (stocking density) of pasture as some forage must be left at the end of the grazing period to maintain adequate plant pro-

duction. Overuse will weaken the plants and re-growth will be slower. Adjusting the stocking rate requires experience; forage growth is not uniform throughout the year or from year to year and adjustments must be made accordingly.

2. Harvesting un-grazed forages as hay or silage at an immature stage of growth when forage growth is more rapid than it can be grazed; this provides high quality feed when grazing is not available. Cross fencing will keep animals concentrated on small areas while excess growth accumulate on other paddocks. Under these circumstances, short duration rotational grazing through a series of paddocks, or strip grazing, are good alternatives to consider.
3. When high quality forage is in short supply, restriction of its use for supplementation of other low quality pastures, hay or silage is a good management practice. This can be achieved by letting goats graze high quality forages for a few hours at the end of the day, or by grazing the limited high quality supply every other day.

Steven Hart, author of "Forage Based Dairy Goat Management" (2002), has developed a pasturing technique used for goat dairies in Oklahoma. This technique is fairly management intensive yet it delivers the necessary nutrition for maintaining a productive dairy goat herd without supplementation. Its applicability to goat pasturing in Yukon is limited, however, some might find it useful. Hart utilises multiple pastures disked and seeded at staggered intervals, this ensures that there is fresh rapid growing forage for his dairy goats throughout the kidding and milking season. This method offers an uninterrupted supply of high quality forage for the goats to consume. Hart plants mainly hairy crabgrass in his pastures, this is a drought tolerant and provides a very high quality forage for goats and sheep.

Lendrum Ross Case Study



A local example of forage-based dairy goat management is taking place at the Lendrum Ross Farm near Lake Laberge in Yukon. Brian Lendrum was interviewed on July 24th, 2014 in order to understand the workings of his dairy goat operation. The Lendrum Ross Farm has been raising milking goats since 1988 and turning the milk into cheese which is marketed locally. The goat herd is made up of about 42 animals with around 14 milk producers.

The goats at Lendrum Ross Farms produce around one to four kg of milk per day depending on age and time of season; this falls within the normal range of other organically raised milking goats (Hart, 2002). The interesting thing about these goats, however, is that, during the spring summer and fall, the goats are fed almost exclusively natural forage. The vegetation that makes up the bulk of the Lendrum Ross grazing lease is natural forest of pine, spruce, aspen/poplar/willow interspersed with grassy south facing slopes. There are no cleared or cultivated pastures on the property.

Starting in mid-May the goats are almost exclusively on native forage till mid-September. In the shoulder season the goats are feeding partially on wild forages and partially on grass hay. By early October the goats have transitioned almost entirely too preserved hay which is their primary feed source for the duration of the winter. The hay used by Lendrum/Ross is a mixture of locally sourced brome-grass and imported alfalfa hay.

Milking goats at the Lendrum/Ross Farm are supplemented with between 0.5 and 1.5 kg of commercial dairy ration (depending on production level of the goat) per day; this is consumed while at the milking stall. Mr. Lendrum commented that without this supplement milk production is noticeably reduced; this is consistent with observations by other organic goat milk producers (Hart, 2002).

While the composition and proportions of native forages the Lendrum/Ross goats are consuming is unknown, over the years some general preferences and observations have been made. These goats have a strong preference for forbs such as fireweed, shrubs such as wild rose (petals and leaves), specific species of willow (they have been seen to pass right by one type of willow bush only to devour a willow bush nearby), aspen leaves (they have a predilection for the crispy leaves of recently fallen aspen trees) and have also been observed to enjoy spruce tips in the spring. Unfortunately, a comprehensive assessment of the diet of the Lendrum Ross goats has not been done so little else is known regarding the amounts and variety of plants which they consume.

In the fall the Lendrum Ross goats are fed the by-products of the fall vegetable harvest. Lendrum Ross farms also grow organic market garden vegetables, mostly brassicas, the goats are fed the outer leaves and tops of: turnips, cabbage, broccoli, cauliflower, kale, colrabi, peas, etc. and seem to consume them with considerable enthusiasm.

This pattern of feeding has been successful for the Lendrum Ross farm for 26 years. It is a low impact, low cost method of management which maintains acceptable levels of production and a healthy herd of livestock. This method of production has several advantages over conventional feeding systems:

- Low land development costs as there is no cleared land and no planting
- Low equipment cost as no land needs to be cleared, tilled or harvested
- Lower start-up costs associated with land purchase and development, Lendrum/Ross forage their goats on a grazing lease
- Lower impact on the environment as native species are kept and wildlife and birds are not displaced
- Fertilizers and pesticides are not used, weeds are less of an issue as ground is not cultivated
- Intestinal parasites are considerably less of an issue, in natural environments goats tend to forage above belly level, this is above the height that larval parasites typically are encountered
- Natural browse typically contains plants high in tannins, these compounds have been shown to naturally reduce intestinal parasite loads in goats
- Goats have access to a wide range of plants to browse from, this allows them to select the most nutritious foodstuff available at a given time; because native plants grow

and mature at different rates throughout the season goats are able to select the most nutritious and palatable plants. In contrast, monoculture crops mature at the same time, animals grazing in these conditions do not have the ability to switch forage species to a more nutritious variety.

Some drawbacks to this feed management system are as follows:

- More animals are lost to predation in natural forest environments (although this has been effectively mitigated through the use of guardian dogs)
- Individual animal nutrition is more difficult to manage
- Optimal nutrition is unknown; no research has taken place with regards to natural Yukon vegetation and goat requirements
- Preserved forages must still be purchased throughout the winter, nutrition levels and palatability of purchase forages vary considerably year to year and farm to farm
- Animal densities are likely lower on natural forages compared to cultivated forages, Lendrum/Ross goats have access to 100 ha of grazing land, which is likely more land than they are able to effectively utilize. If grazing/browsing space is limited on your farm, this form of land management might not be effective.

Supplementing Forages

Forages are the most natural, healthy and cost effective way to feed goats and other small ruminants. Goats fed forages, preserved or fresh, experience less digestive issues or health problems compared with goats fed concentrates and grains (Kleinschmidt, 2009). The feeding of grains and concentrates becomes necessary, however, when high performing breeds are expected to produce to their maximum. Milking goats and developing kids with fast growing genetics are commonly supplemented with grains and proteins.

Kleinschmidt (2009), discusses occasions when feeding goats grain and concentrates is beneficial:

1. Flushing is the practice of providing extra energy and/or protein to breeding ewes and does prior to the breeding season and for the first several weeks of the breeding season. The increased weight gain may translate into higher fertility and ovulation rates, though many factors will determine the female's response to flushing; thin does respond best to this practice. Does and ewes are usually flushed with a quarter to half a kilogram of grain or protein supplement per day. Flushing can also be accomplished by moving females to a lush pasture prior to breeding. Care must be taken not to provide excessive soluble protein (alfalfa) when flushing ewes and does. Excessive soluble protein can create a toxic environment around the reproductive tract, rendering semen un-viable and potentially killing foetuses in the first trimester.

2. Nutrient requirements increase greatly during late gestation and are affected by expected kidding rate. Inadequate nutrition during late gestation may result in ketosis, low birth weights, weak kids and poor milk production. It is common to feed grain to ewes and does during late pregnancy, especially if a high lambing/kidding rate is common.

   If high quality forage is being fed during late gestation, whole corn or barley is usually all that is needed to meet the ewe's/does nutritional needs. Small ruminants like sheep and goats do not seem to require the same level of feed processing as cattle as they chew their feedstuffs more thoroughly prior to ingestion. Research has shown little benefit to processing (rolling, grinding, pelleting) grain fed to goats and these processes will only add another costs.

   If grass hay is being fed during late gestation, the grain portion of the ration should also include a good source of protein and calcium. It is best to feed a mixed grass-legume hay during late gestation and to save the best quality hay for lactation as protein and calcium needs are highest.
3. Lactation places the greatest nutritional demand on all mammals, including ewes and does. Young mothers and females nursing multiple offspring are particularly under nutritional demands. Supplementing lactating females on pasture will usually improve lamb and kid gains and improve body condition of the females at weaning. It is very difficult for does to

raise a good set of triplets on pasture without some sort of grain supplementation. Giving young mothers and triplet-rearing ewes/does access to more pasture is another way of increasing their nutritional intake. Dairy goats are usually fed concentrates to sustain milk production, while at the same time attempting to maintain body condition. Well-bred dairy goats "put it in the pail" before maintaining body condition, making it a challenge to balance milk production and body condition without feeding concentrates. Even when concentrates are being fed to high producing dairy goats, (Alpine, Toggenburg, Saanen and Oberhasli) they will continue to increase milk production rather than increase body condition.

4. Creep feeding is supplemental nutrition provided to nursing lambs and kids. Creep feeding is especially beneficial for breeds that have a high percentage of multiple births. Creep fed lambs and kids grow faster. Young lambs and kids can be started on creep feed as early as ten days. A creep ration does not need to be complex, but it should be fresh and highly palatable, approximately 20% crude protein. Grains which are palatable and easy to digest are favoured in creep rations, for example cracked corn, rolled oats and soybean meal. Creep grazing is another method of providing better nutrition to nursing lambs and kids, this is the same principle yet with quality pasture as opposed to grains.

5. If adequate forage is available, but of poor quality, it may be advisable to feed a supplement. Protein is usually the first limiting nutrient in dormant forage. Increased protein intake will improve forage utilization.

When feeding grains or supplements to goats, or any livestock, there are a few general guidelines that will ensure animal health.

- Ruminants are not able to process large amounts of concentrates or grain, these should be incorporated in small amounts and staggered throughout the day. Lage amounts of grain can increase rumen acidity, (lactic acid bacteria) which can lead to acidosis and enterotoxemia. For goats more than half a kilo of grain is considered excessive.
- Try not to feed finely ground grain, this increases digestion rate and rumenal acidity.
- Feed hay before concentrates/grain, this primes the rumen and allows buffering of pH levels.
- Ruminants needs forages to remain healthy, the minimum amount of forages to stay healthy is considered to be 1.5% of body weight per day of forage.
- Rumen microorganisms need time to adjust to changes in feed, make dietary changes slowly by increasing the new feed proportion slowly over a period of weeks.

- Goats should be fed grains in a whole state, processing increases digestion rate and leads to acidosis, it is also an added cost with no benefit.

Supplemental grains commonly fed to goats and sheep include: corn, barley, wheat, oats and rye. In Yukon, rye, oats and barley are common crops and are locally available, organic versions are still difficult to source and are shipped up from southern markets. Protein supplementation is more difficult to source locally as none of the traditional protein sources are grown in the north; common protein sources in western Canada are: soybean meal, canola meal, corn gluten meal, linseed meal, distiller's grains and animal proteins. Industrial by-products are also used in animal feeds, these products are not produced in Yukon and will not be discussed as feed options.

There is a range of vegetable crops that can be fed to goats: carrots, beets, turnips, potatoes, etc. these can all be fed without issue, however, it is not advised that they make up a large proportion of the diet. Lendrum/Ross farms feed their goat's trimmings and waste from their market garden business which the goats seem to enjoy.

Forages and productivity

Throughout most of the world goats are mainly fed forages. They rely on the nutrition of forages for growth, maintenance, lactation and all other requirements. Typically goats are grazed and survive where other livestock do not. With this in mind it comes as some surprise that there is a distinct lack of published information regarding forages and goat productivity (Heart, 2002).

Hart (2002) was involved in overseeing a study on goat milk production and milk composition based on level of grain supplementation. He fed three levels grain to pastured dairy goats for 2 years to evaluate the production level and milk quality. The results were interesting, milk production responded to the grain, but not dramatically, and at higher levels of grain supplementation milk production decreased. Milk fat percentage was higher in grain fed animals; however, cheese made from pastured goat's milk was rated as higher in flavour tests.

Hart (2002) concluded that acceptable milk yields could be obtained with high quality pasture alone, supplementing with grain was a good management practice to maximize yields and maintain body condition, furthermore, goats on a pasture only diet had higher levels of conjugated linoleic acids in their milk, the only animal product/compound classified as an anti-carcinogen.

Non-Ruminants

Poultry

Poultry are typically described as being; any domesticated bird within the fowl and water-fowl orders kept for meat, egg and feather production. This commonly includes: chickens, turkeys, quail, and domesticated ducks and geese. During the last census (2011) 39 farms reported raising: 3601 hens and chickens, 190 turkeys, and 41 birds classified as "other poultry". This is fairly consistent with previous surveys except for turkeys, in 2005 it was estimated that turkey production was around 1000 birds per year (Hill et al., 2005).

Digestive System

The gastrointestinal tract of poultry is physically quite different to that of most other livestock animals. Functionally, however, it is quite similarly to that of other monogastrics; being relatively short, simple and with little capacity for fermentation, poultry have difficulty digesting and extracting nutrients from fibrous plant material (Church, 1991). Poultry require a diet relatively low in fibrous plant matter and high in easily digestible, protein rich feed (Church, 1991).

The feeding adaptations of poultry start with the mouth which is a narrow beak specialized in seed eating. Poultry have no teeth and instead rely on the grinding action of the gizzard to mechanically break down plant matter (Blair, 2008). Food moves from the gizzard into the proventriculus which is the site of chemical breakdown of the foodstuffs (this organ acts like the stomach). The chemical breakdown is accomplished through enzymes and digestive juices. This process reduces the feed particles to a size capable of being absorbed through the gut wall (Blair, 2008).

Poultry Nutrition

Poultry need five basic nutrients for a healthy diet: energy, protein, minerals, vitamins and water. Energy is generally easy for poultry to access and typically comes from grains (Blair, 2008). Protein requirements for poultry are a bit more complex, as birds need to source all amino acids form their diet (this is different than ruminants which can synthesise most in there gut). Under optimal conditions poultry can extract about 30-60% of their required amino acids (AA) from cereal grains (barley, maize, wheat, sorghum) and forages, however, for a complete AA profile (and healthy productive birds) other sources of protein are typically required (Blair, 2008). These protein sources conventionally come from soybean meal, canola meal, sunflower meal, fish meal, worm meal etc. (Blair 2008).

As you might have noticed, none of these high protein crops are routinely or successfully grown in Yukon, therefore, poultry producers either need to import these high protein crops or find another alternative.

In his book on organic poultry nutrition and feeding, Robert Blair (2008) has identified a wider range of potential protein sources, some of which can and are grown in the Yukon. The most practical of these alternatives are field peas and domesticated lupins. While neither of these are recommended to be the only source of supplemented protein, they can be incorporated into poultry feed offsetting costly imported feeds. Within the literature, recommended feed inclusion rates vary, however, rates of between 200 and 700 g/kg for peas and up to 250 g/kg for lupines have been trialed with good results (Roth-Maier, 1999, Perez-Maldonado, 1999, Castell et al., 1996, Daveby et al., 1998).

Forage field peas have been researched by the Yukon Agriculture Branch for

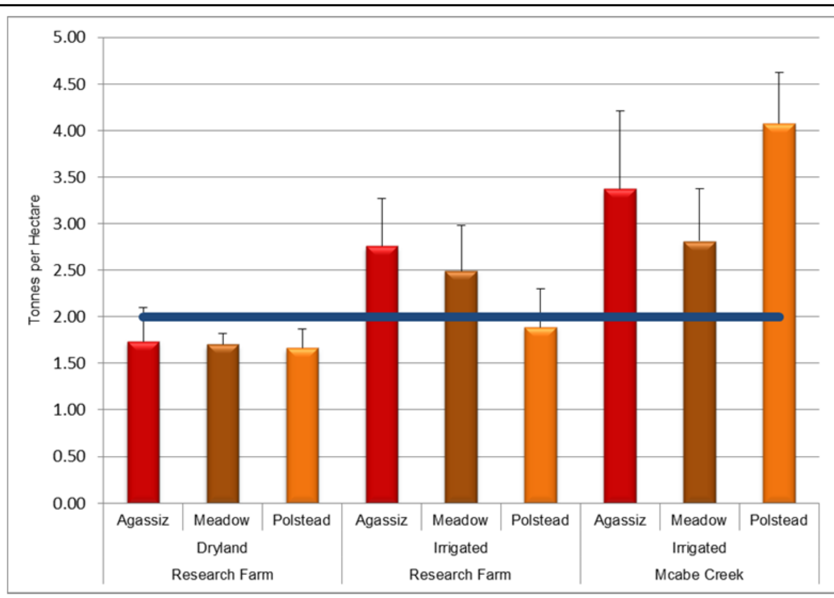


Figure 16. Results of the 2010 field pea trials at Yukon Research Farm

yields and maturity. A brief description of the research has been already been discussed in "Field Pea Trials, Yukon Research Farm, 2010-2012", and initial results look promising. Yields were found to be comparable to those found in other parts of western Canada and, in good years, are expected to mature producing around 2 t/ha (and as high as 4 t/ha). Figure 16 shows the pea varieties and yields for the two Yukon trial sites. It should be noted that the Central Yukon site at McCabe Creek is typically 1 or 2 land class designations better than the Research Farm location, yields at this site are expected to be much higher.

Field peas have huge potential in the Yukon as a high protein crop for all types of livestock (and human) feed. Field peas are marketed as a "dry pea" for livestock and a "split pea" for human consumption; they are essentially the same product. Field peas contain significant amounts of protein and carbohydrates that are metabolized by both monogastrics and ruminants.

Peas are typically considered a crude protein source, however, peas contain energy levels similar to corn for most livestock species (Harrold et al., 2002). When compared to other commonly fed grains, peas have high total digestible nutrients and crude protein (Table 71).

Table 71. Analytical comparison of field peas and other grains

	Peas	Corn	Barley	Oats
Dry Matter (%)	89	89	89	89
Crude Protein (%)	24.5	9.5	13.2	13.1
ADF (%)	8.0	3.3	5.8	14.0
NDF (%)	15.1	10.8	18.1	29.3
TDN est. (%)	90	90	85	83
Fat (%)	1.55	4.30	2.25	5.05
Calcium (%)	0.05	0.03	0.05	0.10
Phosphorus (%)	0.48	0.31	0.37	1.73
Potassium (%)	1.01	0.33	0.56	1.89
Source: adapted from NRC, 1984, 1996.				

When feeding field peas to poultry one of the key factors to be considered is the species of poultry; according to Harrold *et al.*, (2002), not all poultry can utilize peas properly (unfortunately he fails to mention which species these are) and so inclusion rates may vary. Harrold (2002), claims that peas can be fed at rates of up to 40% of the diets of laying hens without adversely affecting performance, however, rates of 10% are considered more practical. Harrold (2002), goes on to mention that broilers and turkeys can consume inclusion rates of 20-30% without impacting performance. It should be noted that these inclusion rates are offsetting a commercially available feed which is otherwise balancing the nutritional requirements of the bird. Inclusion rates for birds on a forage based diet will differ than the aforementioned rates.

Feed Management Systems

Feeding poultry, using any feed management system, is the most expensive component of a poultry operation. Some research estimates that up to 75% percent of the cost of production is attributed to feed costs: of that feed, only 1/4 is used for productive purposes the remaining 3/4's is used for maintenance needs (Church, 1991, Blair, 2008).

With poultry, perhaps more so than with other operations, choosing the right feed management system can help increase the success and profitability of your farm. With small production margins in poultry, it is important to carefully balance the nutritional requirements of your birds appropriately in order to ensure good weight gains or egg production. Choosing the right feed at the right time, maximizing utilization, and providing appropriate environmental conditions all help to keep production costs to a minimum and keep productivity high. The following sections will discuss some of the common feeding methods and some of the not so common feeding methods.

The All Mash Method

There are 3 common feed management systems that are used to feed poultry. The most common system used today is known as the "all mash method". This method is simple, effective and is used with all forms of poultry operations and at all life stages. The feed is formulated according to very specific nutritional requirements and fed as either pellets, mash or in a crumbled form. The advantages to this system are:

- only one feed is required, this feed meets all nutritional and energy requirements
- the product is consistent
- mechanical feeders can be used
- birds cannot be selective feeders, as long as they are eating they are getting a complete feed

Disadvantages to this system are:

- expense, this feed is expensive both to purchase and to ship
- inflexibility, alternative or seasonal feeds are not easily introduced into this system

The Mash-Scratch Method

Prior to the all mash method, the scratch-mash method was the most common poultry feeding technique. This method of feeding is still common on smaller operations to feed mature birds. With this method a combination of whole grains and formulated mash feed (also called concentrates) is provided for the birds. The combination of grain to mash depends on a number of factors such as: grain availability, bird life stage, nutritional requirements, type of poultry operation (layers or meat). Typically the grain to mash ratio is about 1:1, which provides an average protein intake of around 15% (20% for mash and 10% for grains).

Not all grain has the same energy and nutrient values so the ratio of grain to mash will need to be determined based on the grain locally available. With this method it is recommended that at least two different grains are provided in the feed. This method has the advantage of being less expensive as birds can be fed less expensive whole grains, it also helps to maintain good litter conditions within pens. One of the key disadvantages is that it is more difficult to ensure that the nutritional requirements of the birds are being met. Some birds may prefer the grain over the mash and become less productive. This can cause eggs and meat birds to be of varying size and quality.

The Whole Grain Method

The whole grain method is the most traditional of the feed management systems used for poultry. This method relies on a combination of supplemented grains forages and mineral mixes. Forages typically include: insects, worms, green vegetation, and domestic scraps. The supplemented grains would traditionally include anything readily available, however, these would normally include: wheat, barley, oats, corn etc (Church, 1991).

This method of feeding works well in small scale operations and occasionally in medium scale operations. If this method is combined with a "chicken tractor" birds can be efficiently moved onto fresh feed sources as needed. For very large operations this method requires an enormous amount of labour and space to be effective making it challenging (or impossible) to be economical.

For both the whole grain and the scratch-mash methods, it is important that the grain being supplied to the birds is of sufficient nutritive and digestible value. In, "Livestock Feeds and Feeding", the author ranks commonly available grains used for poultry according to their suitability.

- High energy grains: corn, milo, wheat, rice, triticale and oat germ
- Medium energy grains: barley and heavy oats
- Low energy grains: oats and spelt

Many other grains are and have been used as poultry feed and the aforementioned grains are by no means required, they are merely the most common. Blair, "Nutrition and Feeding of Organic Poultry", provides recent research and nutrition tables for a vast number of alternative feeds, many of which have similar (but largely untested) nutritive values as conventional grains.

Poultry Feeding in Yukon

Now that we have discussed the 3 conventional methods of poultry feeding we can focus on feed management systems practical to, and in place in the Yukon.

The Yukon's poultry industry has remained fairly stable since 2000, there are around 3600 meat chickens, 1146 laying hens and several hundred other types of poultry (turkeys, ducks etc,.) raised annually (Ball *et al.*, 2013). According to the Muti-Year Development Plan (2007) the average producer raises between 50 and 300 birds in a free range production system. Birds are typically fed a combination of locally grown grains (Yukon Grain Farm) imported organic feed (mash) and forage. For Yukon producers this system is a balance of: ethics, animal health, economics and locally available feeds.

As virtually every chicken raised in the Yukon has access to, and to some degree relies on forages for its nutrient intake, this is an important area of investigation. Unfortunately, quantifying the value and usage of forages by poultry is difficult and little work has been done in this field in North America. Research into poultries use of forages and the production performance of free range birds has been done in Europe and Australia and we will look at those examples for information.

In 2005, researchers in Australia (Glatz, 2005), investigated the production performance of free range chickens (Hyline) compared with the published values of the breed development company for the same hens on a complete feed. As expected the researchers found that production performance fell and mortality increased (lower levels of some AA in free range diets prompted higher levels of cannibalism) on a free-range system.

Table 72. Production performance of free-range birds compared to standard over 18-40 weeks

	Treatment	
	Free-Range	Commercial Feed
Mortality and Culls (%)	9.1	1.2
Rate of Lay (%) 22 weeks	72	75
Rate of Lay (%) 30 weeks	89	94
Rate of Lay (%) 40 weeks	79	93
Egg weight (g) 40 weeks	57.2	63.9
Live weight (g) 40 weeks	1.93	2.17
SOURCE: adapted from Glatz, 2005		

Researchers labelled the performance of the hens to be good considering that environmental conditions at the time of the experiment were highly unfavourable; 17 days exceeding 37°C and roost temperatures approaching 47°C. Performance results of the research is shown below in Table 72.

Research conducted by the Danish Poultry Council in 2003, (Hermansen et al., 2004) showed similar production drops by free-ranged chickens on an organic diet. This research, however, also looked at the value of the organic-free-range egg prices vs. those raised on commercial feed and in cages.

Table 73. Average productivity and prices in the period 1995–2002 per hen housed as reported by the Danish Poultry Council, 2003.

	White layers in cages (21-76 weeks)	Organic brown layers (21-68 weeks)
Feed/day (g)	112	131
Rate of lay (%)	86.8	73.5
Mortality (%)	4.9	14.8
Kg feed/kg eggs	2.07	2.81
Egg price (DKK/kg)	5.89	14.21
Price relation egg/feed	4.17	6.39

SOURCE: Hermansen *et al*., 2004.

The poultry council found that the egg price (market price not production costs) for a given feed cost was much higher in organic free-range birds which resulted in greater profitability for the organic farms (Table 73). In simpler terms, organic farmers received $6.39 worth of eggs for every dollar of feed while standard non-organic farmers received $4.17 worth of eggs for every dollar worth of feed. In systems where a steep premium is paid for free-range eggs, the performance deficiency is greatly outweighed by the higher market price.

Foraging not only has the value of reducing feed costs but also in: fertilizing pastures, reducing insect pests, and reducing weed species. This service has a value that many local producers would gladly accept in lieu of higher production values. On organic farm settings, the poultry manure is especially valuable as it can offset the cost of expensive organic fertilizers.

Other European research (Sorensen and Kjaer, 2000) has investigated how different breeds of chicken fair under organic production and their results are presented in the Table 74) below. Selecting the breed that will have the highest productivity under free-range organic conditions will greatly increase productivity, as shown in Table 74, ISA Brown will produce almost 20% more eggs than New Hampshire (although cannibalism was very high during this study).

Table 74. Productivity under organic conditions of four genotypes of laying hens from 18 to 43 weeks of age.

	ISA Brown	New Hampshire	White Leghorn	New Hampshire X White Leghorn
Rate of Lay (18-43 weeks)	84.6	63.2	72.4	69.2
Eggs/Hen Placed	127.2	88.8	103.4	105.5
Age at first egg (weeks)	19.8	22.2	22.9	21.4
Egg weight (g)	59.3	54.7	58.3	57.0
Cannibalism (%)	17.5	2.38	0	1.11
Total Mort (%)	21.25	14.3	6.67	3.89

SOURCE: Sørensen and Kjaer, 2000.

For Yukon producers of both broilers and laying hens a combination of free-range and supplemented feed will likely be the most economical and effective method of raising birds. This method takes advantage of the rapid and nutritious spring/summer growth, allows the birds to engage in foraging and pecking behaviour, fertilizes fields and pastures, reduces insect pest loads and utilizes local grains, market garden and or other farm waste products.

Most (if not all) broiler producers in the Yukon only raise birds in the spring and summer which allows them to fully take advantage of this system. Laying hens will also have access to the outdoors either via chicken runs or chicken tractors during this season, however, they will need a heated/insulated shelter in which they can overwinter. Feeding table scraps or vegetable scraps (sourced from local supermarket, garden or restaurants) can also be a nutritious and inexpensive way of supplementing commercial feed and grains.

When feeding grains, Blair et al., (1978, 2008) recommends that whole grains are fed to chickens as opposed to processed grains. He states that:

> Namely that since the bird has a digestive system capable of processing whole grain it seems illogical and unnecessary to feed a pre-ground diet….the process of grinding …and pelleting requires a large input of electrical energy amounting to approximately 10% of the total feed costs.

Blair's (2008) statement is corroborated by Bennett (2006) who, in a Manitoba extension article for choice-feeding poultry, states:

> You do not need to grind the whole grain when you choice-feed your hens. The birds will readily eat whole wheat, whole oats or whole barley (but they can have difficulty eating whole corn). After about three weeks of eating whole grain, the hens' gizzards will increase in muscle mass and will grind the grain as efficiently as a hammer mill. Hens can successfully consume 70% of their diet as whole grain when it is choice-fed.

Both Blair (2008) and Bennett (2006) stress the importance of allowing hens to adapt thoroughly to the whole grain diet prior to laying eggs; this will allow time for the gizzard to develop the muscles needed to pulverize the grain well enough so that the gut can extract the nutrients.

Blair (2008) also states that free-choice-feeding is a more practical and economical (and closer to the natural way chickens feed) feeding alternative to complete feeds. In this system birds are offered three types of feedstuffs:

1. An energy source such as whole grains,
2. A protein source such as canola meal or fish meal (supplemented with minerals and vitamins)
3. A source of granular calcium such as oyster shells along with grit to aid in gizzard function.

This system of choice-feeding works well because birds (even chickens) retain some degree of "nutritional wisdom" which allows them to assemble their own diets according to their particular activity level, productivity, and age (Blair, 2008).

In studies designed to assess the nutrient content of self-selected diets in chickens, results indicate that chickens will self-select diets that closely match scientifically recommended requirements (Table 75) (Dove, 1935). In a study by Dove (1935) chicks were able to select from a range of feedstuffs to meet their daily nutritional needs, researchers found that the self-selected diets were almost nutritionally identical to recommended diets.

Table 75. Dietary self-selection by chicks and effect on nutrient intake.

Feed Ingredients Offered	Intake % of total	Nutrient content of selected dietary mixture	NRC-estimated requirements (1994)
Yellow maize	52.8	Crude Protein, 179 g/kg	180 g/kg
Oat meal	8.9	ME, 2729 kcal/kg	2880 kcal/kg
Wheat bran	21.3	Calcium, 13 g/kg	9.0 g/kg
Fishmeal	11.4	Phosphorus, 11 g/kg	4.0 g/kg non-phytate P
Bone Meal	2.9		
Dried skim milk	2.1		
Oyster shell	0.6		
SORCE: Dove, 1935.			

This style of feeding nicely complements birds with access to free-range forages. Birds can select and regulate the energy and nutrient that are lacking in the forages from a selection of provided feed ingredients. This system also offers an effective way to incorporate on-farm products such as whole grains and market garden by-products. Costs are further reduced with this method as grinding, mixing and pelleting equipment is not necessary (Blair, 2008).

Choice feeding has the added benefit of reducing feed costs when compared with conventional feeding (even without foraging). In a review of many choice-feeding experiments, Blair (2008) found that when birds are offered a choice of feed ingredients *ad libitum* they consumed less feed than birds on a conventional "ration" diet. The results of six of these studies is summarized in the Table below (Table 76).

Table 76. Estimated feed savings by adopting choice-feeding with laying hens.

Reference	Conventional Diet (g/hen/day)	Choice-feeding (g/hen/day)	Savings in feed Intake (%)
Henuk et al., 2000b	123.8	120.3	2.9
Blair et al., 1973	116.2	108.9	6.7
Leeson and Summers, 1978	114.4	107.2	6.7
Leeson and Summers, 1979	118.4	110.7	7.0
Henuk et al., 2000a	126.5	114.6	10.4
Karunajeewa, 1978	132.5	18.5	11.8
SOURCE: Henuk and Dingle, 2002.			

In a Manitoba Agriculture Extension Services document, Bennett (2006) makes the following six recommendations for small scale egg producers using the choice-feeding method:

1. Do not give the hens too many choices. Hens can handle up to three choices quite well (grain, 'supplement' and limestone or oyster shell). When using more than one

grain, such as wheat and barley, mix them together in the same feeder.

2. Give the hens choices that are nutritionally distinct. For example, grain is high in starch and energy, supplement is high in protein and vitamins and limestone is high in calcium. When provided with such clear choices, the hens learn which feeders to go to and how much to eat in order to meet their basic nutritional needs. Some choices may not be clear enough for the hens. For example, wheat and peas both are high in starch and have moderate levels of protein. Having separate feeders containing wheat and peas may not provide a distinct enough nutritional difference for the birds to detect.
3. Introduce the whole grain and choice-feeding a month before the start of egg production (about 15 weeks of age). This adjustment period will allow the birds time to learn how to choice-feed themselves before they are exposed to the nutritional demands of egg production. It will also allow the pullets the opportunity to increase their calcium intake and build up the calcium reserves in their bones before they start to lay eggs. Finally, it takes the gizzard 3 weeks to build muscle mass and the intent is for the hens to be able to grind the grain efficiently in this organ once egg production begins.

4. Do not feed vitamins or trace minerals in a separate feeder. Use the supplement as a source of these nutrients. If vitamins or trace minerals are placed in a separate feeder, some birds may not eat them because they do not like the taste while other birds may over consume them and suffer toxic side effects.
5. Give the bird's adequate feeder space. With a large flock, several feeders are required for each ingredient. For a 100-hen barn, two hanging feeders each of grain, supplement and limestone are suggested.
6. Purchase a supplement designed to be mixed with grain or grain and limestone (or oyster shell) to provide a complete laying hen diet. A supplement formulated in this way will contain 250–400 g crude protein (CP) per kg protein. A grower supplement may be used prior to the start of egg production but a layer supplement should be used once the birds start to lay.

Feed Grain for Poultry

Grain is the main energy source for poultry and comprises a large part of their diets. Grains are concentrated forms of energy (compared with grasses and forbs) and are needed to ensure a healthy productive flock. There are a number of ways to process feed grains for poultry: grinding, pelleting or whole. The simplest and cheapest (some members of the organic and natural communities think best) way of feeding grains is whole as no processing equipment is needed and poultry are perfectly adapted for grinding grain in their gizzards (Blair, 2008, Henuk and Dingle, 2002). There are a number of traditional feed grains used in poultry production and some of them are grown and sold in the Yukon. These include: barley, wheat, oats, maize, triticale etc. Blair (2008) explains that the main factor when choosing which grain to feed is local availability. As locally available grains are typically cheaper than imported grains, Blair (2008) advises that, as long as there is a good source of suitable local grain it is normally the most economical option. For example, the increased gains one might get by feeding maize instead of barley will be negated by the added cost/kg of production.

Grain legumes for poultry

There is increasing interest in developing northern varieties of grain legumes for poultry production in northern regions. Grain legumes are characterized as having high protein contents and good amino acid profiles for poultry development. Soybean meal is ubiquitously used as a supplement in all forms of poultry feed with good success, however, soybeans need a significant amount of heat to mature which northern regions do not possess. This has resulted in a renewed interest in developing new cultivars of grain legumes for northern climates.

Many of these developments are taking place in northern Europe and are showing a high degree of success. The grain legumes commonly focussed on are: field peas, sweet lupin, and faba beans.

These alternative feeds are also showing good results when trialled against the omnipotent soybean. In recent broiler performance studies conducted by Nalle et al., (2010), faba beans, white lupin and field peas were compared to a soybean meal and meat meal poultry feed. The inclusion rate was only 20% for this trial, however, at these rates broilers showed no deleterious impacts on growth and performance. In fact, performance on some of the alternative legume grains were shown to be improved (Table 77).

What was equally interesting, but for different reasons, is that weight gain per gram feed was shown to be better when meat meal was removed from the feed (Table 77).

Table 77. Performance of broilers as influenced by grain legumes and meat inclusion, 1-35 days post hatch

Legume	Meat meal	Weight Gain (g)	Feed intake (g)	Feed per Gain (g/g)
No legume	No	2459	3718	1.516
	Yes	2438	3738	1.538
Faba bean	No	2500	3687	1.497
	Yes	2431	3709	1.542

White lupin	No	2576	3861	1.523
	Yes	2495	3803	1.560
Peas	No	2548	3772	1.491
	Yes	2369	3694	1.582

Source: Adapted from Nalle et al., 2010.

There have been other studies (McNeill et al., 2004) showing "deleterious" effects of higher (more than 20%) inclusion rates of alternative legume grains. Perhaps deleterious is the wrong word, however, as the effects were simply lower weight gains when compared to the control group. This may not be a significant factor for Yukon producers as the feed costs associated with importation are very high. If lower performance is the result of feeding vastly cheaper feed alternatives that are produced locally, then perhaps the economics will still favour the local option.

Forages for Poultry

When feeding green forages to poultry there are a few important aspects to consider:

1. How much feed do free range poultry consume?
2. How well is the consumed feed utilized by the bird?
3. How well does the forage meet the nutritional needs of the birds?

Not a lot of research has taken place regarding these topics within mainstream poultry production, however, Danish researchers (Horsted et al., 2007) have investigated various aspects of poultry foraging within organic production. This research investigated how poultry utilized pastures when fed either a commercial feed mixture or a whole grain and oyster shell mixture. The forages consisted of grass clover pastures (*Lolium perenne and Trifolium repens*,) forb pastures (*Fagopyrum esculentum*, *Phacelia tanacetifolia* and *Linum usitatissimum crepitans*, which were expected to attract insects), or chicory pasture (*Cichorium intybus* cv. Grassland Puna).

The results of this research showed that poultry fed the whole grain/oyster shell diet ate less feed than poultry on the commercial feed diet, 129-155g/day vs. 89-92 g/day. The whole grain fed birds ate significantly more oyster shell than the commercial fed birds. Egg production for birds on grass/clover pastures was significantly lower than birds on the commercial feed diet, 0.75 vs. 0.91. For birds on the chicory and forb diets egg production was 0.83 eggs per hen per day. Of the forages tested in this study, chicory was found to be highest nutritionally and the most readily consumed by foraging chickens.

This research also showed that hens with a restricted nutrient diet, whole grain and oyster shell, greatly increased their intake of plant material compared to hens on the complete feed. The authors also showed that forage vegetation type does play a small role in the amount of forage poultry will consume. A better predictor of forage intake, however, is supplementary feed type; the authors found that by reducing the nutrient content of the supplemented feed (whole grains over commercial feed) the birds will naturally consume more forage and spend more time foraging (Horsted et al., 2007).

Another important consideration for free range birds is how forages affect egg quality; one of the important parameters for the consumer is yolk color which can be a richer darker yellow/orange on good forages (Blair, 2008). Egg yolk color was found to be much darker and richer looking from hens provided with chicory forage regardless of supplementary feed type (Horsted et al., 2007).

Recent evidence now supports the assumption that pastured hens have more nutritious eggs than confined layers. Grass fed chickens produce eggs with less cholesterol, more vitamin A and E, much higher Omega-3 content and a better ratio of Omega-3 to Omega-6 (Fanatico, 2010, Rybina and Reshetova, 1981, Davtyan and Manukyan, 1987, Karsten et al., 2010, Gorski, 2000).

In 2006, Horsted *et al*., conducted herbage removal experiments by laying hens in small plots. Supplementary feed for these hens was the same as the previously described study, whole grain (wheat) and concentrate commercial feed. Table 78 shows the estimated herbage removal by both groups of hens per day.

Table 78. Estimated herbage removal by hens in small experimental plots

Dietary Treatment	Herbage DM removed (g DM/hen/day)
Grass/Clover	
Wheat	17
Concentrate	9
Chicory	
Wheat	73
Concentrate	51
Source: Adapted from Horsted et al., 2006	

The herbage removal is far greater in the chicory plots that in the grass/clover plots and is much higher in the hens on the whole grain diet. Chicory fed hens also were able to maintain high egg production while not losing weight, hens fed grass/clover diets were unable to maintain weight and decreased in egg production. It is thought that because chicory has high levels of lysine and methionine, it makes a higher quality forage for laying hens.

In another forage study, this one by Steenfeldt, *et al*., (2007), laying hens were fed a layer diet and one of three forage supplements: maize, barley pea silage or carrots. Interestingly, hens fed the carrot forage consumed the most forage, produced the most eggs, had the lowest mortality and had the highest weight gains, Table 79 has the complete results.

Table 79. Production, body weight and mortality of laying hens fed a layer diet with or without supplements.

	Layer Diet	Layer Diet + Maize Silage	Layer Diet + Barley Pea Silage	Layer Diet + Carrots
Egg production (%)	89.9	91.4	87.2	92.0
Egg weight (g)	61.5	61.1	61.5	61.9
Feed/hen/day (g)	130.1	177.7	165.4	221.7
% silage/carrot	N/A	33.4	35.1	48.5
Body Weight (g)				
Start	1750	1742	1718	1726
End	1813	1787	1805	1917
Mortality (%)	15.3	1.5	2.5	0.5
SOURCE: Adapted from Steenfeld et al., 2007				

While data is still limited with respect to poultries use of forages the research available indicates that forages can be used to make up a significant portion of poultry feed. Because forage intake can be difficult to quantify, Blair (2008) recommends that an appropriate way to handle the situation is to "choice-feed" the flock on whole grain and supplements. By feeding in this way birds are able to adjust the amount of protein, energy and minerals they need from supplements according to those received by insects, soil and forages. If forages are supplemented with a complete feed, birds are not able to select from the feed the elements of nutrition that are lacking from the forage. For more information on choice feeding poultry refer to the section on poultry feed management.

Dietary proportion of forages for poultry

Even under the best circumstances forages can only make up a small proportion of poultry diets, however, the nutrients and minerals obtained are very important to poultry health (Spencer, 2013). In an analysis of available data, Mattocks (2002) found that pastured poultry can get 5-20% of their diet from pastures; this figure is dependent upon: bird age, bird type and quality of the available forage.

The nutritional benefits of forages is explained by Spencer (2013) in "Pastured Poultry Nutrition", he explains that forages are high in minerals, vitamins, fibre, protein and energy. Forages also provide the birds with important sources of compounds like carotenoids and Omega-3 fatty acids; these chemicals are important for metabolic function in animals and improve the nutritional value of the meat and eggs. Spencer (2013) adds that forages provide essential vitamins to the chicken's diet that are normally added to rations. Vitamins in rations can degrade over time (especially A, D, riboflavin and B12) and loose effectiveness, forage based vitamins act as a "back up bank of nutrition" which prevents vitamin deficiencies. Foraging birds are also exposed to high levels of sunlight which allows the birds to produce ample amounts of vitamin D (Spencer, 2013).

Allowing birds to forage also provides them with alternative sources of proteins and amino acids (AA). The most limiting AA in poultry feed is methionine (MET), this AA is chemically synthesized in most commercial feeds from petroleum sources and is largely absent from organic feeds (Fanatico, 2010). Organic growers can have a difficult time providing sufficient MET in their poultry diets without foraging. Foraging provides a source of fresh plant protein and, more importantly, protein from insects and invertebrates; insects and invertebrates are the natural sources for MET in ancestral chickens (Fanatico, 2010). Horsted et al., (2006) found that chicory was a readily consumed forage by poultry and had relatively high MET levels, 0.40%, chicory is considered an excellent forage for poultry.

Foraging behaviour of poultry

There are a range of factors that will determine the amount of plant matter consumed while a flock of birds is foraging. Several of these factors are explored by Spencer in the article "Pastured Poultry Nutrition" (2013) and are discussed below:

- *Species/Type* – Different breeds of poultry have different foraging habits and consumption rates. On two separate ends of the spectrum, geese are able to meet nearly all their nutritional needs with the vegetation they graze on, whereas modern broilers like the Cornish Cross can only make modest (though still economically and nutritionally important) supplements to their diet from pasture. Turkeys are voracious foragers, and will forage as a flock, forming a line and cleaning a pasture of insects, tasty forages, and seeds with almost military precision. Among chickens, laying hens forage much more than their meaty broiler cousins. Many pastured poultry farmers who have experience with both modern layer hybrids and heritage breeds of hens see little general difference between the two in terms of foraging, but quite a difference in feed conversion and production from the more modern breeds.

Additionally, producers notice variability in grazing ability from hatchery to hatchery, flock to flock, and even among individuals within the same breed (Salatin, 2001). Pousga et al. point to research that suggests genetics also play a role in chickens' ability and efficiency in balancing their nutritional deficiencies, at least in free-choice feeding systems (2005). They report that brown-egg layers seem to be able to adapt more readily to free-choice feeding systems than white- or tinted-egg layers. Within a flock, individuals show a range in their capability to select for their own needs, along the same lines as the experiences mentioned above.

- *Time of day* – Poultry are most active during the morning and evening hours. Of the two times, poultry are most active right before sunset (Dawkins et al., 2003). Danish research has found that laying hens with constant access to forage consumed the most vegetation prior to sunset (Horsted et al., 2007). The birds really prefer to fill up before they head off to the roost for a good night's sleep. Filling up their crops enables them to digest the seeds, feed, insects, plants, and other food items overnight. Likewise, the birds will be out foraging first thing in the morning, looking to get food into their empty stomachs, but not to the same extent as they do at night. Long-time pastured poultry producer and innovator Joel Salatin, with decades of pastured poultry experience under his belt, advised in the 1990s of the importance of providing chickens fresh pasture early in the morning, noting that "the birds' most aggressive grazing period is two hours pre-daylight, which occurs long before the sun rises. Every quarter hour we wait to move pens after daylight reduces the grazing time period. As the dew comes off and the day gets warmer, the birds begin lounging not because they have grazed their fill, but because physiologically they demand a rest period" (Salatin, 2001). The results of research and experience are clear: give access to forage in the morning and evening if you want to maximize forage utilization.

- *Experience* – It takes time for a flock of birds to adapt to new types of feed (Jones, 1986). Novel food types require time for the birds to figure things out. Some producers give their birds a head start by placing a tray of chopped forages daily in the brooder (lawn clippings work well). Others dig a chuck of sod and place it in the brooder for the chicks to investigate and pick through. Broiler intake is positively correlated with age (de Almeida et al., 2012). When broilers are first put on pasture, they may pick half-heartedly at forages or totally ignore them. This will change over time, but with the short lifespan of broiler chickens (as short as seven weeks), the sooner they get on pasture, the faster they learn that forages are food. Poultry raised in pens tend to learn faster than those in day-range-style systems because the birds feel a competitive drive to eat fresh forages before their flockmates gobble them up first. Laying hens seem to learn to eat forages faster than their broiler kin, but it must be remembered that meatbirds grow much faster than layers, and although their body size is large, they are still essentially chicks in terms of instincts and habits that they are developing.

- *Shade* – Shade/protective cover encourages foraging (Dawkins et al., 2003), most likely from the protective effect of shelters (Rivera-Ferre et al., 2007). Shade, whether from trees or shelters, especially encourages layers to roam. Chickens originated in the jungles of Southeast Asia, and turkeys in the hardwood forests of Eastern America. Staying hidden under tree or plant cover seems to afford the flock an instinctive sense of protection from predators (a false sense when it comes to hawks!). Brightly lit, open areas are one of the least desirable habitats for most poultry, and for centuries farmers have noticed that poultry will often overgraze the areas immediately surrounding their housing even if undergrazed forages are available just a little further away.
- *Height of forage* – Poultry like their forages relatively short. Virginia producer Joel Salatin prefers forages under four inches (Salatin, 2001) but ideally around two inches.

Before his birds get to the pastures, he grazes ruminants until the pastures are the preferred height for the birds (Salatin, 1996). Meanwhile, Oregon producer Aaron Silverman prefers a sward height of six to eight inches for his chickens (Silverman, 2000). Producer and research observation have noted that chickens go for shorter forages over longer plants when given the choice (Horsted, 2006). Turkeys do not seem to be nearly as picky, eagerly ingesting long strands of grass either in pieces or whole, like slurping noodles. It is worth considering, though, that forage height usually correlates with palatability, as younger, more succulent plants tend to be shorter.

Forage palatability and poultry

There are a number of factors that will affect the palatability of forages consumed by poultry. The two main characteristics that determine palatability are plant species/variety and stage of growth.

Many plants have chemical compounds that will either deter or encourage consumption by poultry. There are some generalities when selecting forages to plant, legumes and soft young grasses are normally readily consumed, however, some trials might be necessary to select specific varieties your flock prefers (Spencer 2013).

Because foraging poultry has largely been abandoned in the last 50 years and is only recently becoming more common, finding information on specific forages can be difficult. Specifics on poultry forages exists in old texts and journals and some good information can be found there. In the 1955 manual "Feeding Poultry", Heuser has this advice for pasturing birds:

> "For poultry pastures, plants capable of forming a dense, hard wearing, and lawn like turf are desirable. Wild white clover and ladino clover are suitable legumes. Grasses suitable for poultry turf are perennial rye grass, meadow grasses, the fescues, creeping bent, and crested dog's tail However, poultry does not like the plants after they have become aged and woody and will then only eat them as a last resort. Turkeys prefer ladino clover, but other grasses can be satisfactorily used for grazing."

Pastured poultry producer, Aaron Silverman, has developed a pasture blend that works well for his operation, he raises 13,000 broilers outdoors in Oregon. The blend that he plants is a combination of palatable clovers and persistent grasses these include: orchardgrass, perennial ryegrass, tall fescue, annual ryegrass, subclover and New Zealand white clover (Silverman, 2001).

As with the other forages we have discussed thus far, stage of growth is an important factor for consideration; even if all the right forage species are planted but become too old and woody, poultry will not consume them. Forages that stay tender and nutritious for a longer duration are preferred to faster maturing varieties. Clovers and legumes stay palatable for a longer period of the growing season compared to grasses, this is another reason they are recommended as poultry forage. When grasses become stemy later in the season, frequent mowing with either machinery or ruminants will help to prolong its palatability (Heuser, 1955).

Insects and invertebrates as forages

For many bird species, insects and invertebrates make up an important part of the diet and it's no different for pastured poultry (Spencer, 2013). In nutrition studies, researchers have found that insects and invertebrates contain four times the usable energy and protein (for chickens and other poultry) as compared to poultry rations (Bassler, 2005). They also contain higher levels of essential amino acids like methionine that are commonly lacking in forages and organic feeds.

Many of the insects targeted by poultry, crickets and grasshoppers, can be significant pests in pastures. They can feed on the most nutritious plant parts and significantly reduce biomass, pastured birds are able to turn this pest into a high value forage (Spencer, 2013).

Existing and establishing pastures

According to poultry pasture expert, Joel Salatin (1996), utilizing existing pastures, as opposed to planting new pastures, has a number of benefits for poultry operations. The mixture of grasses, forbs and legumes in established pastures are there for a reason, they are adapted to the soil, moisture and microclimate of that pasture. Adding poultry will only increase growth, through manure fertilization, and diversity of plant species through selective grazing. Existing pasture is also cheaper than establishing new or poultry specific pastures, they typically need little maintenance and are made up of a hardy assemblage of plants. They also have an existing insect and invertebrate community that the birds will enjoy (Spencer, 2013, Salatin, 1996). For producers starting out in poultry production, both Spencer and Salatin recommend first using existing pastures, this will reduce input costs and avoid costly mistakes if improper seed is selected and sown.

In instances where new pastures need to be created from forested lands or old weedy pastures need to be rejuvenated, there are a couple of strategies to consider. From his book, "Profitable Poultry Production, published in the 1920's, Kains describes planting poultry specific pastures like this:

> Oats and peas sown together very thinly with a liberal seeding of red clover and a very little rape make a good combination. The oats and peas furnish a rapid growth of green feed. Much of it will get tramped down and some go to seed, but will serve to protect the clover and the rape, which will make good feed late in summer and fall. Three pecks of oats, two of peas, a pound of rape and 5 quarts of red clover seed make a good proportion for sowing an acre. The oats and peas should be first harrowed in deeply, then the clover and rape sown mixed and lightly scratched in. (Kains, 1920)

Considerations Regarding Poultry Type and Breed

For northern poultry producers, perhaps more so than for other producers, choosing the bird type that will best utilize the resources available on your farm can be a challenging proposition. With many options, chickens, ducks, turkeys, geese, etc., and each option having a variety of breeds to choose from, the decision making process can be difficult. However, because of this vast range of choices, there is a very good chance that there exists a breed and strain of poultry that is right for your production system. This section will discuss some of the key features of each poultry group as well as provide some insight into breed selection.

The vast range of poultry breeds available possess a variety of growth, and productivity characteristics that correspond to their differing feed and diet requirements. Most modern strains of poultry are bred for large scale production and highly specialized feeding systems (Blair, 2008). Many of these new strains are not suitable for smaller scale, hybrid (combining a variety of feeds such as: commercial feeds, kitchen scraps, forages) productions systems. For these reasons, small scale and organic producers, find "traditional", "heritage" or "unimproved" strains of poultry more suitable (Blair, 2008).

Laying Chickens:

The most popular and abundant form of poultry in the world are chickens. Through domestication and careful selection, chicken breeds have become specialized to perform two distinct tasks: egg production and meat production.

In North America, white eggs come from strains of Single Comb White Leghorns and brown eggs come from strains developed from a cross of Rhode Island Reds and Barred Plymouth Rocks (Blair, 2008). These strains have been developed for high egg production and good feed conversion rates, best performance occurs when these birds are housed in cages. Selection of behavioural characteristics favourable to caged production has reduced the ability of these strains to properly forage in a natural setting (Blair, 2008). Predator detection and avoidance in these types of birds has also been shown to be compromised (Blair, 2008).

Producers allowing access to the outdoors and to forage as part their feed management system might have better results with a less modified strain. There exist numerous resources, both online and in print (available at the EMR library) which discuss the various heritage breeds and list their particular traits and characteristics.

Meat Chickens:

Meat chickens differ from layers in growth rate, feed conversion efficiency and size. Conventional meat birds, such as the white-feathered Cornish Cross, have been selected for very rapid weight gain at a young age which has resulted in faster production cycles and theoretically more profit for producers. These types of bird do best in a closed production system where climate and nutrition are closely monitored and exposure to pathogens are minimized.

This rapid development has some negative consequence associated, measured increases in incidences of ascites (water belly), sudden death syndrome, immune disorders and increased skeletal abnormalities are noted in these strains of birds (Emmerson, 1997). In a research paper by Deeb et al., (2002) investigating high performance broilers grown in suboptimal conditions, i.e., free range and organically, they found that the incidence of ascites and sudden death syndrome increased in cooler conditions.

For producers wanting birds that adapt to a more versatile production system, (a production system which combines commercial feeds with locally produced feeds, scraps and forages) there are hardier and slower growing strains to consider. While these strains cannot claim the same high production yields as Cornish types, they still perform well (Blair, 2008). These birds will gain weight on a variety of feeds, and under free range/organic production systems while suffering lower rates of health related problems (Blair, 2008). Productivity of these birds will be lower and feed conversion will be less, however, due to the marketing benefits of "free range", "natural", and "organic", these lower rates of production are often offset by higher market price.

For many smaller scale producers, as well as some larger scale organic producers, the dual-purpose chicken breeds are best adapted to a varied diet and a range of environmental conditions. These breeds also retain some ancestral characteristics necessary for foraging and predator avoidance making them excellent candidates for free range production systems. These breeds have much lower incidence of health related problems, however, develop much slower and do not reach the same weights as the higher performance breeds (Blair, 2008).

Some of the more common dual purpose breeds include: (list adapted from Blair, 2008)

- *Rhode Island Red*. This popular breed has been used to produce many cross-bred varieties available today. It is a good producer of large brown eggs and is quiet and easy to handle. Both males and females have dark red plumage. At the end of lay the hens weigh approximately 2.5 kg.

- *Barred Plymouth Rock*. This is another heritage breed and is still used in some countries because of its good meat qualities, combined with good production of brown eggs. Both hens and cockerels are grey-barred, the hens weighing 2.5–2.75 kg.
- *New Hampshire × Barred Rock*. This cross is from two of the oldest heritage breeds and produces a very hardy chick. The birds are reported to be very quiet, with an attractive plumage. The hens have a red comb and a jet-black body laced with brown on the neck and breast. They lay brow shelled eggs and reach about 2.75 kg at the end of lay. Males have dark coloured bars.
- *Rhode Island Red × Columbian Rock*. This bird is reputed to be a very hardy dual-purpose breed and has had excellent performance in small flocks over the last 30 years. The pullets are reddish-brown in colour, very quiet and easy to handle, and have a body weight of about 2.75 kg at the end of lay. The eggs are rich brown in colour, with good shell texture and interior quality. The cockerels are white with black markings.
- Other dual-purpose breeds developed by large breeding companies include the Shaver Red Sex-Link and the Harco Black Sex-Link, which is reported to be one of the best producers of large brown eggs.
- *Chantecler*. This breed was developed in the Canadian Province of Quebec to be used for both egg and meat production in the Americas. A small comb and wattles allow this breed to withstand the cold

Eastern Canadian winters without the problem of frostbite. In addition to being very hardy, the breed is noted for being an excellent layer of brown eggs and has a fleshy breast. It is also noted for being calm and easy to manage. Like several other heritage type poultry the stocks are critically low.

- *Favorelle.* This is a white-skinned chicken that was initially developed in France as a dual-purpose breed. It has excellent laying qualities and its performance does not change much with the different seasons. Favorelles are hardy and active and adapt easily to free-range systems.

When selecting the breed of chicken to raise, typical advice recommends talking with other poultry producers local to you. These producers will likely have considerable knowledge regarding what does and does not work, which breeds do well and which don't.

There are some general recommendations regarding selecting chicken breeds for northern growing and these were found on akchickens.org, a site for chicken enthusiasts in Alaska.

The author of the site advises that larger, robust birds with thick feathers are a good choice, as well, birds with small combes and wattles are less prone to having these parts frostbitten.

Turkeys:

Turkeys have had a similar domestication experience as chickens, however, it has happened much more recently. Until European contact, turkeys remained in a wild state in much of North America. Domestication has altered turkeys in much the same way that it has changed chickens, breast meat contributes much more to the overall mass of the bird, and white meat (70% as opposed to 50% in heritage breeds) is a larger component as well. Commercial strains of turkey are typically ready in 3-4 months while heritage birds are ready in 7-8 months (Blair, 2008).

Traditional breeds are quite good at utilizing a varied diet including pasture forages and insects, they are slower growing, hardier and less prone to disease (Grimes, et al., 2007). For these reasons, traditional breeds would likely perform better in a forage based production system over more commercial stock (Grimes, et al., 2007).

Heritage turkeys are well adapted to utilizing pastures and will do well foraging on a mixed stand of grasses and legumes. Legumes are an important part of turkey pasture, especially for the young developing birds as they need higher protein levels for healthy growth. Rations are typically fed along with the pasture to ensure sufficient energy, protein, mineral and vitamins are present in the diet (Grimes, et al., 2007).

Waterfowl:

Domesticated waterfowl can provide a range of products and services on the farm, these can include: meat, eggs, herding, weeding and guarding (Blair, 2008).

The type of waterfowl chosen will reflect its intended end use. Domesticated waterfowl typically is limited to ducks and geese.

Ducks have been bred for meat production (Muscovy, Pekin, Rouen) as well as egg production (Khaki, Campbell, Indian Runner). Ducks are relatively good foragers, however, some literature recommends that a grain supplement is provided year around (Blair, 2008). Peking ducks can grow rather rapidly reaching weights of 3.2 kg in seven weeks (Blair, 2008).

Ducks also come in a dual-purpose breed producing both large numbers of eggs and meaty frames. Some breeds are: Aylesbury, Cayuga and the Maya (Blair, 2008). As with chickens, dual-purpose ducks will not produce as much as single purpose breeds, however, they are typically hardier.

There is not a great deal of information regarding ducks and forages, most of the literature states that they are "good foragers" however good is rarely quantified. There are some articles on the internet which discuss duck foraging in slightly more detail, but this is mostly anecdotal. These resources make reference to the limited amount of available information regarding raising ducks in small quantities, possible forages, and the lack of duck specific information. Here are some specifics that were found pertaining to small scale duck production. http://agroforestrysolutions.blogspot.ca/2012/05/ducks-are-not-chickens.html).

> **WATER - they need lots!**
>
> We've found that our ducks are happiest when they have access to a water fountain in addition to a small tub they can bathe in. While not essential to their survival, the pool clearly makes them love life. Since ducks root around in the ground,

they need water they can submerge their heads into to clean out their nostrils. This is why the water also gets really dirty quick. I've realized there is a difference between sorta dirty and this-needs-changing-now dirty. It's better to use a small tub and change more often than try and get away with

FORAGING - they are real good at it.

Ducks are incredible foragers. The few books out there claim that some breeds may be able to forage for almost 100% of their own diet. We've certainly noticed a reduction in feed costs vs. chickens for mature birds, though this is at best anecdotal. The research I'm doing this year will determine how much we actually feed, and we'll actually see if the difference is as much as we think.

BURROWING vs. TILL & SCRATCH

Probably my favourite aspect to their foraging is that ducks don't till/scratch like chickens, but instead burrow into the soil with their beaks. This means that while they can remove seeds and insects as they forage like chickens, they don't turn over and decimate the soil. In fact, I think the rooting promotes healthy aeration of the soil, without destroying its structure. This quality also means that ducks can be grazed in forested settings, as they won't destroy the leaf cover and understory like chickens would.

HOW THEY EAT - they swallow food whole

Unlike chickens, who will peck at things for hours and pre-digest food in a gullet before swallowing, ducks take their food whole. This is a VERY significant difference because it means that ducks can be used in agricultural situations as a pest control while the plants are growing. Only the tender greens and shoots will be tempting for ducks. This is a big difference to chickens as they are often useful to the garden at the beginning and end of the season, but never during, as they'll annihilate a garden in short order.

DISEASE & COLD TOLERANCE

Ducks are extremely disease and cold tolerant; we don't have to concern ourselves as much with mites or foot rot or anything of the like (as long as the bedding stays clean) and the cold tolerance is key; duck houses don't need to be heavily insulated come winter and ducks are happy to get wet and dry out, whereas chickens can easily get cold and need to be kept dry.

Geese:

Domestic geese are primarily used for meat production and down production; little attention to breeding has been done to develop strains for egg production (Blair, 2008, Buckland and Guy, 2002). At least one attempt has been made to develop a goose strain specifically for egg production. In 1991, a report was issued following an 8 year breeding program attempting to develop a goose strain with higher egg productivity (Shalev et al., 1991). The results were not great, the new line of geese produced roughly 11.1-13.6 more eggs per year than the control.

The main reason for lack of interest in geese eggs is due to their extremely high levels of cholesterol and fat making them unhealthy choices for human consumption (Blair, 2008). For these reasons, no special diets are suggested for goose egg production or goose down production.

Geese may prove to be good choices for operations looking to produce poultry using mostly forages; they have an ability to consume green forages and crop residues. However, due to a lack of research, there is little knowledge about how well they utilize these feedstuffs (Blair, 2008).

An article from the University of Minnesota Extension on small farm geese production also acknowledges the excellent foraging ability of geese. High quality pastures and clippings can be provided to the geese as early as within the first week. Once the geese become a little older, forage consumption increases and by 5-6 weeks of age a good deal of ingested feed is coming from forages. The document also states that geese will select forages such as clovers, bluegrass, timothy, and brome grass and should avoid mature dried pasture. Silages also make good feed for geese. Given good pasture conditions, geese can be stocked at rates of between 20-40 birds per acre and once geese are established on pasture, they can remain there, un-supplemented, for the duration of the grazing season. Geese to be finished are recommended to go on a turkey finishing ration for the final 3-4 weeks before processing (Hamre, no date).

Most geese are raised for the holiday market in the late fall, they are typically harvested at 5-6 months of age so will need to be started in May or June. Geese grow very rapidly (fastest initial growth rate of any bird kept for meat production) between hatching and 13 weeks of age and are sometimes harvested early as growth slows dramatically after 13 weeks (Hamre, no date).

Geese life cycle corresponds to peak forage production making them ideally suited for sustainable animal production systems (Buckland and Guy, 2002). Of domesticated poultry, geese are uniquely capable of ingesting and utilizing high amounts of fibrous forages and feeds (Buckland and Guy, 2002). Geese have a specialized digestive tract that enables them to do this; organs such as a large muscular proventriculus and extremely well-muscled gizzard (which produces much more pressure than both ducks and chickens) allows the breakdown of plant matter into extremely small components. The action of the goose gizzard releases cell contents (which is not released in most monogastric digestion) from the forages for increased efficiency. Microbial breakdown of fibre is also highly developed and happens in the caeca and large intestine of the goose. These combined factors allow geese to digest up to 30% of the acid detergent fibre in feeds (Buckland and Guy, 2002).

For a range of reasons, domesticated geese appear to be a good option for producers looking to raise poultry in forage based production systems. Geese, more so than other poultry, are able to use fibrous forages to good effect from about one week of age till harvest. Geese gain weight faster than any other form of poultry and do it on a relatively simple diet. Add to this the fact that geese make difficult prey for predators and can act as guardians to other more accessible livestock. Geese also produce down, further diversifying a farms income stream. Geese are hardy creatures and are able to sustain colder temperatures than chickens.

Yukon farmers looking for a hardy and lower-input form of poultry would do well to consider goose production. This said, however, it would be critical to develop a local market for goose meat and related products prior to heavily investing in this species.

Feeding and Temperature

Temperature is another significant factor to efficient utilization of feed. With higher environmental temperatures, birds require less energy for maintenance and consequently reduce their feed intake and feed costs (Church, 1991, Blair, 2008). The thermo-neutral zone for chickens is between 18-24°C, this is the ambient temperature range that chickens are able to thermoregulate within without having to adjust their metabolic rates. At temperatures above this range, chickens must reduce feed intake to lower body temperature, this can reduce weight gain and egg production. At temperatures below this range chickens must increase feed intake in order to maintain body temperature. Feed intake increases by a rate of 0.12% per degree Celsius of temperature drop below 18°C (Howlider et al., 1987).

Temperature of chicken housing is an important consideration for northern producers as colder temperatures will require higher feed rates for poultry. When birds are fed ad libitum they will simply eat more in colder weather. If birds are being fed rations they will be eating more of a complete feed, however, research has shown that this is not the most efficient method of feed utilization in these conditions. In colder temperatures birds should be provided with higher amounts of fibre and roughage (i.e., forages) in their diets, the breakdown of which helps to keep the chickens warm (Blair, 2008). Blair (2008) recommends that in cold weather when birds are increasing their daily intake of feed the relative proportion of protein, amino acids, and micronutrients can be reduced. For instance, if gross feed intake increases by 15% in cold weather, then the concentration of protein, amino acids and micronutrients can be reduced by 15%. This seems counter intuitive as one would assume that the birds would need more of all nutrients, however, it turns out that they only need more of some nutrients like roughages and energy (Blair, 2008).

Chicken Feed System Summary

While there is no perfect feeding system that will work for every producer in our region, some systems seem to work better than others. Based on the local availability of feeds and supplements, combined with the scale of local production systems, a feeding method using a combination of free-choice-feeding and free-range foraging makes the most sense both in theory and in practice.

When practiced on small scale farms, this combination of methods is the most nutritious, least expensive, most adaptable and provides the highest quality of life for the birds. This method of feeding allows poultry to adapt their supplementary intake to changing environmental conditions and to changes in available forage. This method allows producers to utilize whole grains grown locally or on farm, the poultry improve pastures with manure, control weeds and control insect pests.

With proper marketing the products produced with this feed management system (eggs and meat) will have a higher market value and higher returns for the producer resulting in a more sustainable production system.

For more information on organic poultry production or the free-choice-feeding system read "Nutrition and Feeding of Organic Poultry" by Robert Blair (2008).

Hogs

Pork production in the Yukon is a small industry. In most cases, weaner pigs are brought up in the spring from down south, fed on farm all summer and butchered in the fall. In the 2011 farm Census, there were seven farms reporting to raise pigs and they collectively butchered around 56 animals. This is down from the previous census which reported 160 hogs from seven farms. Although there is no published data at this time, it is speculated that hog production has increased since the 2011 census. In the 2008-2009 State of the Industry Report one of the reasons stated as being a barrier to increased production was the high cost of imported feeds (Ball et al, 2010).

Digestive System

Pigs are digestively described as omnivorous monogastrics; this means they have a single stomach and are able to digest a variety of feed stuffs including: fibrous plant matter, nuts, grains, seeds, fruit etc. They are not as efficient at digesting low quality feed as ruminants but are better at it than poultry. Pig digestion and weight gain is optimized on a diet of rich grains and high protein feeds. If pasture is used as the primary source of nutrition for pigs it must be excellent pasture, if not, productivity will be compromised (Blair, 2007). In the wild, pigs rely on a varied diet of roots, nuts, fruit and some forages, however, this is not considered economical for commercial operations as it requires a large amount of foraging space and a diversity of forages (Church, 1991).

Pigs have a single stomach and (compared to a ruminant) a relatively simple digestive system. They do not have the digestive capacity of a ruminant and thusly cannot utilize bulky fibrous feeds or synthesize necessary amino acids and vitamins. Pigs need to ingest a well-balanced, high quality and low fibre feed in order to reproduce and gain weight (Blair, 2007).

Nutritional Requirements of Swine

Information on pig nutritional requirements is widely available and covered in exacting detail for all life stages of various pig breeds. For detailed information on pig nutritional requirements see: Nutrition and Feeding of Organic Pigs by Robert Blair, 2007, Livestock Feeds and Feeding by D.C. Church, 1991, or the NRC publication, Nutritional Requirements for Swine.

These guides give the general nutritional requirements of pigs at a variety of life stages and production levels. These tables are fairly useful for larger operations where feed is custom ordered to meet the specific needs of a cohort of pigs. For smaller scale producers, these tables are often confusing and of less importance. Small scale produces tend to provide a more diverse assortment of feeds to their pigs; in addition to forages, grains and supplements, this can range from: excess or lesser quality market garden produce, kitchen and table scraps, restaurant scraps (even donuts), damaged produce form grocery stores and spent grains from breweries. These food sources are generally included in an attempt to reduce feed costs and increase nutritional diversity.

This is not to dismiss the nutritional needs of pigs; pigs require a varied diet which provides all the essential amino acids, minerals, vitamins and energy needed to grow and remain healthy. For smaller producers, a more useful indicator of adequate nutrition is often by assessing performance. If pigs are meeting management objectives, i.e., weight gain, reproduction, etc., then the nutritional value of the feed is likely sufficient.

Feed Management Systems

Conventional Feeding

Conventional feeding of swine consists of providing premixed feeds (total complete rations) to pigs in confinement pens. This method of feeding results in a uniformity of product and maximization of production. This method of production works well in areas with large amounts of cheap feed. These formulated feeds primarily consist of a grain base, barley or corn, for energy and a protein source such as soymeal. These feeds also contain necessary minerals and vitamins for optimal growth and production.

This system of feeding has several hurdles for adoption into a Yukon production system. Some of these include:

- Yukon producers generally have a holistic view of animal production where access to the outdoors and natural forages are highly valued
- Consumers of Yukon raised meat are concerned with animal wellbeing and quality of life, producers not aware of this may find moving product that has been raised in a conventional manner difficult

- There are few cheap feeds available to pork producers in the territory (like spent grain and manufacturing by-products) increasing reliance on total mixed rations which are expensive
- Feed is normally imported in large quantities (enough to last the season) in order to reduce shipping costs; vitamins in feeds stored for long periods can begin to degrade impacting performance and yields.

Considering the aforementioned factors, an alternative form of feeding may be better suited to Yukon conditions.

Forage based Feeding

Except for the past 60 years, forage based feeding systems and pastures were considered vital for successful pork production. Starting in the 1950's synthetic vitamins became available, grains became cheaper and efficiency became paramount. During this time pastures and forages fell out of favour while confined feeding and concentrated feeds became common (Kephart et al., 1990). Prior to the 1950's, pork producers could not have considered a feed management system that didn't include some form of pasture; this is because synthetic vitamins were not yet universally available (Kephart, 1990).

> ***Forages and Protein for Pigs***
> *When using forages as part of your pig's diet it is important to note that proteins found in forages are less available to the pig. Increasing the relative concentration of protein in the ration may be necessary to account for the lower volume of consumption.*

Pasture Based Forages

Pigs are able to better utilize forages and pastures than is conventionally thought. With the right adaptation period, about two months, pigs are able to digest an increasing amount of fibre as they mature (Shurston et al., 2002). The adaptation period allows the gut to alter so that it can properly digest the increased fibre intake (Shurston et al., 2002).

There are a number of reasons that producers would want to consider forages as part of a feed management plan. Perhaps most important, access to forage allows pigs to engage in foraging and rooting behaviour, which is essential to ensuring pigs have a good quality of life. Providing forages can also result in significant cost savings for the producer; access to forage reduces the intake of grains and protein supplements which can be as high as 75% of total cost of production in many conventional pork operations (Church, 1991).

In order to see any benefit of providing forages to pigs, forages must be of high quality and nutritionally dense. Young forages are more nutritious and more easily digestible than older forages and these should be used whenever possible. When providing forage for pigs this is especially important to pay attention to as pigs have a much lower capacity for fibrous feeds than ruminant livestock. Pig performance will be improved, utilization will be higher, and intake of rations will be reduced when young forages are provided.

Age should be considered when determining how much forage pigs will consume and how much supplementation to provide. For example, when feeding high quality forages, gestating sows can graze *ad libitum* (at liberty) without adverse effects on weight gain or reproduction. Sows have also been shown to be more content with a forage based diet, they store less fat which reduces the need for restrictive diets, and it reduces constipation (Blair, 2007).

Simplifying feeding and nutritional management is another advantage to foraging pigs; pigs consuming complete feeds need to have the feed portioned out, this makes it difficult to ensure each pig gets the correct amount of feed. Foraging pigs can feed *ad libitum* (at liberty), assuming sufficient forage is available, all pigs should get the necessary amount of feed (Blair, 2007).

When raising pigs on pasture based feeding systems, Kephart (1990), recommends providing pigs with a complete feed as well. He suggests sows get 2-3lb. of complete feed per day and growers and finishers have free access to a complete feed.

Kephart (1990), also stresses the importance of engaging in pasture management, ploughing, disking, and re-seeding, every few years in pastures frequented by pigs. This reduces parasite loads, levels the pasture and rejuvenates plant growth. He also recommends that producers in northern latitudes allow perennial legumes to grow at least 6 inches tall prior to a killing frost, this reduces winterkill, stores more reserves in the roots, and enables rapid, robust emergence the following spring.

There are some drawbacks to pasturing pigs: much more space is needed for pastures, high degrees of wastage can occur, pastures are unavailable for much of the year and pastures must be rotated if bacteria and parasite contamination occurs (Kephart et al., 1990). Another drawback to pasturing pigs results from the increased amount of energy expenditure spent on foraging and rooting behaviours; while this increases quality of life, it reduces daily weight gains and feed conversion efficiency. For many, this reduced conversion efficiency is offset by: the reduced costs of feed (forages are typically cheaper than total mixed rations), the higher price that "free range" labelling demands in the marketplace, and the knowledge that the livestock are getting the highest quality care.

Sources of Protein

Because pigs are monogastrics, like chickens, they need to ingest all essential amino acids from their feed (Blair 2007). Unlike ruminants, monogastrics are unable to synthesize amino acids in their digestive tract; this results in a more complex feed management system to ensure pigs obtain adequate nutrition.

In the Yukon, protein is commonly the most difficult nutritional element for producers to source or grow locally. Most high protein supplements for pig diets are by-products of soybean, canola or fish manufacturing. These products are not grown or processed in the Yukon making importation necessary. In free range pork production, producers will rely heavily on crops like alfalfa and clovers for protein while at the same time providing some supplementation to make up lacking nutrients (Blair, 2007).

It is common for annuals to be used as pig forage as well: pulses, cereal grains, oil seeds and brassicas are all used with good effect. In most cases, however, in order to obtain high yields, minerals, grains and sulphur-containing amino acid supplementation is typically required.

Of the annual forages suitable for both the Yukon's climate and as a source of protein, field peas look to be one of the best options. Field peas are a high protein crop and make decent pig feed (Osland and Morton, 1931, Stein et al, 2006). Field peas are also high in easily digestible carbohydrate which reduces the daily requirements for grains.

There are a number of northern hardy pea varieties available and several have recently been trialed in the Yukon. As discussed in the section on northern crop development, pea trials by the Yukon Agriculture Branch showed good forage yields and decent seed maturity. These result are promising and could lead to an affordable local source of high protein feed (refer to "Field Pea Trials, Yukon Research Farm 2010-2012" for more information).

Within the literature, there is some debate over acceptable inclusion rates of peas into pig diets. This debate revolves around how much to include and at what developmental stage; inclusion rates are typically reduced for younger pigs and increased for growers and finishers. In a recent paper investigating the inclusion rates of field peas as a replacement for soybean meal in pig feed, the authors concluded that field peas can replace all of the soybean meal in diets fed to finishing and growing pigs without negatively impacting pig performance, carcass composition, carcass quality or meat palatability (Stein, et al., 2006). Field pea inclusion was as high as 66% of the total diet, completely replacing the soybean meal. This is good news for Yukon producers looking to offset some of the feeding costs associated with imported, high cost grower and finishing feeds. The option of producing on-farm high protein feed could considerably reduce input costs for pork producers.

Silage and Haylage

There is little information pertaining to feeding pig’s haylage and silage, the information available indicates that feeding of silage should be limited to gestating sows or gilts, and that it should be supplemented with approximately 1.25kg of concentrate per day. It is also recommended that silage be chopped to prevent sorting by sows and to ensure good utilization rates (Blair, 2007, Kephart, 1990).

The available information regarding feeding pig's silage was limited to silage made from corn and legumes. Silage made from grass hay (haylage) was not covered in the available literature so gain results are unknown. Considering that haylage typically has a lower feed value than silage, it may be assumed that pig performance would be lower than when fed legume/corn silage. Again is would seem probable that haylage (if fed at all) should be limited to replacement gilts and non-lactating sows.

Determining the Economics of Forages for Pig Diets

It can be difficult to evaluate the savings associated with adding pasture into the feed management of pigs. There are a number of difficult to calculate factors such as: how much forage are the pigs consuming, what is the feed value of the forage, how much complete feed is the forage offsetting? There are some approximate values used to determine these utilization rates, however, they are approximations and are by no means hard facts. In the Extension Services document by Kephart et al., 1990, called "Forages for Swine", forages are calculated to offset 3.5 lb (1.6 kg) of complete feed/day for sows and 0.75-1.0 lb (0.34 - 0.45 kg)of complete feed/day for growing pigs.

The tricky part comes in when you have to calculate the cost of owning and maintaining pastures. For example, if we assume the annual costs to own and maintain perennial pasture is $500/ha/year, each ha of pasture can support 10 sows and each day the sows are on pasture it offsets 1.6 kg of commercial feed per head per day. The sows are on pasture roughly from June to August for a total of 100 days.

This means that $500 (ha/year)/100 days on pasture = $5.0/day

There are 10 pigs on each ha so $5.0 (pasture cost per day/ha)/10 (sows per ha) = $0.50/day/sow. If pasture is offsetting 1.6kg/day of commercial feed we then divide $0.50/1.6 kg/day = $0.31. To make utilizing pasture profitable, in this hypothetical situation, the cost of purchasing commercial feed needs to be more than $0.31/kg.

The actual annual cost of owning and maintaining pastures will vary by farm. The figures presented here ($500/ha/year) was made up for use as a reference only. To determine if pasturing will offset any costs on your farm, calculate the pasture ownership costs and substitute it into the formula, then calculate an acceptable stocking rate (head/ha) and do the calculation.

In many cases determining the economic component of pasturing pork will be irrelevant. For many smaller producers, providing pasture access, is an integral part of ensuring a high quality of life for their pigs superseding any economic justification.

When discussing pasturing economics, it would be remiss to overlook the marketing advantage offered by producing in a more natural production system. In recent years, the terms "pasture raised" and "natural" have gained in consumer awareness, resulting in these products demanding a higher price point in both farm gate and grocery retail locations. Add to this, recent studies linking healthier fatty acid profiles in pasture raised meat, and you have a pretty clear marketing advantage (Schmutz et al., 2014, Kalac, 2011, Wood et al., 2007, Noviandi et al., 2012).

Pig Feeds

In this section feeds are listed according to its suitability as a feed source. Only feeds capable of growing and maturing in Yukon are addressed. It should also be noted that within the literature alternative feeds are, compared to, and evaluated against, a perfectly balanced formulated ration. This does not mean that a specific feed is not good if it gets a poor review, it only means that weight gain and performance was not as good as animals fed rations. In almost all cases, feeds listed are combined with a high protein supplement and necessary vitamins and minerals prior to being used as feed.

In the US (and Canada), 85% of the protein supplied to pigs comes from soybean meal (Blair, 2007). In Yukon, we lack a local protein source that is comparable to soybean meal, however, several alternative options are investigated that are used in comparable jurisdictions.

Throughout most of history pigs were fed what grew regionally, what was available and what was in season. They were fed scraps of all kinds, they foraged for nuts, fruits and whatever else they could find. These pigs matured, bred and had litters, gained weight and were harvested. These historic pigs would not have had the same production values as today's pigs, however, they survived, thrived and produced meat and offspring. I mention this for two reasons: firstly to remind readers that growing animals is not as complicated as some might have you believe; for example, in small scale production, calculating lysine levels in gestating sows is likely unnecessary. Secondly it is important to consider the wellbeing of the animal as well as the growth performance. Providing pigs with a hectare of turnips might not have the same performance returns as feeding rations, however, it supports healthy foraging activity, provides a cheap source of energy, and utilises some land.

Grain Feeds for Pigs

Barley

Throughout the temperate world the most widely grown grain is barley (Blair, 2007). In Canada it is grown predominantly as a feed grain, with higher grades used for malting. Barley makes an excellent grain for pig feed and in North America, Europe and the UK it is the principal feed base for pigs (Blair, 2007). Its adaptation to cool dry (2 row varieties) and cool wet (6 row varieties) conditions make it a good choice for northern agriculture. Not only is barley a good agronomic species for the north, it also results in firmer and leaner pig carcass than other (corn based) diets.

Barley Facts

-barley is classified as 2 row or 6 row depending on the kernel arrangement on the plant.

-2 row barley is adapted to dryer growing conditions and 6 row is adapted to wetter conditions.

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The nutrient profile of barley can be variable and it is important to have feed tested. Barley can range in protein from about 9 - 16 %; barley has a good amino acid profile and bioavailability of amino acids is high (Blair, 2007).

Pig Terminology

- Barrow - castrated male

- Boar - mature male pig

- Farrow - to give birth or a litter of piglets

- Gilt - female that has never been pregnant

- Shoat - a young weaned pig

- Sow - mature female

Because of its high fibre content, barley is less usable by young pigs but is well suited for sows and finishing pigs. Several studies (Newman and McGuire, 1985; Graham et al., 1989) have found that by fine grinding and pelleting the grain, growth rates can increase by up to 12%.

Overall barley is an excellent grain for pig feed. It can be variable in nutrient value and testing is recommended. Barley can, and is grown in the Yukon as an animal feed.

Oats

Oats are used as pig feed, however, it is less common than barley. Oats have a higher fibre content and higher protein content (10-17%) compared to barley, but digestibility is lower. Oats are limiting in several important amino acids (lysine, methionine, and threonine).

It is recommended that oats be used in limited quantities and fed predominantly to gestating sows. Again, for best usage and digestion it is suggested that oats be ground and pelleted. Oats are also used at low levels in weaned pigs to prevent diarrhoea and low levels of oats fed to finishing pigs help to prevent ulcers (Blair, 2007).

Varieties of naked oats have been tested as pig feed with good results. Naked oats have less fibre and a nutrient profile similar to maize. While yields are less than conventional oats, digestibility is better and naked oats are only limiting in two as opposed to three amino acids (Blair, 2007).

Rye

Rye (*Secale cereale*) is used as a pig feed and has an energy value close to barley and oats. The digestibility of amino acids is 5-10% lower than barley and rye can contain toxic anti-nutritional factors which inhibit digestibility and lowers growth performance (Blair, 2007). Rye can be fed to gestating sows without limit, however, should be limited to less than 50% of grower/finisher/lactation diets.

Other Feeds

There are many other feeds that are used to offset grain usage in pig production. In almost every case these are lower in nutrient, poorly digested, by-products of manufacturing. These feeds are cheap and incorporated into feeds in order to reduce the costs of purchasing more expensive feeds. These types of feed include: dried brewers grain, wheat bran, wheat middlings, oilseed by-products, cottonseed meal, etc. In the Yukon there are very few sources for this type of feed and will not be discussed in any detail. There is a local brewer producing a spent grain product, however, as they do not source their grain locally this will not be considered for our purposes.

Non Grain Based Forages

There are a number of non-grain based forage crops that are used in small scale pig production that are of considerable interest to this project. While these forages are not intended to replace a grain based diet, they can drastically reduce grain consumption while maintaining high yields.

Potatoes are a less dense form of energy than grains; in order to replace 1kg of barley you need 4kg of cooked potatoes.

Potatoes

Potatoes have a higher dry matter (DM) and protein yield per hectare than any grain crop (Blair, 2007). Potatoes grow well in Yukon yet are predominantly used as a human food. Cull potatoes or surplus potatoes can be used as a pig feed. While potatoes are not a complete feed they are a good source of starch and energy for pigs. Potatoes used for pig feed need to be cooked in order for them to be effectively utilized.

Because potatoes are not a dense form of energy (mostly water) they are not recommended as a feed for young pigs. Young pigs cannot consume enough volume of potatoes to glean the necessary nutrients; mature pigs should only be fed a maximum of 50% potatoes (DM) per day (Blair, 2007).

Legumes

For best results pastures rich in legumes like alfalfa, field peas and clover should be used as pig forage. The most common forage crop used for pastured swine is alfalfa and alfalfa is the most widely researched forage crop for pigs (Kephart, 1990). Some resources recommend using only small quantities of alfalfa with certain life stages, however, most organic and traditional pork producers use large quantities with good results (Blair, 2007).

While alfalfa has not been shown to grow well in the Yukon, sweetclover, vetch, lupine, peas and other legumes do grow well. While alfalfa is commonly fed to organic pigs, scientific data suggests that rate and efficiency of weight gain decreased progressively as alfalfa is increased in the diet (this does not mean they did not gain weight, it simply means they did not gain as fast as pigs on conventional feeds). It is unknown how pig performance will do on local leguminous plants. Lupine has been used in Denmark as a protein source for pig production, it was incorporated at a rate of 150g/kg of feed with good effect (Blair, 2007; Kephart, 1990).

Other recommended legumes include: alsike clover, birdsfoot trefoil, crimson clover, ladino clover, and red clover (Kephart, 1990; Blair, 2007).

Field Peas

Field peas have a nutrient density and fibre level that make it a viable option for pig diets. According to Harrold et al., (2002), field peas can replace all the soybean meal that is traditionally found in finishing pig diets without compromising performance. Growing diets can contain up to 40% field peas and starter pigs can utilize about 15% ground field peas in their diet. Harrold (2002) goes on to recommend that weaned piglets be about 20 lbs and at least 20 days old before introducing field peas into the diet. Lactating sow diets can have up to 30% replacement with field peas without affecting performance.

Field peas do not have sufficient levels of the sulphur bearing amino acids to completely replace traditional amino acid sources; this makes addition of either synthetic sources or canola meal (high in methionine) recommended (Harrold et al., 2002).

Field peas can also be provided as a green forage to pastured pigs. Unfortunately, there is considerably less contemporary information available on performance expectation and "best practices" of pigs raised in this way. In modern pork production systems, pigs are rarely provided with natural forages, resulting in far less published material on the subject. In the past, many pork producers did provide pasture forage for pigs. This was done in an attempt to keep costs down while at the same time provide a simple means of producing high protein feedstuffs on farm.

Research conducted in 1931, by Osland and Morton, resulted in the publication of a handbook called "Field Peas for Fattening Pigs". The authors conducted a range of experiments that duplicated common production practices of the time. The most common practice was to allow pigs to "hog off" paddocks of field peas while also providing some form of supplementary nutrients. In some cases, supplementary nutrients were not included and this scenario was tested as well. In all cases, pig yields and gain performances were evaluated. The results showed that acceptable yields could be obtained by allowing pigs to consume a field pea only diet, however, far better results were realized when field peas were supplemented with a high energy grain (such as barley) and provided a complementary source of amino acids (to make up the shortcomings of the peas). Hardy field pea options for Yukon producers include varieties such as: Agassiz, APCM397107, CDC Golden, Meadow, Peace River and Polstead. These varieties have been tested successfully by the Yukon Agriculture Branch and more detailed information is available in section “Field Pea Trials, Yukon Research Farm, 2010-2012”.

This paper highlights an alternative feeding strategy to conventional mixed ration based feeds. In the Yukon, importing pork feed is expensive, this increases production costs which in turn is handed down to the consumer increasing the costs of the marketable product. Pork producers capable of producing, not only energy feeds such as barley, oats and rye, but a protein crop such as field peas may find a significant cost savings over importing mixed complete feeds.

Grasses

While grasses are not as protein rich as legumes they can make up an important component of pig pastures. Kephart (1990) lists some pasture grasses that are suitable for pigs and are as follows: bluegrass, smooth bromegrass, timothy (as a minor part of pasture), rye and winter wheat. "Hogging off" is the term applied to allowing pigs to self-harvest standing grain crops (Gegner, 2010). Yukon grains that can be self-harvested include: rye, oats, and barley.

Brassicas

In organic pig feeding there is an interest in providing pigs with root crops to allow expression of natural foraging behaviour and a source or roughage. Turnips, (rutabaga, swedes, etc) provide that foraging experience as well provide a feed source which can offset grain requirements. While there is not a great deal of empirical data on how pigs utilise turnips as feed, anecdotal evidence suggests pigs get a great deal of enjoyment from rooting for them.

Kale and rape has been grown historically as pig forage. These feeds are high in protein, highly digestible and make good pig pasture. These crops can also be allowed to freeze in the field and be grazed throughout the fall and winter.

Haylage and Silage

Haylage and silage retain roughly the same nutrition as the parent crop from which it is made. This means that it can replace any form of dried forage in the diet at about a 1:1 ratio (Kephart, 2010). In, “Forages for Swine”, an extension manual by Kephart (2010) recommends that haylage and silage are fed only to gestating sows or replacement gilts weighing more than 250lb. He continues by saying “forages should be finely chopped to prevent sorting by the sows. To avoid reproductive problems, be sure that any ensiled forage is fresh and free of mold”.

Kephart (2010) feeding as much haylage as the sows will clean up, this is around 6-8lb. per head per day, and around 2.5lb. of complete feed to ensure adequate nutrition.

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ture%2Fswine%2Fdesigning-feeding-programs-for-natural-and-organic-pork-produc-tion%2F&ei=uMhTVK7QOovyigKHnICACg&usg=AFQjCNFSMyKk7sK2umiq_9dlbyPlzRO_PA&sig2=hA2kd7I9qKxh7IhAqFiYqA

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Reference Materials and Summaries

General

1. Church, D.C., Livestock Feeds and Feeding, Third Edition: New Jersey, Prentice Hal, 1991.

Church takes a conventional approach to livestock feeding and feed management systems in this text. The author discusses feed requirements for the most common livestock animals including: cattle, horses, sheep, goats, pigs, poultry, cats/dogs and rabbits. Amongst other topics, this document covers the science of nutrition and digestion in great detail, likely beyond the needs of most livestock managers.

This book is helpful in understanding the specific nutrition requirements of livestock animals in all life stages and provides information on conventional feeding systems and feeds. If you are looking for up to date and detailed information on alternative/organic growing practices look elsewhere as this text deals mostly with large scale production practices and formulated feeds. Livestock Feeds and Feeding does provide the reader with a thorough understanding of livestock digestion and nutrition and is a great resource to build a foundation in livestock nutrition. This publication contains information primarily from the contiguous United States, however, much is transferrable to the north.

2. Briske, D.D., Derner, J.D., Brown, J.R., Fuhlendorf, S.D., Teague, W.R., Havstad, K.M., Gillen, R.L., Ash, A.J., Willms, W.D. (*2008*) Rotational Grazing on Rangelands: Reconciliation of Perception and Experimental Evidence. Rangeland Ecology & Management: January 2008, Vol. 61, No. 1, pp. 3-17.

"Rotational Grazing on Rangelands", is a synthesis of published literature regarding the perceived benefits of rotational grazing systems over continuous grazing systems. This paper assesses and presents data from the past 70 years and objectively compares the two systems.

The authors conclude that there are no objective benefits to rotational or intensive pasture management, in fact, they determine that in most cases, continuously grazing under careful management generates better results with less monetary and time investment. They recognize that this conclusion differs from conventionally held beliefs and they provide reasons for this misinterpretation.

This is a well written paper with terminology and information accessible to a wide range of readers. This document should be of interest to anyone interested in experimenting with alternative grazing systems or wanting more information about managing a continuous grazing system.

Poultry

3. Spencer, T., Pastured Poultry Nutrition and Forages: National Center for Appropriate Technology Agriculture Specialist 2013 https://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0CCoQFjAB&url=https%3A%2F%2Fattra.ncat.org%2Fattra-pub%2Fdownload.php%3Fid%3D452&ei=ZJctVLLaFczyoASy5oG4Aw&usg=AFQjCNFOE0aNn3jZkoojyiuMbkkQepw8Ug&sig2=yJU0i8ZISD2yIT9UsW1oqg

"Pastured Poultry Nutrition and Forages", investigates new and old research that assess the role that forages can play in poultry production. This paper specifically looks into the nutritional benefits of foraging poultry and its impacts on bird health and the resulting quality of meat and eggs. Traditional poultry farming practices are discussed early on in the paper, and mention is made of planting grain crops and kale for feeding specifically to poultry. Grains mentioned include: barley, winter wheat and oats, poultry specific pastures are also mentioned which include: ryegrass and clover spp. Greens were also raised, both for domestic purposes and specifically for poultry, special mention is given to a variety of kale called 1000 headed kale, this plant grows up to 6 feet in height and can be harvested as needed. In winter months poultry was fed root vegetables such as mangels, carrots as well as winter greens like cabbage.

Quoted within this paper is Jeff Mattocks, a organic livestock nutritionist who has studied pastured birds for many years, who has found that pastured poultry are able to eat between 5-20% of their diet from the pasture.

One of the key advantages of pasturing birds is it provides a fresh source of vitamins, proteins and minerals. Many added vitamins degrade over time in commercially prepared feeds which can lead to deteriorating bird health. Another advantage to foraging birds is the access to insects and invertebrates, the ingestion of which provides the birds with much needed sources of key amino acids.

Another aspect of pastured poultry that this paper discusses is the improvement in quality, taste and nutrient profile compared with ration based diets. This paper cites many studies that have shown a link between pastured birds and increases (sometimes huge increases) in nutrients and vitamins. This paper also notes the importance of choosing a good pasturing breed of bird to maximize success.

This paper is filled with valuable (and peer reviewed) information and is a must read for anyone pasturing poultry. An interesting point made in the article (which is highly relevant to this research paper) is the question of what to seed into your poultry pasture. This paper posits that over time, foraging pressure will transition the pasture by itself towards forbs and forages that will best work in your area and soil type. If new land is being converted into poultry pasture it is recommended that a planting of oats, peas, a liberal seeding of red clover and a very little rape make a great forage crop.

4. Bassler, A. Organic broilers in floorless pens on pasture: PhD Thesis. Swedish University of Agricultural Sciences, Uppsala, Sweden. 2005 http://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CCwQFjAA&url=http%3A%2F%2Fpub.epsilon.slu.se%2F859%2F1%2FEPSILONArKappa2.pdf&ei=q5ctVKiBFIn1oATkgoHAAg&usg=AFQjCNHEa1uuBbcSeb51ixn6_4OYo_zTog&sig2=pjOVNG-Ro8YipJ9KR5IBrA

This series of papers takes a holistic investigation into the methods used or poultry production, specifically organic poultry farming in northern Europe. Not only are standard cost benefits taken into account but ethical and environmental considerations are also weighed.

This paper was not able (within the confines of its methodology) to find a feed savings while pasturing 2 types of broiler chickens. This paper found that the pastured birds ate less feed than conventionally raised birds, however, their market weight was also less resulting in no net savings.

5. Blair, R. Nutrition and Feeding of Organic Poultry: CAB International Publishing, Oxfordshire, UK. 2008

http://www.hua.edu.vn/khoa/cnts/index2.php?option=com_docman&task=doc_view&gid=469&Itemid=398

Nutrition and Feeding of Organic Poultry is a massive paper (322 pages) which discusses everything from the ethics of organic farming to the specifics of organic chicken production. This document would be of significant interest to persons interested in organic poultry farming. It covers many topics associated with chicken farming and cites many recent and interesting studies.

This paper is filled with interesting and helpful information, I will briefly discuss some of the notable topics here. For more detailed and in depth information on organic chicken feeding download the full article here:

http://www.hua.edu.vn/khoa/cnts/index2.php?option=com_docman&task=doc_view&gid=469&Itemid=398

This article cites a recent study that found chickens preferred feeds of a specific colour, yellow-white seeds were chosen over orange-red seeds, red, blue and black feeds were eaten only when the birds were very hungry, this research also showed that chicks retain a preference for same colour feed as was fed after hatching. This information could be quite helpful for growers looking to provide a varied and locally sourced feed option for their birds. By making available varied foods post hatching, birds will be more willing to eat them in later stages.

Nutrition, digestibility and true digestibility are discussed, true digestibility is the actual nutrient extracted by the gut from the ingested food. This can vary greatly from feedstuff to feedstuff. The author discusses the limitations of various grain based feedstuff and the reasons for its deficiency: nutrient tables are provided as are recommended daily requirements.

Recommended grain based feeds are: maize, wheat, oats, barley and sorghum. Hull-less barley gets an excellent review in this paper, comparing equivalent to or slightly better than conventional wheat diets for laying birds.

Nonconventional feeds such as buckwheat, naked oats, rice, rye, triticale, peas, lupins, potatoes and oilseeds are also discussed as options. Extensive nutrition tables are included in this report for all common and many uncommon feedstuffs. This publication also discusses poultry appropriate forages.

Cattle

6. Blair, R. Nutrition and Feeding of Organic Cattle: CAB International Publishing, Oxfordshire, UK. 2011
http://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=8&cad=rja&uact=8&ved=0CE4QFjAH&url=http%3A%2F%2Fanatomiayplastinacion.wikispaces.com%2Ffile%2Fview%2FNutrition%2Band%2Bfeeding.pdf&ei=75stVLDEIIi2ogT3sIHgDA&usg=AFQjCNGfpWWJdP2DYIroO9U6OSXdvUFktg&sig2=JP9-kic8eTcNsYxWVM_5Bw

This publication by Blair is a large and comprehensive work that covers many topics: organic farming principals, cattle nutrition, organic diets for cows, cattle breeds for organic production, and feeding organic cattle.

At 304 pages this book covers many topics and thoroughly explores all aspects of organic cattle production. It should be on the "must read" list for any organic beef producer.

Blair includes a good mix of "tried and true" farming practices and cutting edge research into improved organic techniques. One drawback to this publication is the lack of information pertaining to northern agriculture, the bulk of the document refers to agriculture in the lower 48 states.

Blair does state that pastures, ideally, should be a mixture of grasses and legumes, this mixture can provide cattle with all necessary nutrients and energy requirements. He notes that the presence of legumes have a number of benefits: they fix up to 240 kg N/ha/year into the soil, it increases pasture protein content, animal productivity is increased as a result of higher feed intake, and legumes such as clovers, can extend the grazing season. Blair also discusses preserved forages in the form of hay and silage as well as types of feed grains.

7. Huhtanen, P., Jaakkola, S., Nousiainen, J., An overview of silage research in Finland: from ensiling innovation to advances in dairy cow feeding: 2013 Agriculture and Food Science, 22: 35-56.

This paper investigates the nutritional value of grass silage used in the Finnish dairy industry. Because of its northern location and challenging climate, Finnish farmers have traditionally grown grass silage as opposed to grains for dairy cow feed. In this region grass dry matter yields are double those of cereal grain yields due to cool growing seasons which favour the grasses. Researchers also found that the nutritive value of forages grown in these northern regions is relatively high, this is due to cool climates and long day length which delays lignification of cell walls resulting in a more digestible feed.

During the short growth season cattle are able to obtain about 20-25% of total feed energy intake from grazed feeds. The remaining 75-80% needs to be made up by preserved feeds. Much research has been conducted in Finland regarding the optimal preservation of forages.

This paper presents findings on ensiling techniques and technologies and the quality of the resulting feed. This paper is fairly technical and would only be applicable to producers looking to maximize silage production and nutritive value.

One interesting aspect of the paper, however, is the level of research that has gone into grass based feeds; it can be difficult to find research regarding commercial cattle operations that do not rely heavily on grain and concentrate based feeds.

8. Producing Forage Finished Beef In Manitoba (2007) Prepared by the Manitoba Forage Council, with support from Greencover Canada, MRCA and Manitoba Agriculture, Food & Rural Initiatives. http://mbfc.s3.amazonaws.com/2007_projects_&_technical_info_page/1_forage_finished_beef_final_sept_7_e-book.pdf

This publication does a great at explaining what forage finished beef is, why it is beneficial and how to do it successfully.

Pigs

9. Kennedy, D.W., Pasture Based Swine Management: Arkansas State University, 1998. http://www.clt.astate.edu/dkennedy/pbsm.htm

This article provides a concise and brief overview of the benefits of foraging pigs. It discusses important options such as: fencing, shelters and shades, nutrition and feeding, production costs as well as, environmental and social issues around pig farming. The article cites studies that have shown a reduced production cost and lower mortality associated with free range pigs.

This article recommends that for best results, pastures for hogs need to be: high in protein, young and tender, low in fibre. Rotational grazing is promoted on pastures of: clover, wheat, oats, ryegrass. The author suggests that up to 50% of the diet can be made up of forages with the remainder coming from grain supplements.

10. Blair, R., Nutrition and Feeding of Organic Pigs: CAB International Publishing, Oxfordshire, UK. 2007

Nutrition and Feeding of Organic Pigs, is another great feeding manual by Blair. This publication, like his others, clearly explains the methods and feeds for raising organic pork. Blair covers all aspects of nutrition and diets incorporating research and information from around the world. Blair does an excellent job of combining factual information with the ethics of organic production.

This book is a valuable resource for anyone involved in organic pork production.

11. Edwards, S., Feeding Organic Pigs,: Handbook of Raw Materials and Recommendations for Feeding Practice, Newcastle U.K., 2002.

Feeding Organic Pigs covers a wide range of topics related to pig production: organic standards, formulating pig diets, considerations for feeding different types of pigs, diet specifications for pigs, and a feedstuffs compendium.

This publication covers, in some detail, traditional and non-traditional feedstuffs for pig production. The author rates barley based feed as "the best all round cereal for pig feeding", adding that there are no intake limits for barley at any stage of pig development.

The paper also covers important forages (pastured and preserved) along with potential cost savings and health benefits associated with them. Grass/clover pasture is rated quite high, however, it is not suitable for all life stages, it also is not shown to offset significant amounts of concentrated feed (about 5% total daily energy intake). There are health, social and ethical benefits associated with pasturing pigs, however, the studies referenced did not find a significant improvements in production or feed costs.

Whole crop silage (barley, oats, wheat, etc,.) is also discussed as a feed option, much higher consumption rates are allowable compared with grass/clover pasture. Pregnant sows are able to maintain body condition with inclusion rates of up to 75% (of their daily energy needs) of whole crop silage. Lactating sows need higher energy feed than pregnant sows so a smaller portion of their daily energy intake can come from whole crop silage.

Not all information in this article are pertinent to Yukon agriculture, most of the information comes from Britain, however, many of the crop types discussed are grown in Yukon and available as a feed for pigs.

12. Osland, H.B., Morton, G.E. (1931) Field Peas for Fattening Pigs. Colorado Agricultural College, Colorado Experiment Station, Fort Collins. Bulletin 381, Oct. 1931. http://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CCIQFjAA&url=http%3A%2F%2Fdigitool.library.colostate.edu%2Fwebclient%2FDeliveryManager%3Fpid%3D18435&ei=ZrtKVI7cIY

WtyAS_44GQCg&usg=AFQjCNFU2DtsHKLuWfeH-ObbcMdaD6HdqQ&sig2=FvukfL3aaijet65lXzU4zA

Although this is a very old document, the information contained within it is still valid to some extent. "Field Peas for Fattening Pigs", contains information regarding performance expectations when fattening pigs on a diet primarily based on green field pea forage. The researchers compare pig performance on a diet of only field peas to a diet of field peas supplemented with a range of other feed options.

It should be noted that this work was conducted in Colorado so some of the yields might be different, however, much of the information will be transferrable. Field peas were provided as pasture not in grain form.

This paper is one of the only documents available that investigates the performance of pigs feeding primarily on pea forage. For producers interested in pursuing this feeding method for their pigs, they should peruse this publication. There have been advances in field pea cultivars over the years resulting in better yields and lower anti-nutritional factors which would indicate that results may be slightly better than those experienced in 1931.

13. Shurston, J., Whitney, M., Johnston, L., Koehler, B., Hadad, R., Koehler, D. (2002) Designing Feeding Programs for Natural and Organic Pork Production. University of Minnesota Extension Services. http://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CCgQFjAA&url=http%3A%2F%2Fwww.extension.umn.edu%2Fagriculture%2Fswine%2Fdesigning-feeding-programs-for-natural-and-organic-pork-

produc-
tion%2F&ei=uMhTVK7QOovyigKHnICACg&usg=AFQjCNFSMyKk7sK2umiq_9dlbyPlzRO_PA&sig2=hA2kd7I9qKxh7IhAqFiYqA

This publications is a review of management and nutritional practices that are available in order to become certified in organic or natural pork production. While organic production has strictly enforced guidelines and regulation, natural production does not. Natural production of pork has no legal or widely accepted definition resulting in some confusion in what natural means. This paper discusses some of the similarities between these two systems and offers some methods of formulating feed and feed management systems.

Aside from discussing the particulars of organic pork production, this document also offers strategies and recommendation overcoming common challenges associated with organic and natural production methods.

This document was written for Minnesota Agriculture Extension Services, however, most of the information is transferrable to the Yukon. This document provides a good resource for anyone involved in, or planning to be involved in, any form of pork production. This paper has good advice for both conventional and organic producers.

Sheep/Goats

1. Weisbrot, D., Jaboeuf, T., Foster, A., Klein, L., Sawyer, C., Steffens, T., Grazing Management For Sheep Production: Government of Saskatchewan, Department Of Agriculture, 2003 http://www.agriculture.gov.sk.ca/Default.aspx?DN=3024b1e5-9515-458b-b759-6ed2501dba3c

This is a web article produced by the Saskatchewan Department of Agriculture, it covers many aspect of grazing sheep and managing pastures. Topics covered are: Sheep grazing patterns and behaviours, grazing management principals and planed grazing systems, multispecies grazing, sheep stocking and nutrient requirements.

This article provides a good overview of sheep pasturing, it is not overly technical and covers a variety of topics that sheep farmers would find interesting and useful.

2. Kosinski, S., An Introduction to Managed Grazing for Sheep and Goat Producers: Alberta Lamb Producers, 2013.

An Introduction to Managed Grazing for Sheep and Goat Producers is an Alberta Government publication featured in Alberta Lamp Producers, 2013. This article covers a wide range of livestock management topics including: plant growth, pasture productivity, sheep and goat nutrition, grazing behaviour, managing a grazing system, and grazing issues.

This article covers the aforementioned topics in moderate depth and explains nutrition and digestion in easily understood terms. This publication covers specifics regarding sheep and goat nutritional changes throughout their annual cycles. The paper contains some useful tables showing nutritional and energy need changes through time.

The author covers pasturing strategies to maximize utilization of available forage based on animal needs. She suggests giving sheep and goats with the highest nutritional requirements (lactating females and growing young) first access to new pastures. Animal groups (dry females and older males) with lower requirements are added to the pastures once the first group has consumed the highest quality plants.

Grazing habits and sheep/goat behaviour are covered. This section discusses the importance of observing your herd and monitoring their behaviour. Feeding behaviours of sheep and goats can be indicative of pasture condition. For instance, when animals are grazing during the hottest parts of the day indicates that pasture condition is suffering, goats and sheep prefer to rest and ruminate during this time. Grazing for more than 11 hours per day also is indicative of stressed pastures, sheep and goats will spend less time grazing when better pasture is available. Mature pastures are also difficult for sheep and goats, they tend to be higher, stemmier, lower in nutrient value, and are trampled ad wasted.

This document has a lot of good information in it, it is applicable to sheep and goat farming in Yukon and it is an accessible/easy-to-read document. It can be found online at:

http://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=15&ved=0CIEBE-BYwDg&url=http%3A%2F%2Fwww.ablamb.ca%2Fdocuments%2Fmanagement-modules%2FAn-Introduction-to-Managed-Grazing-for-Sheep-and-Goat-Producers.pdf&ei=My2aU-PdJcX9oAT9koKoBA&usg=AFQjCNH3WQ9sqto5NGG65THw8PqywJVxiA&sig2=fIRxNEp--_tu-3iAKZDdOg

3. Edited By, Kastanje, V., Traditional Sheep Keeping on Estonian and Finnish Coast and Islands: A publication of the Knowsheep-Project, 2013. http://www.knowsheep.eu/userfiles/file/Lambakasvatus_raamat/lambakasvatus_ingl_netti.pdf

Traditional Sheep Keeping compiles a series of studies and topics about traditional sheep keeping in Estonia and Finland. Topics covered are: Sheep parasites and control, wool structure and properties, experiences of free-ranging Estonian native sheep, large carnivore and eagle damage prevention measures, resources and development needs of the sheep industry, sheep feeds and feeding characteristics (Baltic Sea Region).

This book covers a wide range of management topics regarding traditional sheep farming. This book covers little in the way of feed management and forage types, however, it covers how sheep utilize pastures and forage, their diurnal behaviours, and how their pasture utilization changes with changing climate and weather stresses.

This book would be a valuable document for anyone involved in small scale sheep farming, although the information comes from Europe, much of it is applicable to Yukon. This document contains traditional and new information and is available for free download by following the link above.

4. Daskiran, I., Kor, A., Bingol, M., (2006) Slaughter and Carcass Characteristics of Norduz Male Kids Raised in Either Intensive or Pasture Conditions: Pakistan Journal of Nutrition 5 (3): 274-277.

This paper investigates the differences in carcass composition between Norduz goats raised on native pastures and those raised in intensive management situations. This paper is based on goat production in a small Turkish province, however, it is one of very few papers comparing traditionally raised goats with more modern methods of goat production. While not dealing with the specifics of forages, this paper does assess carcass quality based on a forage diet.

The findings of this paper are quite interesting, while the live carcass weights are significantly lower for the pastured goats, the hanging carcass weights are almost identical. Intensively raised goats are adding their extra mass into unmarketable areas of the body like hooves, head weight, omental fat, kidney-knob, pelvic fat, subcutaneous fat and waste. Total fat was 10% for the intensively raised goats and 4% for the pastured animals. Interestingly the pastured animals had larger testicles.

5. Kleinschmidt, J., 2009. Sheep and Goat Management in Alberta, Nutrition: in *Alberta Lam Producers, Alberta Goat Breeders Association*, http://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CB4QFjAA&url=http%3A%2F%2Fwww.albertagoats.com%2Fresources%2FNutrition%2520book.pdf&ei=Nf_HU7CGCoKrjAKV_IDQAw&usg=AFQjCNF3o_Ux7SxJqRezHMG3rlh-_3hQvw&sig2=H2S8gGY6CVu9Qo8GaskcaQ

Kleinschmidt has written a very comprehensive document on the management of goats and sheep, at 184 pages, this manual covers a vast range of topics, is easy to read and has very useful information. Kleinschmidt covers everything from the digestive system, nutrient requirements, feedstuffs, working with the feed industry to disease management. This document was created for the Alberta Lamb and Goat producers which makes the information particularly relevant.

Overall this is a good document and goat and sheep producers in the territory will find it interesting, while it does discuss forages and natural foodstuffs it does not deal with the nutritional specifics of native species found in western Canada. Another area where the document is lacking is browse; while the author states that browse makes up 60% of the diet of goats she fails to mention what browse species the goats are targeting.

6. Hart, S. P. and B. R. Min. 2002. Forage Based Dairy Goat Management. Pages 36-40 in *Proc. 17th Ann. Goat Field Day, Langston University*, Langston, OK.

Hart has written a very useful manual that covers forage based feed management for dairy goats. Hart acknowledges the lack of useful and goat specific information on this topic and does a decent job filling in the gaps. His research takes place in Oklahoma which makes specifics such as yields and pasture species less applicable to the industry in the Yukon, however, this paper is filled with good data and management strategies.

The research outlined in this paper investigated the milk yield differences in pastured dairy goats based on three different levels of grain supplementation. The results showed a positive correlation between grain supplements and increased milk production. More grain equalled more milk to a point. After a certain amount of grain milk yields declined. Differences in milk production were found to be scientifically significant between the no-supplement and the highly supplemented groups, however, acceptable yields were realized without grain supplements. Hart also found that pastured goats produced better cheese than grain fed goats, as well they found that pastured goats had higher levels of conjugated linoleic acid, an aniticarcinogen.

Forage Crops

7. Dingle, C.L. and Czapla, P.K. (1012) Alaska Forage Manual. Department of Natural Resources Division of Agriculture. https://store.extension.iastate.edu/Product/pm417h-pdf

The Alaska Forage Manual provides the reader with an introduction to grasses, legumes and cereal crop species commonly planted and grown throughout Alaska as forage for livestock animals. This manual was created for livestock managers to use as a tool when determining what forages to plant and how those forages would fair regionally.

This manual is more than just a tool for forage selection, it covers theory and implementation of planting, irrigation, fertilization, harvesting and soil management. This manual covers 24 plant species chosen based on their ability to survive and their nutritional value as livestock feed.

This is a good resource for Yukon forage producers, it has usable and applicable information, many of the soil, climate, planting and harvesting information is transferrable to Yukon.

8. Bowren, K.E., Cooke, D.A., Downey, R.K., Yield of Dry Matter and Nitrogen From Tops and Roots of Sweetclover, Alfalfa and Red Clover at Five Stages of Growth: Research Station, Canada Department of Agriculture, Melfort, Saskatchewan, 1968

This research paper assessed the nitrogen fixation and dry matter yields for sweetclover, alfalfa and red clover.

In Yukon, there has been little success in cultivating alfalfa as a forage crop. Plants have difficulty overwintering, are outcompeted, and quickly die out. This is unfortunate as alfalfa is an excellent forage, green manure, and soil building crop. In recent years it has been observed that sweetclover has become a dominant (invasive) plant species in the ditches and gravel pits along the highways in the Yukon. Like alfalfa, sweetclover fixes nitrogen, builds soil fertility, makes excellent green manure and can be used as a hay, forage and silage crop. Sweetclover may have real potential as a nutrient rich forage crop for Yukon.

This paper discusses the results of 4 years of field trials in Saskatchewan investigating the nitrogen and dry matter production of three legumous crops: sweetclover, red clover and alfalfa. Of most interest to this project is the results of the sweetclover trials. Sweetclover dry mass yields were quite high, in the second year of production reaching 4472kg/ha. Nitrogen fixation rates were comparative with those of alfalfa and red clover and were as high as 93.9kg/ha.

If these results can be replicated in the Yukon, sweetclover could become a valuable companion crop to the more commonly planted grasses. If harvested/consumed at the right time sweetclover can provide valuable nutrients to livestock. As it also fixes nitrogen it improves soil structure and increases yields of grasses.

9. Van Veldhuizen, B.M., Zhang, M., Knight, C.W., Agronomic Crops Developed in Alaska: AFES Publication MP 2014-01

"Agronomic Crops Developed in Alaska", is a newly released document (2014) that presents an overview of the history of agronomic crops developed in Alaska for the Alaskan agricultural sector. This paper covers crops developed in the early 20th century, as well, crops developed very recently at the UAF research farm.

This document discusses varieties of: barley, oats, spring wheat, winter rye, and the oilseeds, polish canola and dwarf sunflower. The paper provides information on yields, date of maturity, resistance to lodging and some general information about each variety.

This would be a good resource for farmers looking for information regarding northern varieties of grain crops. This publication does not cover the specific growing requirements for each variety, however, most (if not all) are cultivated in the Fairbanks area, growing conditions for Fairbanks are discussed in Summary of Agronomic Conditions for Comparative Jurisdictions.

Elk and Bison

10. AMBOCA, 2005,. Nutrition and Habitat Requirements of Elk and the Capacity of Yukon's Native Range to Provide Them. Prepared for Yukon Agriculture Branch.

This publication starts by describing the history of Yukon's elk population; it outlines the re-introduction and management of the wild herd since that time. The author explains the biogenetics of wild elk and summarizes nutritional and habitat requirements of these animals. The author goes on to evaluate the native plants and habitats that support the local herds in Yukon.

The purpose of this research project was to provide information to landowners looking to shift from farming elk to ranching elk; reducing reliance on cultivated forages and commercial pellets and instead, providing large areas of native vegetation for which the elk could utilize.

This paper covers a lot of information and specifics pertaining to nutrition and physiology of elk and can be fairly technical. On the plus side this paper is very specific to our location and filled with valuable information.

11. Chambers, J. H. S., (2010) Habitat use and ecologically sustainable carrying capacity for elk in the Takhini Valley, Yukon. A Masters Degree Project, University of Calgary. http://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CCcQFjAB&url=http%3A%2F%2Femrlibrary.gov.yk.ca%2Ftheses%2Fchambers_j_%25202010%2FChambers_Jesse_MDP_FINAL.pdf&ei=677bU4ngFKO1igLFq4GQDg&usg=AFQjCNHC6AL8HxFE_KVcLw_b_7tKo3u6iA&sig2=EojQfCBWtpWQfp3BEp3vAg

Habitat use and ecologically sustainable carrying capacity for elk in the Takhini Valley, Yukon is the result of research done by Jesse Chambers in 2010 investigating the carrying capacity of the Takhini Valley elk herd. This work assess the vegetation types in the area and estimates vegetation production based on forage species found there. Her work estimates the sustainable herd population that this region can support.

This work is interesting for this report on forages in that it allocates a food value and stocking numbers for elk farmers utilizing native vegetation as part of their elk feed source. This work illustrates the degree of susceptibility that native vegetation has to being over utilized. This publication would be of interest to game farmers looking to use native forages as part of their feed management strategy.

12. Klein, L., (2008) Pasture and Forages for Wapiti, Government of Saskatchewan Department of Agriculture online publication. http://www.agriculture.gov.sk.ca/Default.aspx?DN=8828aef0-6983-42fb-89df-159699b2c7da

Klein provides a concise and easy to read manual for providing pastures and forages for elk. This document is regionally specific to Saskatchewan, however, much of the forage species recommendations and management techniques are applicable to Yukon game farmers. This document covers many topics pertaining to elk farming, pasturing, and pasture management. It also covers basic biology and the history of the species. This is a valuable article for farmers looking for species specific information on forages and pasture management.

13. Thorleifson, I., Pearse, T., Friedel, B., (2000) Elk Farming Handbook. North American Elk Breeders Association: (no publisher given, book available at EMR Library, Whitehorse Yukon, call no. SF401.E4.2000)

Thorleifson, Pearse and Friedel have pretty much written the definitive elk farmers manual. Elk Farming Handbook is described by the North American Elk Breeders Association like this "The Elk Farming Handbook is the most complete, most user-friendly guide to farming elk available. It draws on the knowledge and experience of some of the world's leading farmers and elk consultants, covering all the necessary elk farm management skills."

This is a fairly accurate description of the book which covers about every topic imaginable that is related to elk farming and elk production. It covers forages and feeds, pasture management, animal behaviour, elk products such as meat and elk velvet antler. This is a great book for any elk farmer, it mainly has information related to the Prairie Provinces, however, much of the covered material is applicable to northern producers. A must read if you are in the industry.

Methods and Work plan

The Agricultural Feed Options for Northern Livestock project consists of 4 phases of research, information gathering and reporting. These steps are listed below.

1. Summary of Yukon conditions, identification of similar jurisdictions, and detailed report of agri-environmental and market conditions in those jurisdictions that will be used in the study;

2. Provide a reference binder with peer reviewed materials and reference materials and a short summary of the information provided by each reference;

3. Summary report ranking the most suitable livestock, agronomic crops and native feed options that have the potential to successfully grow in Yukon. This summary report and summary of project to date will be presented at the N60 Conference in early November;

4. Final report detailing production strengths, weaknesses, opportunities and constraints, optimum feed, and feed management system for each livestock species listed. As well as detailed cost of production sheets for the top 5 most appropriate livestock species identified.

With these steps, research will follow a progressive and logical direction, determining the agronomic conditions within which we are operating will narrow the variety of feed options and limit the comparative jurisdictions to evaluate. This approach will serve to answer the three basic questions of this research:

1. What can we reasonably expect to successfully grow in our region based on what grows well in similar regions.
2. Will those crops meet the nutritional requirements of our livestock?
3. Are these feed management options economical and affordable?

The Agricultural Feed Options for Northern Livestock project will largely rely on information gathered from published articles; journals, books, industry publications, as well as consultation with industry.

Completed Steps/Steps to Complete:

Step 1: Understanding Objectives and Orientation:

Meet with Matt Ball and Robert Cooke to clarify and fully understand the objectives of the project. Ask for clarification on points

1. Obligations around N60 conf, when it is? What is required? etc,.
2. Timeline flexibility and penalization?
    a. Should we have an official document used when requesting a scope or timeline change.
3. Identify pertinent materials that contractor may not have accessed or considered that proponent would like included
    a. Past studies

Step 2: Research and Reporting:

Research and reporting on Yukon agronomic conditions and the conditions of comparative jurisdictions.

- Information for this section will come from a number of sources, weather data collected throughout the Yukon will be used to build a climate profile, this will be compared to other climactic regions in the circumpolar north for comparative purposes.
- Information on soil characteristics will be gathered from publications at the EMR library.
- Online publications will be used to identify regions with similar agricultural conditions.
- Research and summarize publications pertaining to livestock feed management practices in comparative jurisdictions.
- Submit results in the form of a reference binder containing copies and summaries of materials reviewed.

Step 3: Industry Consultation/Interviews/Feedback:

Industry consultations: This stage of the project will allow industry to have input into the direction of the project, under considerations is the drafting and distribution of a survey. This survey would allow producers to provide information to the project regarding familiarity and comfort levels with potential feed options.

The survey is under consideration at this stage and would be jointly drafted by Yukon Research Centre, the Agriculture Research Committee and the Yukon Ag Branch.

Step 4: Summary Report:

Compile, assess and rank the most suitable livestock, agronomic crops and native feed options that would be successful in the Yukon. Summarise this information in report and graphical form, this will be reviewed by the oversight committee and presented at the N60 Conference in November.

Step 5: Final Reporting:

The final report will be submitted to the proponent no later than January 31 2015, the final report will include the reference binder, a report outlining appropriate forages for livestock, and comparing various feed management options for northern livestock. The attached appendices will include; budget information, presented materials generated for the N60 conference, and any other pertinent materials.