



Strategic Assessment

Alternative Forages for Dairy Production in Water
Scarce and Drought Prone Regions

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1. Project Background, Purpose and Methods

1.1 Background and Purpose

The agriculture industry in B.C. has identified a need for support to help the sector adapt to climate change, mitigate Greenhouse Gas (GHG) emissions, and improve environmental sustainability. This project has been initiated to support dairy farmers, who are reliant on forages produced on farm to help with adaptation to climate change through the adoption of low water use crops and beneficial management practices.

Drought has impacted the B.C. agriculture sector in recent years, with the 2023 drought placing significant pressure on dairy farms reliant on forage production. The purpose of this project is to address information gaps for farmers seeking to identify forages to be grown in areas with limited or reduced water availability.

1.2 Methods

The foundation of this strategic assessment was a review of research and literature available from local and international sources. These included peer-reviewed scientific journal articles, online factsheets and extension resources from government agencies and universities. Where available, information from B.C. or other regional jurisdictions was preferred, however many topics lacked local information and resources from around the world were used.

In addition to the research and literature review, engagement and interviews with six farmers and ten industry experts such as nutritionists, seed suppliers, and researchers, were completed. These individuals were selected due to their direct experience with the crops included in the strategic assessment, and their familiarity with the dairy sector in one or more of the regions assessed.

A regional approach was taken to this assessment to provide locally relevant information to farmers and sector stakeholders. The regions assessed included the Lower Mainland, Southern Interior, Vancouver Island, and Bulkley Valley. Regional climate analyses were also completed using outputs from the Agriculture Water Demand Model to compare historic (1991-2010) climate attributes to a near-future climate period (2021-2050).

We reviewed all the information collected and developed regional recommendations for crops and farming practices that can help B.C. dairy farmers deal with drought and less water.

2. Dairy Sector Background and Context

2.1 Dairy Production in B.C.

The dairy industry in British Columbia is comprised of over 400 farms that produce more than 800 million litres of milk annually. Although farms are located across most of the province, the industry is not equally distributed geographically with 76% of quota holdings (kg/bf) in the Fraser Valley, 17% in the Interior, 6% on Vancouver Island, and 1% in the North (BC Milk Marketing Board, 2024). Dairy is the largest land industry within the B.C. agriculture sector by farm cash receipts (B.C. Ministry of Agriculture, 2022).

2.2 Impacts of Drought

B.C. dairy farms are reliant on forage produced on farm to meet their herds' feed and nutrition requirements. Although most farms purchase some portion of their feed ration, maximising on-farm forage/feed production is essential for farms to operate economically. Drought in recent years has significantly impacted forage production in the main dairy producing areas of British Columbia and has resulted in increased feed imports and costs for farmers. In response to these impacts, the BC Agriculture Council and BC Dairy have publicly called for a prioritization of irrigation water supply to ensure agricultural production and food security are protected in B.C. (BC Dairy, 2024).

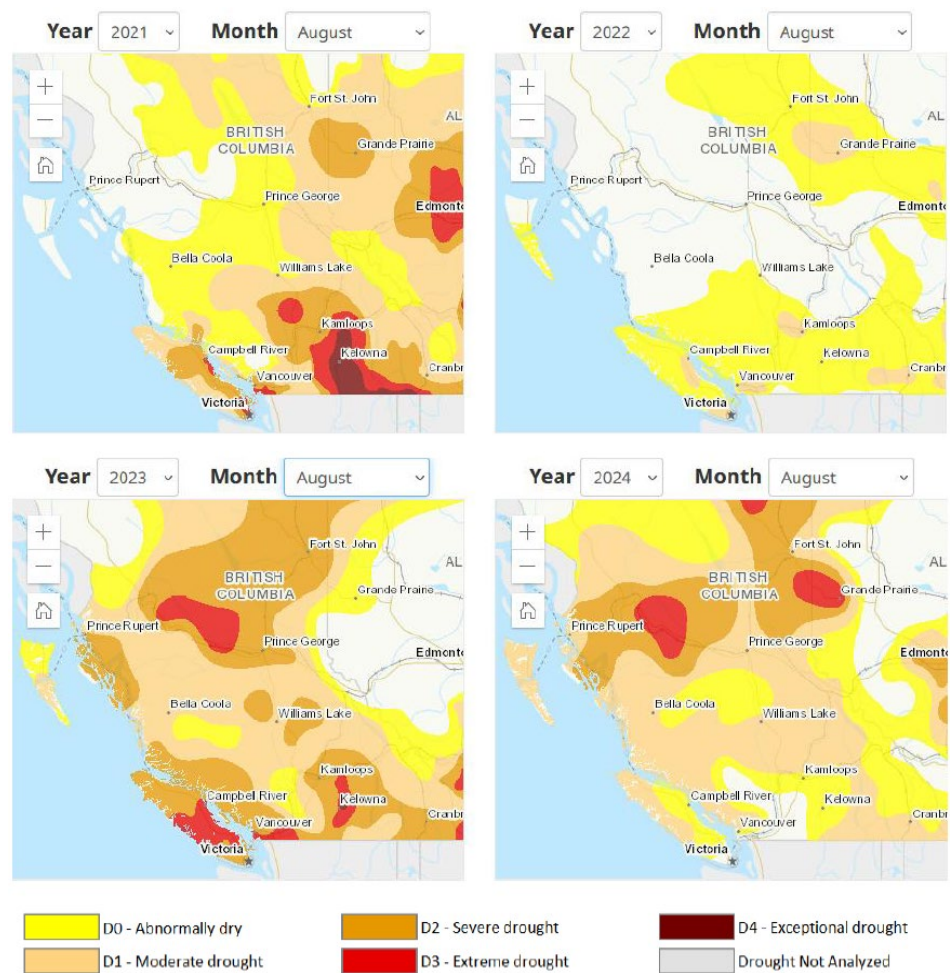


Figure 1 – Agriculture and Agri-Food Canada's Canadian Drought Monitor (CDM) provides monthly drought assessments derived from several data source that classify drought severity, extent and impact.

Recent years have seen an increase in the intensity, severity, and geographic distribution of drought in British Columbia (Figure 1). A five-category system rates from abnormally dry (D0), to moderate (D1), severe (D2), extreme (D3), and exceptional (D4) drought. In each of the last four years, significant areas of the B.C. agricultural land base have been impacted by some level of drought.

Although drought changes throughout the year, using August 31 as a reference point shows the extent of drought at the end of the summer growing season. At this date in the last four years, the percent of the agricultural landscape classified as at least “D0 – Abnormally Dry”, has been: 91% (2021), 68% (2022), 99% (2023), and 91% (2024). Even the wetter year of 2022 had an abnormally dry period for much of the province in late summer and fall that resulted in at least an “D0 – Abnormally Dry” rating increase from 68% at on August 31 to 99% on October 31 for the agricultural landscape.

Although drought is especially impactful to dry farmed operations, hydrologic drought (low flows in rivers and streams) in recent years has led to curtailments for irrigation users as well. Prior to 2016, the Fisheries Protection Act (FPA) allowed for surface water licence users to be curtailed in circumstances where fish populations were at risk. This was implemented twice in B.C.: in 2009 in the Nicola watershed affecting four irrigation licences and again in 2015 in the Coldstream River watershed impacting 50 licences.

In 2016 the Water Sustainability Act (WSA), was introduced which required all surface and groundwater users for commercial purposes be licenced. The WSA also contains expanded options to manage water use in times of drought, including options to restrict water use on specific types of crops including forage. In August 2019, a Temporary Protection Order (TPO) was issued in the Koksilah River watershed on Vancouver Island that curtailed irrigation for 40 forage producers including several dairy farms. In 2021, TPOs were enacted again in the Koksilah as well as the Bessette, Salmon, and West Kettle watersheds, affecting a total of 482 irrigation licences. In 2023, the Koksilah, Lower Salmon, Bessette, and Tsolum watersheds received TPOs, affecting a total of 543 licences (Watershed Stewardship and Security Branch, 2024).

2.3 Dairy System Management Considerations and Drought Resilience Options

2.3.1 Nutrition Requirements

Forage is the main part of a dairy cow’s diet. Growing enough good-quality forage on the farm is key to keeping cows healthy and helping the farm stay profitable. Cows have a requirement both for nutrient density as well as sufficient fibre to maintain rumen function; forages contribute both. Typical strategies for lactating cows include growing a high energy forage such as corn silage, growing (or purchasing) a high protein forage such as alfalfa or early harvested perennial grass and then supplementing the remainder

with a blend of grain and byproducts such as canola meal as well as a mineral/vitamin package.

Dairy farms also care for dry cows and young animals, which have different nutritional needs. For these animals, farmers often grow or buy moderate-quality forage. As cattle are fed free choice, a large volume of forage is required on an annual basis. Depending on ration, a lactating cow can require 4-5 tons of forage dry matter per year. Compounding this requirement is the limited and competitive agricultural land base within the main dairy regions of B.C.

While most dairy farm's nutritionists use rumen modelling software to balance diets, this document will use some common forage test terms for comparative purposes between crop options:

Dry basis vs as-fed (wet) basis:

Dry basis is reported with all water removed and is used to compare forage quality and formulate rations. All the following nutritional values will be reported as dry basis. Sometimes yields are reported on farm in as-fed (wet) basis and in these cases the percent dry matter (%DM) or moisture will be accounted for in yield and feeding calculations.

Crude Protein (%):

Crude Protein (CP) is a measure of the nitrogen content in feed and is critical for animal growth and production. Typical forage values range from 8% for mature grass and corn silage to >20% for forages harvested early such as alfalfa.

Energy:

Energy is one of the key values measured and calculated in forage tests, and is essential for animal growth, milk production, and overall health. Energy in forage comes from sugars, starch and the digestibility of the fibre.

Net Energy Lactation (Mcal/kg):

Net Energy for Lactation (NEL) is a way to measure how much available energy a feed provides for milk production and overall maintenance of the animal. NEL is used to balance rations and compare different types of feed.

Total Digestible Nutrients (%):

Total digestible nutrients (TDN) are traditionally calculated from acid detergent fibre (ADF). Some labs now use a new formula that also accounts for fibre digestibility. It can be used to compare different types of forage and to determine if they meet the nutritional needs of their animals.

Acid Detergent Fibre (%):

Acid detergent fibre (ADF) is the least digestible fibre consisting of lignin and cellulose. Generally, values of 30% or lower are desired for lactating cattle. Fibre levels are driven by stage of cut and crop.

Neutral Detergent Fibre (%):

Neutral Detergent Fibre (NDF) is made up of Acid Detergent Fibre (ADF) plus hemicellulose. It represents the slowly digestible part of the fibre and is used to estimate how full a cow's stomach (rumen) will get and how much it will eat. Grasses usually have higher NDF levels than alfalfa, typically ranging from 40% to 55%.

Neutral Detergent Fibre - Digestibility (%):

Neutral Detergent Fibre Digestibility (NDFd) shows how much of the fibre in a forage can actually be digested by the animal. It's measured over time—usually at 30, 48, or 120 hours—by placing forage samples in rumen fluid (the liquid from a cow's stomach) to see how much fibre breaks down. Higher NDFd usually means animals can eat more feed and produce more milk. Digestibility depends on the type of plant and the conditions it was grown in, such as weather, day length, and temperature.

Lignin and Undigested NDF (%):

Lignin used to be the main way to measure the part of fibre that animals cannot digest; newer research shows that undigested neutral detergent fibre (uNDF) gives a more accurate picture of how much fibre truly stays undigested in the animal's system. A lower uNDF value is usually better, because it means more of the fibre can be digested and used by the animal.

Ash (%):

Ash is the amount of minerals and soil left over after the sample is burnt. This can indicate soil contamination during harvest. Values over 8% for grass and 10% for alfalfa typically indicate soil contamination.

Although modern ration balancing software does not directly use Total Digestible Nutrients (TDN) and Crude Protein (CP), lactating cow rations are usually formulated to provide at least 70% TDN and 16–17% CP. Dry cows far from calving are typically fed closer to 55% TDN and 12% CP, with these values increased as calving nears. Dairies also may have growing stock or have them raised by another operation with additional forage availability.

In addition to supporting milk yields, dairy cow rations must also achieve milk fat and protein composition with desired parameters that are optimized for farm profitability. Milk fat (kg) produced per cow is used as a production target and is tied to quota allocation.

Nitrates and Drought:

Many of the crops discussed below can build up toxic levels of nitrates when under drought stress or when they receive too much nitrogen fertilizer compared to how fast they are growing. It is critical to take forage tests for nitrate levels to ensure that risk can be managed.

2.3.2 Crop Selection

Dairy farmers have a range of decisions to make when it comes to crop selection. These choices are impacted by the farm's feed and nutrition requirements, availability of varieties and species, suitable climate and soils, storage requirements, and equipment availability. Dairy forages can be categorized many ways: warm season or cool season; perennial or annual; grass, legume, or broadleaf; single-cut or multi-cut.

Warm or Cool Season

Warm season crops grow most efficiently in warm to hot conditions, while cool season crops prefer milder temperatures. This variation is often, although not always, due to a difference in the mechanism of photosynthesis between C-3 and C-4 species. A C-3 crop refers to a plant that uses the C3 photosynthetic pathway, which is the most common method plants use to convert sunlight into energy. The name "C3" comes from the fact that the first product of carbon fixation in this process is a 3-carbon compound. A C-4 crop is a plant that uses the C4 photosynthetic pathway, which is more efficient than the C3 pathway under hot, sunny, and dry conditions. The name "C4" comes from the fact that the first product of carbon fixation is a 4-carbon compound. C-3 plants can grow at temperatures as low as 4°C and are most efficient at 18-24°C while C-4 species require warmer temperatures for growth and are most efficient at 32-35°C (Oregon State University, 2025). Among grass species, cereal crops and most perennial grasses grown for forage in temperate climates are C-3 species; in contrast, corn, sorghum, millets, and many other perennial and annual grasses not typically grown in temperate regions are C-4. Although not C-4, some legumes (e.g. soyabean, alfalfa, common bean etc.) perform well in warmer weather. Generally, C-4 species have poor cold tolerance and cannot survive winters in B.C. and are therefore grown only as annuals.

The C-4 photosynthesis pathway enables greater water use efficiency, i.e., more yield per unit of water used. However, this advantage is only realized when warm weather coincides with good moisture availability to the crop. Cool-season species, while less efficient with the water they uptake, grow most effectively when temperatures are cooler, and evapotranspiration rates are lower. The most productive choice for a farm between cool and warm season species depends on whether more yield can be achieved in the cooler shoulder seasons when moisture is typically more available, or during the shorter, hotter summer season when the more water efficient C-4 plants thrive. This will vary across B.C. with climate, soil moisture holding capacity, and irrigation availability (Bittman & Hunt, 2013).

Cool season species like perennial grasses and cereals perform best where there is a long cool season in the spring and fall, or where summers remain cool. During hot and dry weather, cool season crops will either grow with poor water use efficiency or go dormant and stop growing altogether, depending on the species and variety. Planting cool-season

crops at the right time to take advantage of favorable weather or choosing perennial varieties that can handle heat and drought, are both good ways to make the most of the water that's available.

The silage corn and perennial grass (or alfalfa in warmer regions) cropping system that is prevalent on many B.C. dairy farms balances production between cool-season perennial grasses, and warm season silage corn. In warm summers corn production will be maximized, while in long cool springs the perennial grass forage will thrive. Building resilience to drought can be as much about selecting crops and varieties that take advantage of these varying optimal windows for growth and moisture availability, as it is selecting the most water use efficient crops.

Perennials or Annuals

Choosing between perennial and annual species can provide drought resilience depending on the climate, soils, and needs of a dairy farm. Where annual moisture balances are negative (evapotranspiration exceeds precipitation) and irrigation is unavailable or limited, annual crops can be seeded to match the best growing conditions, helping to avoid low-yielding perennial stands and making better use of the moisture available. For example, if soil moisture is depleted, a fall to spring fallow could allow moisture to replenish and a summer annual crop seeded to make most effective use of this moisture. There is some risk of moisture loss through tillage and practices that limit this should be used (Moore, 2015).

In other situations, well established and productive perennial stands may have greater drought resilience as they can take advantage of spring moisture and depending on the variety, regrow quickly as moisture returns after summer drought. The deeper rooting systems of many perennials may also provide greater soil moisture availability than shallower rooted annuals. Certain perennial species may be less desirable where their low water use efficiency during summer results in poor productivity from limited available moisture.

Crop Variety Selection

Currently, the availability of alternative crops that are not already currently grown in B.C. can be limited. A widely grown species like corn has many varieties, with a wide range of production traits, available to farmers. Turning to new species can be challenging simply because of the lack of choice and access to what may be the most suitable variety. Seed suppliers make efforts to access novel crops for producers, but without established markets it can be difficult to find supplies and good prices.

Beyond access to the seeds themselves, there are often barriers with equipment capabilities and sufficient knowledge of production requirements to achieve adequate yields and quality. It takes determination on the part of the farmer to persist with

alternate crops, and they assume a risk that not all farmers are willing to take (Seed Supplier Interview, 2024).

On-farm experimentation and trials are an opportunity for farmers to assess the suitability and appropriateness of alternate crops, while learning the management practices required to optimize their production. The BC Forage Council's "A Guide to On-Farm Demonstration Research"¹ provides a guide for implementing practical research on farms in B.C.

2.3.3 Soil and Nutrient Management

Nutrient management is an important consideration for dairy farmers in B.C. Although the impact on cropping decisions varies with location and available land base, many farms are challenged to balance crop fertility needs, regulatory compliance, and manure storage and management. Corn has a high nutrient demand, but as manure cannot easily be applied during the growing season, meeting this demand with manure is limited to applications before planting (Turek & Andrews, n.d). Full-season corn also offers little opportunity for post-harvest application as fall-seeded cover crops have relatively low nutrient uptake. Adjusting crop systems to allow more opportunities for manure applications throughout the year can help improve how nutrients and manure are managed on the farm. This can reduce nutrient losses and make better use of the nutrients in manure, leading to more efficient and sustainable production.

Soil management practices that build soil organic matter, improve soil structure, increase crop rooting depth, and reduce runoff and erosion can all help farms better withstand drought. Reduced tillage, no-till drilling, compost or manure applications, and cover cropping are all practices that can contribute to improved soil health and function, particularly moisture holding capacity.

Soil organic matter can store large amounts of water and improve soil structure. Although there is a positive relationship between soil organic matter and water holding capacity, results are inconsistent, and the potential to mitigate drought impacts is likely limited by the practical challenges in achieving and maintaining significantly increased soil organic matter at the farm scale (Libohava, et al., 2018; Huntington, 2020). Practices that increase soil cover, like reduced tillage and cover cropping, have the potential to increase soil water storage both through increased infiltration and reduced runoff, and improved snow accumulation.

¹ <https://www.bcclimatechangeadaptation.ca/app/uploads/FI03-On-Farm-Demonstration-Research-Guide.pdf>

2.3.4 Irrigation Management

Forage irrigation on dairies in B.C. is mostly done with hard hose travelling reels with high pressure guns as they are easily movable, fit on abnormally shaped fields and can handle tall growing crops like corn. Many producers have upgraded to computer-controlled models that allow for more uniform speed control and application. Recently, more pivot irrigation systems have been installed in areas where the field size and shape make them practical. In other areas, side-roll wheel move systems are still being used, likely due to field constraints or cost considerations. In the future it is likely to see more pivot irrigation systems being installed because they help save labour and improve irrigation efficiency.

Increasing irrigation water supply and expanding irrigated acres would contribute to improved drought resilience on dairy farms in B.C. However, due to limited water resources in the province, this may not be feasible in many dairy-producing regions. The Water Sustainability Act, enacted in 2016, introduced water licensing for agricultural groundwater users for the first time. Existing users that submitted water licence applications prior to March 1, 2022, had their water rights grandfathered in. It has been estimated that less than half of existing groundwater users that require licensing applied by this deadline (MacLeod A., 2023). Any users who missed the deadline, along with new water users, now must apply as for a new water use approval. The granting of new licences is dependent on the specific watershed and availability of water to be allocated. In much of the interior of B.C. and on Vancouver Island, many watersheds, including those with significant agricultural presence, are considered “fully recorded”, i.e., fully allocated, and new water use applications with withdrawals during the low-flow season are unlikely to be approved. Additionally, watersheds deemed under significant stress can have the allocation of water rights modified through the completion of a Water Sustainability Plan (Curran & Brandes, 2019). The Koksilah on Vancouver Island is currently the only watershed where this planning process has been initiated.

The impacts of drought are also likely to be felt by producers who have irrigation licences with volumes allocated under past climate conditions. Many dairy producing areas of B.C. are experiencing increasing moisture deficits, and this trend is anticipated to continue. This will result in licenced volumes that will be increasingly insufficient in meeting crop water demands.

3. Crop Assessments

3.1 Silage Corn

Corn (*Zea mays*) is a C-4, warm season annual species that has become the primary forage source of dry matter yield and energy for lactating cows in B.C. where there are sufficient heat units and growing season length. Corn's ability to produce very high yields of high energy palatable forage, and its relative ease to grow, manage, harvest, and feed, have led to this position as the dominant forage crop in most dairy producing regions of B.C. Additionally, its prevalence has led to ready availability of custom operators who specialize in planting, spraying, and harvesting the crop.

Depending on the hybrid, optimum quality and yield of corn silage occurs when harvested at approximately 35% DM, this relates to a staging of approximately ½ - 2/3 milk line (diagram 1) on the corn kernels (Corteva Agriscience, 2019). Corn silage harvested at the right stage can have energy levels over 70% TDN. This energy comes from two main sources: Starch, which makes up about 30–40% of the dry matter yield and comes from the grain portion, and digestible fibre, primarily from the plant's stalks and leaves.

Corn is a full-season summer crop with relatively high-water use, but this is largely due to its high yield and dry matter

production. Corn has widely been demonstrated to have the highest water use efficiency (WUE) of forage crops under optimal moisture conditions (Neal *et al.*, 2011; Farre & Faci, 2006). Under drought conditions, corn will typically see a greater reduction in yield than in forage quality. Corn is particularly susceptible to drought stress during pollination which can lead to poor ear development. A lack of ear development will lead to a 50% reduction in tonnage. Late season drought conditions can also cause a reduction in starch deposition resulting in lower energy forage.

Variety selection can contribute to drought resilience in corn. Each seed supplier has ratings for drought tolerance and in some cases “brands” of hybrids which have been selected for performance under reduced water availability. Choosing these varieties that can perform well under reduced moisture conditions can be a hybrid selection strategy used in conjunction with the agronomic considerations below to help reduce risk. Corn



Diagram 1 - Corn milk line stages.

hybrids are often also ranked by supplier for “ear flex”, which is the plant’s ability to produce a longer/bigger ear with optimal growing conditions at a lower plant population. Hybrids which do not have a high “ear flex” are considered a “fixed ear” and produce a consistently sized ear throughout a range of plant populations. Another strategy used by producers in areas with regular late season moisture deficits is to select shorter season hybrids than normally adapted, and plant as early as possible to try to get the plant as mature as possible before it runs out of water. An example would be to grow a 2100 CHU (Cumulative Heat Unit) corn hybrid in an area where 2600CHU hybrids are normally grown.

Agronomic considerations to minimize risk and maximize efficient water use include:

- For highest grain and starch yield it is critical that corn has adequate moisture during pollination. Deferring irrigation from vegetative stages to reproductive stages while reducing plant height and yield can still result in high quality forage.
- Selecting multiple hybrids for a wider pollination window.
- Reducing plant populations and planting more “flex ear” hybrids.
- Keeping weeds under control during the key weed-free period—from crop emergence to the 6-leaf stage—is important for conserving soil moisture.
- Using management strategies for pests such as western corn rootworm.
- Considering narrower row spacings, reducing tillage to conserve moisture, and earlier planting dates.

3.2 Perennial Grasses

Cool season (C-3) perennial grass is grown throughout the province either in pure grass stands (single or mixed species) or mixed with perennial legumes. For dairy use it is typically harvested at boot stage (before the seed head appears) and harvested multiple times depending on growing season length and moisture availability.

Cool season grasses respond to drought through two different mechanisms of adaptation: drought tolerance and drought resilience.

Drought tolerant crops can remain in a vegetative and productive state through drought and heat, either through increased water use efficiency, deeper rooting depths, or a combination of both. This enables continued production throughout the drought period, although water use efficiency may be lower and prolonged drought may result in plant loss and stand thinning.

Drought resilient crops favour dormancy during drought and will produce little or no yield to ensure survivability. Once moisture returns these crops regrow from tillers; how quickly they shift from dormancy to growth is key in how productive they can be over the growing season.

Perennial grasses can vary a lot between different varieties of the same species, and their performance can depend on the soil and climate conditions. This results in trade-offs between drought tolerance/resilience and yield/quality; the most favourable species for drought are not necessarily the best forage quality or highest yielding in multi-cut high management systems. Many species and varieties that favour dormancy for drought resilience cannot achieve the yields expected in intensively managed dairy systems.

Additionally, some studies have examined the relative forage quality of perennial grasses harvested at the same growth stage, and results show some differences among species in fibre digestibility (NDFd). Generally, ryegrass has the highest NDFd followed by Fescue and Orchardgrass and sometimes Brome. Wheatgrass, timothy, and reed canarygrass usually have lower NDFd, which means they may be less digestible; higher NDFd is important in dairy feed because it helps increase forage intake and produce more milk. (Jensen, 2017)

Despite these differences, plant maturity (harvest timing) is still the main driver of forage quality with its tradeoff of overall yield. For pure stands of perennial grass, Crude protein can be over 20% in early growth stages but drops below 8% in late bloom, while TDN can start above 60% and fall below 50% as the plant matures.

3.2.1 Comparison of Perennial Grass Species for Forage

Perennial ryegrass (Lolium perenne)

Sometimes used in the Fraser Valley and Vancouver Island, perennial ryegrass is a shallow rooted, poorly winter hardy and very high quality (high NDFd) forage. It can have high productivity and water use efficiency under intensive management when temperatures are moderate, and moisture is available but has poor tolerance to drought and is slow to recover from those conditions.

Orchardgrass (Dactylis glomerata)

Orchardgrass is a bunchgrass and one of the most commonly grown grass species in B.C. It has a range of maturities and good regrowth characteristics. Early maturity varieties are used for pure stands and late maturity varieties are preferred for blends with alfalfa. Orchardgrass has lower winterhardiness and is not tolerant of flooding or poor drainage. In addition to performance, when selecting varieties for coastal regions of B.C. it is also important to consider resistance to rust and cocksfoot mottle virus (CMV).

Tall fescue (Festuca arundinacea)

Tall fescue has good drought tolerance and can be slightly more tolerant than orchardgrass due to its deeper rooting depth. It is tolerant to poor drainage and responds well to aggressive cutting schedules but can be slower to establish. Older varieties of tall fescue have rough leaf edges which reduce palatability and intake. These have been replaced with "soft-leafed" varieties. Some trials in coastal and interior B.C. have shown a

yield advantage to tall fescue over orchardgrass, some of which can be attributed to earlier spring growth. Tall fescue matures earlier than orchardgrass, and there is a wide range of maturities between different varieties (BC Forage Council, 2000-2011).

Meadow fescue (Lolium pratense)

A “new” older species that is seeing a resurgence of popularity across North America. Meadow fescue is desirable for dairy forage as it has higher fibre digestibility (NDFd) than orchardgrass or tall fescue. However, this benefit comes at the cost of slightly lower yield. Meadow fescue has good tolerance of poor drainage and moderate to good drought tolerance. Meadow fescue has a beneficial endophyte which can increase plant longevity with no negative nutritional aspects. Endophytes are a fungus that has a symbiotic relationship and grows within a grass plant often conferring disease, drought and insect resistance. Endophytes found in turf type tall fescue and perennial ryegrasses and can cause hoof disorders and reduced feed intake / performance in cattle (Ball et al, 2015).

Festulolium (x festulolium)

Festulolium are hybrids between fescue and ryegrass. The parents could be either tall or meadow fescue crossed with perennial or Italian ryegrass. This is a way to combine some of the hardiness and drought tolerance of fescue with the very high forage quality, rapid establishment and growth of ryegrass. It often leads to a yield increase compared to the parents. There is a wide range in diversity among festuloliums depending on the selection goals of the breeding program, the parents, and number of backcrosses. Evaluation is ongoing to determine the suitability of these varieties throughout the dairy regions of B.C. Many seed suppliers have Festulolium varieties available, and producers have mixed results depending on the variety and producer expectations.

Bromegrasses (Bromus spp.)

Commonly used bromegrass species include smooth brome, meadow brome, and hybrids of the two. Bromegrass can present seeding challenges due to large seed size (meadow brome especially) and can be slow to establish compared to other perennial grasses. Bromegrasses are intolerant of poor drainage.

Smooth brome has more upright growth than meadow brome and is rhizomatous. Smooth brome has very good drought tolerance with a deep rooting system but will not persist under an aggressive cutting schedule with an early first cut harvest. It also has less summer regrowth than orchardgrass and tall fescue. Although it is drought tolerant, it may not be ideal for dairy use unless included in blends or used specifically for dry-cow forage.

Meadow brome is often used in grazing programs due to its shorter height and lower leaf attachment relative to smooth brome. It has faster regrowth than smooth brome and better tolerance to a multiple cut system.

Hybrid bromes are crosses between meadow and smooth brome that capture the upright growth and first cut yield of smooth brome with the regrowth of meadow brome. They also have reduced rhizomatous nature compared to smooth brome.

Wheatgrass

There are many types of wheatgrass used for forage, including crested wheatgrass (*Agropyron cristatum*) and intermediate wheatgrass (*Elytrigia intermedia*). They have excellent drought tolerance, relatively poor regrowth and lower forage quality (NDFd) than many other perennial grasses. Crested wheatgrass is suited to single cut non-irrigated systems. Intermediate wheatgrass has suitability in blends with alfalfa as it has late maturity to better match alfalfa harvest scheduling. Seed size is quite large and high seeding costs can be prohibitive.

Timothy (Phleum pratense L.)

Timothy is a bunchgrass with excellent flooding but poor drought tolerance. It produces very high yields in first cutting but can have lower forage quality and very poor regrowth. It is not typically used for dairy production except on sites where regular flooding of 4-6 weeks prevents the survival of other species.

Reed canarygrass (Phalaris arundinacea)

Reed canarygrass is the most flood tolerant perennial grass utilized by dairies. It is often low in quality due to its large stems and tall height. Harvest is usually delayed until the wet ground dries enough for equipment to get in. It is mainly suitable for dry cow forage, and it can be a useful resource in drought years. Reed canarygrass contains alkaloids that can negatively affect palatability but cultivars with reduced alkaloids are available, although seed cost is often higher. It is considered an invasive species in wetlands across much of B.C. (Invasive Species Council of BC, 2023).

Mixed stands

A technique with perennial grass stands is to include multiple species and varieties (3+) along with a legume component. This can help spread the risk between each species' own suitability to wet and dry years and account for variability within a field. Although a diverse mix may not necessarily optimize productivity in all situations, it provides a balance of traits and allows different species and varieties to thrive in the locations they are best suited (Farmer Interview, 2024).

3.3 Alfalfa

Alfalfa is the primary perennial crop grown in dairy systems where climate and soil conditions are suitable. It is grown in pure stands and in blends with perennial grass throughout the interior and in some locations of the Lower Mainland and Vancouver Island. Alfalfa is considered a high-water use crop as it has a long growing season and has a deep rooting system that can extract moisture throughout the soil profile. Research data

has shown that Alfalfa yield has a linear response to applied water and that water use efficiency declines after the 1st cut (Shewmaker, 2013).

Alfalfa harvested at the early bud stage offers high nutritional value, providing over 20% crude protein and approximately 60% total digestible nutrients. High quality alfalfa is used in lactating rations and lower quality can be fed to dry cows and growing stock. Alfalfa yield is a function of the number of stems, stem length (plant height), and leaf size and number. Typical alfalfa yields range from a total of 2.5-6.0 tons/acre dry matter (DM) per year over 1-4 harvests. In coastal regions, perennial grass will offer more total yield. However, in irrigated interior regions with deep soils, alfalfa can be comparable or higher total yield than perennial grasses (BC Forage Council, 2000-2011).

Drought can significantly reduce alfalfa yields, though it may sometimes improve forage quality. On soil with sufficient rooting depth and good water-holding capacity, fall rains and snowmelt can recharge the soil profile, supporting a reasonable first cut.

Drought stress soon after harvest can be particularly damaging to alfalfa yields due to loss of basal buds, reduced stems per plant, shortened stem internode length and reduced plant height. Stress can also trigger early flowering in alfalfa which can force difficult decisions to be made regarding harvest timing. Despite these impacts, alfalfa often retains good leaf size and leaf to stem ratios to maintain good forage quality.

When alfalfa is drought-stressed for an extended period, healthy stands of alfalfa can enter induced dormancy. If moisture is applied later, it can then regrow. Fields experiencing other stressors, such as micronutrient deficiencies or plant disease, often exhibit greater yield reductions compared to healthy stands.

Few studies have examined differences in water use efficiency among alfalfa varieties. However, it is likely that high-yielding varieties under optimal conditions will also perform better under stress. Disease resistance ratings can vary significantly between varieties and should be carefully considered in regions where disease pressure is a concern.

Effective alfalfa management includes strategies to promote stand longevity, which is closely linked to the plant's ability to accumulate nonstructural carbohydrate reserves in the roots—essential for winter survival. It is generally recommended to allow alfalfa 4 to 6 weeks of regrowth before a killing frost to rebuild root reserves, which are critical for winter survival. Maintaining a higher stubble height in the fall also helps with snow capture, providing insulation through winter. Ensuring adequate soil fertility further supports plant health. While harvesting all available growth during a drought year may be necessary, it increases the risk of reduced stand longevity.

When irrigation is available, it is best to prioritize stands which have the best productive potential as assessed by soil type and stand health. It may also be worthwhile in drought conditions where the plants are still growing, but slowly, to shift harvest dates later than

normal (move from 4 to 3 cuts or 3 to 2 cuts annually). This could allow time for an increase in yield without much reduction in quality, as well as better prepare the stand for over-winter survival.

3.4 Clovers (*Trifolium* spp.)

The primary clovers used in dairy forage production are red clover and white clover. Red clover is used for hay / silage and white clover for pasture. Red clover can tolerate poor drainage and lower pH soils much better than alfalfa. Red clover is classified into two types: double-cut or “medium” and single cut or “mammoth”. Double cut is more often used for forage as it has better regrowth and overall yield as well as persistence. Improved clover varieties have less pubescence (small hairs) on stems for improved dry down characteristics. Nutritionally, red clover has a higher percentage of rumen undegraded protein than alfalfa which can be beneficial in some dairy rations (Cornell University Extension, 2014).

3.5 Spring Cereals

Spring cereals are often grown for forage in northern regions where there are inadequate heat units for corn silage. They are also seen in crop rotations and on interior rain-fed acres as an alternative to corn. Species include barley, oats, wheat, rye, and triticale. They are grown on their own or in blends that can include a mix of cereal species, legumes like peas, or annual grasses.

Typically, single species cereal crops are harvested at late milk to soft dough stage when the highest yield and energy is achieved. When grown in blends, harvest is timed to match the optimum for the dominant species or variety. At the late milk to soft dough stage, forage typically contains 9.5% to 11% crude protein and 55% to 65% TDN, depending on the grain-to-stover ratio. Spring cereals grown in cooler climates such as the Central Interior typically have higher energy than grown in the Southern Interior. Yields can vary greatly depending on species, variety, seeding date, and growing location/conditions and can range from 3-5 tons/acre Dry Matter (DM) at late milk to soft-dough stages, though yields exceeding 6 tons/acre DM have been achieved in Alberta (Helm & Salmon, 2002; Juskiw, Helm, & Salmon, 2000).

There are varieties that have been bred primarily for forage production with traits such as tall plant height, increased leafiness and smooth or reduced awn type. These traits are especially important for greenfeed or haylage harvested at advanced maturity and fed without blending.

When harvested as silage, most high yielding grain varieties will also provide high silage yields and forage quality. Be aware there are some semi-dwarf or shorter stature grain varieties that may yield less overall volume. One of the advantages of cool-season annuals

is their shorter growing season, in areas with late season drought they may be able to reach silage maturity before drought conditions have a large impact on them.

3.5.1 Comparison of Spring Cereals

Barley (Hordeum vulgare)

Barley is the most common spring cereal used in the interior. Both 2-row and 6-row varieties are available, with awn types that can be smooth, semi-smooth, or rough. When used as silage, rough awns are less problematic. However, in dry forage applications, they can pose issues by irritating the animal's mouth and reducing palatability. Anecdotal evidence suggests that some European-derived genetics offer improved heat tolerance, though these varieties may exhibit shorter plant stature.

Oats (Avena sativa)

Oats can be very high yielding and there are leafy varieties available. It is typically lower in quality compared to other cereals. Oats are often used in blends, as a nurse crop for perennial establishment.

Triticale (X triticales)

Triticale, a hybrid of rye and wheat, is known for its drought tolerance and high yield potential. Varieties may have full-length or reduced awns, with the latter preferred for dry forage to minimize the risk of irritation to livestock.

Wheat (Triticum spp.)

Many dairy producers in Alberta have switched to soft white spring wheat for their main cereal silage crop. Soft white wheat out-yields other cereals. It also has excellent lodging resistance and a high grain to stover ratio that results in high quality forage with a wider harvest window compared to barley. The higher grain to stover ratio is due to many wheat varieties being selected for shorter plant height and high grain yield.

3.6 Winter Cereals

Winter cereals are fall planted and require vernalization (a period of cool conditions) to go through stem elongation and produce a seed-head. They vary in winter hardiness which impacts their suitability around the province.

In general, winter cereals have better utilization of fall and spring moisture than spring cereals as they have a head-start and can resume growth early. However, adequate moisture is required in the fall to ensure establishment and growth, this can be limiting when and where later summer and fall is dry.

The earlier start in to spring growth can give two different harvest opportunities: early (boot) stage or late (milk-dough). In areas with adequate corn heat units (2400CHU+), producers can harvest at the boot stage and still plant corn, if harvested at milk-dough

stage it will likely be too late to plant corn and alternatives should be considered. Early season growth can also provide alternate manure application windows which may result in nutrient management benefits. Winter cereals also open up opportunities for rotation benefits when grown in rotation with corn and perennials.

Early harvest dates can yield forage with energy levels ranging from 60% to 65% TDN, making it suitable for inclusion in lactating cow diets. Later harvest dates of winter cereals are more often utilized in dry cow and heifer diets with TDN ranging from 54% to 58%. Crude protein levels depend on harvest timing and nutrient availability. When harvested early, CP can exceed 18%, while later harvests typically result in levels ranging from 8% to 12%.

3.6.1 Comparison of Winter Cereals

Winter Wheat

Winter wheat is commonly used in fall seeded “cover crop” in the Fraser Valley along with Italian ryegrass. Rust resistance is a concern and many of the available varieties of hard red winter wheat from the Prairies are not suitable, instead varieties from the Pacific Northwest of USA are more commonly used. The long growing season of winter wheat can result in a high yield potential. Field-scale demonstration plots conducted in the 1980s in the Lower Mainland and Vancouver Island consistently produced dry matter yields exceeding 6 tons/acre using European winter wheat varieties harvested at the dough stage (Zadok’s growth stage 78–83) under intensive management. In one instance, yields surpassed 10 tons/acre. (Bomke, Temple, Kennedy, Cain, & Langlet, 1991). Whether these yields can be consistently replicated at the farm scale is unclear.

Winter Triticale

Triticale, a hybrid of wheat and rye, offers improved winter hardiness and higher yield potential compared to wheat, while maintaining good forage quality. It serves as a strong compromise among winter survival, productivity, and nutritional value. Winter triticale is planted by itself or in blends with winter wheat and Italian ryegrass.

Fall Rye (Secale cereale)

Fall rye is the most winter-hardy among the winter cereal options and its adoption is increasing in interior regions. Fall rye starts growing at a lower temperature and thus has a larger early yield in the interior especially in a cool and delayed spring. Hybrid fall rye varieties are now available which can have increased yields over older open pollinated varieties. Generally, fall rye has lower forage quality than triticale and wheat when harvested at the same date, some of this may be due to its earlier growth.

Other Winter Cereals

Winter barley has been tried in B.C.; it has potential but has low winter hardiness and poor early spring vigour. Winter peas can be successfully grown as a legume component in winter cereal blends, with some producers reporting positive results.

3.7 Warm-Season Annual Grasses

Warm season annual grass species utilize C-4 photosynthesis, which gives them superior water use efficiency and heat tolerance compared to cool season crops. These characteristics come with the trade-offs, including the need of warm soils for germination, poor competitiveness in cool temperatures, and zero frost tolerance.

Some of the benefits include fitting well within a winter cereal rotation as soil and air temperatures can be more optimal for germination and growth after the winter cereal forage harvest. There are also options for varieties and hybrids within species that have the Brown Midrib (BMR) mutation for higher fibre digestibility (NDFd). Challenges can include nitrate accumulation, relatively slow dry down and the potential for increased ash accumulation in the forage during harvest. Forage tests of annuals should include nitrate analysis.

3.7.1 Comparison of Warm-Season Annuals

Forage Sorghum (Sorghum bicolor)

Forage sorghum is typically grown in a single cut system, like silage corn. It can reach heights exceeding 7 feet and has a smaller seed size compared to sorghum-sudangrass (*Sorghum bicolor* × *S. bicolor* var. *Sudanese*), which may result in lower seeding rates and reduced establishment costs. It is available in male sterile types, which promote increased sugar production, and in BMR varieties. Male sterile BMR types are ideally harvested after head emergence; however, achieving this stage may be challenging in much of B.C. due to the long growing season required—typically over 90 days depending on planting date. The crop can be harvested in a vegetative state with high forage quality but will require more dry-down before ensiling compared to after head emergence. Crude protein levels can range from 11 to 12%, with TDN exceeding 65%. With its relatively low seed cost and low seeding rate (6-10 lbs/acre), forage sorghum often costs 30% less than corn to establish. Some producers find it better to harvest with a corn type header rather than a mower-conditioner due to its height and volume, if moisture content allows.

Sorghum Sudangrass

Sorghum-sudangrass is a hybrid of sorghum and sudangrass (*S. bicolor* var. *Sudanese*). It is typically grown for multiple cuttings although some hybrids may be suitable for a single harvest depending on their agronomics and planting/harvest date. It is available as BMR or non-BMR. It is typically harvested at a height of 2.5-3ft for high energy feed (65-68% TDN) and can be suitable in rotation for producers who have irrigation systems that are

too short to allow the production of tall, full-season crops. Prussic acid poisoning can be a concern when grazing. Prussic acid usually dissipates below toxic levels when dried for hay or ensiled and can be tested for with proper handling.

Forage quality is often high enough to feed sorghum-sudangrass to lactating cows. There have been issues with too much ash accumulation during harvesting practices and poor dry down leading to producers having fermentation issues from overly wet silage. It is important to ensure harvest equipment such as rakes are set up properly to minimize ash contamination and ensure the weather is suitable for an extended dry-down period. With warm soil temperatures at seeding, and sufficient heat during growth, a first harvest can be expected around 60 days after seeding, with following harvests approximately 30 days after.

Sudangrass

Sudangrass is grown for a single harvest and can reach heights of over 7 feet. It has lower prussic acid levels compared to sorghum-sudangrass and dries down more effectively, making it a suitable option for harvesting as cured dry forage. It is possible to interseed with other annual grass species, such as ryegrass. Interspecies competition can be managed using techniques like alternate row seeding.

Millets

Millets are C-4 warm season annual grasses that have a range of traits depending on species and variety. They have good drought tolerance and low water use, but require heat to produce well, although they have better tolerance of cool conditions than the sorghum family. They can be well suited to use as an emergency forage on land that has experienced flooding, crop failure, or following the harvest of a winter cereal. Depending on the millet species, relatively low seeding rates of 10–30 lbs/acre compare favorably to those of annual cereal crops, making millet a viable substitute in certain situations. Millet often produces 10-12% CP and 60-65% TDN when harvested at late vegetative to early heading stage.

Many of the millets are relatives of warm season grass weeds such as foxtails or barnyard grass. Producers may want to be sure to harvest them before they set seeds. They can be challenging to dry for hay and can accumulate nitrates. In general, forage quality is lower compared to the sorghum family.

Species	Description
Red Proso Millet <i>Panicum milaceum</i>	Earliest maturity (55-60 days) but has lower yield, best drought tolerance
Japanese Millet <i>Echinochloa esculenta</i>	Good cool temperature and wet soil tolerance

Foxtail Millet <i>Setaria italica</i>	Siberian type: Early maturity (70 days) and good cool temperature tolerance Golden German: Later maturity
Pearl Millet <i>Pennisetum glaucum</i>	Very late maturity, there are hybrid options for increased vigour but do not tolerate cooler temperatures. Grows best in similar conditions to sorghum family.

Table 1 - Comparison of Millet Species

3.8 Warm-Season Annual Legumes

Forage Soybeans (*Glycine max*)

Late maturity soybeans have potential for a large single forage cut with tonnage and quality similar to alfalfa. Soybean maturity is ranked by “group number” from 0.0 to 9.0; with a higher group number being a later maturity. Herbicide tolerant options are available for weed control. Variety selection must be based on whole plant yield rather than grain yield. As soybeans are rarely grown in B.C. it is critical to inoculate the seed using the supplier recommended method with the correct strain of rhizobial seed inoculant so that nodules can develop and fix nitrogen. Like many legumes, soybeans nodulation can be impacted by soil nitrogen levels so they may not work well on manured fields. Other situations that can reduce nodulation include compacted soils, excess moisture (anerobic conditions), and extreme high or low pH.

Other warm season (C-4) annual legumes that are not readily available in B.C. but could have potential within a blend include cowpeas and mungbeans.

3.9 Warm-Season Perennial Grasses

There are many warm-season perennial grasses with the potential to survive winters in B.C. Some promising options include switchgrass (*Panicum virgatum*), big bluestem (*Andropogon gerardi*), indiagrass (*Sorghastrum nutans*), and little bluestem (*Schizachyrium scoparium*), among many other species (Barnhart, 1994; Neal, Fulkerson, & Sutton, 2010).

Despite the many options, warm-season perennial grasses are typically used in warmer climates in grazing systems. Although these species show potential, further research in B.C. or in regions with similar climates is needed to evaluate their suitability for local dairy production.

3.10 Cool-Season Annuals

Annual ryegrass (*Lolium multiflorum*)

Annual (westerwold) ryegrass is a true annual with better drought tolerance but generally lower feed quality than Italian ryegrass. It is not commonly used on dairies except as a

component in forage blends. If allowed to set seed, it has the potential to volunteer in subsequent crops.

Italian ryegrass is a biennial cool season grass with poor winterhardiness. In coastal regions of the province, it overwinters and produces high quality forage and is often used in blends with winter cereals to increase tonnage. In interior regions it is planted in the spring and typically managed with an aggressive cutting schedule, irrigation, and nutrient management to produce high quality forage. It does not root deeply and is not considered drought tolerant.

Annual Clovers

There are a number of annual clovers including berseem, balansa, Persian, crimson and others. There has been some use of Berseem and balansa with mixed success.

Vetch

Hairy vetch is an aggressively growing legume that can overwinter in the southern part of the province that has the potential to contribute a large amount of nitrogen. It is suited to use in blends and can regrow after cutting. Hairy vetch seed pods can be poisonous to livestock.

Faba beans (Vicia faba)

Faba beans (fava beans) are a cool season legume typically grown for grain in Western Canada and have been harvested and fed to dairy cows in Canadian and Northern Europe research studies. Faba beans have starch levels comparable to barley silage, along with higher protein content (17–18% crude protein). Their energy levels are similar to other high-quality forages, ranging from 60–64% TDN. A Saskatchewan study from 2021 showed no negative impact to feed intake, milk production, or composition or rumen health. Some studies have shown that forage quality is comparable to high-quality grass-legume silage, with livestock performance being similar or slightly reduced. However, overall forage yield tends to be lower. (MacLeod M. D., 1977; Palmio, 2022; Guevara-Oquendo, 2021).

While faba beans are promising from a forage quality perspective, their sensitivity to drought and lower yields have limited adoption.

Brassicacae

Other regions such as New Zealand have had success seeding brassicas for additional fall grazing in drought years, and they could be used as a component of annual blends in B.C. Brassicas have very wide range of cultivars and species, including turnip, radish, forage rape, kale, and hybrids. Potential concerns include nitrate accumulation, and their small seed size that requires adequate soil moisture to germinate and establish.

3.11 Perennial Herbs

Chicory and Plantain

Forage chicory and plantain varieties have been used in grazing-based systems in other regions of the world with improved livestock performance from reduced lignin and higher digestibility compared to alfalfa. Chicory also has good drought tolerance and has been used in some areas of Western Canada in forage blends with cereals and annual grass but with limited use for dairy production in B.C. There may be potential to further utilize these species for producers with a grazing component.

3.12 Non-Legume Annual Broadleaves

Diverse Blends

In other cropping systems, such as beef production, many cool-season annual species are grown in diverse blends alongside cereal crops. These mixtures aim to enhance soil health while improving forage yield and quality. There are some on-farm demonstrations and research findings from other regions supporting the use of diverse annual blends for dairy production. However, adoption in B.C. remains limited due to risk aversion and concerns over forage quality when not properly managed (Akins, 2022).

4. Regional Assessments

4.1 Bulkley Valley

4.1.1 Current Cropping System

Dairy forage production in the Bulkley Valley is based primarily on perennial grasses with the addition of some spring seeded annual crops, often a mix of barley, oats, and peas. Perennial grasses are harvested relatively late often due to weather conditions at 11-16% crude protein, with good sugar levels, high fibre digestibility, and TDN of 60%+. Typically, one or two cuts of perennial grasses are taken, or a single cut with some fall grazing. Yields depend on the season but generally range from 2.0 to 3.5 tons/acre of dry matter (DM). (BC Forage Council, 2000-2011). Cereal based annual crops have a more variable harvest timing but are typically harvested early and do not attain high starch levels. The main ration deficiencies from on-farm forage production are energy and protein for lactating cows. Many producers also utilize some summer grazing with their lactating cows.

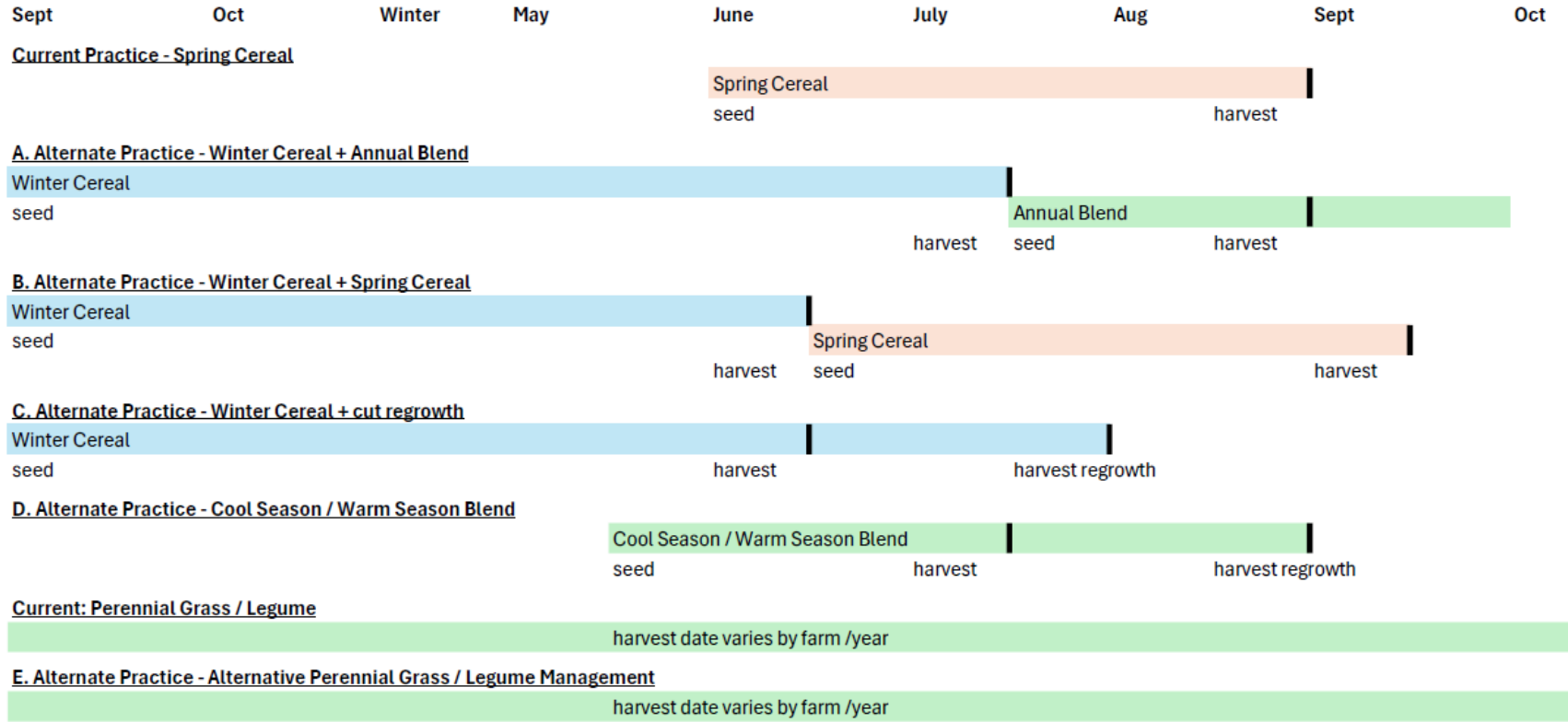
Irrigation is not currently widespread in the Bulkley Valley. Only 121 hectares of irrigated forage was reported in the 2013 Agricultural Land Use Inventory of Smithers, Telkwa, and Electoral Area A, an area that includes most of the region's dairy farms (B.C. Ministry of Agriculture, 2014).

4.1.2 Climate Change Projections and Impacts

Climate change is projected to increase annual mean temperatures and annual precipitation in the Bulkley Valley. Comparing the historical baseline climate of 1981-2010 (1990s) to the near-future climate period of 2021-2050 indicates that while summers will become warmer and the growing season will lengthen, increases in precipitation should, on average, keep up with increasing evaporation. As a result, the Bulkley Valley will experience a longer and warmer growing season with increased growing degree days (+194) that will increase production opportunities for dairy farmers (see appendix 1). The area will remain susceptible to drought as annual potential evapotranspiration exceeds annual effective precipitation. Further, these projections do not account for a possible increase climatic variability and extreme precipitation and temperature events may increase (BC Agriculture & Food Climate Action Initiative, 2019).

4.1.3 Potential Cropping Solutions

Bulkley Valley



A. Winter Cereal + Annual Blend

	Winter Cereal	Annual Blend
Seeding	Late August – Early September	Mid-July
Harvest	Mid-July (soft dough stage)	Late August +Fall regrowth
Forage Yield and Quality	4-6 tons/acre DM	0-2 tons/acre DM
	8-10% CP	12-14% CP
	58-60% TDN	60%+ TDN
Advantages	<ul style="list-style-type: none"> ▪ Maximizes tonnage from winter cereal crop ▪ If moisture allows, it creates the opportunity to plant an annual blend afterwards, with potential for dual use with fall regrowth for grazing or harvest. ▪ Opportunity to incorporate diverse blends with soil and rotational benefits. ▪ Can be used for summer grazing if needed ▪ Allows for in-season manure applications ▪ Potential fall regrowth of annual blend for soil health/grazing 	
Disadvantages and Risks	<ul style="list-style-type: none"> ▪ Quality of soft dough winter cereal silage is lower than ideal for lactating rations ▪ Risk of inadequate moisture in fall seeding window 	
Notes	The annual blend component can have a range of species depending on the producers' goals (harvesting or fall grazing). This planting window can offer the opportunity to incorporate warm season species such as millet along with cool seasons such as cereals, ryegrass, clover, and other annuals.	

B. Winter Cereal (early harvest) + spring cereal

	Winter Cereal	Spring Cereal
Seeding	Late August – Early September	Early/Mid-June
Harvest	Early/Mid-June (pre-boot stage)	Late August
Forage Yield and Quality	2-3 tons/acre DM	1-2.5 tons/acre DM
	12-14% CP	11-14% CP
	60%+ TDN	60%+ TDN
Advantages	<ul style="list-style-type: none"> ▪ Maximizes quality from the winter crop ▪ More reliable moisture availability for planting following spring cereal crop ▪ Flexibility to switch to option A if weather window does not allow early harvest. ▪ Allows for in season manure applications 	
Disadvantages and Risks	<ul style="list-style-type: none"> ▪ Less overall tonnage than option A. ▪ Regrowth of the winter cereal can be a competitor to the spring cereal and create varying stages of maturity at harvest. ▪ Opportunities for harvesting in June in wet years can be difficult. 	

Notes	This option can be a good fit for producers who prefer feeding cereal silages and need to balance volume and quality.
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C. Winter Cereal (early harvest) and harvest regrowth (2nd cutting)

	Winter Cereal	Winter Cereal (2nd cut)
Seeding	Late August – Early September	n/a
Harvest	Early/Mid-June (pre-boot stage)	Late July
Forage Yield and Quality	2-3 tons/acre DM	1.5-2.5 tons/acre DM
	12-14% CP	11-13% CP
	60%+ TDN	60%+ TDN
Advantages	<ul style="list-style-type: none"> ▪ Maximizes quality from the winter crop ▪ Lowest cost system with winter cereal as there's no additional seeding ▪ Flexibility to switch to option A if weather window does not allow early harvest 	
Disadvantages and Risks	<ul style="list-style-type: none"> ▪ Risk of inadequate moisture in fall seeding window. ▪ Opportunities for harvesting in June in wet years can be difficult. 	
Notes	Winter cereals such as fall rye when harvested at pre-boot stage can have excellent regrowth and provide 60-70% of the first cuttings yield in a second harvest. Adequate plant population is critical for this to be effective.	

D. Cool Season / Warm Season blend harvested twice.

	Blend	Blend (2nd cut)
Seeding	Mid-May	n/a
Harvest	Late June-Mid July	Late August
Forage Yield and Quality	2-2.5 tons/acre DM	0.5-2 tons/acre DM
	12-16% CP	12-15% CP
	60%+ TDN	60%+ TDN
Advantages	<ul style="list-style-type: none"> ▪ Can offer additional harvesting opportunities vs. spring cereals, also flexibility for summer and fall use including grazing (species dependant). 	
Disadvantages and Risks	<ul style="list-style-type: none"> ▪ Depending on season, yields may be higher or lower compared to cereals grown alone ▪ Warm seasons would be difficult to establish when seeded in cold soils/weather. 	
Notes	This system replaces the typical cereal blend of barley – oats – peas with a blend that includes a reduced cereal rate and additional species such as ryegrass and clover. It can also include species like chicory, and weather allowing warm season crops such as millet. There is also an option of adding warm season species after the first cutting to help boost tonnage of a second harvesting.	

E. Modification of Existing Perennial Grass / Legume system

There is potential to incorporate a variety of grass species, including additional tall fescue and winter-hardy orchardgrass. Higher levels of legumes such as alfalfa and red clover can also be utilized where pH and soil conditions are suitable. Advantages include increased forage quality and yield.

4.2 Lower Mainland

4.2.1 Current Cropping Systems

Silage corn and perennial grasses dominate dairy forage production in the Fraser Valley. Corn is planted between late April and June and harvested from the end of August to late October. Corn varieties ranging from 2000 to 2800 corn heat units are typically planted, with the middle of that range being most common (Seed Supplier Interview, 2024). As-fed yields (~35% DM) exceeding 20 tons/acre (~7 tons/acre DM) are typical and expected for corn silage in the Lower Mainland, with good yields reaching up to 30 tons/acre (~10.5 tons/acre DM). Perennial grass stands are dominated by orchard grass and fescues, but may also contain wheatgrass, creeping fescues, reed canarygrass, perennial ryegrass and, increasingly, festulolium (Seed Supplier Interview, 2024). Grass crops are typically harvested 4 – 6 times in the growing season and can yield 4-6 tons/acre DM cumulatively over the season (BC Forage Council, 2000-2011).

Fall seeded winter cereal cover crop blends are widely planted following corn harvest and will be harvested in the spring prior to corn planting, typically yielding 1-3 tons/acre as fed. Western areas of the Lower Mainland have high winter waterfowl pressure that can damage or eliminate winter crops; this pressure is increasing across the region. These blends often have a component of Italian ryegrass which can increase forage quality and are usually harvested in a vegetative stage (pre-boot) based on the winter cereal.

An additional current practice utilized by some producers is to interseed Italian ryegrass into corn at V4-V6 growth stages. The Italian ryegrass continues to grow after corn harvest, overwinters successfully, and is harvested the following spring as high-quality forage.

Agricultural Land Use Inventory data from 2010-2013 in the Lower Mainland records irrigation on 6,668 ha, or 26%, of forage and pasture land in the Fraser Valley Regional District and 2,867 ha, or 20%, in Metro Vancouver (B.C. Ministry of Agriculture, 2016; B.C. Ministry of Agriculture, 2014). Irrigation of forage crops in the Lower Mainland is increasing in response to recent droughts and increasing pressures on dairy farms to maximise yields and quality.

4.2.2 Climate Change Projections and Impacts

Climate change is projected to increase annual average temperatures at three analysed locations in the Lower Mainland (East Delta, Sumas Prairie, and Agassiz). Annual effective

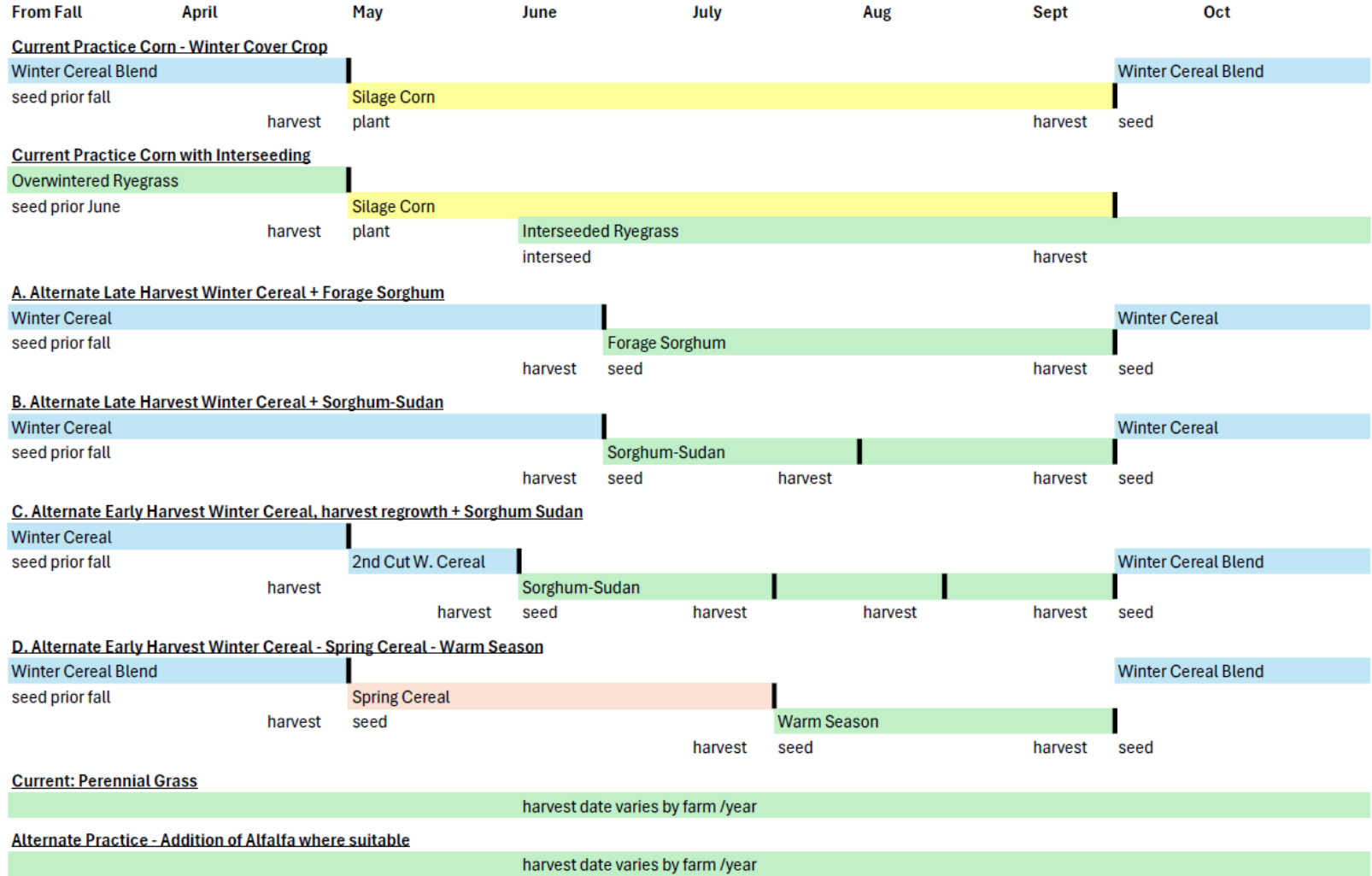
precipitation is projected to increase a small amount in East Delta, remain nearly the same in Sumas Prairie, and decrease in Agassiz. Despite this variation in annual effective precipitation, a consistent decrease in growing season (April 1 – September 30) precipitation combined with increasing potential evapotranspiration will result in a potential moisture deficit of an additional 3-4" (76-103mm) in the 2030s over the historical 1990s baseline across the three locations. This 'near-term' future climate is likely partially realized and accounts for the increasing summer droughts experienced in the region. Warming temperatures will also bring a longer growing season, with annual increases in Base 5° Growing Degree Days ranging from 300 to 400 and corn heat units increasing by 450 to 650 (see Appendix 1).

4.2.3 Potential Cropping Solutions

Winter Cereal and Warm Season Annual

Winter cereal cover crops are common on Lower Mainland dairy farms. For most farms, this crop is integrated with their silage corn rotation—typically seeded after corn harvest and harvested early in the spring to allow timely corn planting. This typically results in relatively low yields – less than 5 tonnes/ha dry matter (DM) (2 tons/ac) – as the crop is harvested before its optimal period of growth. If allowed to mature to soft dough stage, winter cereals have the potential to produce dry matter yields exceeding 20 tonnes/ha (over 8 tons/ac DM) (Bomke, Temple, Kennedy, Cain, & Langlet, 1991). This harvest can occur in early summer and a warm-season, multi-cut forage such as sorghum-sudangrass can be planted immediately following. This timing ensures the C-4 species is seeded and growing during the hottest period of the year when its water use efficiency is at its peak. The yield potential of warm-season annuals is uncertain and would depend largely on timing of seeding and moisture availability, but one industry expert reported yields over 10 tons/acre as-fed. It appears feasible to achieve combined yields of a winter cereal and warm season annual that match or exceed those of silage corn and winter cover crop.

Lower Mainland



A. Winter Cereal (late harvest) + Warm Season (Forage Sorghum)

	Winter Cereal	Forage Sorghum
Seeding	September	Late June
Harvest	Mid June	September
Forage Yield and Quality	4-8 tons/acre DM	2-4 tons/acre DM
	8-10% CP	9-12% CP
	58-60% TDN	65%+ TDN
Advantages	<ul style="list-style-type: none"> ▪ Maximizes tonnage from winter cereal crop ▪ Single harvest of forage sorghum reduces harvesting costs ▪ Forage sorghum seed is relatively economical compared to corn seed ▪ Allows for in-season manure applications ▪ Provides both high volume and high-quality forages ▪ The warm season species can persist through dry conditions 	
Disadvantages and Risks	<ul style="list-style-type: none"> ▪ If Italian ryegrass is included in the winter cereal blend, it could be setting seed by this harvest window creating volunteers and reducing quality. ▪ Risk of inadequate moisture in fall seeding window ▪ Risk of excess moisture in June delaying harvest 	
Notes	Forage sorghum is available in BMR varieties for additional forage quality. Allowing it to reach adequate maturity for direct harvesting is desirable and may be difficult.	

B. Winter Cereal (late harvest) + Warm Season (Sorghum-Sudan)

	Winter Cereal	Sorghum Sudan
Seeding	September	Late June
Harvest	Mid June	Multiple
Forage Yield and Quality	4-8 tons/acre DM	2-4 tons/acre DM
	8-10% CP	11-14% CP
	58-60% TDN	65%+ TDN
Advantages	<ul style="list-style-type: none"> ▪ Maximizes tonnage from winter cereal crop ▪ Multiple harvests of sorghum-sudan maximize forage quality and spread harvest risk. ▪ Sorghum-sudan seed is relatively economical compared to corn seed ▪ Allows for multiple in-season manure applications ▪ Provides both high volume and high-quality forages ▪ Harvesting can utilize existing equipment for many producers ▪ The warm season species can persist through dry conditions 	
Disadvantages and Risks	<ul style="list-style-type: none"> ▪ If Italian ryegrass is included in the winter cereal blend, it could be setting seed by this harvest window creating volunteers and reducing quality. ▪ Risk of inadequate moisture in fall seeding window ▪ Risk of excess moisture in June delaying harvest ▪ Additional harvesting costs vs. A. 	

Notes	Sorghum-sudan is available in BMR varieties for additional forage quality. Proper cutting and windrow management is important during dry down to minimize ash contamination risk.
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C. Winter Cereal (multicut) + Warm Season Annual

	Winter Cereal		Warm Season Annual
	First Cut	Second Cut	
Seeding	September		Early June
Harvest	Late April (pre-boot stage)	Late May (pre-boot stage)	Multiple Options
Forage Yield and Quality	2-4 tons/acre DM	1.5-2.5 tons/acre DM	1-2 tons/acre DM
	12-14% CP 60%+ TDN	11-13% CP 60%+ TDN	12-14% CP 65%+ TDN
Advantages	<ul style="list-style-type: none"> Provides additional high quality winter cereal forage. Flexibility to switch to option A or B if weather window does not allow early harvest. 		
Disadvantages and Risks	<ul style="list-style-type: none"> May require termination of winter cereal to reduce competition Risk of inadequate moisture in fall seeding window. Can be challenging to establish vigorous warm season crop if conditions are cool at seeding. 		
Notes	There are multiple options for the warm season component including forage sorghum (to be harvested one time) and forage sorghum-sudan (to be harvested multiple times). These options are compared above in options A and B. Both species are available with BMR options to provide highly digestible high energy forage.		

D. Winter Cereal (early harvest) + Spring Cereal

	Winter Cereal (early harvest)	Spring Cereal	Warm Season
Seeding	Mid to Late September	Mid-May	Mid July
Harvest	Early/Mid-May (pre-boot stage)	Mid-July	Multiple Options
Forage Yield and Quality	2-4 tons/acre DM	1-3 tons/acre DM	1-3 tons/acre DM
	12-14% CP 60%+ TDN	10-12% CP 58-62% TDN	12-14% CP 65%+ TDN
Advantages	<ul style="list-style-type: none"> Multiple harvest and manure application options Potential to produce a spring cereal crop before moisture is too limiting More reliable moisture availability for planting following spring cereal crop 		

	<ul style="list-style-type: none"> Flexibility to switch to other options if weather window does not allow early harvest.
Disadvantages and Risks	<ul style="list-style-type: none"> Spring cereal productivity could be low in with a hot early summer compared to alternatives. Regrowth of the winter cereal can be a competitor to the spring cereal and create varying stages of maturity at harvest. Potential for soil moisture loss if tillage is needed to terminate winter cereal Low moisture may not allow seeding of the warm season component
Notes	This option can be a good fit for producers who prefer feeding cereal silages and need to balance volume and quality. An option to consider for producers who have double cropped spring cereal silage in the past. It also allows some flexibility for years when late summer moisture is uncertain.

E. Modification of Existing Perennial Grass/Legume System

As alfalfa varieties improve in disease resistance and tolerance to low pH, there is growing potential for their utilization in the Lower Mainland.

4.3 Southern Interior

4.3.1 Current Cropping Systems

Silage corn, alfalfa, and perennial grasses are the primary crops on dairy farms in the Southern Interior. Corn is typically planted between late April and mid-May. In the past, little corn was grown on rainfed acres in the interior. However, as hybrid varieties have improved, their use has increased- gradually displacing spring cereal crops. Alfalfa is the primary perennial crop; however, grasses are grown in areas where low pH, high water tables, or peat soils make conditions unfavourable for alfalfa. Annual cereal-based production also occurs and there has been a shift to more winter cereals and fewer spring cereals as improved winter cereals have become available. Some producers have experimented with sorghum and sorghum-sudangrass, but it has not been widely adopted. Some of the barriers to adoption include risk aversion due to previous management issues, such as excess moisture and ash at harvest, as well as inconsistent seed availability.

Irrigation is more widespread in the Southern Interior than other dairy-producing regions of B.C. The Agricultural Land Use Inventory for the Regional District of North Okanagan reported 12,593 ha of irrigated forage and pastureland, representing 58% the total (B.C. Ministry of Agriculture, 2016).

4.3.2 Climate Change Projections and Impacts

The three locations selected for climate analysis for the southern interior – Salmon Arm, Armstrong, and Creston – are all projected to experience increases in annual temperatures, growing degree days, corn heat units, and potential evapotranspiration. At

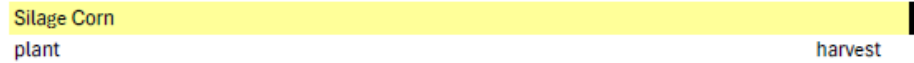
the same time, decreases in effective precipitation are expected and result in significant increases in potential moisture deficit. The annual projected change in moisture deficit from the 1981-2010 historical baseline to the near-term future period of 2021-2050, is 125.3mm for Creston, 157.9mm for Salmon Arm, and 169.7mm for Armstrong. This is expected to increase the severity, duration, and frequency of droughts, along with greater demand for irrigation water where it is available (see appendix 1).

4.3.3 Potential Cropping Solutions

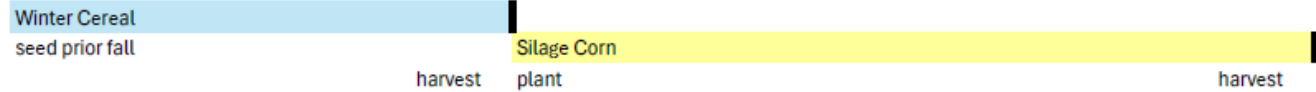
Southern Interior

From Fall April May June July Aug Sept Oct

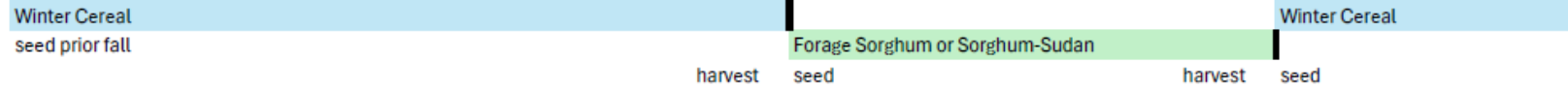
Current Practice - Silage Corn



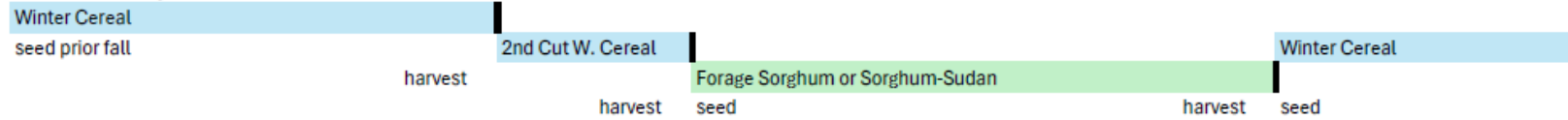
A. Alternate Practice - Winter Cereal (early harvest) + Silage Corn



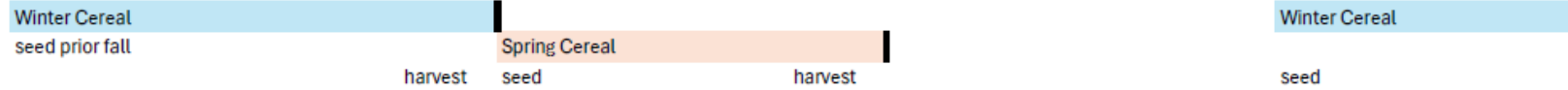
B. Alternate Late Harvest Cereal + Warm Season



C. Alternate Early Harvest Cereal, harvest regrowth + Warm Season



D. Alternate Early Harvest Cereal, Spring Cereal



E. Alternate Practice - Alfalfa altered cutting schedule



A. Winter Cereal (early harvest) + Silage Corn

	Winter Cereal	Silage Corn
Seeding	September	Mid-May
Harvest	Early May	September
Forage Yield and Quality	1-3 tons/acre DM	6-9 tons/acre DM
	14-18% CP	7-8% CP
	60%+ TDN	70%+ TDN
Advantages	<ul style="list-style-type: none"> ▪ Harvest of high-quality forage early in season ▪ Opportunity to incorporate diverse blends with soil and rotational benefits. ▪ Can be used for summer grazing if needed ▪ Flexibility to switch to option B due to weather window or forage requirements 	
Disadvantages and Risks	<ul style="list-style-type: none"> ▪ Some corn yield reduction vs. earliest planting dates ▪ Cereal crop yield can be low in cool springs ▪ Can reduce soil moisture and require irrigation for even corn germination ▪ Can be operationally tight on time for manure spreading and tillage practices ▪ Requires adequate moisture for germination of winter cereal in fall 	
Notes	Producers have had the most success using fall rye for very early spring growth, spring triticale can also be successful in years with warm springs. Producers are encouraged when selecting corn hybrids to reduce corn heat units to offset later planting date.	

B. Winter Cereal (late harvest) + Warm Season Annual

	Winter Cereal	Warm Season Annual
Seeding	September	Early July
Harvest	Late June	Multiple Options
Forage Yield and Quality	4-7 tons/acre DM	1-4 tons/acre DM
	8-10% CP	12-14% CP
	58-60% TDN	65%+ TDN
Advantages	<ul style="list-style-type: none"> ▪ Maximizes tonnage from winter cereal crop ▪ If moisture allows, gives opportunity to plant warm season afterwards. ▪ Allows for in-season manure applications ▪ Provides both high volume and high-quality forages ▪ The warm season species can persist through dry conditions 	
Disadvantages and Risks	<ul style="list-style-type: none"> ▪ Quality of soft dough winter cereal silage is lower than ideal for lactating rations ▪ Risk of inadequate moisture in fall seeding window 	
Notes	There are multiple options for the warm season component including forage sorghum (to be harvested one time) and forage sorghum-sudan (to be harvested multiple times). There are advantages to both systems depending on	

operation; forage sorghum can be cut once saving operational costs while the multiple cuttings of sorghum-sudan can help spread out weather risk and utilize existing perennial forage harvesting equipment. Both species are available in BMR varieties, which offer highly digestible, high-energy forage.

C. Winter Cereal (multicut) + Warm Season Annual

	Winter Cereal		Warm Season Annual
	First Cut	Second Cut	
Seeding	September		Mid-June
Harvest	Mid-May (pre-boot stage)	Mid-June (pre-boot stage)	Multiple Options
Forage Yield and Quality	2-4 tons/acre DM	1.5-2.5 tons/acre DM	1-3 tons/acre DM
	12-14% CP 60%+ TDN	11-13% CP 60%+ TDN	12-14% CP 65%+ TDN
Advantages	<ul style="list-style-type: none"> Maximizes quality from the winter crop and warm season Reduces risk of establishing warm season crop during May-June if cool Flexibility to switch to option B if weather window does not allow early harvest. 		
Disadvantages and Risks	<ul style="list-style-type: none"> Less tonnage than option B May require termination of Winter Cereal to reduce competition Risk of inadequate moisture in fall seeding window. Harvesting in June can be challenging during wet years. 		
Notes	As with option B, there are multiple options for the warm season component including forage sorghum (to be harvested one time) and forage sorghum-sudan (to be harvested multiple times). There are advantages to both systems depending on operation; Forage sorghum can be cut once saving operational costs while the multiple cuttings of sorghum-sudan can help spread out weather risk and utilize existing perennial forage harvesting equipment. Both species are available in BMR varieties, which offer highly digestible, high-energy forage.		

D. Winter Cereal (early harvest) + Spring Cereal

	Winter Cereal (early harvest)	Spring Cereal
Seeding	Mid to Late September	Mid-May
Harvest	Early/Mid-May (pre-boot stage)	Mid-July
	2-4 tons/acre DM	1-3 tons/acre DM

Forage Yield and Quality	12-14% CP 60%+ TDN	10-12% CP 58-62% TDN
Advantages	<ul style="list-style-type: none"> ▪ Potential for higher yields compared to regrowth from winter cereals ▪ Potential to produce a spring cereal crop before moisture is too limiting ▪ More reliable moisture availability for planting following spring cereal crop ▪ Flexibility to switch to option A if weather window does not allow early harvest. 	
Disadvantages and Risks	<ul style="list-style-type: none"> ▪ Less overall tonnage compared to option A. ▪ Regrowth of the winter cereal can be a competitor to the spring cereal and create varying stages of maturity at harvest. ▪ Potential for soil moisture loss if tillage is needed to terminate winter cereal ▪ In dry years, the spring cereal may not reach soft dough and will have reduced forage quality 	
Notes	This option can be a good fit for producers who prefer feeding cereal silages and need to balance volume and quality. An option to consider for producers who have double cropped spring cereal silage in the past.	

E. Modification of Existing Perennial Grass/Legume System

For alfalfa stands, water use efficiency is highest during the first cutting. Producers may consider their overall forage requirements (volume and quality) and potentially allow the first cutting to be harvested at a later maturity than normal to optimize tonnage, particularly on stands with lower plant/stem counts.

Stands with high plant / stem counts, along with high yield potential, are better suited for irrigation during reduced water supply seasons. These stands can be managed more aggressively to meet the high-quality forage requirements.

4.4 Vancouver Island

4.4.1 Current Cropping Systems

Silage corn and perennial grasses are the dominant forage crops for dairy farms on Vancouver Island. Corn is planted between late April and June and harvested between late summer and early fall. Corn varieties with heat units ranging from 2100 – 2400 are typically selected. A range of perennial grasses are included in silage mixes, but orchard grasses and fescues are the primary species. Irrigated fields will be harvested 4-5 times over the growing season, while dry land sites typically rely on a high yielding first cut, with subsequent harvests dependent on rain.

Agriculture Land Use Inventory (ALUI) data collected in 2012 the Cowichan Valley Regional District reports a total of 2,166 ha of irrigated forage land, representing 36% of the total (van der Gulik, Neilsen, Fretwell, & Tam, 2013), while 2013 ALUI data for the Comox Valley Regional District reported 1,150 ha irrigated, representing 15% of the total (van der Gulik, Nielsen, Fretwell, & Tam, 2014). Interviewees in 2024 reported growing interest in

irrigation expansion. However, many agricultural watersheds on Vancouver Island are considered fully recorded, meaning no new water allocations are available and new water licences are unlikely to be granted.

4.4.2 Climate Change Projections and Impacts

For the two locations analysed (Koksilah and Black Creek) climate change is projected to increase annual average temperatures leading to increases in growing degree days, corn heat units and growing season length. Climate models project an increase in annual effective precipitation for the Koksilah region and a decrease in Black Creek; despite this difference, both regions will experience increasing moisture deficits through the April 1 – September 30 period as summer precipitation decreases and potential evapotranspiration increases. The result will be an increase in total production based solely on temperature, but a corresponding increase in drought length and severity, and potential for more challenging shoulder seasons where drainage is poor (see Appendix 1).

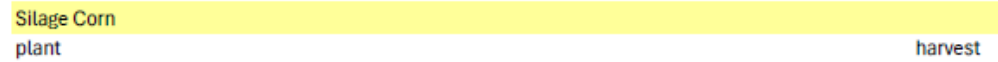
4.4.3 Potential Cropping Solutions

One of the major challenges identified in interviews on the island is the wildlife pressure on the viability of winter cereals for forage, thus many of the alternatives discussed below do not rely on a winter cereal component. If a producer is in a location where conditions allow for reliable winter cereal use it can be added to the first three alternatives.

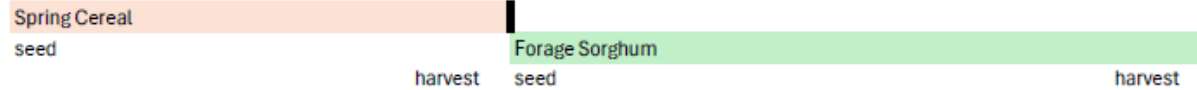
Vancouver Island

From Fall April May June July Aug Sept Oct

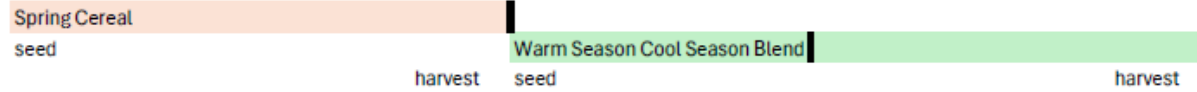
Current Practice - Silage Corn



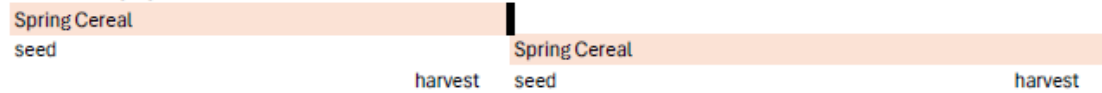
A. Alternate Practice - Spring Cereal - Warm Season



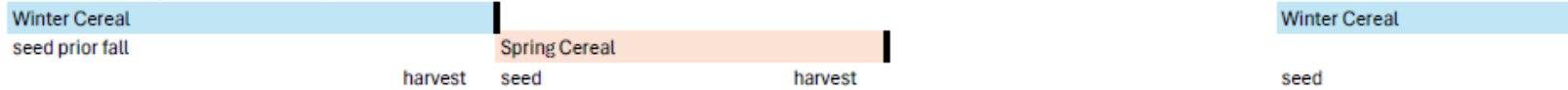
B. Alternate Practice - Spring Cereal - Warm/ Cool Season Blend



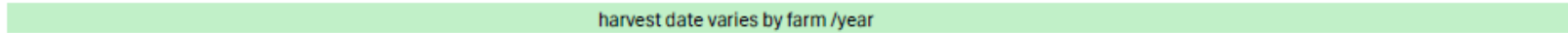
C. Alternate Practice - Double Crop Spring Cereal



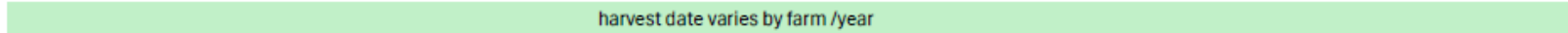
D. Alternate Early Harvest Cereal, Spring Cereal



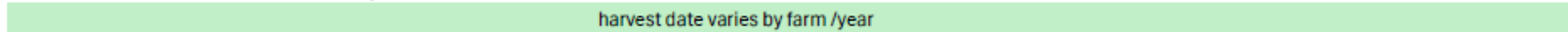
Current: Perennial Grass



E. Alternate Practice - Addition of Alfalfa where suitable



F. Alternate Practice - Addition of grass species with higher drought tolerance



A. Spring Cereal + Forage Sorghum

	Spring Cereal	Forage Sorghum
Seeding	April	Late June
Harvest	Mid June	Late Sept
Forage Yield and Quality	2-4 tons/acre DM	1-3 tons/acre DM
	12-14% CP	10-12% CP
	60%+ TDN	58-62% TDN
Advantages	<ul style="list-style-type: none"> Utilizes cool season crop during cooler spring weather and warm season during hot summer Relatively low seeding and harvest costs 	
Disadvantages and Risks	<ul style="list-style-type: none"> May require custom operator to harvest forage sorghum and can require dry down for optimal fermentation. Achieving optimal quality during the June harvest window may be challenging 	
Notes	This option can be a good fit for producers who prefer feeding cereal silages and need to balance volume and quality. An option to consider for producers who have double cropped spring cereal silage in the past.	

B. Spring Cereal + Warm Season / Cool Season Blend

	Spring Cereal	Annual Blend
Seeding	April	Late June
Harvest	Mid June	Multiple
Forage Yield and Quality	2-4 tons/acre DM	1-3 tons/acre DM
	10-14% CP	10-12% CP
	60%+ TDN	58-62% TDN
Advantages	<ul style="list-style-type: none"> Allows for risk management with the annual blend to include both cool and warm season annuals such as ryegrass and sorghum-sudangrass family With sufficient moisture, multiple harvests of the annual blend are possible Utilizes existing equipment Multiple manure spreading windows 	
Disadvantages and Risks	<ul style="list-style-type: none"> Overall lower tonnage than alternatives Achieving optimal quality during the June harvest window may be challenging. 	
Notes	A good option for risk management, particularly for producers with the desire to grow a cereal while enabling multiple harvests. Some flexibility of species selection and seeding methods within the annual blend, allowing producers to tailor approaches to their specific needs.	

C. Spring Cereal Double Crop

	Spring Cereal	Spring Cereal
Seeding	April	Mid June
Harvest	Mid June	September
Forage Yield and Quality	2-4 tons/acre DM	1-3 tons/acre DM
	10-14% CP	10-12% CP
	60%+ TDN	58-62% TDN
Advantages	<ul style="list-style-type: none"> ▪ Potential to produce a spring cereal crop before moisture is too limiting ▪ Reliable moisture availability for planting following spring cereal crop 	
Disadvantages and Risks	<ul style="list-style-type: none"> ▪ Second crop of spring cereal may not reach high tonnage or quality in dry years or sites. ▪ Optimal quality during the June harvest window may be challenging. 	
Notes	This option can be a good fit for producers who prefer feeding cereal silages and need to balance volume and quality. An option to consider for producers who have double cropped spring cereal silage in the past.	

D. Winter Cereal + Spring Cereal

	Winter Cereal	Spring Cereal
Seeding	September	Mid-May
Harvest	Early May (pre-boot stage)	Mid-July
Forage Yield and Quality	2-3 tons/acre DM	1-3 tons/acre DM
	12-14% CP	10-12% CP
	60%+ TDN	58-62% TDN
Advantages	<ul style="list-style-type: none"> ▪ Fits for producers who are able to utilize a winter cereal ▪ More reliable moisture availability supports planting following spring cereal crop ▪ Flexibility to switch to option A if weather window does not allow early harvest. 	
Disadvantages and Risks	<ul style="list-style-type: none"> ▪ Wildlife and waterfowl risks to winter cereal reliability ▪ Timing of harvest of winter cereal and spring cereal may not allow for optimal forage quality ▪ Regrowth of the winter cereal can be a competitor to the spring cereal and create varying stages of maturity at harvest. ▪ Potential for soil moisture loss if tillage is needed to terminate winter cereal ▪ In dry years, the spring cereal may not reach soft dough and will have reduced forage quality 	
Notes	This option can be a good fit for producers who prefer feeding cereal silages and need to balance volume and quality.	

E. Addition of alfalfa where suitable

As alfalfa varieties improve disease and low pH tolerance there is additional potential for their utilization on the island where drainage allows. This could provide more reliable late season production in drought conditions.

F. Addition of more grass species

There is potential to incorporate a variety of grass species including fescue type festuloliums, meadow brome and tall fescue.

4.5 Additional management strategies:

Throughout this project additional strategies were identified for consideration to build resilience in drought years including:

- Stockpiled forage supplies from good to poor years
- Irrigation development
- Importance of growing high-quality forage for more efficient milk production

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Appendix 1 – Agriculture Water Demand Model Climate Projections

Methods

A climate analysis was completed for nine locations using outputs from the Agricultural Water Demand Model. Specific locations were selected for analysis based on their proximity to a high density of dairy farms, relative to their region of the province. Each location was modeled under historic climate data for 1981-2010 and for 2021-2050 for the following predictive climate models:

- ACCESS 1-0 rcp 8.5
- CanESM2 rcp 8.5
- CNRM-CM5 rcp 8.5
- inmcm4 rcp 8.5
- CSIRO-Mk3-6-0 rcp 8.5

The model outputs consisted of the following data:

- Julian Day
- Maximum Temperature
- Minimum Temperature
- Mean Temperature
- Precipitation
- Effective Precipitation
 - in wet climates, 75% of the measured precipitation
 - in dry climates, 75% of measured precipitation above 5mm
 - a wet climate is defined as receiving > 125mm precipitation between May 1 and September 30
- Reference Evapotranspiration (ET₀)

This data was averaged across all model outputs for each Julian day for the relevant 30-year climate period and used to calculate the following agriculturally relevant climate metrics:

- Growing Degree Days Base 5 (GDD-5)

$$\text{GDD-5} = (\text{Tmax} + \text{Tmin})/2 - 5$$

- Corn Heat Units (CHU)

$$\text{CHU} = [3.33 * (\text{Tmax} - 10) - 0.084 * (\text{Tmax} - 10)^2 + (9/5) * (\text{Tmin} - 4.4)] / 2$$

- Potential climatic water balance

$$\text{Effective Precip} - \text{ET}_0 = \text{Water Balance}$$

Agassiz - 49.231897017413694, -121.77639616180993										
	GDD-5		CHU		Effective Precip		ETO		Water Balance	
Month	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s
January	0.0	0.0	0.0	0.0	160.5	150.2	13.3	12.6	147.1	137.7
February	5.3	18.9	0.0	0.0	99.6	113.0	23.4	22.8	76.2	90.2
March	63.5	84.5	36.6	70.2	113.7	105.8	48.2	48.8	65.5	57.0
April	150.5	175.5	231.0	283.7	90.7	88.0	77.8	79.1	12.8	8.8
May	264.2	298.7	457.7	517.1	75.4	72.6	112.1	116.8	-36.7	-44.2
June	328.5	372.3	571.2	636.6	68.5	53.2	122.7	132.2	-54.2	-79.0
July	422.1	479.4	706.4	771.4	44.6	26.0	142.1	156.9	-97.5	-131.0
August	426.0	474.8	710.3	764.8	40.7	29.3	126.2	136.9	-85.5	-107.6
September	319.7	362.7	553.3	613.4	63.0	58.6	83.6	89.8	-20.6	-31.1
October	178.1	206.2	276.9	336.9	131.7	125.7	41.8	43.8	89.9	81.9
November	35.0	49.2	6.9	21.1	202.2	176.8	16.4	17.4	185.8	159.4
December	0.0	0.0	0.0	0.0	150.7	161.5	10.6	11.1	140.1	150.4
	2192.9	2522.2	3550.4	4015.4	1241.1	1160.7	807.7	857.1	422.8	292.5

Armstrong - 50.4487675403743, -119.17547540627025										
	GDD-5		CHU		Effective Precip		ETO		Water Balance	
Month	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s
January	0.0	0.0	0.0	0.0	40.9	37.3	16.4	16.7	24.5	20.6
February	0.0	0.0	0.0	0.0	24.9	23.6	23.5	24.7	1.4	-1.1
March	3.6	25.3	0.0	16.2	25.0	19.9	51.7	53.9	-26.7	-34.0
April	102.6	170.7	148.1	286.0	24.6	19.1	88.0	95.9	-63.4	-76.8
May	248.0	330.2	425.5	551.2	33.2	26.6	128.3	141.3	-95.2	-114.6
June	352.9	439.3	589.7	691.6	37.8	28.9	146.8	162.4	-109.0	-133.5
July	456.2	552.2	707.0	779.7	27.9	18.6	167.8	188.4	-139.9	-169.8
August	436.2	527.5	682.4	758.7	25.5	19.8	146.2	162.5	-120.7	-142.8
September	262.6	348.4	449.6	571.9	30.2	22.7	90.3	100.9	-60.1	-78.2
October	75.5	145.1	87.5	215.6	34.9	27.7	45.9	50.6	-11.0	-22.9
November	0.0	4.3	0.0	0.0	45.7	37.1	21.1	22.9	24.6	14.2
December	0.0	0.0	0.0	0.0	43.9	39.7	14.8	16.7	29.1	23.0
	1937.7	2543.0	3089.9	3870.9	394.5	320.9	925.9	1020.1	-546.3	-716.0

Black Creek - 49.83431063829301, -125.146455010908										
	GDD-5		CHU		Effective Precip		ETO		Water Balance	
Month	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s
January	0.0	0.0	0.0	0.0	164.9	162.3	12.9	13.3	152.0	149.0
February	0.0	9.2	0.0	0.0	108.7	122.4	21.8	22.8	86.9	99.6
March	21.8	60.3	0.0	30.0	104.5	109.3	44.7	48.1	59.7	61.2
April	100.0	144.6	122.5	222.3	67.7	62.1	73.9	78.9	-6.3	-16.8
May	210.9	255.7	357.0	441.3	48.2	41.3	107.9	114.3	-59.7	-73.0
June	295.8	343.9	515.5	592.1	43.0	34.8	124.0	132.1	-81.0	-97.3
July	383.8	444.0	651.5	729.1	30.8	19.0	138.5	152.3	-107.7	-133.3
August	381.3	436.8	645.6	719.6	32.4	26.0	123.0	131.2	-90.6	-105.2
September	264.6	314.7	459.7	542.0	44.7	42.5	77.6	82.1	-32.9	-39.6
October	122.5	166.8	156.6	254.0	118.6	115.3	37.8	39.8	80.7	75.5

November	14.8	44.6	0.0	13.4	184.4	178.0	16.1	17.4	168.2	160.7
December	0.0	0.6	0.0	0.0	177.1	186.4	10.4	11.4	166.7	175.0
	1795.4	2221.1	2908.4	3543.9	1124.9	1099.4	778.5	832.4	336.0	255.6

Creston - 49.09542399718361, -116.5457957172434										
	GDD-5		CHU		Effective Precip		ETO		Water Balance	
Month	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s
January	0.0	0.0	0.0	0.0	39.9	39.1	18.1	18.4	21.7	20.7
February	0.0	0.0	0.0	0.0	25.6	26.8	25.2	26.3	0.4	0.5
March	5.4	24.4	0.6	13.6	28.4	26.2	52.0	53.7	-23.6	-27.6
April	107.1	152.3	150.9	245.0	22.7	20.3	85.4	89.5	-62.7	-69.2
May	241.8	300.2	416.8	510.8	35.7	29.7	122.3	132.4	-86.7	-102.7
June	334.8	406.8	568.9	660.8	36.1	28.2	138.5	152.7	-102.4	-124.5
July	456.2	538.5	712.7	780.0	21.7	13.1	165.5	182.7	-143.8	-169.6
August	450.8	520.8	700.3	752.6	17.4	15.3	149.1	163.6	-131.8	-148.3
September	275.8	341.1	471.4	558.4	23.4	19.6	93.9	103.8	-70.5	-84.2
October	85.7	134.3	108.3	198.3	25.2	25.0	50.7	55.0	-25.5	-29.9
November	0.0	1.1	0.0	0.0	49.2	41.5	22.6	24.2	26.6	17.3
December	0.0	0.0	0.0	0.0	45.5	41.1	16.4	17.7	29.2	23.4
	1957.7	2419.5	3130.0	3719.5	370.8	325.9	923.4	1002.4	-569.0	-694.3

East Delta - 49.1008502426735, -122.92003763159008										
	GDD-5		CHU		Effective Precip		ETO		Water Balance	
Month	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s
January	0.0	0.0	0.0	0.0	125.1	129.7	14.0	14.1	111.2	115.6
February	9.1	37.0	0.0	3.6	78.1	98.8	23.2	24.0	54.8	74.8
March	68.0	101.3	34.9	104.9	83.2	85.8	45.1	48.5	38.1	37.3
April	139.8	177.9	201.2	286.0	63.4	65.5	70.4	75.3	-7.0	-9.8
May	244.7	286.1	419.8	496.6	52.2	52.2	101.5	108.8	-49.4	-56.6
June	317.9	362.7	555.4	626.7	41.5	35.2	114.7	124.4	-73.2	-89.1
July	398.3	457.2	682.6	755.6	25.8	16.3	128.5	145.8	-102.8	-129.4
August	400.7	454.2	686.5	752.1	29.7	23.3	112.1	126.0	-82.5	-102.7
September	304.1	350.2	530.5	602.1	41.1	40.8	74.1	82.3	-33.1	-41.5
October	173.4	208.5	262.1	340.7	92.3	96.7	38.0	41.4	54.3	55.4
November	45.7	74.7	16.4	45.7	143.9	144.6	16.6	18.6	127.2	126.0
December	0.0	11.7	0.0	0.0	116.5	130.6	11.5	12.4	105.0	118.2
	2101.7	2521.5	3389.5	4013.9	892.6	919.7	738.3	809.2	142.7	98.1

Koksilah - 48.73382329504284, -123.69164289275372										
	GDD-5		CHU		Effective Precip		ETO		Water Balance	
Month	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s
January	0.0	0.0	0.0	0.0	145.9	159.4	14.7	14.5	131.2	144.9
February	2.5	23.9	0.0	0.0	89.8	113.4	23.5	24.0	66.3	89.4

March	49.9	81.4	12.0	62.6	91.4	102.6	46.6	49.4	44.8	53.1
April	123.1	154.4	171.1	239.5	49.7	56.8	74.6	77.4	-24.8	-20.7
May	233.1	262.3	399.7	453.3	37.4	34.9	108.3	112.4	-70.9	-77.5
June	312.3	348.4	543.7	599.9	27.6	23.1	123.4	130.3	-95.9	-107.2
July	406.7	457.5	685.7	746.0	14.9	9.6	141.0	154.3	-126.1	-144.7
August	407.0	450.9	685.7	739.3	21.1	17.4	123.9	132.5	-102.8	-115.1
September	298.8	342.3	518.9	585.2	28.0	31.3	82.2	86.7	-54.2	-55.4
October	156.5	189.6	229.6	300.7	80.4	92.4	40.6	41.8	39.8	50.6
November	35.7	62.3	6.4	27.1	153.3	156.1	17.6	18.5	135.6	137.6
December	0.0	9.3	0.0	0.0	152.0	171.6	11.8	12.6	140.3	159.0
	2025.6	2382.1	3252.7	3753.6	891.5	968.5	796.5	841.8	83.2	114.1

Salmon Arm - 50.68873341822137, -119.30808821590999										
Month	GDD-5		CHU		Effective Precip		ETO		Water Balance	
	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s
January	0.0	0.0	0.0	0.0	32.0	28.0	16.2	16.5	15.8	11.5
February	0.0	0.0	0.0	0.0	20.3	17.2	23.1	24.4	-2.8	-7.2
March	5.1	20.6	0.7	12.0	19.4	14.7	51.7	53.8	-32.3	-39.1
April	108.4	157.0	159.2	259.4	21.7	16.9	87.6	94.2	-65.9	-77.3
May	251.0	312.6	431.3	526.4	31.9	28.1	127.0	137.2	-95.1	-109.1
June	355.0	422.5	593.3	671.1	33.9	26.7	146.3	160.6	-112.3	-133.8
July	462.5	538.2	715.3	763.7	26.5	17.6	168.1	188.5	-141.5	-170.8
August	446.4	517.5	693.8	744.4	24.7	18.7	147.9	163.7	-123.2	-145.0
September	272.8	338.8	465.9	553.4	27.7	21.5	92.3	102.8	-64.5	-81.3
October	75.9	125.5	89.8	182.7	26.8	21.9	46.4	51.3	-19.6	-29.4
November	0.0	0.3	0.0	0.0	35.6	27.1	21.0	22.7	14.6	4.4
December	0.0	0.0	0.0	0.0	35.2	29.5	14.7	16.4	20.5	13.1
	1977.2	2432.9	3149.3	3713.2	335.8	268.1	927.4	1015.8	-606.2	-764.1

Sumas Prairie - 49.03179588031927, -122.18366413685929										
Month	GDD-5		CHU		Effective Precip		ETO		Water Balance	
	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s	1990s	2030s
January	0.0	0.0	0.0	0.0	152.1	151.8	14.3	13.8	137.8	138.0
February	7.7	32.3	0.0	3.2	97.0	122.0	23.9	23.7	73.1	98.2
March	67.8	100.3	42.9	105.6	107.2	111.0	48.4	50.3	58.8	60.7
April	148.2	182.9	225.5	299.2	85.9	91.6	76.5	79.3	9.4	12.3
May	259.7	300.9	449.2	521.3	71.5	74.9	109.6	115.8	-38.2	-40.9
June	328.7	374.7	571.2	639.6	59.2	49.5	123.6	133.6	-64.4	-84.1
July	413.3	473.6	694.3	761.6	37.3	23.5	142.1	158.8	-104.8	-135.3
August	416.7	469.1	698.2	757.5	38.2	29.9	125.2	136.9	-87.1	-107.0
September	314.4	362.6	544.7	613.7	55.4	56.2	83.1	90.0	-27.7	-33.8
October	178.1	213.8	277.1	353.1	116.0	120.0	41.6	44.0	74.3	76.0
November	41.8	69.1	14.2	41.5	180.9	173.5	17.3	18.7	163.6	154.8
December	0.0	7.5	0.0	0.0	140.3	160.3	11.4	12.1	128.9	148.2
	2176.4	2586.8	3517.2	4096.3	1140.8	1164.1	805.6	865.0	323.8	287.1