Climate Change

The Need for Adaptation

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Climate Change – The Need for Adaptation

In light of anticipated changes in growing conditions and emerging market opportunities, research is required to assess innovative farm practices for adapting to climate change.

A current report issued by The United Nations International Fund for Agricultural Development (IFAD) states that for every dollar invested in climate change adaptation practices, through its Adaptation for Smallholder Agriculture Program (ASAP), producers could earn a return of between $1.40 and $2.60 over a 20-year period. However, the report also states that alongside farm-level actions are a set of non-technical mitigation and adaptation interventions, that include capacity-building, institutional strengthening, services to provide finance, information, extension and research, policy and legal frameworks, and, finally, program management, particularly for monitoring and evaluation that should be implemented (from: https://www.ifad.org/documents/10180/7e3dff00-db38-40c6-a2a1-672ff84a0526).

In 2013, a study by the British Columbia Forage Council (BCFC), "Forage Production and Export Potential in BC's Central Interior", confirmed opportunities to expand the export forage market, identified existing limitations to the forage sector, and provided several recommendations including supporting local, applied production research. The report concluded that in light of anticipated changes in growing conditions and emerging market opportunities, research is required to assess innovative farm practices for adapting to climate change impacts and weather related production risks, and to identify new and adaptive management practices.

In 2014, the BCFC began a project "Demonstrating Innovative Forage Production Practices to Increase Climate Change Adaptation". The Climate Change Adaptation program included: the development of an On-Farm Demonstration Research Guide, four local field trials with participating producers in the Vanderhoof area testing climate change adaptation practices, and four accompanying weather stations to increase access to current weather data and provide a network for climate monitoring. The results of the four on-farm field trials have been published in the On-Farm Demonstration Manual, available through the BCFC at: www.farmwest.com/sites/default/files/images/client/BC%20Forage%20Council/Research_Manual_digital.pdf.

This report will focus on presenting and interpreting the 2016 results from the four weather stations installed in the Vanderhoof area.

Water – Critically Scarce

The role of water in the production of agricultural crops is complex, and the interactive processes involved in crop production can be difficult to quantify. While the upper limit of crop production is determined by both the local climatic conditions and the genetic potential of the crop, water stress at any growth stage will reduce yield. Additionally, the extent to which the maximum productivity will be affected by water stress is also affected by how closely water availability matches plant water demands over time. Therefore, it is critical to understand both the physiological demands of the crop species as well as the moisture conditions within the cropping system. Water use by alfalfa in relation to its production is quite high – alfalfa has a water requirement 2.1 times greater than wheat, and 4 times greater than sorghum and millet, for the same yield (Briggs and Shantz, 1913; in Poole, 1971). Additionally, *alfalfa is the most sensitive to water deficits just after cutting/grazing* as the plant must regrow.

HISTORICAL ALFALFA CROPPING PATTERNS IN THE VANDERHOOF AREA

It is critical to understand both the physiological demands of the crop species as well as the moisture conditions within the cropping system.

Participating producer Wayne Ray shared some of his observations regarding historical weather and cropping patterns:

"Until about 2002 we used to try to seed our alfalfa by about the middle of May, however in recent years it has been so cold and dry that we seed later."

In the Vanderhoof area, harvesting of alfalfa may not occur in Year 1. Once the stand is established (Year 2), a producer would typically cut during the middle of June, if a hay curing weather window exists. If regrowth is sufficient, a producer may choose to take a second cut during the month of August, allowing enough regrowth in the fall to ensure winter survival.

"When we had warmer and wetter springs our alfalfa would be ready to harvest between the 10th and 25th of June and we would get a second cut between the 10th and end of August."

Outlined in Figure 1 are the historical precipitation norms (1971-2000) recorded from the Environment Canada weather station located in Vanderhoof. Typically, March to May are dry months with June to October being fairly wet.

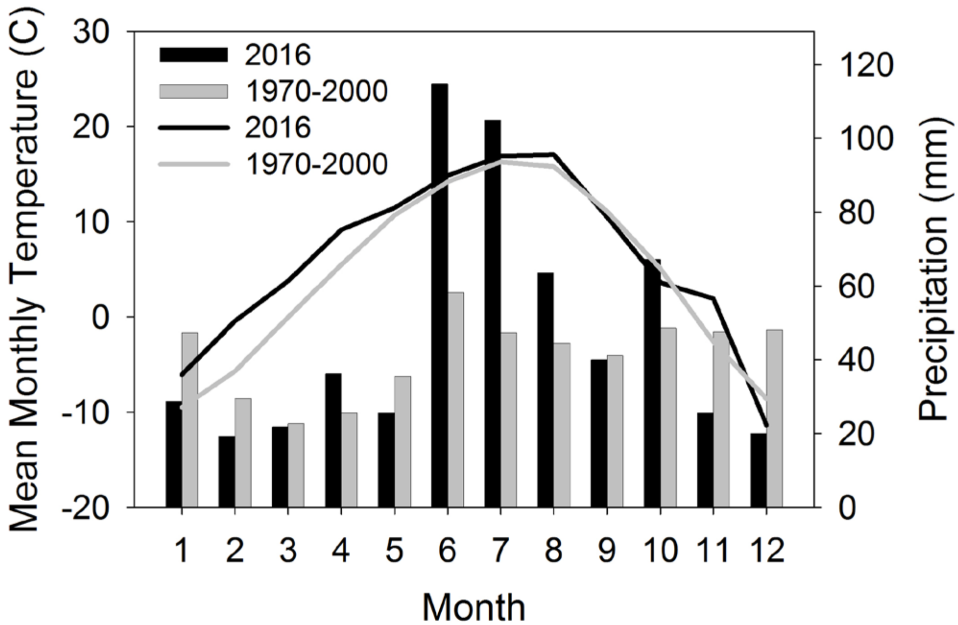


Figure 1 – A comparison of temperature (lines) and precipitation (bars) from the norms (1970-2000) versus those recorded in 2016, from the Environment Canada weather station located in Vanderhoof, BC

CURRENT ALFALFA CROPPING PATTERNS IN THE VANDERHOOF AREA

Producers in the Vanderhoof area are reporting a shift from a warm moist spring, to a cold dry spring. Again, comments from participating producer Wayne Ray:

"In recent years (since 2002) we have had cold, dry and windy spring seasons with frost in the ground over winter, as we have not had decent snow cover that would insulate the ground before long spells of -20 or -30 temperatures. With frozen ground, when the snow melts, it all runs off instead of going into the ground. The wind causes the surface to dry and the frost in the ground keeps the soil too cold for alfalfa to grow until later in the spring."

The cold, dry spring pushes seeding of alfalfa to later in the growing season:

"We usually don't get enough rain for the seeds to germinate until the first part of July so we have a seeding window that lasts from early May to early July."

The effect of anecdotal changes in climate carries through to the harvesting of established stands too:

In recent years we have had cold, dry and windy spring seasons with frost in the ground over winter, as we have not had decent snow cover that would insulate the ground before long spells of -20 or -30 temperatures.

"In recent years we have been cutting our first cut around the middle of July due to slow growth conditions. It's usually extremely dry until about the middle of July; and, if we get any amount of rain it is about the time we are ready to cut, which can delay our cut so our second cut is in September"

It's usually extremely dry until about the middle of July; and, if we get any amount of rain it is about the time we are ready to cut, which can delay our cut so our second cut is in September.

Figure 1 compares historical temperature and precipitation norms to those recorded in 2016. Results from this comparison do support some of the observations of Mr. Ray. The average temperature in the later half of November and through December was colder than the historical norms. As well, there was substantially less precipitation in from November through to February. The cold temperature during November and December combined with less precipitation, likely in the form of snow, could result in the frozen soil conditions that Mr. Ray has been observing.

While the average spring temperatures in 2016 do appear to be warmer than historical norms, these warmer temperatures may not be able to off-set the growing conditions if the soil is frozen. Additionally, winter injury to alfalfa will result in slow spring regrowth - a compounding effect of a reduced snow cover in the winter months. A minimum 10 cm of snow is considered adequate to insulate the soil and prevent direct freezing damage to alfalfa. Temperatures of -9 to -15°C at the crown are capable of causing winter injury. Depending on snow cover and minimum air temperatures, as well as degree of fall hardening, plant health, nutritive status, and soil moisture, stressed or vulnerable alfalfa stands may suffer from winter injury.

The shift from the middle of June harvest date to July harvest date is partially due to a lack of harvest window for alfalfa curing. While mean monthly temperatures were the same between the historical norm and 2016, precipitation in June and July of 2016 was almost double that of the historical norm (Figure 1). The lack of a lengthy harvest window could easily push alfalfa harvesting into August. Figure 2 illustrates the one potential harvest window in July during the 2016 growing season. However, the heavy precipitation preceeding the harvesting window might make field conditions too wet for equipment.

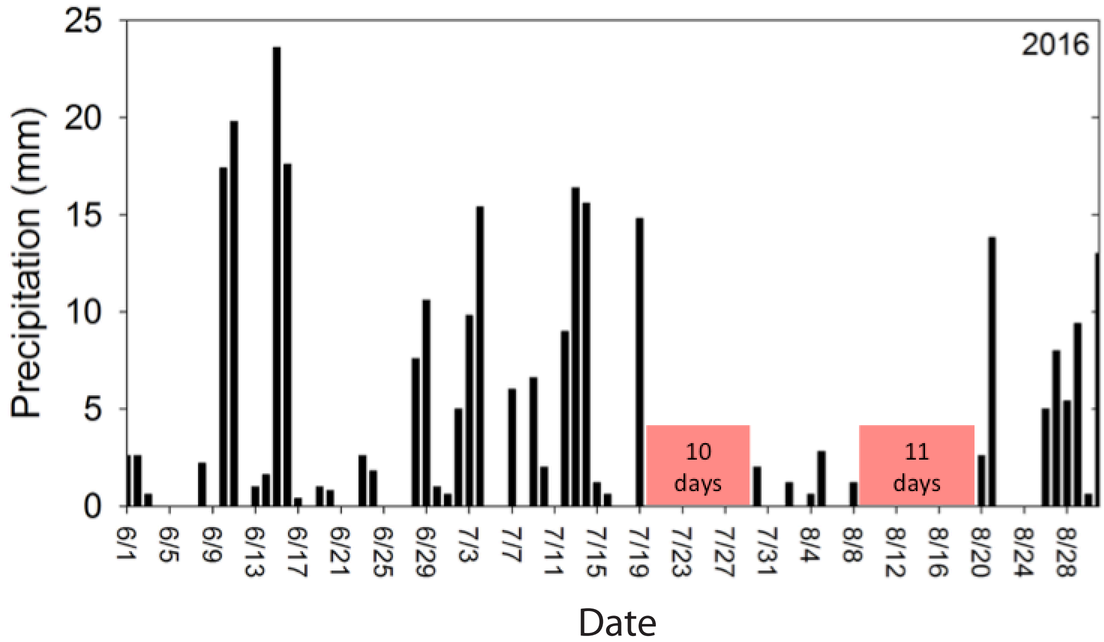
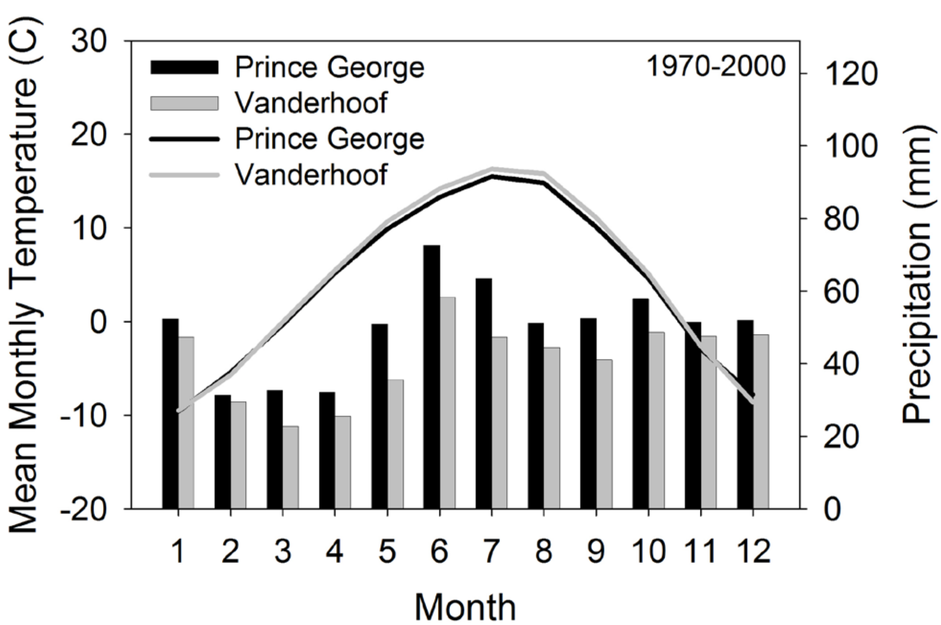


Figure 2 – Precipitation events from June 1 to August 31, 2016 with alfalfa harvesting weather windows (minimum 7 days with no precipitation). Data from the Environment Canada weather station located in Vanderhoof, BC.

While there was one potential harvest window of 10 days in July, producers must rely on weather forecasting information generated from the Prince George airport. As Figure 3 demonstrates, the precipitation historical norms in Prince George do not reflect those in Vanderhoof. As well, producers cite highly variable precipitation conditions within the Vanderhoof region (to be discussed in the following sections)

Figure 3 –



A comparison of historical (1970-2000) mean monthly temperature (lines) and monthly precipitation (bars) at Prince George versus Vanderhoof. Data from the Environment Canada weather stations.

Introduction to the Weather Stations

Climate changes may be difficult to recognize and perceive within a human lifetime or even over multiple generations.

While weather data provides valuable information for the farmer in terms of the current climatic condition, it is invaluable for monitoring changes over time. Climate changes may be difficult to recognize and perceive within a human lifetime or even over multiple generations. Understanding weather patterns, in particular changing patterns, enables producers to predict and modify their farming practices to capture changing cropping opportunities and changes in cropping schedules.

Historically, Vanderhoof producers relied on weather forecasting from Prince George to schedule cutting and hay curing weather windows. However, producers cite that the climate in Vanderhoof is not only different from Prince George, but also has distinct within region weather patterns. To better understand these localized weather conditions and to provide more detailed information for the area, four weather stations were installed at four locations on private property in the Vanderhoof Region, and beyond (Table 1 and Figure 4). The four locations coincide with the four participating producers involved in the BCFC Climate Adaptation Program. The weather stations were installed April 2015. Data gathered from the stations was not reliable until 2016; therefore, data from 2016 will be presented in this report.

The data collected at the weather stations included: air temperature, vapour pressure deficit, solar radiation, precipitation, wind speed, wind direction, soil moisture and temperature at 5 and 20 cm. Most of the climate data collected is standard; however, the addition of soil moisture at 5 and 20 cm was included to provide insight into the depth of moisture infiltration and the length of time moisture is available within the major rooting zone (20 cm). Soil temperature at 5 and 20 cm was also collected and is useful for understanding potential timing of germination and root development.

Table 1 – Reference name and association information for each of the four weather stations installed in the Vanderhoof Region

REFERENCE NAME	PRODUCER	ELEVATION	GENERAL LOCATION	EASTING	NORTHING
Southbend	Solecki	847	Francois Lake	305275	5985747
Carmen Hill	TopHay	755	Vanderhoof	436912	5978878
Braeside	Ruiter	739	Vanderhoof	415886	5997950
Fraser Lake	Ray	761	Fraser Lake	396344	5978163
Vanderhoof	Env. Canada	638	Vanderhoof	433188	5987340

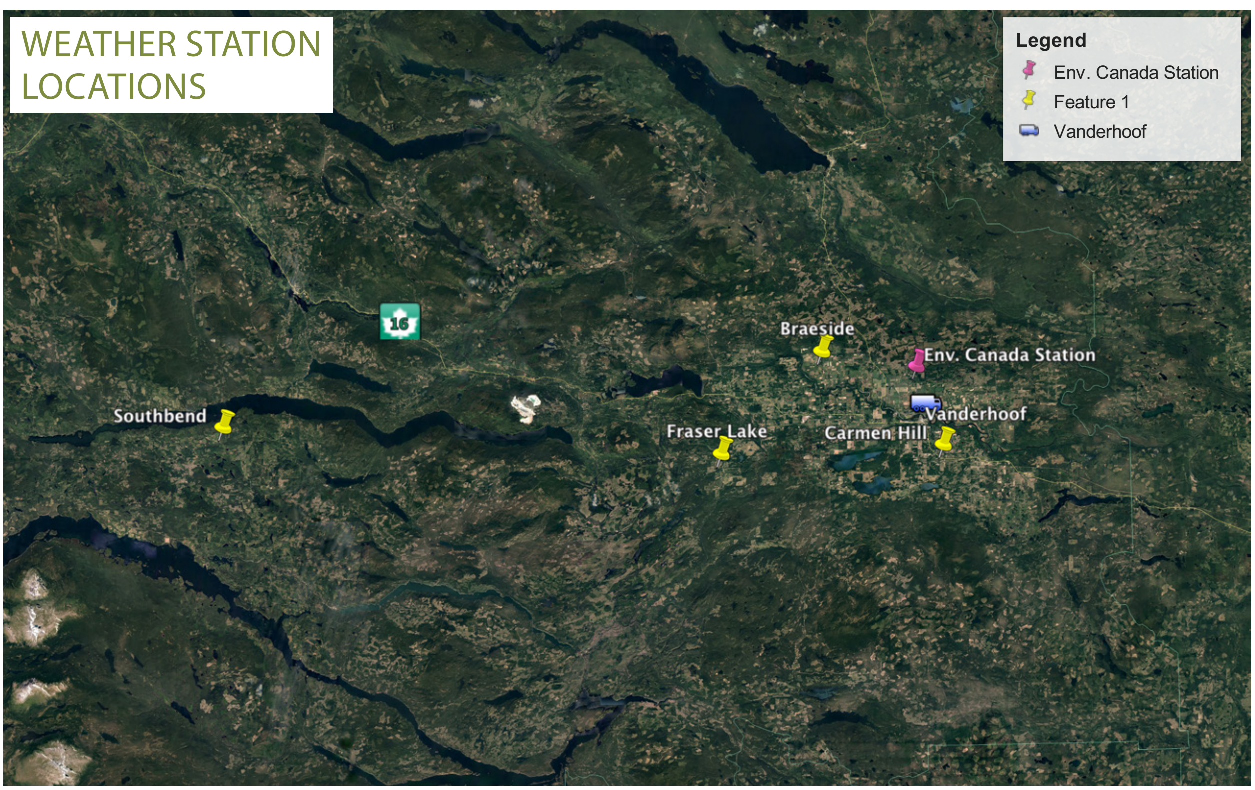


Figure 4 – Map of weather station locations, including the Environment Canada weather Station (Image produced in GoogleEarth Pro, 2017)

Prince George Climate

Precipitation from Prince George cannot be used as a predictor for forecasting precipitation in Vanderhoof.

While statements of differing climates are anecdotal, results from 2016 indicate that temperature data between Prince George and Vanderhoof Region were similar in that average temperatures remain below 20 °C across the growing season. Where the difference in climate became apparent was with regard to precipitation (Figure 5)

A closer investigation of the precipitation data from the Braeside weather station (22 km northwest of Vanderhoof) reveals that precipitation from Prince George cannot be used as a predictor for forecasting precipitation in Vanderhoof. A comparison of the two sites in 2016 shows no relationship (r2 = 0.05) (Figure 6).

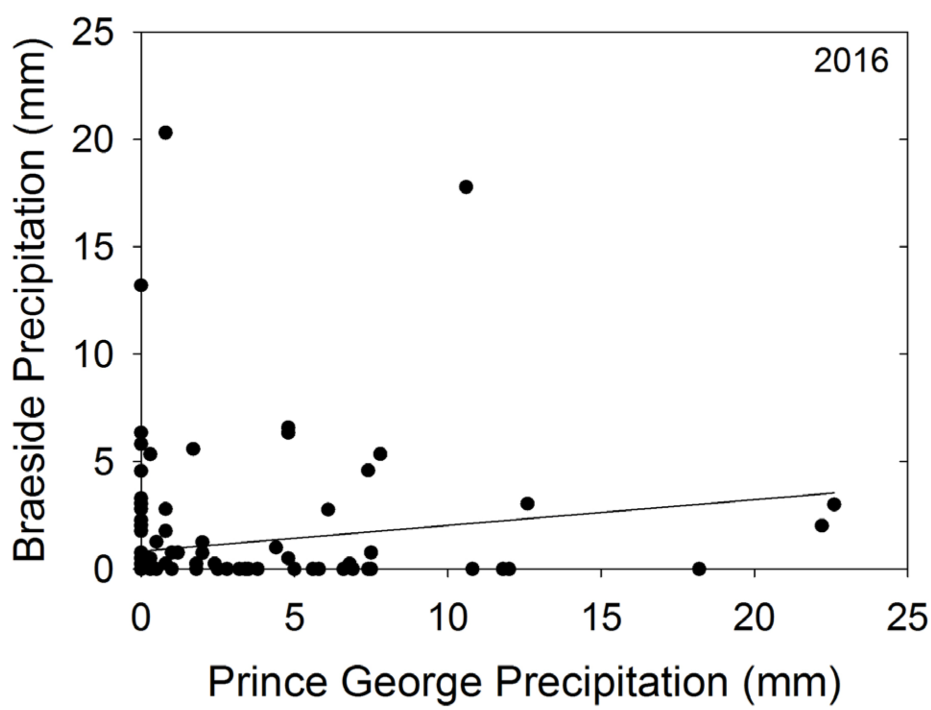


Figure 5 – A comparison of precipitation events in 2016 at Prince George versus the Braeside weather station.

Localized weather patterns make it difficult to predict and plan for operational windows such as planting and harvesting/hay curing. In fact, precipitation patterns are so localized that one cannot rely on precipitation data within the region either. Braeside and Carmen Hill weather stations, located 28 km apart, show no relationship between precipitation events (Figure 6)

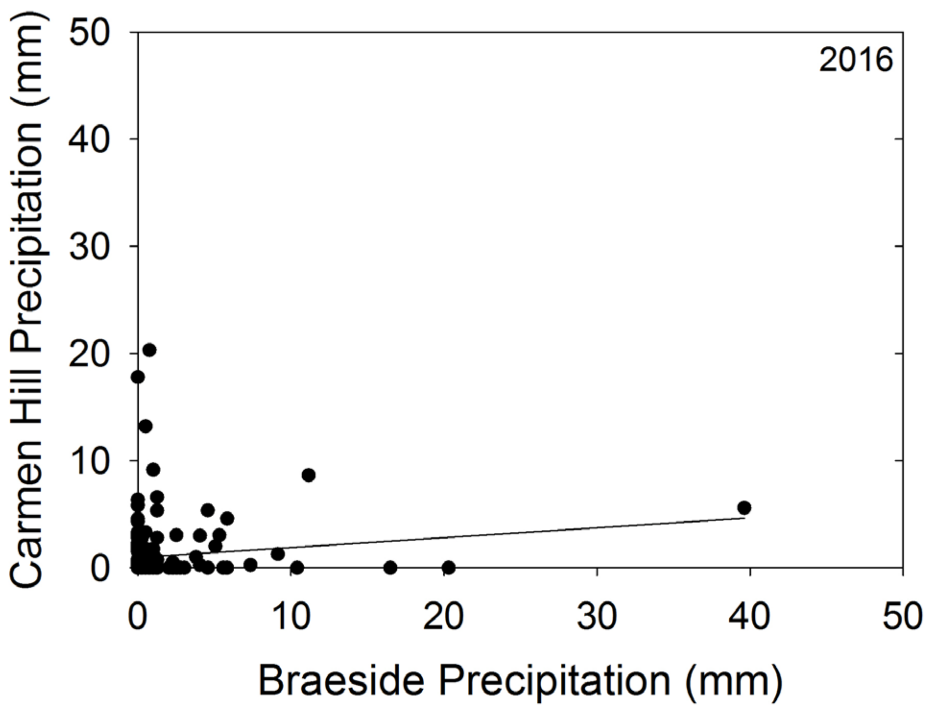


Figure 6 – A comparison of precipitation events in 2016 at the Carmen Hill versus the Braeside weather stations.

Localized weather patterns make it difficult to predict and plan for operational windows such as planting and harvesting/ hay curing.

Results from Weather Stations

For ease of interpreting the soil moisture data presented here, moisture stress is considered to start when 50% of available soil moisture has been depleted. Table 2 reports soil moisture tension (in Centibars) at which 50% of available soil moisture has been depleted for soil types with increasing clay content. Clay-rich soils have a higher percentage of available water at higher soil moisture tensions because such soils have a smaller percentage of macro-pores and a larger percentage of micro-pores, which hold water more tightly.

Presented in the following section (Results by Station) is daily average temperature with daily precipitation (top figure) and soil moisture (bottom figure) for each of the four weather stations. Inserted into the soil moisture figure is a green box indicating periods during which plant growth is not expected to be restricted by moisture deficiency (typically less than 50 to 120 centibars tension) under the soil conditions found at the weather station sites.

SOIL TYPE	SOIL MOISTURE (CENTIBARS)
Sand or Loamy Sand	40-50
Sandy Loam	50-70
Loam	60-90
Clay Loam or Clay	90-120
Soils are dangerously dry!	100-200

Table 2 – The soil moisture tension at which 50% of available soil moisture has been depleted for various soil types (From: Hanson and Orloff, 2002)

GENERAL TRENDS ACROSS THE REGION

Small rain events that occurred outside of the 6-week period, from June to July, tended to have very little to no impact on soil moisture.

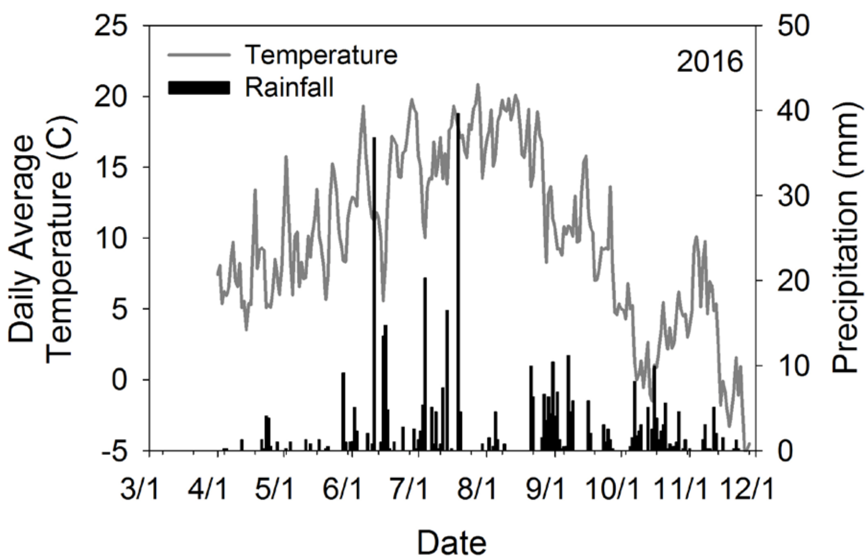
Minimum soil temperature requirements for alfalfa growth (5 °C) typically occur from early May to October 1. Therefore, the growing season for the region can generally be described as May to October.

In general, in 2016, the region experienced perilously dry periods during the month of May and then again through the month of August. There was a 6-week period from the middle of June to the end of July when the majority of the precipitation occurred and was able to infiltrate to at least 20 cm depth. Small rain events that occurred outside of the 6-week period, from June to July, tended to have very little to no impact on soil moisture.

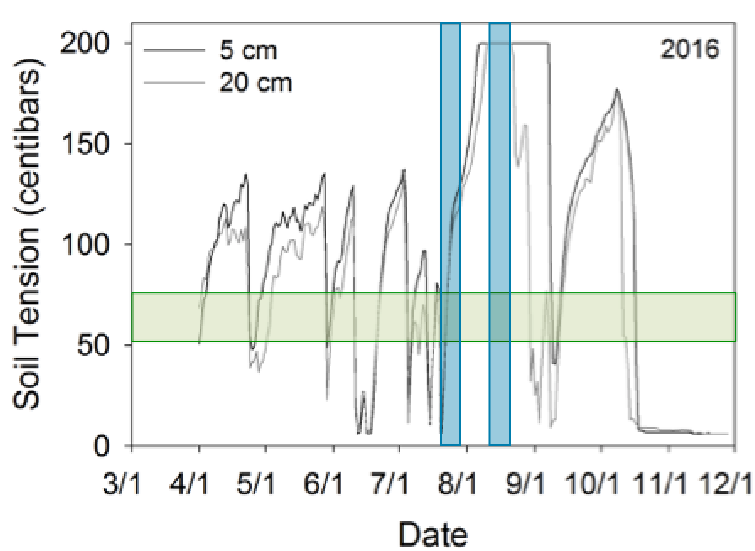
Results by Station

CARMEN HILL

The Carmen Hill weather station is located on Carmen Hill Road, just 8 km south of Vanderhoof along Highway 16. The soils at this location are described as sandy loam, meaning that above 50-70 centibars plant growth will become restricted. The green shaded box indicates the upper limit of soil tension, above which plant growth will be impaired.



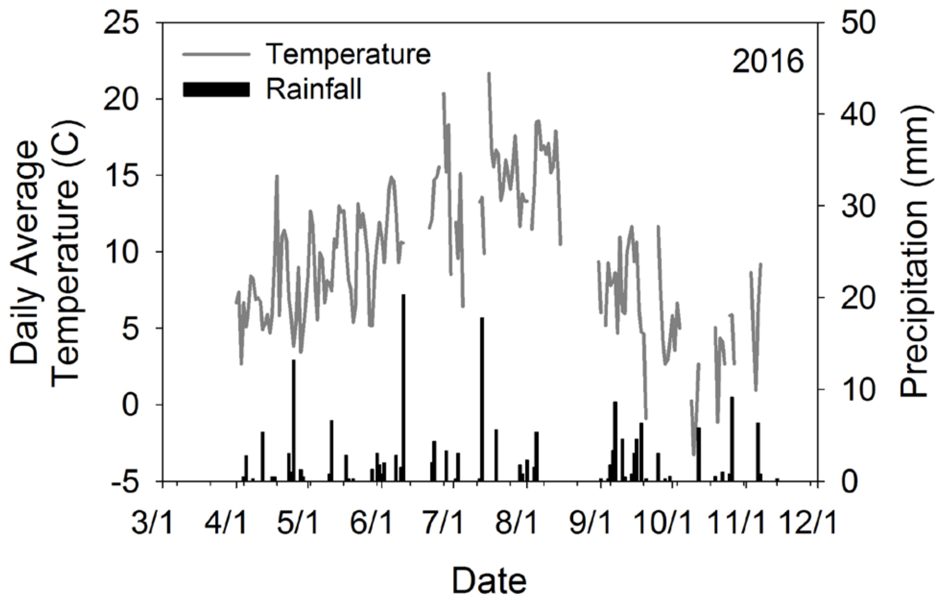
At the Carmen Hill site, 63% of the season (from May 1 to October 1) the soil moisture tension is above the conservative 70 centibar threshold for optimal plant growth; indicating that plant growth is likely impacted by dry soil moisture conditions. There were two alfalfa harvest windows from July 21st – 29th, and from August 10th – 20th. Perilously dry soil moisture conditions occurred through August and October.



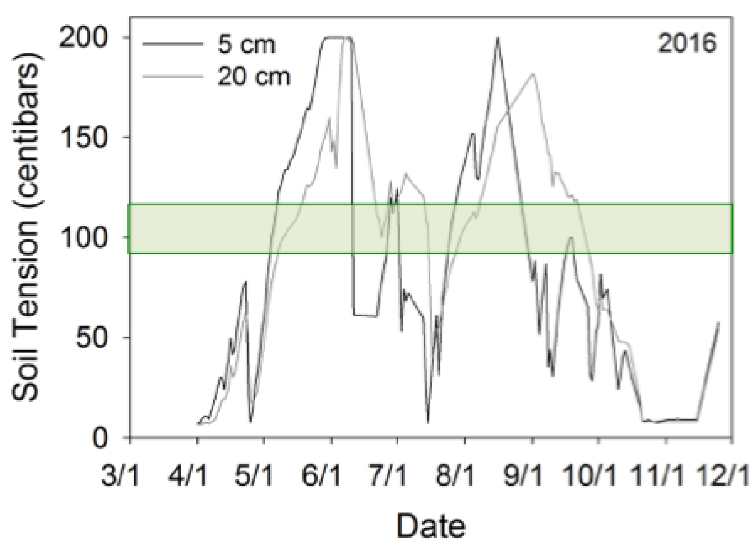
BRAESIDE

The Braeside weather station is located on Goldie Road, just 22 km northwest of Vanderhoof. The soils at this location are described as clay loam, meaning that above 90-120 centibars plant growth will become restricted.

There were two alfalfa harvesting windows from July 20th – 28th, and from at least August 6th – 16th

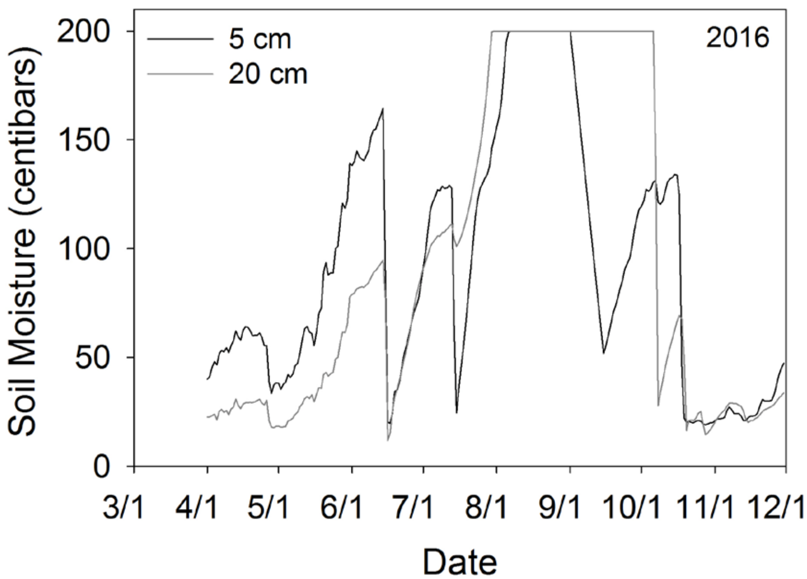


At Braeside, 47% of the season (from May 1 to October1) the soil moisture tension is above the conservative 120 centibar threshold for optimal plant growth; indicating that plant growth is likely impacted by dry soil moisture conditions. There were two alfalfa harvesting windows from July 20th – 28th, and from at least August 6th – 16th. At this site, perilously dry soil moisture conditions lasted 6 weeks, from August 14th to October 1st.



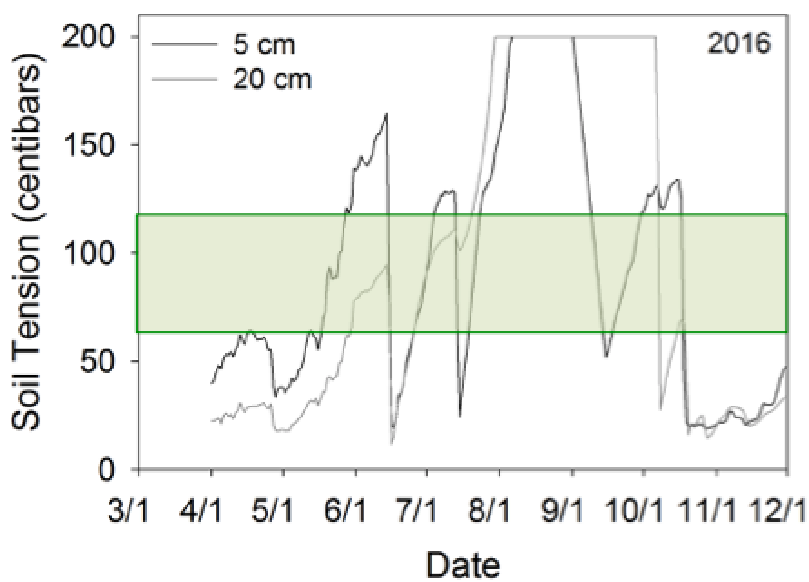
FRASER LAKE

The Fraser Lake weather station is located south of Fraser Lake, approximately 39 km southwest of Vanderhoof. The soils at this location are described as silty clay loam, meaning that above a very wide range of 60-120 centibars plant growth will become restricted.



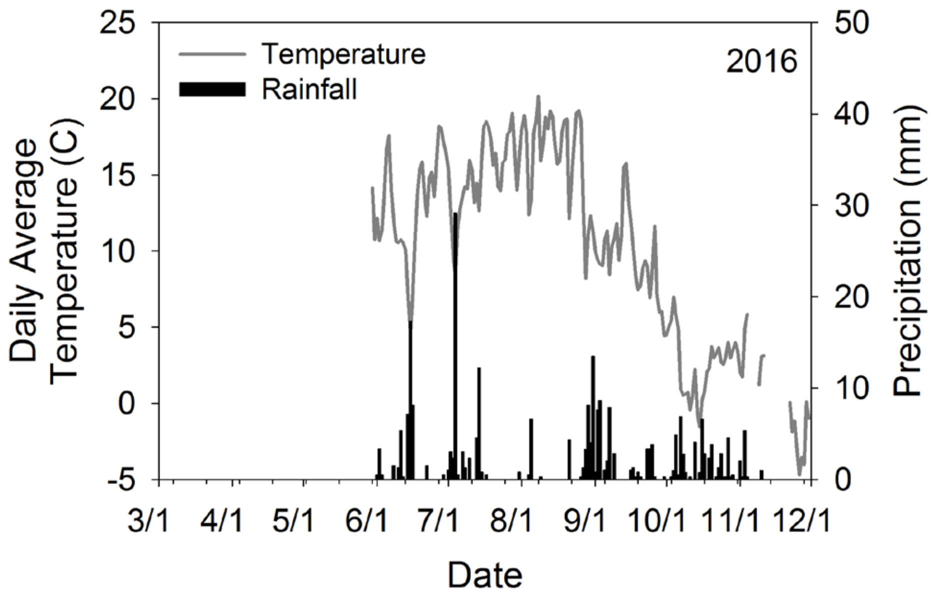
Perilously dry soil moisture conditions lasted much longer than other weather stations at more than 2 months.

At the Fraser Lake site 43% of the season (May 1 to October 1) the soil moisture tension is above the conservative 120 centibar threshold for optimal plant growth; indicating that plant growth may be seriously impacted by dry soil moisture conditions. There was a long alfalfa harvesting window from June 23 – August 3; and again from August 8th – 20th. The long harvest window in July would not have been predicted from the Prince George weather forecasting. Also notable is that perilously dry soil moisture conditions lasted much longer than other weather stations at more than 2 months, from July 20 through to October 6.

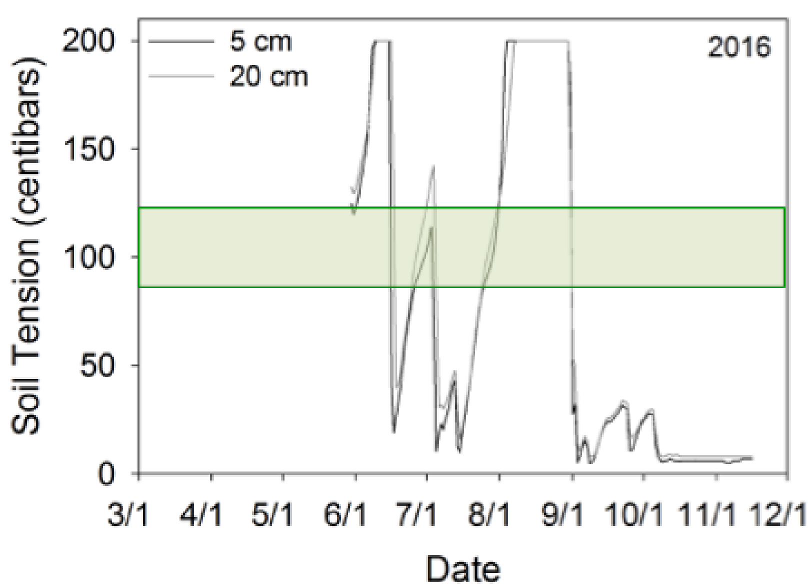


SOUTHBEND

Recall that the Southbend weather station is located on the southside of Francois Lake, approximately 129 km west of Vanderhoof. This weather station represents the western most location within the weather station network. The soils at this location are described as clay loam, meaning that above a range of 90-120 centibars plant growth will become restricted.



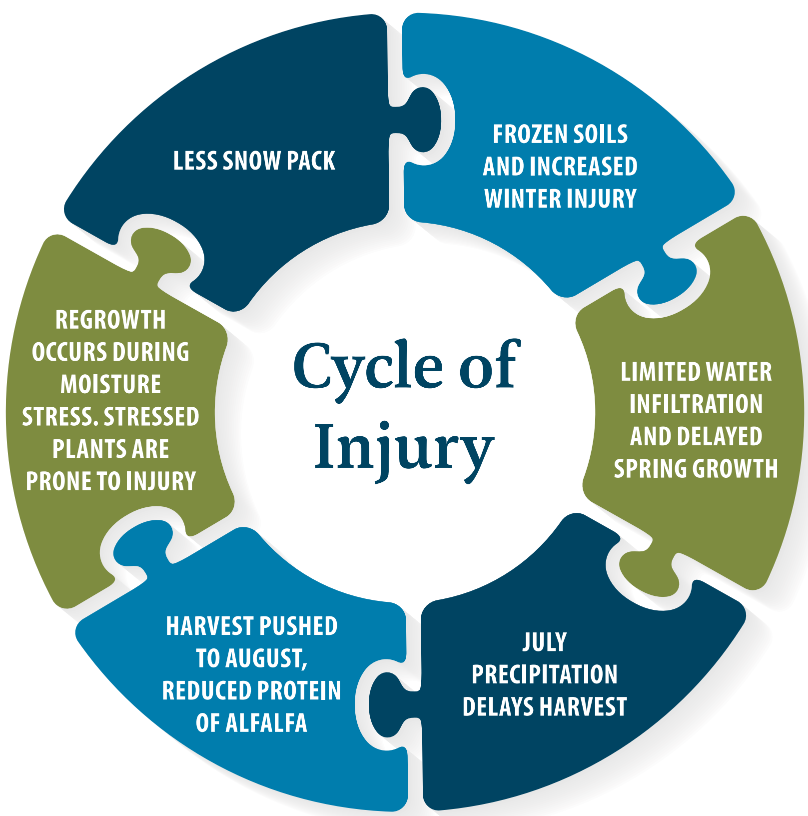
At the Southbend site 44% of the recorded season (June 1 to October 1, data missing due to weather station malfunction) the soil moisture tension is above the conservative 120 centibar threshold for optimal plant growth; indicating that plant growth may be seriously impacted by dry soil moisture conditions. There were two alfalfa harvest windows from July 19th – 31st, and from at August 11th – 21st. Also notable is that perilously dry soil moisture conditions lasted 4 weeks, from August 1st - September 1st.



Conclusions

When the soil moisture data is combined with the phenology of alfalfa it becomes apparent that in 2016, the climate was out of synchronization with alfalfa phenology and typical harvesting practices. There may be a combination of many factors at play. While one year of data is not enough to draw conclusions the results do support the observations of local producers. The winter was drier than normal, indicating less insulating snow cover, which may result in greater winter injury and frozen soils. The frozen soils will prevent water infiltration during the spring snowmelt, thus delaying spring regrowth. Winter injured plants will also be delayed in their regrowth. The more than 2-times the average precipitation experienced in June and July, 2016 limited the ability to harvest and cure alfalfa within a reasonable timeframe. Additionally, the high levels of precipitation may have precluded harvesting due to saturated field conditions that prevent access with heavy equipment. If harvesting is delayed till August not only will the protein content of alfalfa be reduced, the crop will also be regrowing during perilously dry soil moisture conditions – limiting the crop's ability to store carbohydrates for winter survival and spring regrowth. When alfalfa enters the winter season drought stressed it is more likely to experience winter injury.

While these results are not conclusive they do point to the need for more research into alternative cropping practices in order to best adapt to changing climatic conditions.



Recommendations for the Program

The 4 weather stations will provide a foundation upon which to build a baseline weather data platform. It is imperative that the data is monitored from the weather stations in order to develop a climate baseline for the area, and to record changes over time. As well, more weather stations are needed in the region. Differences between weather stations, combined with highly variable soil textures, will result in different growing conditions from site to site. Understanding soil moisture is imperative to optimum forage production in the area.

On a larger scale, the BCFC should work with other stakeholders and governmental agencies towards agricultural capacity building, institutional strengthening; as well as services to provide extension and research; and policy frameworks towards climate change adaptation.

Recommendations for Producers

Although 1 year of data is not enough to develop concrete recommendations for producers in the Vanderhoof area; if the climate patterns recorded in 2016 continue there will need to be changes to cropping systems in order to remain competitive. Some operational options and future research considerations for producers are listed below:

- To preserve protein values and avoid hay spoilage during July rain events, producers may need to invest in silage equipment.
- In general winter injury and summer drought are factors that may be affecting alfalfa growth. Producers could try alfalfa varieties that are frost and drought hardy; as well, they should also be looking towards other forage species that may be better suited to the new weather conditions, or have wider climatic tolerances.
- Producers could consider planting a mix of alfalfa varieties to ensure a more diverse plant community. In general diverse communities are more resilient than simplified communities.
- Producers with irrigation capacity could use soil moisture monitoring equipment to target irrigation with plant demands.
- Producers could experiment with management techniques that increase soil organic matter, which in turn benefits soil moisture availability.
- Producers could experiment with modifying the critical harvest period in the fall. In order to ensure adequate carbohydrate accumulation the final harvest date is typically 4-6 weeks before the first killing frost. Producers may need to expand the critical harvest period in order to reduce winter injury and promote vigorous spring regrowth.
- If reduced snow is the new climatic norm, producers could experiment with leaving more than the recommended 15 cm fall stubble. Higher stubble heights might translate into better snow catchment for soil insulation.

Implementation of more climate change adaptation research is desperately needed, not just in Vanderhoof, but Nationally and Internationally. The effects of climate change are unlikely be mitigated; therefore, producers need to research alternative practices in order to succeed under changing climatic conditions.

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