CLIMATE CHANGE ADAPTATION PROGRAM

Regional Adaptation Strategies: Bulkley-Nechako & Fraser-Fort George

Funding for this project has been provided by the Governments of Canada and British Columbia through the Canadian Agricultural Partnership, a federal-provincial-territorial initiative. The program is delivered by the Investment Agriculture Foundation of BC.

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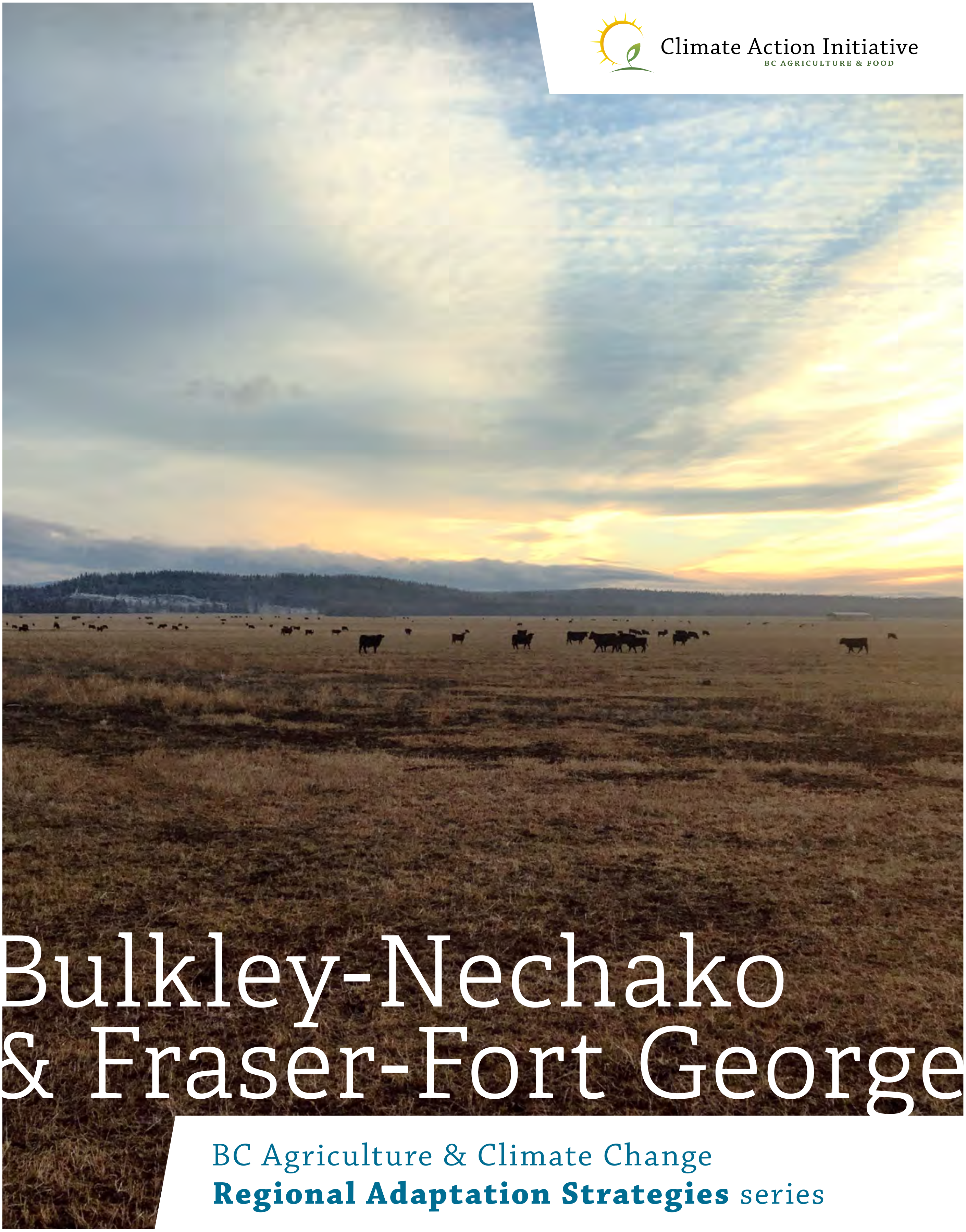

Climate Action Initiative
BC AGRICULTURE & FOOD

Bulkley-Nechako & Fraser-Fort George

BC Agriculture & Climate Change
Regional Adaptation Strategies series

Regional Adaptation Program

BC AGRICULTURE & FOOD CLIMATE ACTION INITIATIVE

Regional Adaptation Strategies: Bulkley-Nechako & Fraser-Fort George

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The BC Agriculture & Food Climate Action Initiative (CAI) develops tools and resources that increase the capacity of agriculture to adapt to climate change. Guided by industry, CAI brings together producers, government and researchers to develop a strategic, proactive and pan-agricultural approach to climate adaptation. The Regional Adaptation Program is part of the BC Ministry of Agriculture's ongoing commitment to climate change adaptation in the agriculture sector while enhancing sustainability, growth and competitiveness.

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Contents

Introduction

In the coming years, climate change will impact the agriculture sector in British Columbia in a range of different ways.

Although agricultural producers are accustomed to adjusting their practices to manage through difficult conditions, the scope and scale of climate change is anticipated to exceed anything previously experienced. Strategies and actions that will enhance agriculture's ability to adapt to climate change are the focus of this plan.

In 2011–2012, a province-wide assessment of climate change-related risks and opportunities evaluated the potential impacts of climate change on agricultural production and the sector's capacity to adapt.[1] The assessment made evident that due to British Columbia's diversity (with respect to agriculture, ecology and climate), a regional approach to climate change adaptation is required. In addition, while some adaptation will occur at the farm level, the context beyond the farm and collaborative approaches, are critical for supporting agricultural adaptation.

Building on these findings, in 2012–2013 a pilot project was initiated with agricultural producers, agricultural organizations and local governments in Delta and the Peace River and Cowichan Valley regions. Each planning process resulted in a distinctive set of local sector impacts and priorities, as well as a series of strategies and actions for adapting and strengthening resilience. The plans are intended to offer clear actions suited to the specifics of the local context, both with respect to anticipated changes and local capacity and assets.

Following completion of the pilot, in 2013–2014 the ***Regional Adaptation Program*** was launched. The Program is delivered by the BC Agriculture & Food Climate Action Initiative (CAI). Since the Program's inception, additional adaptation plans have been completed for the Cariboo region (2014), the Fraser Valley region (2015), the Okanagan region (2016) and the Bulkley-Nechako & Fraser-Fort George region and Kootenay & Boundary region in 2019. Between 2017 and 2018, five of the plans (Peace, Delta, Cariboo, Fraser Valley and Okanagan) were updated to reflect implementation progress and near-term priorities.

From 2018 through to 2023, the Regional Adaptation Program is funded by the governments of Canada and British Columbia through the Canadian Agricultural Partnership. Once regional adaptation plans are completed, Canadian Agricultural Partnership "seed" funding is available to regional partners (working with the CAI) to develop and implement collaborative priority projects.

Completed plans and details regarding projects (completed and underway) are available at *www.bcagclimateaction.ca*.

Project Delivery

A local Advisory Committee for the Bulkley-Nechako & Fraser-Fort George region was formed to provide input throughout the project. This Committee included participants from the two regional districts, the BC Ministry of Agriculture, the University of Northern British Columbia and seven local/regional agricultural organizations.

The agricultural producer participants volunteered their time throughout the project, representing four distinct local production systems. The regional district partners provided staff time and expertise and covered costs associated with the workshops. With funding from the Canadian Agricultural Partnership, the BC Agriculture & Food Climate Action Initiative provided core management and human resources for project delivery. Please see Acknowledgements for more details.

photo by Harmony Bjarnason

Project Methodology

The development of the ***Bulkley-Nechako & Fraser-Fort George Adaptation Strategies*** involved three key stages:

Stage 1 – Project Development

A project plan was drafted and background research was conducted through a review of relevant documents and related activities. Nine preliminary meetings were held with producer organization representatives and local and provincial government staff to discuss local issues and priorities. An initial meeting was held with the local Advisory Committee to receive input on the project outline and the proposed approach for the first workshop.

Stage 2 – Workshops & Focus Groups

Two sets of workshops were held (each set held in two locations — Prince George and Quick[2]) for a total of four workshops. Due to the size and diverse geography of the Bulkley-Nechako & Fraser-Fort George region, two supplementary focus groups were also held (both in Dunster in the Robson Valley).

The first set of workshops (held in November 2018), focused on reviewing climate change projections, discussing the associated agricultural impacts and identifying priority areas of risk. Developing strategies and actions for adapting to these priority areas then became the focus of the second set of workshops.

Prior to the second set of workshops (held in February 2019), a series of overarching goals, strategies and sample actions was developed and reviewed by the Advisory Committee. These materials provided support for the workshop action planning process (which also incorporated consideration of local priorities, context and resources). A total of 106 individual participants attended one or more of the project workshops and/or the final implementation meetings.

Stage 3 – Implementation Meeting

An implementation meeting and a supplementary focus group were held in March 2019 with participants representing many of the local partner organizations. The meetings involved prioritization of draft actions based on which were most important, which were easiest to implement and which would support enhancement of capacity for additional adaptation. The meetings also included discussion of steps to implement prioritized actions.

Regional Context

Geography, Climate & Production Capacity

The geographic scope of the ***Bulkley-Nechako & Fraser-Fort George Adaptation Strategies*** includes the Regional District of Bulkley-Nechako (RDBN) and the Regional District of Fraser-Fort George (RDFFG). The Regional District of Bulkley-Nechako is directly north of the Cariboo region, bordered by the Hazelton Mountains to the west and the Omineca mountain range to the north.

The Regional District of Fraser-Fort-George is east of Bulkley-Nechako, and extends to the Alberta border, including the Robson Valley which follows the Fraser River to the southeast.

The entire region covers a total area of 124,037 square kilometres.[3] Within the two regional districts there are 12 municipalities, 14 electoral areas and 18 First Nations communities.[4,5,6,7] The combined population of the RDBN and RDFFG is 341,818, just under 7% of BC's total population.[8,9,10]

FIGURE 1 Map of Bulkley-Nechako & Fraser-Fort George region (with ALR shown in green)

The centre of the Bulkley-Nechako & Fraser-Fort George region is in the Sub-Boreal Spruce biogeoclimatic zone with a continental climate that is characterized by significant annual variation in temperature (hot summers and cold winters). Summers are short but warm and moist, while winters can be severe. Most of the zone is under snow for four to five months, and the primary growing season is only a few months long.[11]

The climate of the Robson Valley is distinct from the rest of the region and is characterized by Interior Cedar Hemlock zone, commonly called the Interior Wet Belt. The valley has long, warm summers and cool, wet winters. Although summers are relatively dry in most of this zone, the slow-melting snowpack generally helps keep soil moisture levels high during the summer.[12]

The Bulkley-Nechako & Fraser-Fort George region receives an average of 859 mm of precipitation annually, but this does not reflect sub-regional variation. For example, Vanderhoof receives an average of 488 mm annually, while McBride receives 687 mm.[13] Smithers receives the most precipitation in June and from September through to November, whereas in Prince George, precipitation is more evenly distributed throughout the year, with relatively high precipitation throughout the summer months starting in May.[14]

For most of the Bulkley-Nechako & Fraser-Fort George region, long cold winters and cool nighttime temperatures are the major climatic limitations for agriculture. Historically, the region has excellent capability for forage production without irrigation.[15] Only 3,980 hectares, or approximately 1.4%, of land in production is under irrigation and water has typically been a plentiful resource in the region,[16] although this is changing (see Impact Area 3).

To the south of Prince George and through the Robson Valley, the agricultural land runs along the Fraser River. Stretching northwest from Prince George towards Smithers, much of the agricultural land lies in proximity to Highway 16. Most of the agricultural production is concentrated around Prince George, Vanderhoof, the Bulkley Valley and Lakes District, where the land is relatively flat and the soil is fertile.[17] Soils are diverse across the region with twenty soil series and two soil complexes in the Robson Valley alone.[18] Soils across much of the region have high clay content, but with good soil management are favourable for the production of forage, silage and grain crops.[19] The majority of soils in the region are class 4 and 5, but some areas are class 3 or higher with irrigation improvements.[20] Currently, an acidic pH and a lack of adequate organic matter are challenges for many producers in the region.[21]

Economic & Institutional Context

The forestry industry is the major economic driver in the Bulkley-Nechako & Fraser-Fort George region,[22] employing close to 50% of the population in some areas.[23] Other key economic drivers are mining, services and supplies for natural resource and construction activities, and tourism.[24] Agriculture in the region contributed 2.5% of total provincial gross farm receipts in 2016, generating over $91 million.[25] Profitability remains the greatest challenge for agricultural production within the region, in part due to high input costs.[26] In 2016 there were 1925 farm operators in the region, 7 % of the total number of provincial operators.[27]

There is an abundance of Crown rangeland in the Bulkley-Nechako & Fraser-Fort George region, with approximately 3,829,473 hectares of range under 117 different tenures[28] (accounting for 7% of total provincial range tenures). There are 5 class A and B slaughter facilities in the region (4 in Bulkley-Nechako and 1 in Fraser-Fort George[29]), but processors are challenged to meet their labour needs.[30]

Agricultural land prices in the region are lower than the rest of the province and have remained relatively stable in recent years while land prices elsewhere have increased dramatically. In 2017, farm land in production in Northern BC increased by +0.2% (using a farm property benchmarking system established by Farm Credit Canada) compared to +0.5% just south in Cariboo-Chilcotin and +23.6% on Vancouver Island.[31] Low land prices provide a competitive advantage for farmers and can attract new entrants to the region.[32] Another draw for new entrants is a strong

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demand for local food.[33] Local markets are utilized by many farmers (almost a quarter of all farms in the region do some form of direct marketing). Although transportation costs to large markets in the south are high, the region is well connected through the Highway 16 corridor, as well as to Alberta markets (in the case of the Robson Valley).[34]

The Regional District of Bulkley-Nechako (RDBN) has completed an Agriculture Plan (2012) and has an Agriculture Committee (which consists of elected Board Directors) to guide plan implementation and to review land use applications and other planning decisions that may affect agriculture. A more recent and unique initiative of RDBN is the piloting of an Agriculture Coordinator position to provide information and resources to the industry. Fort St. James has completed an Agricultural Action Plan (2009).[35] The Regional District of Fraser-Fort George (RDFFG) does not, to date, have an Agriculture Plan or Agricultural Advisory Committee.[36]

In 2011, RDBN and RDFFG collaborated to develop Beyond the Market, an economic development program to assist producers in getting their product to market across the Highway 16 area. The Beyond the Market initiative is no longer running, but it previously encompassed both regional districts and a small section of the Cariboo Regional District. The regional districts have also both contributed to Agricultural Land Use Inventories (ALUIs). In RDBN ALUIs were completed for specific areas in 2013,[37] and in RDFFG inventories were last undertaken in 2006/2007.

The BC Ministry of Agriculture has staff located in Prince George and Smithers, including one regional agrologist in each location. From the 1940s to the 1970s, local research took place through federally funded experimental farms in Smithers and Prince George.[38] There has been a substantial gap in research capacity in the region since these facilities closed, but in recent years a variety of short-term programs and initiatives have been supported by the local educational institutions.

The University of Northern British Columbia is delivering an Agricultural Network pilot project through which they have advanced research on bioenergy, value chain enhancement and cash crop feasibility, conducted garlic and seed trials, and developed soil test kits. The College of New Caledonia leads a small amount of applied research and five of its six campuses are located in the Bulkley-Nechako & Fraser-Fort George region. The BC Forage Council has conducted forage trials in the region, as well as research on winter grazing and forage export potential.[39] A new project is underway on pasture rejuvenation practices.[40]

With respect to extension, the Community Futures Development Corporation (Nadina and Fraser-Fort George offices) plays a valuable role in mentoring, training, and building capacity for agricultural businesses. Quick College (near Smithers) hosts local courses and workshops, some of which are agriculturally related, and the Smithers Farmers' Institute hosts workshops and a conference each year for all type of producers. The Young Agrarians has a Central BC coordinator, a Land Matcher position for Central and Northern BC and hosts extension and networking events in the region.

Agricultural Production

There are 1,239 farms in the Bulkley-Nechako & Fraser-Fort George region (7% of farms in BC) and the average age of producers is 56. In 2016, the total amount of land farmed was 292,115 hectares, including 77,198 hectares in crops. Between 2006 and 2016, average farm size in both regional districts increased, from 174 hectares to 188 hectares in Fraser-Fort George[41] and from 308 hectares to 320 hectares in Bulkley-Nechako and Stikine.[42] Only 6.2% (764,600 hectares) of the region's overall land base is included in the Agricultural Land Reserve (ALR).[43]

Cattle ranching and forage production are the most common agricultural activities in the region. Other agricultural production in the region includes dairy and other livestock (bison, sheep, goats and hogs), grain, horticultural crops (vegetable, greenhouse, fruit and berry) and apiculture. Livestock operations are primarily cow/calf and cow/yearling operations.[44]

Despite the fact that backgrounding (feeding calves for feedlots) is well established in Bulkley-Nechako & Fraser-Fort George, 47% of central interior calves are finished in other areas, particularly in Alberta.[45]

More grain is grown in the Vanderhoof area than in any other part of BC outside the Peace River region.[46] Local experts indicate that grain farming in the region is increasing and there was an increase from eight to sixteen grain farms in the region between 2011 and 2016 (from 10,087 hectares to 10,785 hectares).[47] This could be a valuable development for the livestock sector since more local grain could help to bring down high feed costs during the long winter feeding period (mid-November to mid-May). The Robson Valley produces canola, wheat, barley, oats, specialized forage seed and forage crops.[48]

Between 2000 and 2010, there was a decline in dairy, poultry and egg production in the Bulkley-Nechako & Fraser-Fort George region.[49] Chickens are farmed primarily at non-quota volumes. However, the number of dairy cows increased by 22% across the region from 2011 to 2016. In 2016, there were 23 dairy farms in the region, representing 4% of BC dairy farms, with most operations located in the Bulkley Valley.

In the Robson Valley and Prince George areas, there is a long history of vegetable production, consisting mostly of root vegetables and other storage crops. Closer to the coast in the northwest, where there is less wind and exposure and the temperature generally warms a few weeks earlier,[50] there are also some greenhouses and tree fruit operations. Many of the vegetable and berry producers in the region grow a large variety of crops on a small scale, and half of the vegetable and berry producers extend their growing season with greenhouses.[51] There was an increase in vegetable farming in the region from 2011–2016.[52] Vegetable and small fruit sales are typically off-farm, direct to stores or at farmer's markets.[53]

Honey production in the region increased substantially between 2011–2016, indicated both through the number of farms reporting colonies (from 38 to 57 farms) and the number of colonies reported (from 600 to 712).

Regional Climate Science

Accessing the best possible information about climate change is the first step in determining the options for adaptation.

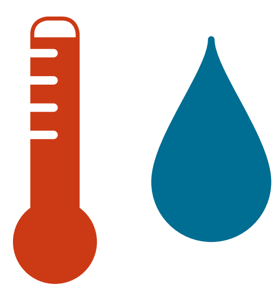
For many years, climate scientists have been improving and refining climate models to produce more accurate future projections.[54] These models have been validated in several ways, including against observed climate records.[55] The resolution of the data and models continues to increase, enabling the kinds of regional projections that follow.

The Pacific Climate Impacts Consortium (PCIC) is a regional climate service centre at the University of Victoria that provides practical information on the physical impacts of climate variability and change, in support of long-term planning.[56] As with the previous (CAI) *Regional Adaptation Strategies*, PCIC has assisted in the production of the agriculturally-relevant regional climate projections for the 2020s to 2080s that are presented in this document.

Additional information about regional climate projections, maps, and related definitions may be found in Appendix B and Appendix C, and in PCIC's *Omineca Climate Summary*.[57]

Climate Projections

Key climate projections for the Bulkley-Nechako & Fraser-Fort George region from the 2020s to 2080s are summarized on the following pages.



Projections are derived from PCIC's *Statistically Downscaled Climate Scenarios*[58] at a gridded resolution of 300 arc-seconds (roughly 10 km) for the simulated period of 1950–2100.[59] Numbers provided are the median of all model runs under the Representative Concentration Pathways 8.5 (RCP 8.5) high GHG emissions model (red and blue solid lines in the graphs that follow). The shaded areas on the graphs show the range of projected possible future conditions. RCP 8.5 assumes minor reductions in emissions leading to a +3.5° Celsius increase in global temperatures. It is standard practice, when planning for future conditions at the local level, to focus planning around the worst-case scenario occurring at the middle of the century (2050s). The climate projections in this report follow this convention.[60]

Temperature

Projections for key temperature variables (see sidebar) show a strong increasing trend with all models projecting warming in all seasons. This trend is significant compared to historical variability, represented by the black line in Figure 2. Average summer temperatures are projected to increase slightly more than average temperatures in other seasons, while average daytime maximum and nighttime minimum temperatures are also expected to increase across all seasons.

As shown in Figure 3 (following page), the Bulkley-Nechako & Fraser-Fort George region's complex topography creates considerable climate variability over short distances. Baseline temperatures vary with elevation (warmer in the valleys and cooler in the mountains) and warmer temperatures are found in the southern portion of the region on the Cariboo plateau. Projected warming trends (i.e., the percentage of change from the baseline) are fairly consistent across the region, even when the baselines vary due to topography (see Figure 3, following page) with slightly more pronounced warming projected adjacent to the Fraser River and around Vanderhoof. See Appendix B for sub-regional baselines and future projections.

Temperature Projections

- Annual average temperature[61]
  + 1.6°C *by 2020s*
  + 3.2°C *by 2050s*
  + 5.3°C *by 2080s*
  BASELINE of 1.6°C[62]

- Annual frost-free days[63]
  + 25 days *by 2020s*
  + 52 days *by 2050s*
  + 87 days *by 2080s*
  BASELINE of 146 days

- Growing degree-days[64]
  + 230 days *by 2020s*
  + 520 days *by 2050s*
  + 920 days *by 2080s*
  BASELINE of 817 days

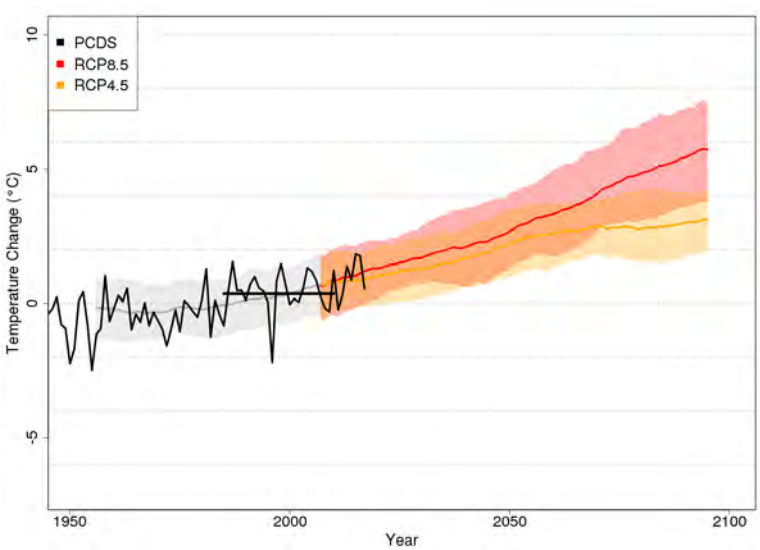
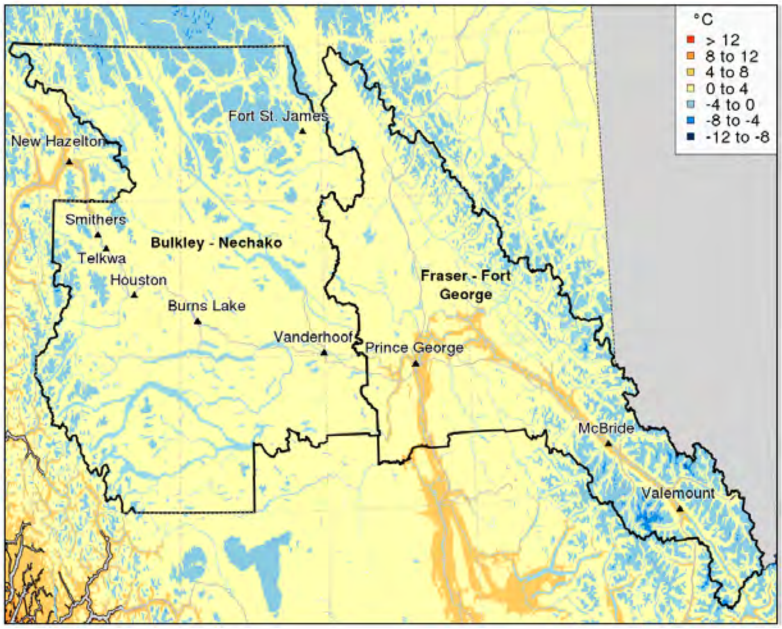


FIGURE 2 Average Annual Temperature change, 1960s to 2080s

RCP (Representative Concentration Pathways) 8.5 is a high GHG emissions scenario. RCP 4.5 is a medium GHG emissions scenario. The bold coloured lines indicate the mid-point of the ensembles of 12 different climate models while shading indicates the projected model range. The black line represents PCDS (Provincial Climate Data Set) and is historic climate data collected from BC.



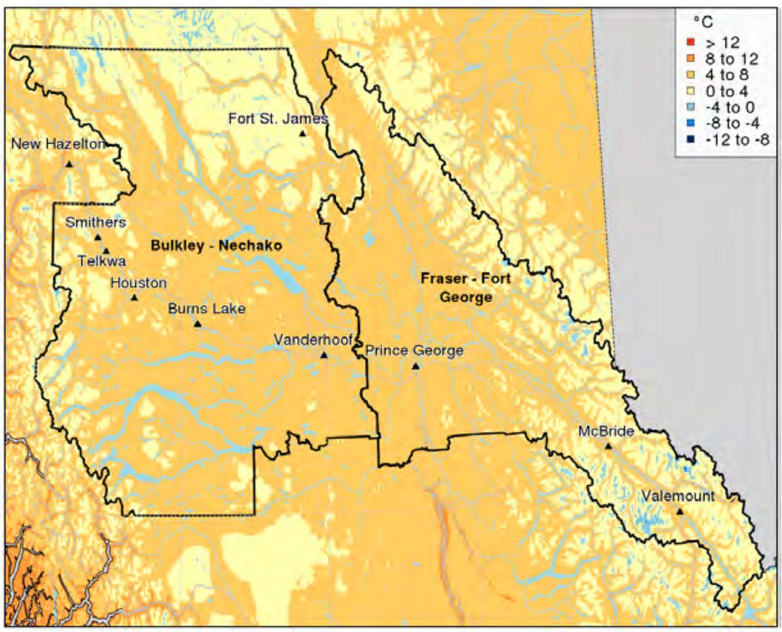


FIGURE 3 Bulkley-Nechako & Fraser-Fort George
Average Annual Temperature
TOP: Historic baseline, 1971–2000
BOTTOM: Projected, 2040–2070

These maps illustrate the spatial distribution of median values for annual temperature.

The baseline map [top] provides a visualization of historic annual temperature, while the 2040–2070 map [bottom] illustrates the projected change in average temperature over a 30-year future period. The global model data has been down-scaled to reflect regional temperature variation, driven largely by topography.

Precipitation

There is considerable variation in average annual precipitation across the region (measured in millimeters) with the majority of precipitation falling in the Hazelton, Omineca and Rocky mountain ranges. Smithers (in the northwest) receives an average of 498 mm of annual precipitation, Prince George (central) receives 638 mm, and Vanderhoof (slightly west of Prince George) receives 488 mm. Projections for average annual precipitation indicate an increase of 4.6% above the annual regional baseline (859 mm) by the 2020s, and an increase of 9.5% by the 2050s.

While local topography continues to create significant variation in sub-regional precipitation, seasonal relative precipitation projections (i.e., percentage change from the baseline) for the sub-regions closely follow the regional trends. Precipitation increases are the most pronounced in spring and fall. By the 2050s, precipitation is projected to increase substantially in all seasons except summer. See sidebar and Figure 4 for seasonal precipitation projections.

Precipitation Projections

- Summer
  - + **2%** *by 2020s*
  - + **1%** *by 2050s*
  - – **4%** *by 2080s*
  - *baseline of 197 mm*
- Fall
  - + **5%** *by 2020s*
  - + **16%** *by 2050s*
  - + **28%** *by 2080s*
  - *baseline of 268 mm*
- Winter
  - + **6%** *by 2020s*
  - + **7%** *by 2050s*
  - + **14%** *by 2080s*
  - *baseline of 233 mm*
- Spring
  - + **6%** *by 2020s*
  - + **13%** *by 2050s*
  - + **24%** *by 2080s*
  - *baseline of 161 mm*

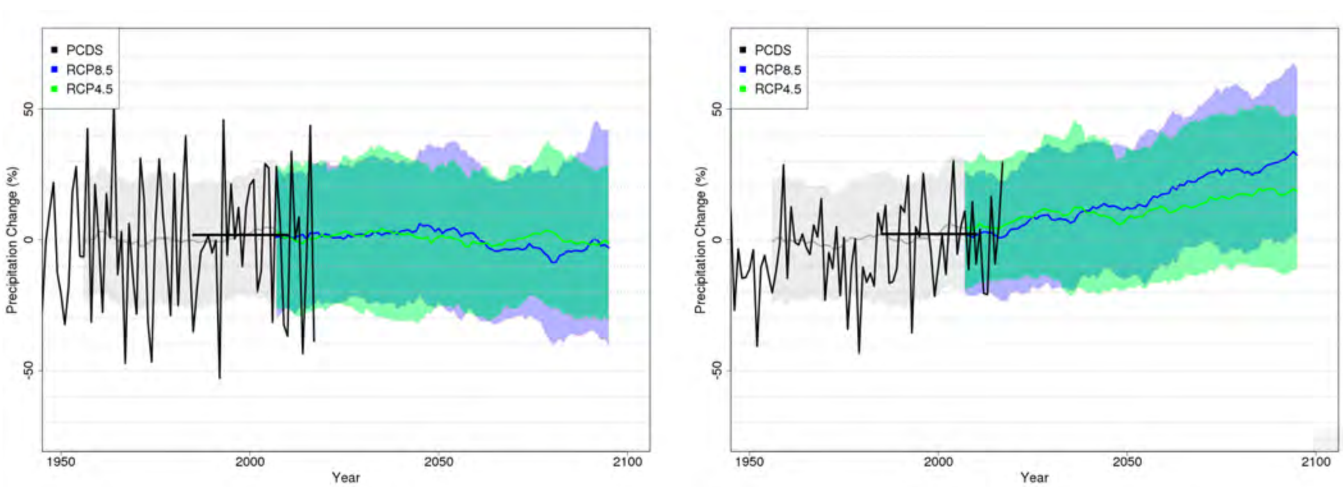


FIGURE 4 Average (Seasonal) Precipitation Change, 1960s to 2080s
LEFT: Summer
RIGHT: Fall

Related Effects

The magnitude and frequency of extreme events, related to both temperature and rainfall, are forecast to increase with climate change. Unusually warm temperatures are very likely to occur more often, and unusually cold temperatures less frequently. Projections are for twice the number of days per year over 25°C and seven times the number of days per year over 30°C by the 2050s. Extremely hot days (defined as the hottest day in the past 20 years) previously reached 31°C. By the 2050s these extreme highs are expected to reach 33°C, and 36°C by the 2080s.[65] The frequency and magnitude of extreme rainfall events are also projected to increase.[66] Detailed projections for 2050s extremes are provided in the sidebar.[67]

The Stuart River is located close to the centre of the region and provides an example of projected streamflow trends. Changes to streamflow will become more pronounced from the 2020s to 2080s, and the Stuart River watershed will remain a snow-dominated basin with streamflows expected to increase during winter and spring, and decrease in summer and autumn (by 2080s).[68] While this watershed provides an example of streamflow projections that are likely to occur across other rivers in the region, separate hydrological studies would be required for accurate projections.

Snowfall is projected to decrease only modestly in the Interior Plateau and Rocky Mountains, largely due to persistent cold temperatures at the higher elevations in this area. The length of the snow accumulation season will be about 38% shorter on average in the 2080s, with a reduction from nearly 80 days to 50 days in the Rocky Mountains and from 65 days to 40 days in the Interior Plateau.[69] The magnitude and seasonality of snowmelt is also projected to shift, resulting in earlier snowmelt freshets and reduced snowmelt volume.[70]

The projected changes outlined in this section will affect the Bulkley-Nechako & Fraser-Fort George region's agricultural sector. The ecological effects and resulting agricultural impacts of these projected climate changes are summarized in the next section.

Extremes

- Days per year over 25°C are expected to occur more than twice as often by 2050.
  BASELINE of 9 days per year
- Days per year over 30°C are expected to occur seven times as often by 2050.
  BASELINE of 1 day per year
- 15% increase in "1-in-20 hottest day" temperature by 2050.
  BASELINE of 30.7°C
- By the 2050s, 43% more of the rain falling will fall in heavy rain events.
- Days with heavy rain[71] are expected to occur up to 33% more often in the 2050s.

Agricultural Impacts

The changes in climate projected for the Bulkley-Nechako & Fraser-Fort George region will have a range of impacts on the agriculture sector. These impacts are summarized in the table immediately below.

TABLE 1 Potential impacts of climate change on agricultural production in the Bulkley-Nechako & Fraser-Fort George region

Projected Climate Changes	Projected Effects	Potential Agricultural Impacts
▪ Increase in summer average temperatures, potential decrease in summer rainfall ▪ Increase in extreme heat events ▪ Increase in winter and spring temperatures (more rapid snowmelt, drier conditions)	***Increasing wildfire risk:*** ▪ More frequent and intensive wildfire events	▪ Increase in costs associated with preparing for, managing and responding to wildfire ▪ Feed and bedding shortages and increase in associated costs ▪ Lost production during active wildfire and recovery period ▪ Negative impacts to animal and crop health, productivity and yield from smoke ▪ Road closures and loss of access to inputs and to distribution channels ▪ Loss of power and associated irrigation ▪ Stress and psychological challenges for producers
▪ Increase in variability of conditions (including temperatures, precipitation and extremes)	***Increasing variability:*** ▪ Fluctuating and unpredictable seasonal conditions ▪ Increased uncertainty of frost risk timing (spring/fall) ▪ Increased variability in spring and fall precipitation/ moisture	▪ Risk of livestock injury due to freeze/thaw ▪ Reduced insulation from snow; increase in forage crop winter damage/ winterkill ▪ Uncertain timing of blossom set and spring growth ▪ Reduced windows for crop development and seasonal tasks (e.g., pollination, planting, germination and harvesting)
▪ Increase in average temperatures ▪ Increase in growing degree days ▪ Increase in growing season length ▪ Increase in minimum winter temperatures	***Changing crop suitability ranges:*** ▪ Changing seasonal conditions ▪ Changing production windows	▪ Potential for additional cuts of hay within season ▪ Opportunities to grow new varieties and types of crops ▪ Potential for season extension ▪ Increase in management complexity, risk and cost (e.g., with season extension) ▪ Inconsistent yield and quality of previously suitable crops ▪ Difficulty in identifying suitable crops for changing conditions

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Projected Climate Changes	Projected Effects	Potential Agricultural Impacts
▪ Increase in average temperatures ▪ Increase in summer temperatures ▪ Potential decrease in summer precipitation ▪ Reduction in snowfall (and associated snowpack)	***Warmer & drier summers:*** ▪ More frequent and extended dry periods in summer ▪ Lower summer and fall stream flow levels (more rapid and earlier spring melt)	▪ Increase in water demand and decrease in water supply ▪ Increase in need for water storage ▪ Increase in costs associated with water supply and water distribution infrastructure ▪ Increase in need for dugout maintenance ▪ Impacts to crop yields and quality (particularly non-irrigated crops) ▪ Increase in need for purchased feed ▪ Late harvest (i.e., due to delayed growth or delayed seed head formation) ▪ Changes to timing and use of rangelands (versus hay) for grazing cattle
▪ Increase in annual temperatures ▪ Increase in winter minimum temperatures ▪ Shifting precipitation patterns	***Changes in pests, diseases, invasive species:*** ▪ Increasing winter survival rates ▪ Increasing in number of cycles in a year ▪ Introduction of new pests and diseases ▪ Changing range/distribution of pests, diseases and invasive species	▪ More frequent and increased damage to crops ▪ Impacts to livestock health ▪ Reduction in forage and pasture quality/yield ▪ Increase in costs for management of pests, diseases, and invasive species
▪ Increase in precipitation in winter, spring and fall ▪ Increase in frequency and intensity of extreme rainfall	***Extreme precipitation events:*** ▪ Increase in runoff ▪ Potential for more rain-driven flood events ▪ Increase in excess moisture	▪ Increase in site-specific flood risk and drainage issues ▪ Reduced access to fields and risk of compaction ▪ Increase in risk of soil erosion and landslides (exacerbated by wildfire impacts) ▪ Damage to infrastructure (e.g., dams and water storage) ▪ Potential for animal health risks from disease or flooding ▪ Impacts to soil health from nutrient leaching ▪ Damage to riparian areas (erosion, washouts, silting etc.) ▪ Negative impact on crop productivity and quality and changes to crop production (e.g., silage instead of hay)
▪ Increase in average and seasonal temperatures	***Increase in extreme heat events:*** ▪ Increasing number of days per year over 25°C and over 30°C	▪ Increase in crop water demand ▪ Change in timing of animal husbandry (e.g., need to shear early or more often) ▪ Increase in crop damage and loss ▪ Increase in prevalence of some pests and associated damage ▪ Impacts to livestock health and productivity ▪ Challenges controlling temperature in poultry and dairy barns

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Projected Climate Changes	Projected Effects	Potential Agricultural Impacts
▪ Increase in average temperature ▪ Increase in extreme events (e.g., wildfire, floods etc.) ▪ Potential for longer, warmer and drier summers	***Changing ecosystems and wildlife populations/distribution:*** [72] ▪ Changes in range and distribution of plant and animal populations ▪ Reduction in feed/water sources for wildlife	▪ Forest encroachment on grazing lands ▪ Changes to plant physiology and nutritional content (e.g., in forage crops) ▪ Increase in conflict with wildlife (bull elk, grizzly bears and wolves) ▪ Increase in pressure on agricultural lands from distribution of deer, elk (loss of crops and feed)

This set of "impact areas" (groupings of projected climate changes and their associated effects and agricultural impacts) formed the basis for discussions at the first set of workshops.

These impact areas were explored in detail with participants and ranked in order of importance for both the individual farm and at the regional level. Based on this input, the highest priorities were identified and some impact areas in the table above were excluded from consideration at the second workshops. Those impacts that were excluded may prove to be problematic or advantageous in the Bulkley-Nechako & Fraser-Fort George region in the future, and should continue to be monitored. Adaptation strategies will still be needed for agriculture to address all impact areas.

photo by Samantha Charlton

Priority Impact Areas, Strategies & Actions

The following four impact areas were identified as the highest priorities with respect to agricultural adaptation in the Bulkley-Nechako & Fraser-Fort George region:

- **Impact Area 1**
  Increasing wildfire risk
- **Impact Area 2**
  Increasing variability and changing crop suitability
- **Impact Area 3**
  Warmer and drier summer conditions
- **Impact Area 4**
  Changing pest[73] *and beneficial insect populations*

In the sections that follow, a background description and adaptation goals are provided for each of the Impact Areas. Following the impact description, a series of strategies and actions to support the Bulkley-Nechako & Fraser-Fort George region agriculture sector with adapting to climate change are outlined.

The strategies and actions presented were developed to:

- Address the highest priority impact areas
- Reduce vulnerability to these impacts, and/or build capacity to adapt and respond to these impacts; and
- Define practical steps forward that address gaps and build on existing assets in the Bulkley-Nechako & Fraser-Fort George region context.

Following the strategies and actions, the final section highlights those actions identified for near-term implementation. Implementation details, key participants, timeframes and cost ranges are provided for these near-term priority actions.

Impact Area 1: *Increasing Wildfire Risk*

Fire is a natural phenomenon in the forests of Central British Columbia and has historically served to reduce build-up of forest fuels and to change the composition of the forest by replacing older stands of trees with trees of different ages.[74] Human management of wildfires has led to an accumulation of fuels in forests and many forest stands in Bulkley-Nechako & Fraser-Fort George have also been affected by die-off due to the mountain pine beetle.[75] These factors, when combined with a changing climate (i.e., warmer winter and spring temperatures, more rapid snowmelt and the potential for prolonged hot and dry summer conditions) are increasing the likelihood of more frequent and intense wildfires in the region, while also increasing the length of the wildfire season.

Relevant Climate Change Effects

- Increasing average and maximum summer temperature
- Increasing number of days per year above 25°C and 30°C
- Increasing intensity/duration of hot and dry summer conditions

The Bulkley-Nechako & Fraser-Fort George region was at the heart of the record-breaking wildfire season (in 2018) which burned over 1,354,284 hectares of land and included the Shovel Lake, Verdun Mountain and Island Lake wildfires.[76] In RDBN the 2018 wildfires destroyed structures on more than 60 agricultural properties and affected 5,055 head of cattle, 250 ranch horses, 850 sheep, 775 goats and other livestock.[77] Despite the extent of the area burned in 2018, large areas of the region continue to be vulnerable to wildfire.

The risk of wildfire (and associated impacts to agricultural operations from wildfire) is largely influenced by the type of forest cover and the quantity of hazardous fuels on the landscape. Successful risk-reduction efforts will need to include coordinated fuel management treatments on both private and Crown lands and a focus on a shift to fire-adapted ecosystems.[78] BC Wildfire Service has incorporated a focus on fuel/land management into its mandate, increasing opportunities for collaborative fuel management projects.[79]

Wildfires not only jeopardize crop production and quality, livestock health and agricultural infrastructure, but also require producers to invest time and money into preparedness planning, response and recovery. The Regional District of Bulkley-Nechako has been proactive in supporting agricultural wildfire preparedness through annual wildfire preparedness workshops. The Regional District of Fraser-Fort George has also supported agricultural wildfire preparedness over the past three years and continues to support preparedness through workshops and seminars, and is currently developing a video series with information specific to agricultural lands.[80] Additional workshops were held in the region by the BC Cattlemen's Association in 2018, and by CAI in 2019.[81] Some communities and groups in the region have also been promoting wildfire preparedness, coordinating response and/or distributing wildfire information and updates (e.g., Pleasant Valley Cattlemen, Chinook Emergency Response Society on the south side of Burns Lake). Continuing to actively engage producers in wildfire planning and preparedness for their operations will enhance and expand the reach of efforts to date.

Producers rely on outside agencies for information during the wildfire season to inform response activities so supporting a consistent and collaborative approach to communication and information sharing (between Regional Districts, BC Wildfire Service and producers), before the wildfire season and during wildfire emergencies, is needed.

The strategies and actions in this section address the following ***adaptation goals***:

- ***Enhancing tools and resources for wildfire preparedness and mitigation***
- ***Facilitating agriculture sector engagement with the forestry sector (re: fuel management and wildfire risk)***

Impact Area 1 > Strategy 1.1

Assess and pilot collaborative fuel management and wildfire preparedness strategies for high-risk (Crown) agricultural interface areas

Many farms in Bulkley-Nechako & Fraser Fort-George are located adjacent to forested Crown rangeland which often contains a combination of heavy fuel loads and/or standing dead wood.[82] Private land and infrastructure on the interface are at risk from wildfires on Crown land, particularly from ember showers igniting spot fires.[83] While producers may take proactive steps to reduce wildfire risk and fuel loads on private lands, often the most significant risk is posed from adjacent lands.

Some options for fuel management on Crown land do exist — such as clearing trees on fenceline right of ways and removing small volumes of non-saleable timber — but removal of felled trees and small fuel to mitigate fire risk is a challenge and available methods are often insufficient to fully address heavy fuel loads.[84] A previous project completed in the Cariboo region identified key barriers to fuel management on Crown land, and could be used to inform actions for this strategy.[85]

To fill current gaps in fuel management, there is a need to support collaborative action that removes, and disposes of fuel at the agricultural interface. Pilot projects could help to identify the most viable approaches while exploring options to streamline permitting processes (e.g., for removing trees from fencelines) and to address logistical barriers to fuel management activities. Successful action would require collaboration between forest managers, licensees, agricultural producers, the Regional Districts and BC Wildfire Service. Due to broad interest in cooperative fuel management projects, there may be opportunities to implement pilots in multiple regions simultaneously to test varying approaches and share findings across regions.

ACTION 1.1A **Assess and pilot collaborative fuel management**	ACTION 1.1B **Pilot an approach to streamlining planning/permitting for fuel management**
▪ Review options (including consideration of costs/economics, challenges/barriers and potential co-benefits) for management of forest fuels near agricultural operations such as: - Harvesting along the grassland benchmark; - Fuel thinning; - Fuel chipping/ shredding; - Silvopasture/agroforestry to remove understory; - Prescribed burning; and/or - Range management practices to reduce fuel loads. ▪ Bring agriculture and other stakeholders together to evaluate possible opportunities and challenges related to particular approaches. ▪ Determine the scope and focus of one or more pilot projects. ▪ Implement pilot projects and monitor results to inform broader fuel management strategies.	▪ Based on options identified in ACTION 1.1A, pilot an approach to streamline planning and permitting: - For fuel management on Crown land close to agricultural operations and infrastructure; - To increase fenceline clearing and increase right of ways.[86] ▪ Evaluate pilot and determine options for scaling up to other regions or provincially.

Impact Area 1 > Strategy 1.2

Enhance and expand farm/ranch and small group wildfire preparedness

Despite the extent of the area affected by wildfire in 2018, wildfire risk is still very high across the Bulkley-Nechako & Fraser-Fort George region and areas that have recently experienced wildfires still need to be prepared. Mitigating damage associated with wildfire requires preparedness planning at the farm, small group and community levels.

There have been a number of activities in the region to support producers with farm-level preparedness planning. In 2018, the BC Agriculture & Food Climate Action Initiative (CAI) released a Workbook and Guide to assist producers with planning for a wildfire emergency and reducing impacts to their operations.[87] These materials were promoted through workshops held across the province by the BC Cattlemen's Association (2018) and CAI (2019). The Regional District of Bulkley-Nechako also hosts annual preparedness workshops. Continuing to support farm-level preparedness planning that is well suited to local circumstances and production types is a key element of this strategy.

Producers in remote areas would also benefit from small group wildfire preparedness planning that enables cooperative response activities such as: planning for relocating livestock, sharing equipment, and distributing wildfire updates/information through predetermined channels. The recently created Chinook Emergency Response Society (focused on the south side of Burns Lake in the RDBN) is an example of a community-led initiative to address the information and preparedness needs of remote communities.[88] CAI is also developing template materials to assist with small group preparedness.[89]

Producers rely on outside agencies (regional districts and BC Wildfire Service) for information during the wildfire season. Ensuring that there is shared understanding of process, roles and responsibilities, and that updates are provided in a timely and effective manner, is critical for reducing impacts from wildfire. A pilot project is underway in the Okanagan-Similkameen region to establish a plan to guide communication between the Regional District of Okanagan-Similkameen, response agencies and agricultural residents.[90] The pilot approach could be adapted/replicated in the Bulkley-Nechako & Fraser-Fort George region.

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ACTION 1.2A **Partner with existing initiatives to promote and deliver wildfire preparedness planning resources for farms/ranches**	ACTION 1.2B **Provide small group wildfire preparedness planning support**	ACTION 1.2C **Develop shared communication plan for wildfire emergencies**
▪ Collaborate with existing wildfire preparedness initiatives and identify any gaps. ▪ Address any identified gaps with supplementary materials or activities including: - Ensuring the unique needs of small-scale farms are met with existing resources; and/or - Delivering supplementary technical/financial support for on-farm fuel management.	▪ Assess level of interest in small group plans across the region (i.e., number and locations of potential groups). ▪ Facilitate expansion of small group wildfire preparedness planning by: - Partnering with existing local initiatives; - Bringing producers and key agencies together in workshop-based planning process; - Utilizing/refining CAI small group planning template; and/or - Supporting cooperative fuel management planning and implementation. ▪ Provide completed preparedness and response plans to response agencies (e.g., Regional Districts, BC Wildfire Service).	▪ Bring producers, Regional Districts, BC Wildfire Service, RCMP and response agencies together to determine stakeholder objectives and to develop the communication plan.[91] This plan may include: - Roles and responsibilities during a wildfire; - Local contact information; - Permitting and re-entry; - How and what to communicate at what times; and/or - Where to post/find information. ▪ Implement wildfire communications plan. ▪ Evaluate outcomes and refine as needed. ▪ Develop a standardized template that can be utilized across BC regional districts.

Impact Area 1 > Strategy 1.3
Initiate dialogue on forest management practices and agriculture wildfire risk

In recent years, wildfire seasons in Central BC have become longer and more intense, largely due to increasingly dry summer conditions combined with excessive build-up of wildfire fuel (resulting from fire suppression and forest management practices, as well as widespread issues with forest health).[92]

Producers living and working on the agricultural/wildland interface would benefit from improved information on forestry practices and how they are being adapted to mitigate wildfire risk, and on other forestry-related topics of importance to the agriculture sector. Compiling existing information and research into a summary tailored to the agricultural sector would be a first step in facilitating the sector's engagement regarding forest management practices. This summary can be used to guide meaningful on-going engagement between agricultural leaders/stakeholders and forestry leaders/stakeholders through a working group or some other mechanism (e.g., forum).

While at present producers do not have an effective way to engage with the forestry sector on topics of agricultural importance, related initiatives do exist in the region. One such initiative is the recently launched Northern Initiative for Wildfire Resilience, that is working with stakeholders to strengthen partnerships and shift forest and fire management practices towards a paradigm that focuses on ecosystem and community resilience.[93] Other multi-stakeholder working groups that have been formed in the past to address complex issues could serve as a model. For example, the "Cariboo-Chilcotin Regional Agriculture-Wildlife Committee" was formed to assess the economic impact of wildlife on agriculture in the region and propose a strategy to prevent loss of forage, annual crops and livestock.[94]

ACTION 1.3A **Summarize current forestry management practices and their potential impact to agricultural wildfire risk**

- Consult with producers to document priority issues/concerns.
- Undertake background research to inform summary that may include the following areas of focus:
  - Clarifying fenceline clearing regulations/policy on Crown land;
  - Assessing how forest management practices affect wildfire risk;
  - Documenting how forest management practices are adapting to climate change (e.g., new stocking standards and adaptive seed transfer guidelines)
  - Summarizing current understanding of how the forest ecosystem is changing and how wildfire impacts may change forest composition;
  - Considering the potential of replanting protocols and treatment option effects on wildfire risk; and/or
  - Identifying options for incorporating agricultural values into forestry planning.

ACTION 1.3B **Facilitate dialogue between agricultural leaders/stakeholders and forestry leaders/stakeholders**

- Identify existing channels for agriculture stakeholders to dialogue with forestry stakeholders.
- Host a forum with agricultural leaders/stakeholders and forestry leaders/stakeholders to share summary from ACTION 1.3 and facilitate initial dialogue.
- Discuss possibilities for joint agriculture/forestry pilot projects (e.g., silvopasture pilots on marginal rangelands with reasonable agricultural soil capability and low quality timber).
- Support initiation of a mechanism for on-going dialogue and input from agriculture (working group, committee, advisory).

Impact Area 2: *Increasing Variability & Changing Crop Suitability*

Increasingly variable conditions (e.g., unpredictable changes in temperature and precipitation, increasing freeze-thaw cycles in winter and spring, late winter rain, extreme heat in summer) are adding to the complexity and costs of farm management. The timing of critical activities in the production season (such as planting, pollination and harvesting) is becoming less predictable. Variable temperatures and abrupt temperature swings result in increased risk of frost damage and can lead to perennial crop loss and animal mortality. Icy conditions brought about by winter rains or melting snow that freezes overnight create hazardous conditions for livestock and can result in winterkill of forage crops.

Adapting to variable conditions requires that producers increase their overall resilience as well as their ability to respond to a broad range of projected changes. Some changes — such as increasing growing degree days and increasing growing season length — may open up new opportunities, provided that producers can adequately manage through seasonal variability.

A critical strategy for adaptation is local research to trial new crops or varieties and to evaluate how differing practices and technologies may strengthen resilience. Some producers are already undertaking applied research, but would benefit from additional research support and expertise, as well improved communication channels for sharing results and/or exchanging information with other producers.

As growing degree days increase in the region (54% faster than the BC average by the 2050s)[95] and the length of the growing season extends, crop suitability may shift in some areas, opening up new production opportunities. Producers are interested in new crops that are shown to be feasible and economically viable, but a successful transition requires local trials as well as market research and support.

Relevant Climate Change Effects

- Shifting precipitation patterns
- Increasing annual and seasonal temperatures
- Increasing growing degree days and growing season length
- Increasing frequency and intensity of extreme events

Limited access to reliable local weather information is a gap for most producers which impacts their ability to manage variable conditions. Increasing the availability of weather data and forecasts would enable producers to be more precise and effective with timing of nutrient management, irrigation scheduling and pest treatments, and would support more accurate assessments regarding the feasibility of new crops under changing climate conditions.

The strategies and actions in this section address the following ***adaptation goals:***

- ***Strengthening farm business resilience through enhanced capacity to innovate, diversify and share knowledge***
- ***Improving sector access to baseline weather information***

Impact Area 2 > Strategy 2.1

Facilitate research and knowledge transfer on innovative farm practices, new and novel crops & crop diversification

Some producers in the region are already adapting to increasingly variable conditions by experimenting with new crops and innovative seed mixes, and by testing new farm practices and shifting the timing of farm activities (e.g., seeding in the fall instead of the spring). Other producers are eager to undertake research but require assistance and support to design and undertake trials and analyze results.

Supporting a collaborative and structured approach to trials (e.g., coordinating trials in multiple locations with producer cooperators, consulting with producers on research topics, coordinating bulk seed purchases) and supporting producers with research design, data collection and analysis, will result in higher levels of confidence in research results. The recently developed *Guide to On-Farm Demonstration Research* provides a structured approach for forage producers to develop research questions, gather data and analyze results.[96] A new project is also underway (from 2019–2022) in the Kootenay and Boundary region, building on the Guide by developing research templates and accompanying Case Studies for a range of commodities and research questions.[97] Results of this work can be extended to producers in Bulkley-Nechako & Fraser-Fort George region to support this Strategy.

The University of Northern British Columbia (UNBC) has recently completed a feasibility study to identify new cash crops and bioenergy crops that could thrive in the region (in a changing climate) and also have strong market viability.[98] Based on this research, in-depth market assessments are being completed for garlic, Jerusalem artichoke and Haskap and Saskatoon berries. There is potential to expand the geographic reach of UNBC's work to include parts of the region not previously involved, as well as to increase the research scope to include additional crops (particularly new varieties of current crops and more drought tolerant varieties). Expanding the market analysis/economic component of the study may also bolster transition to new crops, since producers are interested in diversifying production, but require assurance that there is market demand.

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ACTION 2.1A **Coordinate producer-led knowledge transfer, research and trials**	ACTION 2.1B **Expand local crop studies and strengthen crop suitability analysis and market analysis**
▪ Create an inventory of current producer-led research and identify emerging research priorities. ▪ Develop a program (to distribute existing resources) to support producers with farm research including: - Providing technical input in advance of – and during – on-farm trials; - Assisting with data collection and data analysis; and/or - Coordinating research between farms. ▪ Coordinate producer-to-producer knowledge transfer (e.g., field days, fact-sheets, website). ▪ Create a common database of research results from producer-led trials.	▪ Expand the UNBC Cash Crop Study in order to include: - Crops which producers can use to diversify operations; - New/alternate crops that complement existing production systems; - Crops/varieties that are drought resistant (link to ACTION 3.3B); - Considerations of micro-climate suitability and analysis of crop performance with climate change; - Enhanced market analysis component, including potential climate change affects on consumer behavior and market trends; and/or - New market trends, comparative return on investment between traditional and new crops. ▪ Initiate crop trials with producer cooperators for the most promising crops. ▪ Share results through fact sheets or other complementary resources.

Integrate climate change information into farm business planning programs and resources

Producers in the Bulkley-Nechako & Fraser-Fort George region can access farm business planning services (which include resources on topics such as production economics, business strategy and succession/transition planning) through the Ministry of Agriculture and other local agencies.[99] While these services provide support with assessing the financial underpinnings of a farm business and associated planning, climate change considerations are not included.

Climate change will increase financial risk for producers through a variety of associated impacts. Incorporating climate change considerations into business planning programs would help producers to better understand their risks, and would support informed investment in infrastructure and practices to enhance farm resilience and viability under changing climate conditions.

Small farms can face challenges in accessing business planning services if they generate relatively low farm-gate receipts. For example, to be eligible for the BC Ministry of Agriculture's farm business planning services, farms must have generated over $30,000 in annual gross revenue in the previous year.[100] Working with existing programs to pilot an initiative to serve small farms would be beneficial, as small farms have limited ability to invest in farm-level climate change adaptation solutions.

Crop suitability models are used to determine a crop's performance in a given environment (by simulating key processes driven by plant physiology, soil chemistry and climatic variables) and are an important tool in understanding which crops will be most viable under future conditions.[101] Improving the availability of crop suitability modelling results would help producers to evaluate, and potentially to take advantage of, increasing growing season length and growing degree days.

ACTION 2.2A **Partner with agricultural business planning programs to add climate change considerations to farm business planning resources**

- Complete a scan of existing programs/resources and identify opportunities to add climate change information. This may include:
  - Extreme event preparedness (e.g., understanding and mitigating risk from wildfires and floods);
  - Considerations regarding water supply availability/ infrastructure under current and future conditions;
  - Business management practices for resilience (e.g., insurance, diversification); and/or
  - A "climate risk stress test" for measuring an operation's current resilience.
- Incorporate information on future crop suitability and opportunities (if available) into planning tools.
- Improve producer awareness of, and access to, these resources through outreach/communications activities.
- Pilot specialized business planning for small farms (gross revenue $30,000 and under).

ACTION 2.2B **Complete regional crop suitability modelling for integration into farm business planning**

- Complete a scan of existing crop suitability modelling for BNFFG and comparable regions.
- Determine which new or existing crops have the most potential for expansion in the region and complete crop suitability modeling for these crops.
- Develop resources to communicate crop suitability findings to producers (e.g., fact sheets, case studies, online tools).
- Incorporate resources into a business planning module (as a part of ACTION 2.2A).

Impact Area 2 > Strategy 2.3

Establish a regional weather data and monitoring network and develop decision support tools

Improving access to real-time weather data (such as growing degree day accumulation, daily minimum and maximum temperatures) supports farm planning and decision-making that is more responsive to local microclimates (rather than timing activities based on historical averages). Access to more precise weather data would also allow producers to better track how variable conditions are affecting their operations year over year (e.g., frequency of late spring frosts, spring diurnal temperature differences).

Producers in the region have access to historic data (e.g., temperature, heat units, pest degree days, evapotranspiration) and five-day forecasts for 22 weather stations across the Fraser-Fort George and Bulkley-Nechako region through the Farmwest network.[102] However, not all of these stations measure variables of value to the agriculture sector (e.g., humidity, precipitation) and there remain significant geographic gaps in weather station coverage of agricultural areas.[103] Some weather data (such as temperature and rainfall) is also available through the Government of British Columbia's *Climate Related Monitoring Program* (CRMP).[104]

Improving the weather station coverage in agricultural areas, and enhancing producer access to weather data and weather forecasts, would provide producers with valuable, real-time information to support farm activity planning and decision-making, while also enabling producers to track variable conditions over time to better document changes and extremes. An enhanced weather station network, with more stations covering a broader range of micro-climates, will also support the development of decision support tools which link to real-time weather station data.[105]

Farmwest, working with the BC Ministry of Agriculture and Agriculture and Agri-Food Canada, has developed a system for feeding data to their website from stand-alone weather stations. Connecting new and/or additional weather stations to the Farmwest network will enable station data to be linked with currently available tools (i.e., historic data, five-day forecasts).[106] Some additional decision-support tools are linked to the Peace region agriculture weather network.[107] There are also examples of relevant tools from other jurisdictions (such as the AgWeatherQuebec forage tool).[108]

There is currently a very limited set of relevant decision support tools available to producers in the Bulkley-Nechako & Fraser-Fort George region and there is also a need to increase knowledge about how various tools can support farm activity planning. Effective application of both existing and any newly developed decision support tools requires training to ensure producers are comfortable using the tools and can integrate them into their management systems.

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ACTION 2.3A **Develop an improved weather station network**	ACTION 2.3B **Share weather station data and decision support tools with producers**
▪ Assess coverage of current weather monitoring including identification of geographic and data gaps.[109] ▪ Identify suitable station sites, data to be collected and partners for stations (different criteria and partnerships would be required for private land and public/range land). ▪ Explore potential for partnering with existing networks (Farmwest, CRMP, Peace Region Weather Network). ▪ Explore potential to: - Integrate air quality/smoke data into the weather data system; - Connect new stations to existing wildfire risk models; and/or - Connect to river forecast system infrastructure. ▪ Identify and convene key partners to develop a plan for improving and maintaining agricultural weather data (including consistent collection and quality control of data).	▪ Explore options for decision support tools to be made available in the region including: - Potential for adapting existing tools, or - Opportunities for developing new tools, for commodities such as forage, hay and for farm practices such as range management. (e.g., tools could input current weather data to provide recommendations on the best seeding date and harvest date for a crop). ▪ Develop tool(s) and resources (as prioritized above) and share them with producers. ▪ Establish a long-term outreach and extension plan to communicate availability of improved weather/climate data to producers.

Impact Area 3: *Warmer & Drier Summer Conditions*

Of the 292,115 hectares of land in the Bulkley-Nechako & Fraser-Fort George region used primarily for agricultural purposes, it is estimated that only 1.4% (3,980 hectares) is irrigated.[110] Irrigation systems vary but include wheel lines, hand lines and cannons for field applications (primarily forage/pasture) and drip irrigation for market gardens. A rough estimate derived from available provincial data on dams indicates that there are approximately 127 active dams (30 agricultural) and approximately 773 agricultural water licenses in the region. These are mostly surface water licenses, since groundwater has only been regulated since 2016. Water storage infrastructure is primarily utilizing dams and dugouts.[111]

Climate change projections for warmer and drier summer conditions (an increase in average annual and summer temperatures, as well as a greater likelihood of significantly decreased summer precipitation in some years) will result in increased rates of evapotranspiration and increased agricultural water demand to maintain production. Dry years are already impacting some water systems in the region. In 2018, the Northwest, Upper Fraser West, Upper Fraser East and Nechako regions reached Level 2 to Level 3 drought ratings, meaning these areas were very dry.[112]

Rising winter temperatures are also expected to result in a decrease in snowpack and earlier peak stream flows,[113] reducing water supply during periods of greatest water demand. Large-scale changes in land cover due to the combined impacts of forest management practices, mountain pine beetle and wildfires are also affecting hydrology and water resources. The 2018 wildfire season dramatically altered large forested areas increasing the risk of runoff resulting in soil erosion, landslides and flooding. This risk will be exacerbated by heavy rainfall or rapid winter snow melt as the water holding capacity of the landscape and soils has been reduced.[114]

Relevant Climate Change Impacts

- Increasing average summer temperature
- Increasing number of summer warm days and extremely hot days
- Rising winter minimum temperatures
- Potential for decreasing summer precipitation

The broader context for water management in the Bulkley-Nechako & Fraser-Fort George region includes a range of stakeholders, values and considerations. The Nechako Watershed Strategy identifies water quantity and quality concerns, pertaining to various values including the Nechako White Sturgeon, which has become an endangered species.[115] First Nations water rights and treaty negotiations are also affecting the landscape of water use in the region, as illustrated through numerous emerging initiatives, agreements and projects in the Nechako Watershed.[116] Water infrastructure projects on the Nechako reservoir are another important consideration. Adding to the complexity of the changing water context has been the introduction of the (2016) Water Sustainability Act.[117] Regulations of particular concern for producers are the Groundwater Protection Regulation, the Dam Safety Regulation, and the evolving Livestock Watering Regulation.[118]

As the growing conditions in the region shift, more producers — even in the historically wetter area of the Robson Valley — are considering irrigation.[119] While the relatively high costs of hydroelectric power and narrow profit margins have made the business case for irrigation uncertain, this requires further exploration in the context of climate change.[120] Irrigation infrastructure that can also be used for fighting wildfires, or protecting farm assets during a fire, may make the cost-benefit of irrigation more favourable.

For producers in the Bulkley-Nechako & Fraser-Fort George region, access to sufficient water for irrigation and livestock watering is a significant concern. This is directly linked to the ability to store and/or conserve water during seasons when it is plentiful. A focus on healthy water systems and increased water supply through storage, as well as continuous improvement in agricultural water management practices, will enable resilient agricultural production in the region into the future.

The strategies and actions in this section address the following ***adaptation goals:***

- ***Supporting the establishment of agricultural water storage***
- ***Optimizing agricultural water use and management***

Impact Area 3 > Strategy 3.1

Improve informational resources about farm/ranch water storage development

Enhancing water storage capacity will reduce vulnerability associated with extended dry periods and warmer temperatures. Determining the most appropriate water storage solution is a site-specific process which involves site assessment, analysis of farm/ranch water needs and available water supply, technical considerations for building water storage and adherence to applicable regulations (depending on the water source).

The changing regulatory context for water storage is increasing the demand for clear and accessible information. Both the BC government[121] and agricultural organizations, such as the BC Cattlemen's Association,[122] have taken steps to provide information to producers. Despite these efforts, informational gaps remain and producers — particularly those without support through commodity associations — are seeking additional information as regulations (e.g., the Livestock Watering Regulations) continue to evolve. Improving access to information could include workshop sessions on dam safety (using materials developed through previous projects in the Cariboo[123]), question and answer sessions with agency representatives/experts, and/or development of a database of professionals and contacts with relevant expertise.

Producers are also seeking information to support farm and ranch-level decision making regarding their unique water needs and opportunities. Developing new resources would help to fill information gaps, and more active knowledge transfer through workshops and field days that demonstrate various storage options,[124] as well as highlighting best practices for maintaining existing dugouts in a changing climate (e.g., how to limit evapotranspiration of storage, aerating dugouts to improve water quality) would be beneficial. Providing information through a series of water storage "case studies" would also be valuable. A diverse range of scenarios and considerations could be presented through the case studies (e.g., amount of water needed, soil type, potential water sources) and field days and/or written case study summaries could highlight decisions, challenges and opportunities. Any information shared would also need to address whether current water storage designs are adequate under a changing climate.

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ACTION 3.1A **Identify and implement mechanisms to connect producers with (up to date) resources and expertise associated with water storage regulation**	ACTION 3.1B **Create and/or share resources to assist producers with enhancement or development of water storage**
▪ Identify key resources of interest – and preferred mechanisms for sharing these materials – likely to include: - Delivering agricultural dam safety workshop sessions; - Presenting at industry association meetings/events and/or hosting workshops; and/or - Holding question and answer periods with technical advisors and regulators. ▪ Develop supplementary materials for navigating permitting processes including list of human resources available to assist with regulatory and technical questions. ▪ Support the agriculture industry with provision of information to producers as livestock watering regulations are developed.	▪ Inventory existing informational and technical resources. ▪ Work with local partners to identify exemplary and innovative case studies. ▪ Document case studies and develop resources to address gaps or provide locally relevant information potentially including: - Regulatory considerations; - Suitability of different infrastructure; - Cost-benefit analysis and pay-back period; - Cost-share supports/co-funding; - Climate change considerations; and/or - Management for settlement ponds and dugouts. ▪ Coordinate knowledge transfer (e.g., via field days, written resources) to share resources.

Impact Area 3 > Strategy 3.2

Assess the feasibility of developing water storage that captures run-off to reduce localized flood risk

As the climate conditions that result in rapid snow melt and/or spring flooding become more common, storage of excess runoff during wet periods could improve water availability during dry conditions, while also playing an important role in flood control. Site specific flooding from spring freshet or extreme precipitation can lead to a variety of negative impacts to agricultural production and to the broader community and landscape. By achieving multiple benefits, linking water storage and flood mitigation may enhance collaborative approaches and partnerships for implementation.

The potential for sustainable water storage in the region is affected by local precipitation patterns and snow dynamics (i.e., snow accumulation, timing/rate of melt) which are shifting with climate change. Identifying areas (at a sub-regional level) where additional water is needed, and where there is either excessive runoff or surface flow early in the season, would be an important initial step. Once suitable areas of focus have been identified, an in-depth analysis could identify optimal sites for (potentially shared) water storage.

Collaborative development of a shared water source may help to keep costs down for individual farms/ranches, and may be an important mechanism to increase storage capacity. In areas most impacted by mountain pine beetle and associated forestry activities and/or by wildfires, excess runoff and resulting erosion and/or localized flooding are likely to be acute. There may be potential to collaborate with Regional Districts, or other partners, who would value additional co-benefits of water storage (wildfire suppression, habitat and ecological services).

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ACTION 3.2A **Determine optimal locations for shared water storage development**	ACTION 3.2B **Evaluate the feasibility of combined water storage and runoff management/flood control**
▪ Consult with agriculture sector and local experts to identify locations where additional water storage is needed. ▪ Develop and utilize a set of criteria to determine whether a site is suitable for storage and flood control/ run-off reduction. Criteria may include: - Growth potential for agricultural production in the area; - Insufficient or diminishing water supply; - Proximity of agricultural land to potential water source; - Potential for a significant increase in yields; and/or - Microclimatic conditions resulting in an above average increase in Growing Degree Days. ▪ Monitor sites to measure run-off. ▪ Focusing on areas identified above, map areas of the agricultural land base (that are under production) which are prone to seasonal site-specific flooding: - Standardize the mapping into a functional GIS. - Create mapping layers for hydrology (including seasonal/temporal element) that could overlay existing mapping resources (soil, topography, agricultural capability).	▪ Evaluate the economic, technical and regulatory feasibility of developing new water storage on the most opportune sites identified in ACTION 3.2A: - Determine how storage can best be designed to support flood control objectives; and/or - Identify other uses of water storage beyond agricultural. ▪ Document and quantify co-benefits of new storage (e.g., flood risk reduction, habitat & ecological services, groundwater regeneration, wildfire suppression). ▪ Facilitate co-funding and/or provide technical/ professional support for water storage and irrigation development in locations where it has strong co-benefits.

Provide knowledge transfer for agricultural water use efficiency and soil moisture management

Management practices that maximize water use efficiency will improve resilience by conserving water in storage and enabling producers to manage during periods with reduced water availability. Improved management could include both infrastructure-related solutions and farm practice-related solutions that utilize existing water/moisture on a farm or ranch.

Considerable work has been undertaken in BC to develop tools and resources to guide agricultural water use, such as the BC Agriculture Water Calculator,[125] the BC Irrigation Management Guide,[126] and numerous fact sheets.[127] Improving distribution of existing resources would be a relatively low-cost option for supporting increased levels of adoption and there are already some transferable resources related to technologies and practices for improving irrigation.

It would improve the relevance of the existing materials (and likely increase uptake) if they were supplemented and/or tailored for the local production context. In particular, information is needed for small-scale irrigation systems, market gardening systems/drip irrigation systems and linking irrigation systems to wildfire mitigation priorities.

In addition to increasing distribution and specificity of irrigation information, there is also a need for improving and sharing information on other aspects of farm design and practices for managing dry and/or drought conditions including: selecting suitable crops, minimizing evapotranspiration, improving soil water storage capacity (e.g., enhancing carbon/organic matter) and using native grasses with deeper root systems.

Focusing the knowledge transfer and informational resources on those water conservation and efficiency measures that are relatively straightforward and low cost to implement, rather than those requiring large investments, would be also increase producer interest and adoption. If innovative techniques requiring higher up-front capital investment are identified, and are not yet used in BC, these would first require local piloting, demonstration and evaluation.

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ACTION 3.3A **Provide workshops and field days on existing water management tools and resources (related to irrigation)**	ACTION 3.3B **Provide information on farm design, crop selection and crop management for dry/drought conditions**
▪ Inventory the relevant existing resources for interior BC. ▪ Share and promote existing (BC-specific) irrigation management tools and resources that are appropriate to the region through: - Demonstrations by irrigation equipment suppliers; - Field days at local operations with efficient and optimal irrigation set ups; and/or - Presentations at producer association/institute meetings. ▪ Topics may include: - How to establish new and efficient irrigation infrastructure (connected to EFP planning support/ cost shares); - Efficient irrigation; - Drip irrigation; - Rainwater capture; and/or - Combining irrigation systems with wildfire protection (e.g., greenbelts around infrastructure, shelter-in-place locations).	▪ Consult with producers to identify key topics of interest and information needs to promote uptake. ▪ Confirm the preferred format for providing this information (e.g., workshop, presentation, field days, webinars). ▪ Topics to cover might include: - Crop protection technology (blocking wind, reducing evapotranspiration); - Whole farm design; - Using fodder instead of hay for cattle feed; - Drought tolerant crops; - Native grasses; - Improving soil water retention; and/or - Agroforestry/silvopasture. ▪ Provide this information through on-farm demonstrations where possible.

Impact Area 4: *Changing Pest & Beneficial Insect Populations*

With climate change, shifts in the distribution, lifecycles and prevalence of agricultural pests (insects, diseases, weeds and invasive species) are anticipated. Increasing average annual temperatures (in particular winter minimum temperatures) combined with shifting precipitation patterns are already magnifying pest impacts, pest management complexity and associated costs of production.

Relevant Climate Change Impacts

- Increase in average annual temperatures (and winter minimum temperatures)
- Shifting precipitation patterns
- Increase in growing degree days
- Increase in frequency and intensity of extreme events

Climate change may result in an increase in the number and distribution of existing problem species, and may create favourable conditions for new species to become established in the Bulkley-Nechako & Fraser-Fort George region. Large-scale ecosystem disturbances such as wildfire and flood (which are exacerbated by climate change) are also likely to result in increased pressure from pests and invasive species.

The region has been significantly impacted by Mountain Pine Beetle outbreaks, in part due to increased winter survival rates.[128,129] Modelling of changes to biogeoclimatic zones (BGC zones)[130] show that the Interior Douglas Fir zone will spread northward and increase in area, while the Sub-Boreal Spruce zone will decrease dramatically. While this modeling was completed with a forestry lens, agricultural pests associated with these ecosystems would be expected to shift along with the BGC zones.

An agriculture-focused project in the Cariboo region analyzed how shifting BGC zones, (along with other factors) may potentially affect emerging and priority pests for the Cariboo-Chilcotin agriculture sector.[131] Similar work could be completed in the Bulkley-Nechako & Fraser-Fort George region to determine how best to focus agricultural pest monitoring and management efforts.

Improving resilience to pest outbreaks, begins with healthy soils, crops and pastures which are better able to withstand, and/or recover from, pest-related impacts.[132,133] Producer knowledge and capacity to implement best management practices is also critical. Best management includes everything from detection and identification skills, to having knowledge of a variety of suitable treatment tools to manage pests.

In addition to affecting the distribution and prevalence of pests, climate change may negatively impact pollinator and beneficial insect populations. Pollinators play a critical role in seed and fruit production, as well as in crop yields and quality, and climate change may reduce critical pollination windows. Climate change will also compound and exacerbate other pressures on pollinators including loss of habitat, risk of disease and, impacts from pollution and pesticides. Understanding how these populations will be affected by climate change, as well as how to enhance pollinator and beneficial insect populations, will also support agricultural resilience.

The strategies and actions in this section address the following ***adaptation goals:***

- ***Enhancing and sharing information about pest management***
- ***Improving understanding of pollinators and supporting pollinator health in a changing climate***

Impact Area 4 > Strategy 4.1

Conduct research and demonstration on improving soil and pasture health

Certain pests and weeds thrive — or are more likely to spread and impact production — on unhealthy and dry pastures.[134] Improving soil and pasture health has multiple benefits, including the reduction of pest establishment. Research parameters related to pests and pasture health could include identifying resilient native plants that may prevent establishment of weeds, evaluating inputs for weed reduction and testing management practices to enhance soil characteristics that prevent or minimize pest impacts.

Another prioritized area of inquiry is the link between irrigation, soil health and pest prevalence. Through applied research, a series of case studies could be established to assess the benefits of irrigation in dry years, and to determine when irrigation would have a positive net benefit (considering setup/operational cost, payback period and return on investment). Although a full irrigation cost benefit analysis would be complex, and may not be feasible, economic and cost/benefit information could still be gathered.

The BC Forage Council (BCFC) is conducting applied research with multiple producer cooperators — including one site in the Fraser-Fort George region — to explore methods to rejuvenate pastures.[135] There is an opportunity to create synergy with this work by establishing collaborative research sites (such as on a community pasture) that look at similar questions posed in the BCFC study, while also adding additional research parameters such as those outlined above.

Demonstration and extension of research results could be implemented by facilitating producer-to-producer knowledge transfer, linking producer cooperator site data into a shared regional dataset, monitoring site parameters through "citizen science" and/or piloting a student field position for monitoring trial results and training producers from different commodities on how to collect data.

ACTION 4.1A **Conduct research/ demonstration on pasture rejuvenation**

- Bolster existing pasture rejuvenation research underway and conduct additional research/demonstration in order to assess:
  - Low-till, conservation tillage, no-till or alternative methods of pasture rejuvenation;
  - Local suitability of methods from prairies and elsewhere; and/or
  - Measuring weed competition and soil health in response to methods.
- Identify appropriate collaborative research sites and partners.
- Define research parameters and methodology.
- Engage economic expertise for cost and benefit consideration of practices.
- Coordinate knowledge transfer, possibly connected to existing soil management and pest management platforms/ events.

ACTION 4.1B **Conduct research on irrigation (and irrigation feasibility), soil health and pest prevalence**

- Identify producer, research and other partners (such as irrigation suppliers).
- Determine criteria for case study sites.
- Evaluate linkages between declining pasture and drought by:
  - Consulting with producers, industry specialists and animal health experts; and/or
  - Selecting a small number of sites (case studies) for monitoring/evaluation.
- Assess and quantify the benefits to soil health, pest reduction and crop yield from irrigation.
- Utilize the case study examples to enumerate the capital costs, operational cost, payback period and return on investment for irrigation:
  - Include energy costs; and
  - Assess the business case of each case study under different climate change scenarios.

Identify and share best practices to manage pests and invasive species

Cumulative agricultural losses and/or management costs relating to invasive species and weeds can be substantial over time. To prepare and respond appropriately, producers require up-to-date information about existing, newly established and emerging pests, as well as resources and tools for identifying pests and determining suitable management and control options.

Some producers access information about pests through their commodity organizations while others hire consulting companies to assist with monitoring and management. The BC Ministry of Agriculture generates pest alerts and assists with developing production guides that include commodity-specific pest management information.

In some cases, research is needed to fill key information gaps for effective management of established and emerging pests. In other cases, effective management practices may be known but there is a need for increased outreach and knowledge transfer to support producers with implementation. Two examples of known management practices that require additional knowledge transfer and uptake are the use of Integrated Pest Management (IPM)[136] and the completion of detailed soil testing to understand the linkages between soil nutrients, soil pH and weeds. Currently IPM information is relatively difficult for producers to access, or has not been adapted for the local context.

There are some programs and tools already available to producers in the Bulkley-Nechako & Fraser-Fort George region, or from comparable/near-by areas that could be promoted or adapted. For example, the Northwest Invasive Plant Council (NWIPC) Landowner Weed Removal Rebate Program[137] has had limited uptake, but may benefit from further promotion, or an expansion of the scope of treatments supported through the program to include organic and/or mechanical treatments.

In the neighbouring Cariboo region, CAI is partnering with the Invasive Species Council of BC, local producer groups, and other partners, to develop new informational resources for producers including facts sheets on priority pests and a comprehensive pest reporting app.[138] These resources are likely to be transferable to producers in Bulkley-Nechako & Fraser-Fort George. Supporting active distribution of relevant materials will assist with uptake, and cross-commodity approaches could increase the value of investment in both research and informational materials.

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ACTION 4.2A **Conduct research to fill key pest management information gaps**	ACTION 4.2B **Share existing and new resources/ research outcomes for prevention and management of pests**	ACTION 4.2C **Bolster and supplement existing programs and tools for pest management**
▪ Consult with sector and industry specialists to prioritize existing and emerging pests/invasive species and major knowledge gaps (modeled after Cariboo Emerging and Priority Pests scan). ▪ Consolidate available information (locally and/or from other jurisdictions) to fill research gaps through secondary research. ▪ Conduct primary research to fill gaps. ▪ Research topics may include: - New tools for managing Hawkweed; - How to manage post-wildfire Assart[139] effect; and/or - Using pest thresholds to time harvest for maximum yield.	▪ Review priorities identified under ACTION 4.2A. ▪ Develop knowledge transfer resources using existing information on key gaps or topics of interest. ▪ Working with local partners, coordinate knowledge transfer (i.e., workshops, presentations). ▪ Topics of interest (where resources already exist) may include: - Facilitating soil testing to understand soil health/weed linkages (utilizing UNBC soil test kit); - Managing inputs/fertilizers to reduce weeds; - Integrated Pest Management; - Spread of weeds/invasive species after wildfire; and/or - Using native grasses and well-adapted non-invasive weeds to prevent establishment of invasive species. ▪ Share research outcomes from any new research completed through ACTION 4.2A.	▪ Consult with key local partners to identify which programs/ projects are most relevant to local producers and best opportunities/ mechanisms for distribution. ▪ Support increased knowledge transfer through identified mechanisms likely to include: - Distribution through agricultural groups via AGMs, key events, websites, newsletters; and/or - Coordination of workshops, field days.

Support healthy pollinator and beneficial insect populations in a changing climate

Pollinators play a critical role in seed and fruit production, and influence crop yield and quality. Pollinators and beneficial insects face an array of threats such as habitat loss, pollution, pesticides and the spread of new diseases and predators.[140] While climate impacts will compound these threats, the specific effects of climate change on pollinators and beneficial insects in this region are not well understood. Warming temperatures and more extreme conditions will influence both plants and pollinators and may alter critical interaction windows.[141]

An improved understanding of the effects of climate change on specific pollinators (and the crops that they pollinate) would provide important information to guide efforts to support and enhance pollinator populations. Some pollinators may be more resilient to projected changes (e.g., native pollinators versus honeybees). Managed honeybees are a valuable pollinator for agriculture, but native bees increase yield and are more effective pollinators of many crops.[142] For example, alfalfa — an important forage crop in the Bulkley-Nechako & Fraser-Fort George region — is primarily pollinated by bumblebees and other native bees.

A methodology outlined by the United Nations Food and Agriculture Organization[143] could serve to guide an evaluation of pollinator and climate change vulnerability in the Bulkley-Nechako & Fraser-Fort George region. The proposed approach outlines data requirements and sampling techniques to answer questions related to effects of climate change on pollination, and the recording and management of data pertaining to pollinator/crop interactions.

Integrating pollinator habitat into farm design could help to retain existing pollinator/beneficial insect habitat, and to create new habitat. The literature indicates that establishing pollinator habitat increases the availability of nutrition for pollinators, and also has secondary benefits to the farm: pest population reduction and protecting soil and water quality by mitigating runoff and protecting against soil erosion.[144] Practices could include use of cover crops, as well as increasing pollinator habitat plantings in non-commercial areas of farms such as fallow areas, fence lines and riparian zones. Lack of pollinator habitat on farm landscapes may be due to insufficient locally relevant information about best management practices,[145] as well as the need to document the opportunity cost and co-benefits (including impacts to yields/crop quality) of habitat retention and creation.

There are a number of potential partners and groups with an interest in pollinator health, both locally and provincially. Local stakeholders include: beekeeper associations and clubs, forage and crop producer associations, environmental/habitat protection groups and local entomologists. The Northern Lights Winery in Prince George is also studying the health of native pollinators in partnership with the College of New Caledonia. There are also numerous potential partners from outside of the region including two new programs, the Bee BC Program and Pollinator Partnership Canada. Opportunities would exist to connect with existing events to share findings and recommendations related to climate change, pollination and best practices.

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ACTION 4.3A **Undertake an assessment of climate change impacts on pollinators**	ACTION 4.3B **Support retention and development of pollinator habitat on and adjacent to farms, and in surrounding communities**
▪ Undertake a baseline pollinator health assessment process. ▪ Evaluate the interaction between weather, cropping systems and pollinators by: - Consulting with producers and other experts to determine which crops and pollinators are of key interest; - Determining a framework for evaluation (possibly the UN Food and Agriculture Organization framework); and/or - Undertaking a multi-year study gathering relevant data from selected local sites. ▪ Facilitate discussion about assessment between entomologists, researchers and farmers as part of sharing assessment outcomes: - Connecting to forestry and considering availability of nectar and pollen in nearby forest landscapes (e.g., fireweed).	▪ Complete a scan of existing information/resources on best practices for establishing pollinator habitat. ▪ Develop a set of producer-focused resources to address integration of pollinator habitat into farm/ranch design including: - Management of fallow areas, cover crops, riparian areas, shelterbelt and fence lines that will attract native pollinators and/or beneficial insects; - Documenting co-benefits of pollinator/beneficial insect buffer areas (e.g., potential benefits to drainage, the ecosystem health benefits of pollination); and/or - Identifying the threats to pollinators and agricultural impacts on declines in pollinator populations. ▪ Identify, and seek out partnerships with, organizations that could plant pollinator friendly plants/corridors in proximity to agricultural lands.

Implementation & Monitoring

While all of the actions contained in this plan are important for the sector to adapt to climate change, the actions on the following pages are identified as "next steps." This is due to their importance and may also reflect their relative ease of implementation or their potential to build capacity for further adaptation actions (see text box on this page). Building momentum and capacity for collective action, and addressing the most important issues, will help to ensure implementation of all of the identified actions.

As the final stage in plan development, two implementation meetings were held with key partners (31 individuals in total) to prioritize actions and determine how to move forward with them. The input received at these meetings informs the content below.

In some cases, individual actions have been merged into single projects because this is the most effective and efficient way to accomplish them. Implementation conditions, such as potential partners and cost range, are identified for each of the next steps.

In order to move forward with project implementation, members of the Advisory Committee that supported the development of this plan will transition into a local working group to oversee the implementation and monitor progress. This group will continue to include agricultural organizations, local government and provincial government representatives. The Climate Action Initiative will function as the overall coordinator for this group and will also lead project development and assist with monitoring progress and reporting.

For each action in the Next Steps below, potential partners are identified. Potential partners were determined through workshops and subsequent draft development, but no formal commitments have been made regarding roles in various strategies and actions. Development of partnerships will be a preliminary activity in project development.

- ***Important*** actions are those that address the highest priority impacts or critical gaps for building resilience.
- ***Ease of implementation*** refers to actions that can be initiated without delay because there is a window of opportunity, there are clear co-benefits with other actors or programs, or there are minimal barriers to address. These actions can also create momentum to help move more difficult or longer-term actions forward.
- ***Capacity building*** actions support the sector by strengthening the ability of producers and producer organizations to take effective action. This may include filling knowledge gaps or developing resources that strengthen the ability to act collectively or individually.

Next Steps for
ACTIONS 1.1A

Actions

→ ***Assess and pilot collaborative fuel management.***

Implementation details

- There may be potential to develop a joint project with the Cariboo region, as this action has been prioritized in the *Cariboo Region Adaptation Strategies* and *Strategies Update*.
- Unique fuel management treatments could be piloted at different sites, or the same treatment could be piloted in different contexts.
- Multiple steps of management may be combined, for example fuel thinning combined with subsequent grazing.
- The scale of treatment required to be effective will largely determine the cost of each pilot treatment.
- The first step will be the identification of sites, partners and completing prescriptions. This information will be required in order to pursue subsequent funding for the treatments.

Potential partners

- Agricultural organizations
  - *Eaglet Lake Farmers' Institute*
  - *District C Farmers' Institute*
  - *Smithers Farmers' Institute*
  - *Bulkley Valley Dairymen's Association*
  - *Skeena Regional Cattlemen's Association*
  - *Nechako Valley Regional Cattlemen's Association*
  - *Prince George Cattlemen's Association*
  - *and others*
- Woodlot Associations
- BC Cattlemen's Association
- BC Ministry of Agriculture
- BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (BC Wildfire Service and Range Branch)
- Canadian Red Cross
- Community Forests
- Forest Enhancement Society of British Columbia
- Regional Districts and local governments
- Timber licensees
- Individual producers

Timeframe

- Medium-term (2–4 YEARS)

Cost

- Planning and prescriptions = Medium ($50,000–$100,000)
- Treatments = High ($100,000+)

Next Steps for ACTION 1.3A & 1.3B

Actions

- → ***Summarize current forestry management practices and their potential impact to agricultural wildfire risk.***
- → ***Facilitate dialogue between agricultural leaders/stakeholders and forestry leaders/stakeholders.***

Implementation details

- A review of forest practices at the policy level is outside of the scope/mandate of CAI.
- To identify how forestry practices are impacting agriculture wildfire risk, consultation should include a broad range of types of producers, woodlot owners, community forests and others.
- The consultation would need to identify both specific issues and common issues.
- ACTION 1.3B may also need to include other key groups (e.g., guides, outfitters, trappers).
- ACTION 1.3B would be is an opportunity to hear what is happening with forestry management practices.
- ACTION 1.3A would be implemented first and ACTION 1.3B would ideally follow immediately.

Potential partners

- Agricultural organizations (as listed on page 43, in particular the Nechako Valley Regional Cattlemen's Association)
- Community Forests
- BC Ministry of Agriculture
- BC Ministry of Environment
- BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development
- Other forest users (e.g., guides, outfitters, trappers)
- Producer groups
- Regional districts and local governments
- Timber Licensees
- Woodlot Associations

Timeframe

- Short-term (LESS THAN 2 YEARS)

Cost

- Complete summary = Low (LESS THAN $50,000)
- Host forum = Low (LESS THAN $50,000)

Next Steps for ACTIONS 2.1A

Actions

- → ***Coordinate producer-led knowledge transfer and research/trials.***

Implementation details

- There may be synergies or opportunities for partnership with the Cariboo Agricultural Research Alliance (CARA).
- All research results (successes and failures) should be shared. Clear determination of how to gauge research/trial success will be essential.
- Detailed documentation of research methodology (e.g., variables, research methods, data collected) and effective sharing of research results is imperative.
- Micro-climatic variability will influence geographic suitability of results and will be important to document.
- There is strong interest in this action and willingness to experiment. Producers need support from a strong research coordinator for this action to be a success.

Potential partners

- Agricultural organizations (as listed on page 43)
- BC Agriculture and Climate Adaptation Research Network (BC-ACARN)
- BC Ministry of Agriculture
- Cariboo Agricultural Research Alliance (CARA)
- Community Futures (Nadina and Fraser-Fort George)
- Dunster School Society
- Post-secondary institutions (UNBC, CNC)
- Young Agrarians
- Individual producers

Timeframe

- Medium-term (2–4 YEARS)

Cost

- High ($100,000+)

Next Steps for ACTION 2.1B

Action

→ ***Extend crop studies and strengthen crop suitability analysis and market analysis.***

Implementation details

- Producer interest in the crop in question must be confirmed before initiating a study. Interests are likely to differ across this large region.
- Crop studies must be combined with market analysis.
- Analysis should include information gathered from producers who have experience with the crop of interest.
- Selection of crops should consider what producers are already growing and what the transition process to a new crop would entail.
- Suitability analysis should consider new locations to grow existing crops.
- Prioritization should also consider alternate crops that serve established markets and don't require market development (e.g., forage crops, grain crops, bio-energy crops).

Potential partners

- Agricultural organizations (as listed on page 43)
- Agriculture and AgriFood Canada
- BC Agriculture and Climate Adaptation Research Network (BC-ACARN)
- BC Ministry of Agriculture
- Cariboo Agricultural Research Alliance (CARA)
- Community Futures (Nadina and Fraser-Fort George)
- Northern Development Initiative Trust
- Post-secondary institutions (UNBC, CNC)
- Research Institutions

Timeframe

- Phase 1: Expand the UNBC Cash Crop Study = Short-term (LESS THAN 2 YEARS)
- Phase 2: Initiate crop trials and share results = Medium-term (2–4 YEARS)

Cost

- Phase 1: Medium ($50,000–$100,000)
- Phase 2: Medium ($50,000–$100,000)

Next Steps for ACTION 3.3A & 3.3B

Action

→ ***Provide workshops and field days on existing water management tools and resources (related to irrigation).***

→ ***Provide information on farm design, crop selection and crop management for dry/drought conditions.***

Implementation details

- Variation in soil types across the region adds to the complexity of providing accurate information.
- Recommendations should build on an operation's existing infrastructure rather than requiring significant capital investment.
- Opportunities to combine knowledge transfer activities (on this topic and other actions) should be explored. If there are on-farm field days, or workshops delivered, many topics could be covered at a single event.
- All information shared must address local barriers and constraints.
- Topics of interest include: drought tolerant native grasses; soil inputs; irrigation supply demonstrations (small-scale systems, tying to wildfire protection, market garden irrigation); and optimal irrigation.

Potential partners

- Agricultural organizations (as listed on page 43)
- BC Agriculture and Climate Adaptation Research Network (BC-ACARN)
- BC Ministry of Agriculture
- BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development
- Cariboo Agricultural Research Alliance (CARA)
- Northern Development Initiative Trust
- Young Agrarians

Timeframe

- Phase 1: Sharing existing tools = Short-term (LESS THAN 2 YEARS)
- Phase 2: Developing and providing new information = Medium-term (2–4 YEARS)

Cost

- Phase 1: Sharing existing tools = Low (LESS THAN $50,000)
- Phase 2: Developing and providing new information = Medium ($50,000–$100,000)

Next Steps for ACTIONS 4.1A

Action

→ ***Implement research and demonstration on pasture rejuvenation.***

Implementation details

- This action could connect to prioritized ACTION 4.3B if pasture management practices also have potential to support pollinator and beneficial insect populations.
- An existing BC Forage Council project has five nearby producer cooperator research sites (one in Fraser-Fort George, four Cariboo sites), and a separate project includes Kootenay & Boundary sites.
- There are connections to explore between pasture management and wildfire mitigation.
- Knowledge transfer will be vital to success and could include sharing resources that already exist on this topic in addition to new research findings.

Potential partners

- Agricultural input suppliers
- Agricultural organizations (as listed on page 43)
- BC Agriculture and Climate Adaptation Research Network (BC-ACARN)
- BC Forage Council
- BC Ministry of Agriculture
- BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (Range Branch - Community Pasture Program)
- Cariboo Agricultural Research Alliance (CARA)
- Northern Development Initiative Trust
- Nechako-Kitimat Development Fund

Timeframe

- Medium-term (2–4 YEARS)

Cost

- High ($100,000+)

Next Steps for ACTIONS 4.2A & 4.2B

Action

→ ***Conduct research to fill key pest management information gaps.***

→ ***Conduct outreach/knowledge transfer for prevention and management of pests.***

Implementation details

- A process to identify top risks and gaps could be modeled on the Cariboo Emerging and Priority Pests Scan.
- The Kootenay and Boundary Farm Advisors[146] program is a good model for helping producers access information.
- These actions could strengthen the bridge between the agriculture sector and the North West Invasive Plant Council (NWIPC).
- These actions must happen in a stepwise manner; outreach and knowledge transfer cannot be implemented without first identifying the gaps (e.g., producer knowledge, management options, resources) and conducting research to fill these gaps.

Potential partners

- Post-secondary institutions
- Agricultural organizations (as listed on page 43)
- Environmental Farm Plan Program
- BC Cattlemen's Association
- BC Ministry of Agriculture
- Invasive Species Council of BC
- Northwest Invasive Plant Council
- Regional Districts and local governments

Timeframe

- Conduct research to fill key pest management information gaps = Medium-term (2–4 YEARS)
- Conduct outreach/knowledge transfer for prevention and management of pests = Short-term (LESS THAN 2 YEARS)

Cost

- Conduct research to fill key pest management information gaps = High ($100,000+)
- Conduct outreach/knowledge transfer for prevention and management of pests = Low (LESS THAN $50,000)

NEXT STEPS FOR ACTIONS 4.3B

Action

→ ***Support retention and development of pollinator habitat on and adjacent to farms, and in surrounding communities.***

Implementation details

- Good information is available about the type of habitat that is needed.
- It is important to document and share the value of taking action to improve pollinator habitat; how this affects yields and crop quality, and what the return on investment/ payback is to the farm.
- Consider research on forest practices that harm beneficial insects.

Potential partners

- Post-secondary institutions (i.e., UNBC entomologists, SFU pollination ecology lab)
- Agricultural organizations (as listed on page 43)
- BC Ministry of Agriculture
- BC Ministry of Transportation and Infrastructure
- Bee BC Program
- BC Hydro
- Beekeeping groups (UNBC Bee Club, community bee clubs, local and provincial beekeeping associations)
- Canadian Honey Council
- Environmental/habitat protection groups
- Northern Lights Winery
- Pollinator Partnership Canada
- Regional Districts and local governments

Timeframe

- Phase 1: Complete scan and develop resources for establishing pollinator habitat on farms
  = Short-term (LESS THAN 2 YEARS)
- Phase 2: Establish mechanisms and partnerships to protect and preserve habitat
  = Medium-term (2–4 YEARS)

Cost

- Phase 1: Complete scan and develop resources for establishing pollinator habitat on farms
  = Low (LESS THAN $50,000)
- Phase 2: Establish mechanisms and partnerships to protect and preserve habitat
  = Medium ($50,000–$100,000)

Appendix A: Weather, Climate & Variability

Weather is what happens on a particular day at a particular location. Farmers are continually required to adapt to weather conditions to effectively plan and manage their businesses. In contrast, climate refers to long-term trends, patterns and averages over time. These are more difficult to notice through day-to-day or year-to-year experiences, or short-term records of weather. However, over a period of decades, recorded observations can characterize the climate and identify trends.

Anyone who pays close attention to weather forecasts appreciates that predictions of weather are often limited in their accuracy. This is partly because of the many factors that impact weather. Turning to longer, climate-related timescales, in BC we are familiar with the 3–7 year cycles of El Niño and La Niña ("ENSO"), which dramatically impact the climate of individual seasons and years (see Figure 5). Compared to La Niña years, conditions in BC during El Niño years are typically warmer and drier in winter and spring, and less stormy in southern BC.

Adding to the complexity, the Pacific Decadal Oscillation (PDO) is a known pattern that shifts over longer time periods (20 to 30 years) and this is associated with different temperature and precipitation conditions here in BC. It also has a warm and cool phase, and so it can either enhance or dampen the impacts of El Niño and La Niña conditions in a given year.

Figure 5 shows the difference between climate variability, oscillations, and climate change. The many factors that impact the weather create significant variation in what we experience from year to year. However, we are still able to chart averages over long periods of time.

For additional resources see *BC Agriculture Climate Change Adaptation Risk & Opportunity Assessment Series* (*https://bcagclimateaction.ca/regional/risks-opportunities/*) and Pacific Climate Impacts Consortium video *Climate Insights 101: BC Climate Impacts and Adaptation: The Climate of British Columbia* (*https://pics.uvic.ca/insights/bc-regional-climate-impacts-adaptation/M2L1_SEPT23_2014/player.html*).

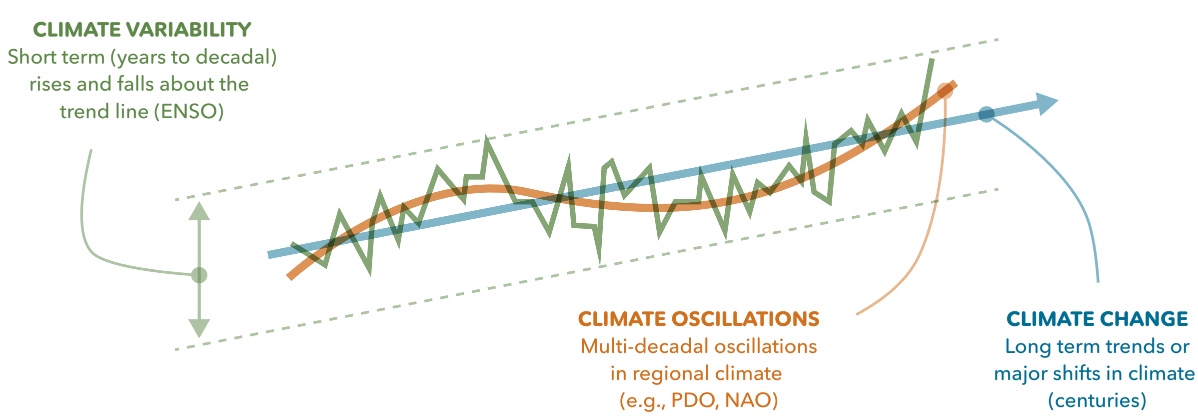

Figure 5 Climate Variability, Oscillations & Change

Diagram showing difference between climate variability, oscillations, and climate change. Adapted from original, courtesy of Pacific Climate Impacts Consortium, www.pacificclimate.org

Appendix B: Future Projections: Climate Maps & PCIC Tables

TABLE 2 Bulkley-Nechako & Fraser-Fort George Climate Projections – 2020s
(SOURCE: Pacific Climate Impacts Consortium, *www.pacificclimate.org*)

Climate Variable	Time of Year	Projected Change from 1971–2000 Baseline to 2020s				BNFFG (Baseline)
		BNFFG (Range)		BNFFG (Average)	BC (Average)	
Mean Temperature (°C)	Annual	+1.2 °C to +2 °C		+1.6 °C	+1.0 °C	1.6 °C
Precipitation (%)	Winter	−1% to +14%		+5.6%	+8%	233 mm
	Spring	+1% to +10%		+5.6%	+6%	161 mm
	Summer	−5% to +6%		+1.8%	+2%	197 mm
	Fall	−5% to +13%		+5.2%	+6%	268 mm
Growing Degree Days (degree days)	Annual	+120 to +323		+230	+153	817
Frost Free Days (days)	Annual	+17 to +32		+25	+10	146
Growing Season Length (days)	Annual	+11 to +27		+19	n/a	143

TABLE 3 Bulkley-Nechako & Fraser-Fort George Climate Projections – 2050s
(SOURCE: Pacific Climate Impacts Consortium, *www.pacificclimate.org*)

Climate Variable	Time of Year	Projected Change from 1971–2000 Baseline to 2050s				BNFFG (Baseline)
		BNFFG (Range)		BNFFG (Average)	BC (Average)	
Mean Temperature (°C)	Annual	+2.2 °C to +4.3 °C		+3.0 °C	+1.8 °C	1.6 °C
Precipitation (%)	Winter	+3% to +14%		+6.8%	+9%	233 mm
	Spring	+5% to +21%		+13.3%	+15%	161 mm
	Summer	−16% to +13%		+0.7%	−1%	197 mm
	Fall	+ 9% to + 26%		+15.8%	+17%	268 mm
Growing Degree Days (degree days)	Annual	+310 to +790		+520	+283	817
Frost Free Days (days)	Annual	+37 to +70		+52	+20	146
Growing Season Length (days)	Annual	+26 to +50		+38	n/a	143

TABLE 4 Bulkley-Nechako & Fraser-Fort George Sub-Regional Baseline
(SOURCE: Pacific Climate Impacts Consortium, *www.pacificclimate.org*)

Climate Variable	Time of Year	McBride	Smithers	Vanderhoof	Prince George
Mean Temperature (°C)	Annual	4.4 °C	3.9 °C	3.4 °C	4.4 °C
Precipitation (mm)	Winter	152 mm	113 mm	119 mm	159 mm
	Spring	134 mm	85 mm	88 mm	118 mm
	Summer	199 mm	145 mm	144 mm	170 mm
	Fall	201 mm	156 mm	137 mm	191 mm
Growing Degree Days (degree days)	Annual	1,257	1,140	161	189
Frost Free Days (days)	Annual	190	175	161	189
Growing Season Length (days)	Annual	182	176	174	183

TABLE 5 Bulkley-Nechako & Fraser-Fort George Climate Projections – 2050s
(SOURCE: Pacific Climate Impacts Consortium, *www.pacificclimate.org*)

Climate Variable	Time of Year	McBride	Smithers	Vanderhoof	Prince George
Mean Temperature (°C)	Annual	+3.1 °C	+3.1 °C	+3.2 °C	+3.2 °C
Precipitation (mm)	Winter	+6.1%	+6.6%	+3.2%	+6.7%
	Spring	+13.8%	+11.4%	+8.1%	+16.2%
	Summer	−2.7%	+4.6%	+1.6%	+0.5%
	Fall	+13.4%	+15.8%	+17.9%	+16.9%
Growing Degree Days (degree days)	Annual	+636	+621	+599	+628
Frost Free Days (days)	Annual	+57	+59	+48	+55
Growing Season Length (days)	Annual	+40	+39	+35	+42

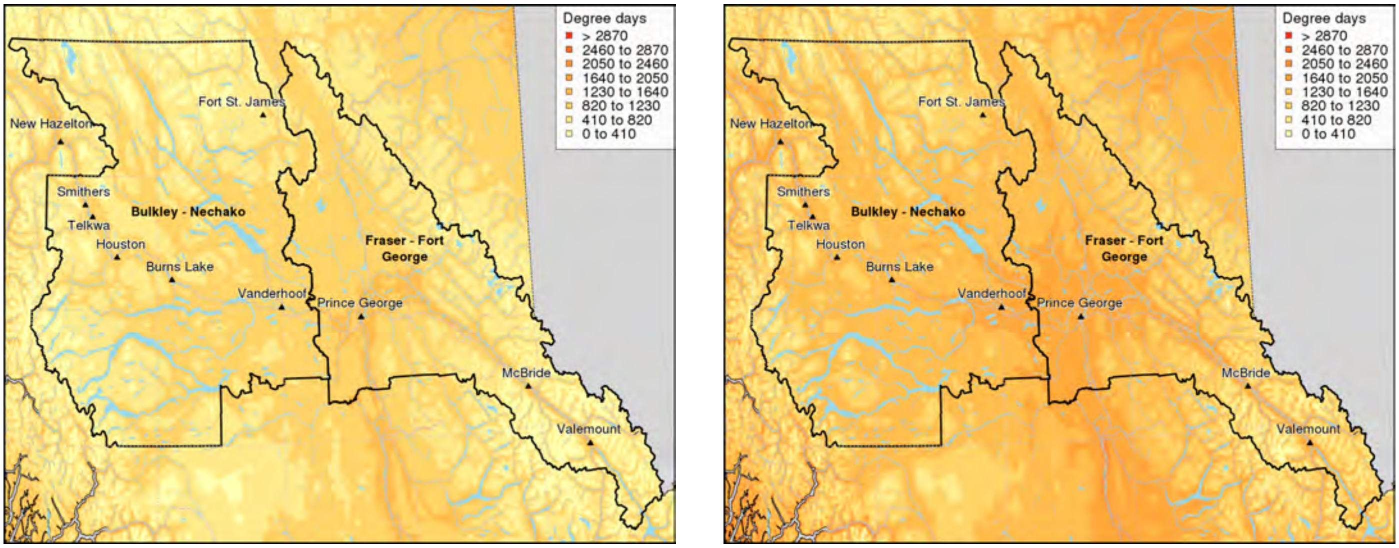

FIGURE 6 Growing Degree Days,
Baseline 1971–2000 (left) and Projections 2041–2070 (right)

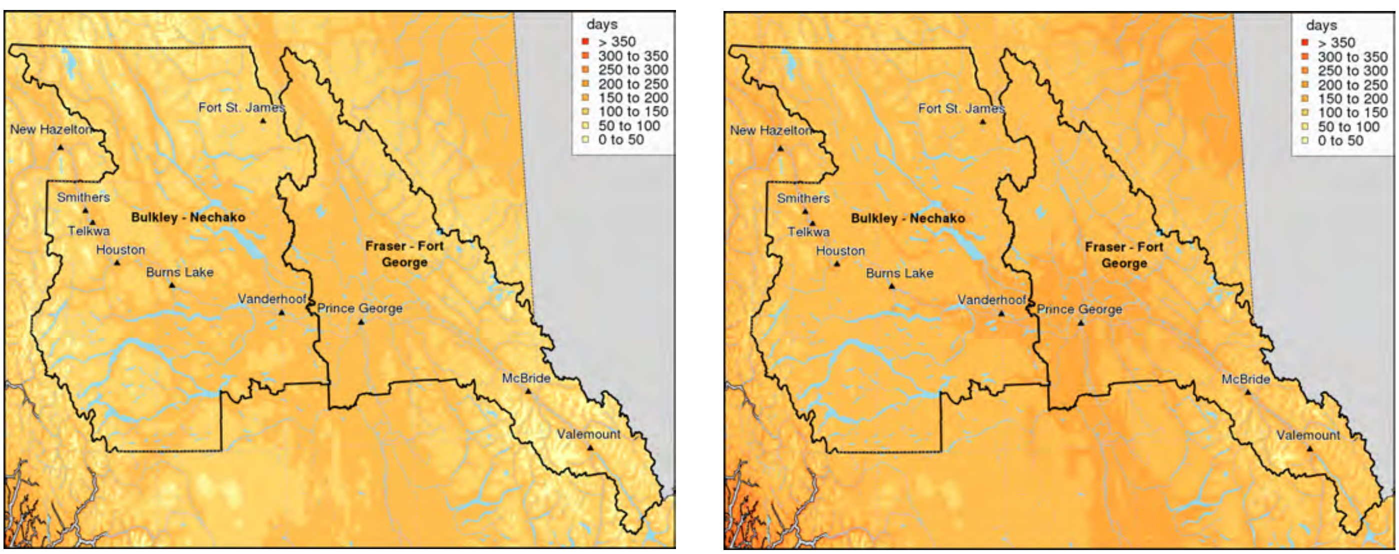

FIGURE 7 Growing Season Length,
Baseline 1971–2000 (left) and Projections 2041–2070 (right)

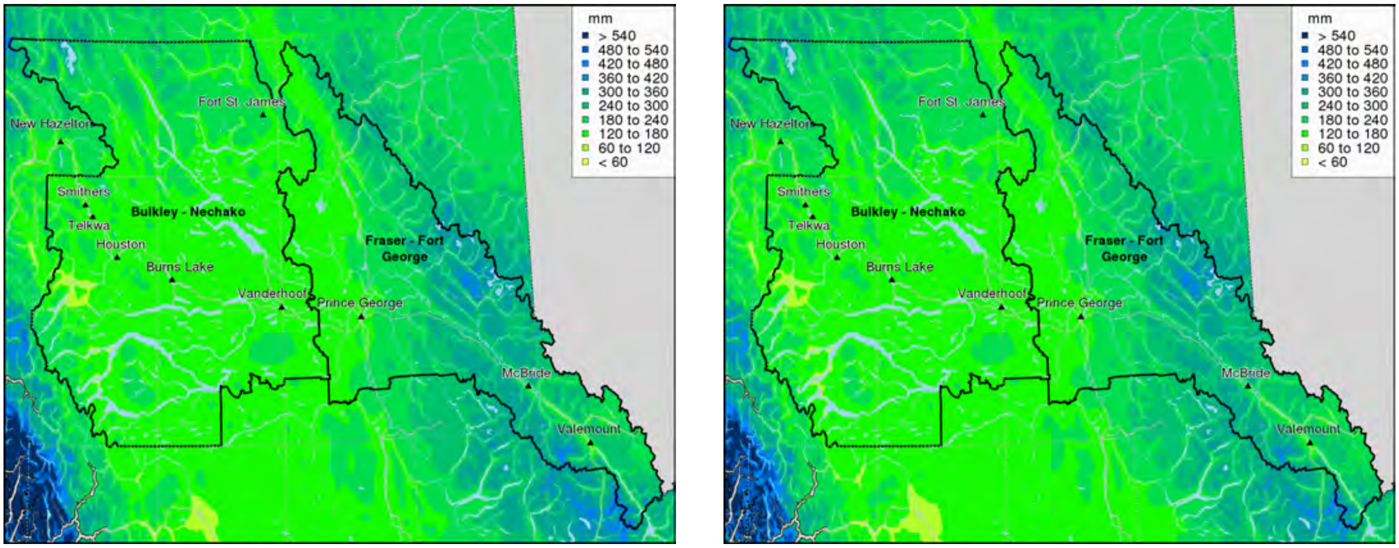

FIGURE 8 Summer Precipitation (mm),
Baseline 1971–2000 (left) and Projections 2041–2070 (right)

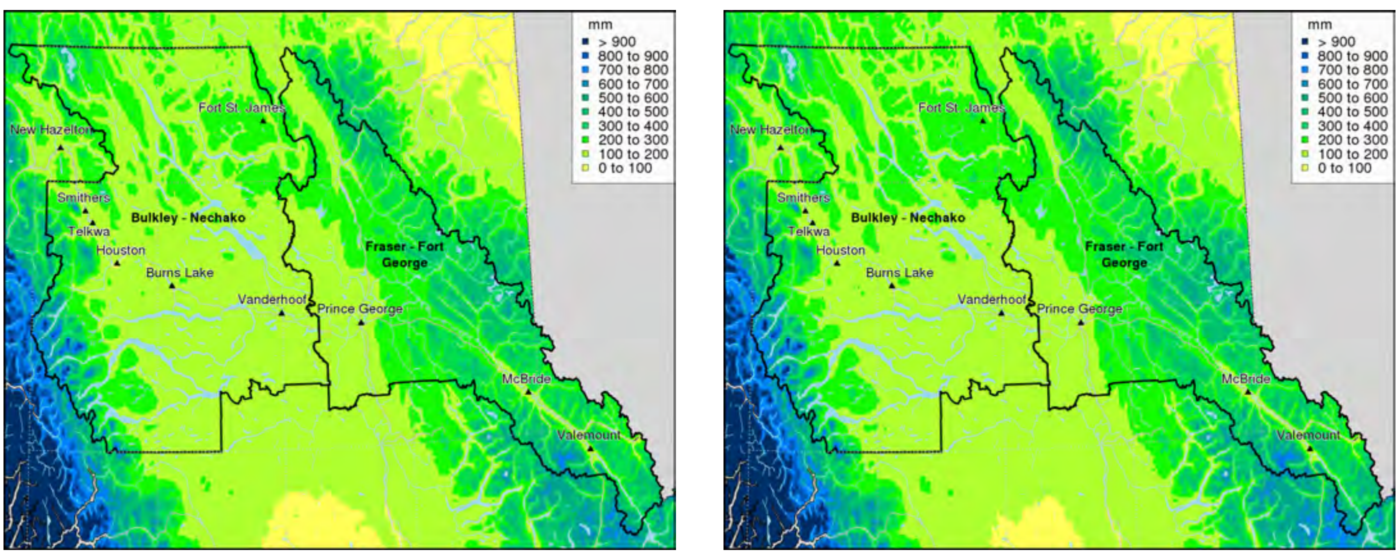

FIGURE 9 Winter Precipitation (mm),
Baseline 1971–2000 (left) and Projections 2041–2070 (right)

Note that for legibility, winter and summer use different legends and so cannot be directly compared.

Appendix C: Definitions

- ***Annual Average Temperature***
  refers to the average of the nighttime low (minimum temperature) and the daytime high (maximum temperature) over a calendar year.

- ***Frost-Free Days (FFD)***
  refers to the number of days (in a calendar year) that the minimum daily temperature stayed above 0°C.

- ***Growing Degree Days (GDD)***
  are a measure of heat accumulation and represent the cumulative number of degrees that the average daily temperature is above a base temperature of 5°C, for all days of the year.

- ***Growing Season Length (GSL)***
  represents the number of days between the first span of six consecutive days with a daily mean temperature above 6°C and the last day with a daily mean temperature above 6°C.

- ***Heavy rain days***
  (i.e., the 95th percentile wettest days)
  represents the total amount of rain that falls on the wettest days of the year, specifically on days when precipitation exceeds a threshold set by the annual 95th percentile of wet days during the baseline period (1971–2000).

- ***Historic Baseline***
  is the average of the variable from 1971 to 2000 (variables are averaged over this 30-year period to smooth out annual variability).

- ***1-in-20 hottest day***
  refers to a day so hot that it has only a one-in-twenty chance of occurring in a given year. That is, there is a 5% chance in any year that temperatures could reach this magnitude.

Appendix D: Adaptive Management of Climate Change Impacts

Climate change adaptation decision-making is an inherently complex task that requires ongoing learning and reflection to adjust to changing information, events and conditions. As learning progresses, new solutions as well as new challenges will be identified. The following questions are provided as tools for navigating this evolving landscape and determining priorities for action.

Additional considerations when determining how to implement priority actions would include:

- Barriers (e.g., legislation, lack of working relationships)
- Assets/Enablers (e.g., leadership, integrating into existing plans/programs)
- Implementation costs
- Operation and maintenance costs
- Financing and resources
- Timeframe

TABLE 6 Developing & Prioritizing Adaptation Actions

Effectiveness	To what degree does this action reduce risk/vulnerability, and/or enhance resilience?
Adaptability	Can this action (and resources dedicated to it) be changed or redirected as conditions change?
Urgency	When does action need to be taken on this issue, in order to be effective by the time an impact is projected to occur?
Gaps & Assets	How does this action address identified gaps or barriers? How can it build on existing assets and resources?
Co-benefits ("no-regrets")	What other benefits would this action have, even if climate change impacts do not occur as projected?
Consequences	What could be the unintended and/or undesirable effects of taking this action? Can these be avoided or mitigated?
Extent	Do the benefits apply broadly in the region, or to specific individuals?
Relevance	Does this action have the support of the agricultural community?

Endnotes

1 BC Agriculture & Food Climate Action Initiative. (2012). *BC Agriculture Climate Change Adaptation Risk & Opportunity Assessment Series: Okanagan Snapshot Report*. *https://bcagclimateaction.ca/documents/AdaptROseries-Okanagan.pdf*

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13 Based on a review of historic seasonal precipitation patterns for Vanderhoof and McBride. Data provided by the Pacific Climate Impacts Consortium and additional information and links to data available in Appendix B.

14 Based on review of Smithers, Prince George and Vanderhoof weather station data. Environment Canada. (2019). *Canadian Climate Normals 1981–2010 Station Data.*

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59 The BCCAQ is a technique developed at the Pacific Climate Impacts Consortium for downscaling daily temperature and precipitation projections, and indices of extremes. It was tested for robustness according to three main criteria: day-to-day sequencing of events, distribution of values, and spatial structure. It is a hybrid of two other methods (BCCA and QMAP) and was developed because none of the methods tested scored well across all three criteria. In BCCAQv2 a modification is used such that the coarse scale projected changes are preserved at each quantile, avoiding an "inflation" problem that quantile mapping methods are prone to. For more information see Cannon, A.J., S.R. Sobie, and T.Q. Murdock. (2015). *Precipitation by Quantile Mapping: How Well Do Methods Preserve Changes in Quantiles and Extremes?* Journal of Climate, 28(17), 6938-6959, doi:10.1175/JCLI-D-14-00754.1 or visit *https://www.pacificclimate.org/data/statistically-downscaled-climate-scenarios*.

60 To view the Bulkley-Nechako & Fraser-Fort George region modelling and outputs in detail, use the PCIC Climate Explorer tool at *https://pacificclimate.org/analysis-tools/pcic-climate-explorer.* An excellent (general) description of climate modelling, outputs, ranges and variables can be found in the report Climate Projections for Metro Vancouver (developed with PCIC) and accessible at *http://metrovancouver.org/services/air-quality/AirQualityPublications/ClimateProjectionsForMetroVancouver.pdf.*

61 Annual average temperature refers to the average of the nighttime low (minimum temperature) and the daytime high (maximum temperature) over a calendar year.

62 The historic baseline (used for all climate variables) is the average of the variables from 1971 to 2000. Variables are averaged over this 30-year period to smooth out annual variability.

63 Frost-free days is a derived variable referring to the number of days that the minimum daily temperature stayed above 0°C, useful for determining the suitability of growing certain crops in a given area. The method used to compute this on a monthly basis is from (Wang et al, 2006).

64 Growing Degree-Days (GDDs) is a derived variable that indicates the amount of heat energy available for plant growth, useful for determining the growth potential of crops in a given area. It is calculated by multiplying the number of days that the mean daily temperature exceeded 5°C by the number of degrees above that threshold. For example, if a given day saw an average temperature of 8°C (3°C above the 5°C threshold), that day contributed 3 GDDs to the total. If a month had 15 such days, and the rest of the days had mean temperatures below the 5°C threshold, that month would result in 45 GDDs.

65 1-in-20 hottest day refers to a day so hot that it has only a one-in-twenty chance of occurring in a given year. That is, there is a 5% chance in any year that temperatures could reach this magnitude. Individual locations could be considerably warmer than the regional average but an increase of about 5°C (by 2080) in the 1-in-20 year hottest day is quite consistent around most of the region.

66 Heavy rain days (i.e., the 95th percentile wettest days) represents the total amount of rain that falls on the wettest day of the year, specifically on days when precipitation exceeds and threshold set by the annual 95th percentile of wet days during the baseline period (1971–2000).

67 Source for extremes projections: Regional Climate model projections from the North American Regional Climate Change Assessment Program, analyzed by PCIC

68 Pacific Climate Impacts Consortium. (n 57)

69 Islan, S.I, Curry, C.L., Dery, S.J., and Zwiers, F.W. (2019). *Quantifying projected changes in runoff variability and flow regimes of the Fraser River Basin, British Columbia*. *https://doi.org/10.5194/hess-23-811-2019*

70 Ibid.

71 Heavy rain days (i.e., the 95th percentile wettest days) represents the total amount of rain that falls on the wettest days of the year, specifically on days when precipitation exceeds a threshold set by the annual 95th percentile of wet days during the baseline period (1971–2000).

72 While workshop participants clearly reported changing ecosystems, and changes to wildlife population and wildlife distribution, it is uncertain how much this can be attributed to climate change. Without a doubt, the changes to climate described affect wildlife habitat, but there are numerous other factors that contribute to this effect and it's potential impacts to agricultural.

73 Pests refers to insects, weeds, diseases and invasive species with potential to negatively impact agricultural production.

74 Forest Practices Board. (2015). *Fuel Management in the Wildland Urban Interface – Update*. *https://www.bcfpb.ca/wp-content/uploads/2016/04/SIR43-Fuel-Management-Update.pdf*

75 Natural Resources Canada. (2011). *Mountain Pine Beetle Annual Displacement Vectors*. *https://www.nrcan.gc.ca/forests/fire-insects-disturbances/top-insects/13381*

76 Wildfire Season Summaries (dating back 10 years) are available on the BC Wildfire Service website. *https://www2.gov.bc.ca/gov/content/safety/wildfire-status/about-bcws/wildfire-history/wildfire-season-summary*

77 Debbie Evans, Agriculture Coordinator, Regional District of Bulkley-Nechako, personal communication. July 4, 2019.

78 Lewis, T., (2013). *Managing Wildfire Risk in Fire-Prone Landscapes: How Are Private Landowners Contributing?* United States Department of Agriculture and Forest Service. *https://www.fs.fed.us/pnw/sciencef/scifi154.pdf*

79 BC Wildfire Service. (2019). *Fire & Fuel Management*. *https://www2.gov.bc.ca/gov/content/safety/wildfire-status/prevention/vegetation-and-fuel-management/fire-fuel-management*

80 Kenna Jonkman, Manager of Development Services, Regional District of Fraser-Fort George, personal communication, July 23, 2019.

81 In winter 2019, the Climate Action Initiative hosted ten provincial workshops focused on farm-level preparedness and planning (including a workshop in Vanderhoof). The BC

Cattlemen Association, in conjunction with AgSafe BC, also hosted a series of farm-level preparedness workshops across BC in winter 2018, including sessions in Vanderhoof and Smithers.

82 Forest Practices Board. (n 74)

83 Burning embers or other flaming material from a wildfire can be carried by the wind to start new spot fires in areas of unburned fuel. It's quite common for burning embers that are thrown ahead of the leading edge of the fire (the "flame front") to allow wildfires to "jump" fuel-free barriers such as highways or bodies of water. FireSmart BC. *https://www.firesmartcanada.ca/resources-library/manuals/*.

84 Blackwell, B., (2018). *Discussion Document: Planning and Information Exchange for Wildfire Impact Reduction.* BC Agriculture & Food Climate Action Initiative.

85 Ibid.

86 Increasing right of ways may also have negative repercussions due to also increasing public access

87 The Climate Action Initiative's *Agriculture Wildfire Preparedness and Mitigation Workbook & Guide leads* producers through a series of modules that focus on actions producers can take before, during, and after a wildfire to protect their operations and business and culminates in the development of an Agriculture Wildfire Plan. The workbook and guide can be downloaded at *https://bcagclimateaction.ca/project/ok05/*.

88 The Chinook Emergency Response Society operates in Electoral Area E of Bulkley-Nechako (on the Southside of Burns Lake and promotes and supports wildfire preparedness which includes emergency skills training, evacuation planning and information gathering and communication.

89 The BC Agriculture & Food Climate Action Initiative's Agriculture resources for small group preparedness will be available for download at *https://bcagclimateaction.ca/wildfire.*

90 Information on the pilot project Wildfire Pre-Season Communications and Information Exchange Pilot Project can be found at *https://bcagclimateaction.ca/project/ok09/*.

91 Ibid.

92 Daniels, L., Gray, R., Burton, P. (2017) *White Paper: RE: 2017 Megafires in BC - Urgent Need to Adapt and Improve Resilience to Wildfire*. Faculty of Forestry. University of British Columbia. *http://bccfa.ca/wp-content/uploads/2017/10/Lori-Daniels-2017-Wildfires-and-Resilience.pdf*

93 Additional information about the Northern Conference for Wildfire Resilience (held in Burns Lake in April 2019) can be found at *https://northernwildfireresilience.wordpress.com/*.

94 The Cariboo-Chilcotin Regional Agriculture-Wildlife Committee operated from 2009–2014 and included representation from the Cariboo Cattlemen's Association, BC Sheep Producers and two provincial ministries, with funding from the BC Agriculture Research and Development Corporation (ARDCorp). *https://www.fraserbasin.bc.ca/ccr_agriculture-wildlife.html*

95 Pacific Climate Impacts Consortium. (n 58)

96 The BC Forage Council and CAI Guide to On-Farm Demonstration Research includes step-by-step instructions on developing research objectives and formulating a research question, deciding what to measure and how to measure it, scouting for relevant research, collecting data and analyzing results. While developed by the forage council, the methodology can be applied to any production system. *https://www.bcagclimateaction.ca/wp/wp-content/media/FI03-On-Farm-Demonstration-Research-Guide.pdf.*

97 Information on the project *Enabling Climate Change Adaptation through Grab & Go On-Farm Research Templates* can be accessed at *https://bcagclimateaction.ca/project/fi19/*.

98 HallBar consulting. Cash & Bioenergy Crop Feasibility Study for the Bulkley-Nechako Regional District. *https://www.unbc.ca/sites/default/files/sections/research/unbccropresearchreport.pdf*

99 The BC Ministry of Agriculture's Agri-Business Planning Program offers specialized business planning and disaster recovery planning. Information about this program can be found at: *https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/programs/agri-business-planning-program*. Other programs include Community Futures Fraser Fort George's Robson Valley Agribusiness program, and programs offered by the Young Agrarians (Farm Business Mentorship Network and Business Management Tools).

100 Eligibility requirements can be found on the BC Ministry of Agriculture's Agri-Business Planning Program webpage at *https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/programs/agri-business-planning-program.*

101 Hodson, D., and White, J. (2010). *GIS and Crop Simulation Modelling Applications in Climate Change Research*. US Department of Agriculture. p 236. *https://naldc.nal.usda.gov/download/47399/PDF*

102 The Farmwest website is a non-profit venture developed by the Pacific Field Corn Association. Producers across BC can access historic weather data and forecast data for 150 stations across the province. *https://farmwest.com/climate/weather*

103 Tam, S., and Anslow, F. (2018). *Gap Analysis and Overview of Weather Station Data in British Columbia Agricultural Regions*. British Columbia Agricultural Climate Adaptation Research Network. *https://www.bcacarn.com/weather-station-project/*

104 The Climate Related Monitoring Program (CRMP) is a cooperative effort among provincial ministries and weather observing agencies in BC. While users can view stations on an interactive map and filter the displayed stations (based on observation date, weather element, observing agency, region and more), the website is cumbersome for producers to navigate and requires the downloading of data files to view historic weather information. *https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/climate-related-monitoring*. The data portal can be accessed at *https://www.pacificclimate.org/data/bc-station-data*.

105 Decision support tools (DSTs) are information technology resources designed to help farmers tackle complex problems in crop production, inputting the best available data combined with knowledge about best practices.

106 Farmwest. (2019). *Expanding the Farmwest Climate Station Network.* *https://farmwest.com/node/938*

107 *www.weatherfarmprd.com* is weather and decision-support tool website developed for agricultural producers in the Peace region. It provides access to in-depth weather forecasting (hourly, daily) and decision tools on a field by field basis; including crop specific growth stages, crop heat units, growing degree days calculator, evapotranspiration/water check, soil water balance, Fusarium Head Blight risk and a forage calculator, as well as raw historical weather data of BC.

108 AgWeather Quebec (AQ) provides dozens of bioclimatic models that help producers determine the best time to apply inputs to their fields (pesticides, fungicides, etc.), depending on the specific climate conditions in their area. AQ also provides a management tool for to hay producers to help them determine the best time for the first cut of hay to ensure optimal forage quantity and yield. *http://www.agrometeo.org/indices/category/plantes_fourrageres*

109 The BC Agricultural Climate Adaptation Research Network's *Gap Analysis and Overview of Weather Station Data in British Columbia Agricultural Regions* can inform regional work.

110 Statistics Canada. (2017). Bulkley-Nechako, RD [Census division], British Columbia. *Census Profile. 2016 Census. Statistics Canada. Table 32-10-0413-01. Irrigation in the year prior to the census.* *https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3210041301*
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Statistics Canada. (2017). Fraser-Fort George, RD [Census division], British Columbia and Canada. *Census Profile. 2016 Census. Statistics Canada Table 32-10-0413-01. Irrigation in the year prior to the census.* *https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3210041301*

111 Andrea Follett, Senior Water Authorizations Technologist, Ministry of Forests, Lands, Natural Resource Operations and Rural Development, personal communication. June 19, 2019.

112 Peters, J. (2018). Drought Codes Elevated in Northern, Central BC. CFJC Today. *https://cfjctoday.com/article/640239/drought-codes-elevated-northern-central-bc*

113 Pacific Climate Impacts Consortium. (n 58)

114 Stranger, D. (2019). BC Government *Asking Public to Report Wildfire-Related Erosion.* CKPG Today. *https://ckpgtoday.ca/article/556835/bc-government-asking-public-report-wildfire-related-erosion*

115 Fraser Basin Council. (2016). *Towards a Healthy Nechako: Nechako Watershed Strategy – Version 1.* *https://www.refbc.com/sites/default/files/Nechako%20Watershed%20Strategy-31Oct2016-FINAL.pdf*

116 Ibid.

117 The Water Sustainability Act includes the following regulations: Water Sustainability Regulation, Water Sustainability Fees, Rental and Charges Tariff Regulation, Groundwater Protection Regulation, Dam Safety Regulation, Water District Regulation

118 Government of British Columbia. (2019). *Water Sustainability Act.* *https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/laws-rules/water-sustainability-act*

119 BC Agriculture & Food Climate Action Initiative. (2019). Workshop#2 summary for Robson Valley.

120 BC Agriculture & Food Climate Action Initiative. (2019). Workshop #2 summary for Telkwa.

121 The Government of BC has used many mechanisms to inform the public (including producers) about the Water Sustainability Act and the associated regulations. Efforts have included: a blog, a brochure, information sessions and presentations. Despite these efforts, producers experience a lack of clarity and support to meet their responsibilities.

122 The provincial BCCA, and regional and local cattlemen's associations, share information with their members about the Water Sustainability Act and the associated regulations as information becomes available.

123 This project standardized, streamlined and improved the clarity and accessibility of Dam Safety Management System forms and templates; developed new informational resources to address priority dam safety topics for dam owners as determined through an evaluation of existing resources and consultation with user and provided direct outreach to assist dam owners to develop effective Dam Safety Management Systems through 5 training workshops for dam owners in the Cariboo and the Thompson/Okanagan. *https://bcagclimateaction.ca/project/cb07/*

124 A previous project (in the Cowichan region) where existing water storage examples were shared via field day and presentations, could provide a model to follow for this action. The Agricultural Water Storage and Management Knowledge Transfer project shared information with producers in the Cowichan Valley and surrounding areas related to water storage development (and the associated requirements and regulations), as well as broader water management techniques, through a farm tour and 2 panel sessions at the Islands Agriculture Show in 2016. *https://bcagclimateaction.ca/project/cw08/*

125 The BC Agriculture Water Calculator helps agriculture water users in British Columbia estimate the annual irrigation or livestock water demand for a farm. The calculator is available at *http://www.bcagriculturewatercalculator.ca/* .

126 The BC Irrigation Management Guide assists British Columbia's farmers and ranchers to optimize water use, thereby improving water management during times of drought, long-term climate change, and competing uses of the water resource. The guide is available at *https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/water/irrigation/irrigation-management-guide* .

127 Farmwest. (2019). *BC Guide to Irrigation Scheduling and Water Conservation.* *https://farmwest.com/node/935*

128 Geography Open Textbook Collective. (2019). *Case Study 1: Mountain Pine Beetle.* *https://opentextbc.ca/geography/chapter/7-6-case-study/*

129 Government of British Columbia. (2019). *Mountain Pine Beetle in BC.* *https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/forest-pests/bark-beetles/mountain-pine-beetle*

130 Centre for forest conservation genetics, University of British Columbia. (2019). *Climate BC and Bioclimatic Envelope Modelling.* *http://cfcg.forestry.ubc.ca/projects/climate-data/climatebc-and-bioclimatic-envelope-modelling/*

131 The Cariboo Priority Pests: Scan, Consultation and Action Plan project help regional producers begin to adapt to emerging pest management issues resulting from climate change by ranking pest issues according to importance and by identifying gaps in regional extension, monitoring and research work, with potential project partners identified and actions identified to fill these gaps. For more information see *https://bcagclimateaction.ca/project/cb09/.*

132 Zehnder, G., Gurr, G. M., Kühne, S., Wade, M. R., Wratten, S. D., and Wyss, E. (2007). *Arthropod management in organic crops.* Annual Review of Entomology 52: 57–80

133 Altieri, M. A., and Nicholls, C. (2003). *Soil fertility and insect pests: Harmonizing soil and plant health in agroecosystems.* Soil Tillage Research 72: 203–211. *https://www.sciencedirect.com/science/article/pii/S0167198703000898*

134 Locke, J. (2011). *Pasture weed management and drought.* The Samuel Roberts Noble Foundation Agricultural Division. *https://www.noble.org/globalassets/docs/ag/pubs/soils/nf-so-11-07.pdf*

135 This pasture rejuvenation research is funded in part through CAI's Farm Adaptation Innovator Program (FAIP).

136 Integrated Pest Management entails using biological, cultural and mechanical controls instead of only chemical controls for pest management

137 Northwest Invasive Plant Council. (2019). NWIPC Public Resources page. *http://nwipc.org/files/public/*

138 For more information on the Agricultural Pest Identification & Management Tools for the Cariboo project, see *https://bcagclimateaction.ca/project/cb13/.*

139 This relates to how plants are more palatable and grazing is very good after a fire because there is a nutrient flush into the plants. There is improved grazing for about 4 years. Following this 4-year period, there is no deep nutrient cycling since roots are shallow, so there is then a decline in plant quality/nutrients

140 Vanbergen, A. J. (2013). *Threats to an ecosystem service: pressures on pollinators.* Frontiers in Ecology and the Environment: 11:5 (pp 251–259). *https://doi.org/10.1890/120126*

141 Kjohl, M., Nielsen, A. and Stenseth, N. C. (2011). *Potential Effects of Climate Change on Crop Pollination.* Food and Agriculture Organization of the United Nations. *http://www.fao.org/fileadmin/templates/agphome/documents/Biodiversity-pollination/Climate_Pollination_17_web__2_.pdf*

142 Gashler, K. (2011). *Native bees are better pollinators, more plentiful than honeybees, finds entomologist.* Cornell Chronicle. *http://news.cornell.edu/stories/2011/10/native-bees-are-better-pollinators-honeybees*

143 Kjohl, M., Nielsen, A., and Stenseth, N. C. (n 141)

144 Wratten, S. D., Gillespie, M., Decourtye, A., Mader, E., Desneux, N. (2012). Pollinator habitat enhancement: Benefits to other ecosystem services. Agriculture, Ecosystems & Environment. 159: 15 (112–122) *https://www.sciencedirect.com/science/article/pii/S0167880912002460*

145 BC Bee Health. (2018). Meadow Restoration Helps Enhance Forage For Victoria Bees. *http://bcbeehealth.ca/2018/06/04/meadow-restoration/*

146 The Kootenay & Boundary Farm Advisors (KBFA) provides producers with free, technical production support and information from a network of specialized resources, including independent consultants and academics. *https://www.kbfa.ca/*

Urls in these Endnotes were current as of July 2019.