Cariboo Agricultural Research Alliance

Applied Adaptation Research Strategic Plan 2020

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This report was prepared by the Cariboo Agricultural Research Alliance, which included representation from:

- BC Agriculture & Food Climate Action Initiative
- BC Ministry of Agriculture
- BC Sheep Federation
- Cariboo Cattlemen's Association
- Cariboo-Central Interior Poultry Producers Association
- Cariboo Regional District
- District H Farmers' Institute
- Kersley Farmers' Institute
- North Cariboo Agricultural Marketing Association (FARMED)
- Thompson Rivers University
- College of New Caledonia
- University of Northern BC
- Williams Lake First Nation (T'exelcemc)

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Introduction

Climate change projections for more variability in conditions across the seasons will increase the management complexity for agriculture. Critical production windows (such as timing of planting and harvesting) may be less predictable, crops and livestock will be exposed to a greater range of conditions and extremes, and parameters for crop suitability may shift in some areas. Local research, including evaluation of technologies, practices and production systems will support producers with management decisions to enhance resilience. Effective sharing of research results and knowledge transfer is also a high priority for Cariboo producers.

The Adaptation Research Strategic Plan will be used by the Cariboo Agricultural Research Alliance (CARA) to support program development that aims to support applied agriculture research and extension activities throughout the region. A research gap analysis was conducted to identify the Top 10 Research Priorities for the region, which were prioritized using an Evaluation Matrix. The top two priorities identified were developed into project proposals, with the goal of the research to be initiated in 2020. Future research priorities can also be assessed utilizing the Evaluation Matrix. Moreover, an outline of how to build collaborative research projects is outlined.

Regional Research Priorities

The Top 10 Research Priorities were determined through an in-depth literature review process, and outreach to CARA members. Any of the needs expressed that related to policy, socio-economic issues, or needs that were not tied to specific research questions (e.g. installation of weather network, establishing monitoring systems, etc.) were filtered out of the list. These issues, however, may be partially or fully addressed in the process of a prioritized research project (e.g. weather stations may need to be installed in order to conduct research, but is itself not research). While some topics had specific research questions identified, many of the needs articulated in prior planning initiatives were general in scope, and additional work is required to identify specific research gaps in those areas.

Evaluation Matrix

An evaluation matrix was developed to assist in selecting the top two projects to be developed into project proposals. The matrix applied a point-rating based on key features of each topic relative to anticipated needs for successful and meaningful research outcomes. The Evaluation Matrix enabled a more objective process to identify the applied adaptation needs for the Cariboo Region. The evaluation was based on the following criteria:

1. Alignment

- Alignment to *Regional Climate Adaptation Strategy*
- Time Frame: relative to ability to provide short- vs. long-term deliverables
- Applied Research/Extension Potential: relative to the ability to align with, create or support extension activities.

2. Methodology

- Practicality of methods needed to successfully complete the research

- Availability of key resources (facilities, personnel, specialized equipment)

3. Adjustments to Create Equity in Research Support

- Location based: regional, sub-regional vs local
- Sector based: pan-agricultural vs sector specific topics

The detailed Evaluation Framework utilized is outlined in Appendix A. The evaluation results identifying the top research priorities are outlined in Table 1. The scope of research identified for the region and outlined within the list of priorities is extensive, and some have been identified as priorities for more than 10 years. To adequately address these topics will require substantial resources, and therefore would be considered medium or long-term priorities for CARA to address moving forward.

Immediate Research Priorities

The highest ranked research need (Priority 1) identified was *Long-term Forage Species and Variety Trials*, and the second highest ranked need (Priority 2) was *Specialty Crop Trials, Horticultural Crop Diversification Trials*. The top two priorities also aligned with the interests of the under-engaged stakeholders of CARA as currently expressed during engagement activities.

Priority 1: Long-term Forage Species and Variety Trials

In order to support the largest segment of existing producers throughout the region, CARA needs to **strengthen the region's primary agriculture sector**: extensive livestock operations (beef cattle, equine, sheep and goats) and forage production (forage crops and improved pastures). The development of Long-term Forage Species and Variety Trials ranked as the highest priority, as it strongly aligns with existing strategic documents developed by the BC Food and Agriculture Climate Action Initiative (CAI). Additionally, they can be implemented relatively quickly and meet long-term objectives and has vast extension opportunities. There are no challenges to methodology that need to be overcome, and there are available resources and expertise that are required for the project. The trials would be relevant across the entire region, and broad relevance throughout the sector. Trials aimed to evaluate and identify well-adapted forage species and varieties under changing climatic conditions will have significant impact in a forage-deficit region that is recovering from multiple large-scale fire seasons (2017-2018), episodic droughts, and flood events.

Priority 2: Specialty Crop Trials, Horticultural Crop Diversification Trials

There is growing demand and interest in **smart diversification within the agriculture sector**, particularly around specialty and/or horticultural production. This priority is also well-aligned to CAI's strategic adaptation plan, with strong methodology and regional balance, and there are multiple available resources and previous projects that will help support such trials moving forward. These include ongoing horticultural research at the College of New Caledonia and the recent alternative and specialty crop study by the University of Northern BC. Though more narrow in scope, this research area will help develop resources to support new entrants and diversification of agricultural production throughout the region.

Table 1. Evaluation Matrix Results for the top Research Priorities identified, in order of priority.

		Alignment			Implementation		Overlap	Regional Balance		Sectoral Balance	
	TOTAL	to Strategy	Time Frame	Extension	Methods	Resource		Scale	Adjust	Scope	Adjust
Topic	**100**	**20**	**10**	**10**	**5**	**15**	**10**	**15**		**15**	
Long-term forage species and variety trials	**95**	20	10	10	5	15	10	15	0	10	0
Specialty crop trials, horticultural crop diversification trials	**90**	20	10	10	5	15	10	15	0	5	0
Nutrient management in perennial crops in sensitive farm areas	**80**	10	10	10	5	15	5	15	0	10	0
Collaborative wildfire fuel management for incremental forage or soil amendments	**72**	20	0	10	2	15	0	15	0	10	0
Grazing systems and practices to increase soil carbon	**70**	10	0	10	5	15	5	15	0	10	0
Silvopasture – relationship between understory production and overstorey density	**70**	10	0	10	5	15	5	15	0	10	0
Pest management trials on regionally adapted biocontrols	**67**	10	10	10	2	0	5	15	0	15	0
Enhancing natural water retention capacity across the region to minimize runoff	**62**	20	0	0	2	0	10	15	0	15	0
Organic/non-chemical methods for weed control in perennial crops	**60**	10	10	10	5	0	5	15	0	5	0
Land-use impacts of beetle-kill and wildfire on soils and watershed	**42**	10	0	0	2	0	0	15	0	15	0

Research Project Development

After determining the top two specific topic areas, research and project delivery teams were assembled, focused on drafting detailed project plans, budgets and funding proposals.

The forage trials group is being led by Dr. Lauchlan Fraser of Thompson Rivers University with support from the BC Forage Council for extension and stakeholder outreach. A copy of the initial funding application addressing a 3-year project, titled "Multifunctional Pasture Rejuvenation in the Cariboo" is appended (Appendix B).

The horticultural trails group is being led by Sorin Pasca of the College of New Caledonia. A copy of the initial funding application addressing a project titled "Greenhouse Innovations for Market Garden Season Extension" is appended (Appendix C).

Assessing Future Research Priorities

The Evaluation Matrix was developed to be an iterative tool for the CARA to use in the future, with the capacity to adapt and reassess priorities in the context of changing circumstances and new opportunities that arise. As projects are completed, capacity is built and additional resources become available, priorities will also change in their rank as research priorities. This can assist the CARA Scientific Advisory to re-assess which projects are best suited to addressing the region's needs.

For example, if a project is successfully developed and implemented that addresses the top priority of long-term forage species and variety trials, that priority will receive a lower score under the re-assessment criteria for 'Overlap', 'Regional Balance' and 'Sectoral Balance'. The reduced score for the topic would concomitantly increase the opportunity for other priorities to shift into near-term priorities.

Building Collaborative Research Projects in the Future

CARA's strength as an organization lies in the partnerships among its member organizations and collaborative efforts to build capacity across the agricultural communities in the region. Therefore, it is critical that CARA continues to provide opportunities to engage the member organizations and stakeholders, by providing regular, core activities designed to have co-benefits for participants. The framework to accomplish this, outlined below, will place CARA is a position to strategically develop long-term initiatives while also being responsive to near-term challenges and opportunities.

Research Network

CARA must continue to develop its network of researchers engaged with the Alliance and the work being conducted throughout the Cariboo. It is proposed that having an annual Applied Research Workshop would support building and strengthening these relationships. The workshop could be coordinated in such a way that research results are shared with producers, but also include sessions that enable both researcher-researcher networking and researcher-producer networking. Not only would this provide researchers from varying institutions and backgrounds connect with other work being done

in their fields, but also ensure researchers would hear directly from producers about the applicability of research currently being conducted and identify producer-specific questions.

It is also recommended that CARA continue to develop its connection to the BC Agricultural Climate Adaptation Research Network (ACARN) moving forward. The Network's mandate to improve linkages and collaboration among agricultural researchers, industry specialists, policy-makers, students and producers across the province complements CARA and would prove mutually beneficial.

Finally, as CARA becomes established and well connected regionally and provincially, it will be important to simultaneously develop connections with other agriculture research initiatives across Canada (and beyond). This may be accomplished through existing networks (e.g. national producer associations that have regional Cariboo associations), as well as during the literature scan review while developing projects.

Scientific Advisory Committee

Part of the role of CARA's Scientific Advisory Committee (SAC) will be to expand the network of researchers and expertise that are consulted for various projects. Now that SAC has been formed (membership outlined in Table 2), it will be important to continue to engage the membership and build momentum in project development. This can be accomplished through the development of regular meetings and confirming a work plan that would initiate strategic planning for socio-economic topics that were not addressed in the current strategic plan process.

Table 2. Cariboo Agricultural Research Alliance Scientific Advisory Committee 2019

Representative	Association
David Zirnhelt	Chair, CARA
Dr. John Church	Thompson Rivers University
Dr. David Connell	University of Northern BC
Steve Storch	College of New Caledonia
Samantha Charlton	BC Food and Agriculture Climate Action Initiative
Nicole Pressey	BC Ministry of Agriculture
Dr. John Janmaat	BC Agriculture Climate Adaptation Research Network
Rob Borsato	Kersley Farmers' Institute
Vacant	Cariboo Cattlemen's Association
Mike Doherty	BC Sheep Federation
Wylie Bystead	Cariboo-Central Interior Poultry Producers Association
Serena Black	CARA Coordinator

Project Development

Research priorities should be reviewed on a regular basis (e.g. every 5 years), to monitor the successes of existing programming and opportunities for improvement. These reviews would also allow for key discussions on new project development needs and opportunities. Once a topic is identified as an immediate need, a process of 1) project scoping and 2) producer engagement should be implemented to inform project direction.

Project Scoping

Each topic outlined in the Top 10 Research Priorities in this plan is broadly scoped, with nuanced complexities of where the research gaps exist. For any topic identified to be addressed, it will be important to start with an updated in-depth literature review on the topic, accompanied by consultation of expertise (e.g. CARA's member organizations and research network). The goal of this process is to enable CARA to identify existing resources that exist (within and outside the region) and subsequently narrow the focus of the topic to two or three specific areas of interest for future investigation. For example, under the topic of Long-term Forage Species and Variety Trials, three different sub-topics were identified: 1) Alternate annual forage crops; 2) Forage species and varieties for pasture rejuvenation, and; 3) Native grass or forb species trial for pasture and rangeland. The information collected during the project scoping phase is used to develop background and framework for producer (and other stakeholder) engagement.

Producer Engagement

Critical to the ultimate success of applied research is the engagement of producers and other project stakeholders at the beginning of project development. Therefore, a process of engagement activities is recommended to help define any project's objectives; initial activities may include surveys and informal interviews of key partners (e.g. producer associations), and then followed up with a focus group session. Participants of the focus group will provide feedback on the priority research area under consideration to share their experiences and perspectives on how to maximize the benefits of the research.

Input from the focus group is used to finalize the specific applied research topics, and to build connections between regional agricultural producers and academic and other research support organizations. These connections are then used to build research teams and develop funding proposals to support implementation of research. The Focus Group Agenda utilized for this project could be utilized as a template for future events (Table 3).

Each Focus Group will result in two to three project summaries to be developed. A final decision on which project(s) are selected to move forward could be made by the CARA Scientific Advisory Committee.

Table 3. Sample Focus Group Structural Format	
Welcome and Introductions	15 minutes
Background Presentation – How did we get here?	25 minutes
Breakout Groups *Participants were invited to choose one topic to focus on for project development. The groups were given a series of questions and 25 minutes to discuss, and then each group reported out.* *There were four rounds of different questions, which included:* • *Are there species or varieties of interest to test?* • *What site preparation, seeding techniques or other operational treatments (e.g. irrigation, fertilizer) that should be investigated as part of the trial?* • *Is there any specialized equipment needed to complete this trial?* • *Which locations, sub-regions will this trial serve?* • *Are there specific locations suitable to implement this research?* • *What are the climate adaptation benefits of this research?* • *What co-benefits (e.g. water conservation, soil quality) could be recognized with this trial work?* • *Are there other important research questions (not limited to adaptation research trials) that could be layered on top of this trial?*	120 minutes
Wrap Up Discussion, Voting and Summary of Next Steps	20 minutes

Appendix A: Detailed Evaluation Framework for Assessing Research Priorities

40	**CARA Alignment**	
	To regional adaptation strategy research needs, time frame relative to programming and linkages to applied research and extension potential to keep producers engaged.	**Alignment to Regional Climate Adaptation Strategy** Unaligned = 0 pts; do not proceed with evaluation Marginally aligned = 10 pts Alignment = 20 pts **Time Frame** Research only provides long-term deliverables = 0 pts Research only provides short-term deliverables = 5 pts Research provides mix of long and short-term deliverables = 10 pts **Applied Research/Extension Potential** Research has no immediate pathway to application = 0 pts Research has tangible linkages to parallel on-farm applied research or to create or support extension tools = 10 pts
20	**Ease of Implementation**	**Methodology** Methods not practicable = 0 pts; do not proceed with evaluation Methods/design with higher risk of failure = 2 pts Methods/design with lower risk of failure = 10 pts **Available resources** (facilities, personnel, specialized equipment Key resources lacking = 0 pts; do not proceed with evaluation All key resources in place = 10 pts
10	**Overlap**	Other relevant regions/organizations already addressing topic? (i.e. opportunity to leverage information through extension project). Yes = 0 pts Partial = 5 pts No = 10 pts
15	**Regional Balance**	Pan-Regional or multi-sub-regional sites = 15 pts Sub-regional or local = 10 pts minus prior activity factor ***Prior activity adjustments*** One project in same sub-region/ locale supported in past 3 yrs, reduce score by 5 Two or more projects in same sub-region/ locale conducted in past 3 yrs, reduce score by 10
15	**Sectoral Balance**	Pan-Agricultural = 15 pts Forage or beef-related = 10 pts minus prior activity factor Other agricultural sectors = 5 pts minus prior activity factor ***Prior activity adjustments*** One project addressing same sector supported in past 3 yrs, reduce by 5 Two or more projects addressing same sector supported in past 3 yrs, reduce by 10
100	**Total**	

Appendix B: Multi-functional Pasture Rejuvenation in the Cariboo – Draft Project Outline

Project Timing

Proposed Start Date: May 1, 2020
Proposed Completion Date: March 31, 2023

n.b. Project is planned to span from May 1, 2020 until March 31, 2023. This proposal is seeking support to help establish the project, including site selections, baseline measures and implementing treatments.

Project Title

Multi-functional Pasture Rejuvenation in the Cariboo

Executive Summary

Applied adaptation research will demonstrate cost-effect, innovative practices enabling forage producers to rejuvenate pastures to achieve production, climate adaptation and fire risk management goals. A minimum of three farms in the Cariboo will host on-site trials investigating forage seeding, mechanical brushing and prescribed grazing, alone and in combination. Site selection, baseline measures and treatment applications will be initiated in May 2020, with full implementation by autumn 2020. The trial will be monitored over three subsequent growing seasons, with annual measures of forages, soil carbon, soil moisture and fire hazard ratings carried out pre-treatment and at 3 years post-treatment. Extension activities will include field days, a project fact sheet, annual updates in the Cariboo Agricultural Research Alliance social media and the Forage Council of BC newsletter (the 'Forager'). Results will also form the basis for a Master of Science thesis and one or more peer-reviewed scientific publications.

Applicant Background

Dr. Lauchlan Fraser, Professor and Senior NSERC Industrial Research Chair in Ecosystem Reclamation, Thompson Rivers University

Dr. Fraser, Ph.D. is a community and ecosystem ecologist who investigates basic research questions in plant ecology as well as applied science for land management. To understand the processes that control plant communities and ecosystem processes, Dr. Fraser takes an integrated, multi-disciplinary approach. He is the Associate Editor of two academic journals (Applied Vegetation Science and Plant Ecology) and chair of HerbDivNet, an international network of over 60 scientists exploring herbaceous plant diversity. Dr. Fraser will recruit and supervise a Master of Science candidate to initiate and complete this research. Through facilities at Thompson Rivers University, Dr. Fraser's lab has access to plant and soil sampling equipment and analytics capacity.

Project Partners

Partner name: British Columbia Forage Council

Partner background: The BC Forage Council's (BCFC) mandate is to promote the growth and development of a viable forage industry in BC. The BCFC secures funding support for and co-ordinates forage research and extension throughout the province. In the past 10 years, the BCFC has conducted trials in the Cariboo Region, Fort Fraser, Lower Fraser Valley, Creston, and along Highway 16. The BCFC is currently coordinating a Farm Adaptation Innovation project 'Demonstrating Innovative Pasture Rejuvenation Practices in Central and Northern Interior of B.C."

Partner name: Cariboo Agricultural Research Alliance

Partner background: The project will be guided by the Scientific Advisory Committee (SAC) of the Cariboo Agricultural Research Alliance (CARA). The Cariboo Agricultural Research Alliance (CARA) was created based on the recommendations of the *Cariboo Region Adaptation Strategies Plan* to strengthen the capacity for regional agricultural research and extension. CARA is an umbrella organization, working with industry associations, local groups, government agencies, First Nation communities and academic institutions. The Alliance was developed to provide farmers and ranchers with better access to research results, to help set regional priorities and to provide coordination for programs and projects which are important to multiple commodity sectors. CARA seeks to establish itself as a hub of agricultural research and extension in the Cariboo. To do so, it is building a network of regional and provincial researchers capable of contributing to current and future projects.

The SAC of CARA is composed of diverse expertise from the agriculture sector and academia, including: David Zirnhelt (Chair, CARA), Dr. John Church (Thompson Rivers University), Dr. David Connell (University of Northern BC), Steve Storch (College of New Caledonia), Samantha Charlton (BC Food and Agriculture Climate Action Initiative), Nicole Pressey (BC Ministry of Agriculture), Dr. John Janmaat (University of British Columbia and BC Agriculture Climate Adaptation Research Network), Mike Doherty (BC Sheep Federation), Wylie Bystead (Cariboo-Central Interior Poultry Producers Association), and Serena Black (Coordinator, CARA).

Additional research partners to host the trial sites will be selected in the initial phase of this trial. Potential regional agricultural producer cooperators, as well as sites within Crown land Community Pastures have been identified by CARA and the BCFC.

Main Objectives

Objective 1: Evaluate the effectiveness of cost-effective rejuvenation practices (seeding, mechanical brush control, prescribed grazing) on regional pasture productivity (forage yield). Local information on appropriate forage seeding methods has been identified in the regional adaptation strategies as key factor for allowing agricultural producers adapt to a changing climate.

Objective 2: Evaluate the effectiveness of rejuvenation practices (seeding, mechanical brush control, prescribed grazing) on pasture soil carbon. Increasing soil carbon can support more reliable forage yields via increased capacity of soils to absorb and retain moisture and also to cycle nutrients.

Carbon enriched soil are therefore more capable of adapting to changing regional precipitation regimes.

Objective 3: Evaluate the effectiveness of rejuvenation practices (seeding, mechanical brush control, prescribed grazing) on fire hazard ratings in agricultural settings. Pastures ingrown with small tree and shrub cover, can have a high risk of conveying interface fires. Fire risks can be lowered by replacing woody vegetation with forage species, where the above-ground herbaceous material is grazed by livestock annually. Pasture rejuvenation can also result in higher soil carbon reserves. This allows for higher soil moisture retention and increased surface relative humidity which also potentially lower the risk of wildfire initiation or spread.

The Problem Being Addressed and Connection to Increase Adaptive Capacity

Tame or seeded pastures account for the largest area of land improved for agricultural production in the Cariboo region, as well as in other interior regions of BC. Through a combination of the length of time since they were established and past grazing and soil management, a significant proportion of these pastures now suffer from diminished soil quality, reduced forage production and elevated risk to wildfire. Pasture rejuvenation trials were identified as a top strategic priority by agricultural stakeholders as part of the regional climate adaptation strategies.

Traditional pasture establishment and rejuvenation practices can involve screefing (blading of the top soil and woody vegetation into piles or windrows), tillage and prescribed burning prior to forage seeding. All of which can increase the release of stored carbon, damage soil structure, and reduce the nutrient and water holding capacity of the soil. To compensate for these productivity losses, agricultural producers have sometimes relied on higher-cost, supplemental inputs of synthetic fertilizers and irrigation. Other pasture restoration practices often depend on the use of chemical treatments to control the existing vegetation on the site prior to seeding. Herbicides, however, can interfere with non-target biological processes, leave chemical residues, and potentially degrade ground and surface water quality.

Trials on alternative pasture rejuvenation practices will help to identify viable methods that can address multiple functions and production goals in an important regional agricultural setting. These include improving soil nutrient cycling, increasing carbon-sequestration, and better water drainage and water retention that can help to mitigate extreme weather related impacts (e.g. droughts, flooding). Pasture rejuvenation can also reduce above ground woody vegetation that presents both competition for space and resources with forages, and also a higher fire hazard rating. Small trees and shrub-dominated pastures can convey uncontrolled wildfires across farms and ranches with both on-site impacts to the agricultural sector and elevated risks and impacts of climate-change driven interface fires reaching other properties and communities.

The results of this project will be directly applicable to those producers living within the Cariboo. Across the region, forage and livestock producers have identified a need for prescribed grazing and chipping/mulching treatments to be tested as part of innovative pasture reseeding trials. The practices that will be tested in this project have been used effectively in similarly challenging soil and environmental conditions outside of the region, but have not been demonstrated locally or regionally. Therefore, this research will help determine their effectiveness in different areas across

the region, and in areas with similar production potentials in the interior of BC (e.g. Fraser Fort George, Bulkley Nechako Regional Districts). The research sites will be located in different biogeoclimatic subzones, to ensure the project is applicable to a wide range of producers in various regional agricultural settings.

Additional Environmental andClimate Mitigation Co-benefits

By utilizing techniques (grazing, mechanical mulching) that can convert woody vegetation *in situ* into soil carbon, these pasture rejuvenation methods offer the potential to provide both climate change adaptation and mitigation benefits. Moreover, by lowering fire hazard rating of the rejuvenated pastures the carbon pools may be more stable in the long-term than above-ground carbon stored in woody vegetation that can be released to the atmosphere in prescribed burning or wildfires.

In addition to potential climate change adaptation and mitigation benefits, the improvements in forage production and soil quality without heavy reliance on chemical controls can create soil water conservation and biodiversity enhancement co-benefits that extend beyond the immediate production setting.

This research will also showcase the innovative use of low-elevation remote sensing to model the ability to capture important soil and vegetation information with near-infrared spectral imaging. These models can be used to extend the application of the research results to a much wider geographic setting than the Cariboo.

Methods and Evaluation

The pasture rejuvenation forage trials and establishment treatments will be evaluated by implementing operation-scale deployment of site preparation and forage seeding and then scientific monitoring of key plant and soil indicators to evaluate the implications for:

- Vegetation cover;
- Forage production;
- Soil moisture and soil carbon sequestration; and,
- Fire hazard ratings.

Vegetation cover and forage production have direct relevance to regional climate adaptation with regards to forage producers' ability to improve pasture productivity under increased climatic variability. Vegetative cover and its influence on fire hazard ratings also has direct implications for supporting land management practices that can abate the prominent and widespread risk of wildfires. Soil carbon and soil moisture measures provide direct evidence of the impacts of the treatments tested on the climate mitigation potential and for adaptation to increased occurrence of growing season drought.

Data collected will be analyzed for statistical significance, using sites as treatment replicates and control areas for treatment comparisons.

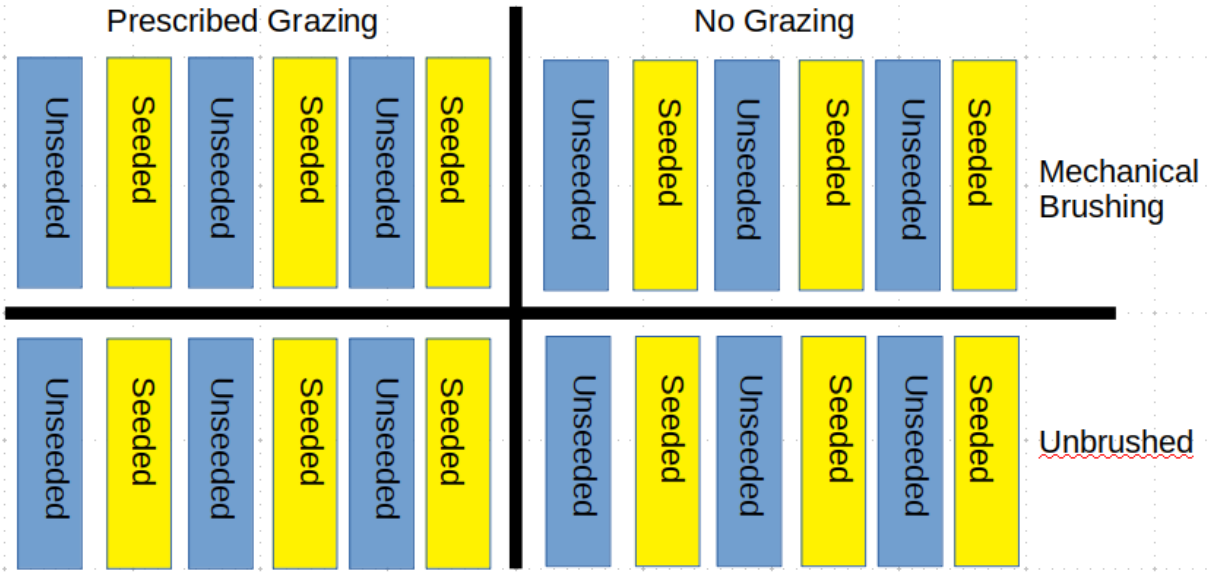
Monitoring Plan

Research Sites. A minimum of three, 6-ha research sites will be selected to implement the research. Some ranch cooperators and Crown land locations (community pastures) have already been

identified for consideration, during the consultation process leading to CARA's prioritizing of this research topic. These and other candidate sites will be evaluated in the first phase of the research (spring 2020) to select the best locations to complete the trials, in consideration of access and other logistical parameters. The sites will be selected such that they are representative of each of the major agricultural production zones in the Cariboo region: sub-boreal northern zone, eastern wet belt, and central/south dry temperate zone.

Treatments. Each site will test broadcast seeding of a mixture of sub-regionally adapted forage species and varieties and will be compared to unseeded controls, alone and in combination with either mechanical brushing, prescribed intensive grazing, or a combination of brushing and grazing (Fig. 1). Each sub-unit containing a combination of the seeding, grazing and brushing treatments will be a minimum area of 0.25 ha (50 x 50 m), and each treatment combination will be replicated 3 times at each site, for a total of 24 sub-units per site.

Figure 1. Representation of treatment layouts at each site.*n.b.* Treatments will be randomly assigned to experimental units at each site.



Measures. Data collected will include soil organic carbon (SOC), soil moisture, existing vegetation cover (broken into forage species, other herbaceous vegetation by species, shrub and tree cover), and forage production completed pre-treatment in summer of 2020, and again at three years post-treatment, in summer of 2023. Additionally, annual measures of seeded forage establishment, forage production and soil moisture will be collected in 2021 and 2022. For each measure, ten subsamples will be collected for each variable (soil, plant cover, forage production) and either pooled (soil samples) or averaged (plant measures) for each experimental unit.

Vegetation cover data, plus other variables will also be used to estimate the site's fire hazard rating, following the procedures outlined in "A Guide to Fire Hazard Assessment and Abatement in British Columbia" (https://www2.gov.bc.ca/assets/gov/public-safety-and-emergency-services/wildfire-

status/prevention/fire-fuel-management/hazard-assessment-abatement/bcws_hazard_assessment_abatement_guide.pdf).

Pre- and post treatment low-aerial surveys of the sites will be completed with a red-edge MX dual camera imaging system to collect near-infrared emissions. These will be compared with satellite imagery of the sites in the same wavelengths for developing predictive modeling of the soil and vegetation parameters monitored.

Knowledge Transfer

Producer-focused extension will be carried out by the BC Forage Council. Scientific reporting will be carried out by Thompson Rivers University staff and students.

The BCFC has the tools and networks in place to ensure that the knowledge transfer of the project activities will be extensive, throughout the region and to other producers in the Province. Project extension activities will include two field days and a workshop presentation. Additional opportunities to present results at various workshops and conferences will also be sought after, at regional, and provincial levels, including Canadian Forage and Grasslands Association(CFGA) Conference in Kamloops, to be held in November 2020. Extension materials will also be developed, including a fact sheet on the practices demonstrated and the results, and updates in BCFC's quarterly newsletter.

All written extension and communication materials about the project will be made available on the BCFC Website, social media network, the Cariboo Agricultural Research Alliance database, and at various events that BCFC participates in (e.g. BC Cattlemen's Convention, BC Agricultural Climate Adaptation Research Network Annual Workshop, etc.). It is expected that approximately 60-70 producers will participate in the extension activities annually, and that 300+ producers will be engaged with the project over three years.

Scientific reporting by Thompson Rivers University will include an annual technical update report to summarize site information, document the treatments employed, interim results and other anecdotal information of relevance (e.g. incidence of pests). Additionally, a Master of Science-level thesis will be published based, on the research conducted, plus one or more peer-reviewed scientific publication.

Work Plan

	Activities	Deliverables
Mar 2020 – Jul 2020	- Recruitment of graduate student and research assistant - Finalize research design - Secure all equipment and materials - Screen and select a minimum of three research sites; layout experimental unit locations. - Develop detailed work plan (with monitoring schedule, field day dates, etc.) for each site. - Baseline data collection / measures of soils, vegetation and conduct aerial survey	- Research work plan with design and work schedule - News release of project throughout the Region, and to CARA mailing list subscribers and BCFC membership
Aug 2020 – Nov 2020	- Mechanical and prescribed grazing treatments applied; forage seeding completed. - Sample processing and analysis - Extension activities (see deliverables)	- Social media and newsletter updates - Presentation to CFGA
Dec 2020 – Mar 2021	- Data summaries and analyses - Fire hazard rating calculations - Spatial information analysis - Reporting	- Establishment report - Annual report - Social media and newsletter updates
Apr 2021 – Sep 2021	- Portable grazing exclosure cages installed on production sampling locations - Data collection - Extension activities (see deliverables)	- Social media and newsletter updates - Fall field day/pasture walk
Oct 2021 – Mar 2022	- Data summaries and analyses - Extension activities - Reporting	- Annual report - Social media and newsletter updates
Apr 2022 - Sep 2022	- Portable grazing exclosure cages installed on production sampling locations - Project end data collection / measures of soils, vegetation and conduct aerial survey	- Social media and newsletter updates - Fall field day/pasture walk
Oct 2022 – Mar 2023	- Data summaries and analyses - Fire hazard rating calculations - Spatial information analysis - Reporting	- MSc thesis and peer reviewed paper(s) - Project fact sheet - Final report - Project fact sheet published - Social media and newsletter updates.

Appendix C: "Greenhouse Innovations for Cariboo Market Garden Season Extension" Draft Project Outline

Project Timing

Proposed Start Date: April 1, 2020
Proposed Completion Date: March 31, 2021

Project Title

Greenhouse Innovations for Cariboo Market Garden Season Extension

Executive Summary

Applied adaptation research will demonstrate innovative practices enabling regional market garden producers to extend their growing season in cost-effect, passively heated greenhouses or high tunnels. Trials will be conducted in greenhouse facilities at the College of New Caledonia's Quesnel and Prince George campuses investigating the use of bed domes and supplemental LED lighting, alone and in combination, on fall-seeded vegetable crops. Greenhouse preparation will be initiated in July 2020, with full implementation by the end of August 2020. Fall-seeded salad vegetable crops (lettuce, scallions) and environmental conditions will be monitored. Extension activities will include an open house for growers at the Quesnel greenhouse, a project fact sheet, and updates in the Cariboo Agricultural Research Alliance social media.

Applicant Background

SorinPasca, Director, Applied Research & Innovation, College of New Caledonia

Sorin leads the College of New Caledonia's (CNC)Applied Research and Innovation program, which connects industry, business and community partners with the expertise and facilities at the college to conduct research and development, solve business challenges, and take advantage of market opportunities. CNC has two passively heated greenhouses to complete the proposed project work; one located at the Quesnel campus and the other, recently constructed at the main Prince George campus. CNC has experience in working with a wide range of business and community partners. The Applied Research program has past and ongoing research supporting horticulture in the region, including projects to find the suitable tomato varieties for unheated greenhouses and high tunnels in the Cariboo, identification of native pollinators for increasing production of northern berry crops, developing a "mezzanine' growing system for increasing growth capacity of conventional greenhouse, and trialing a hydroponic technology to increase local food projection capacity in northern BC.

Project Partner

Partner name: Cariboo Agricultural Research Alliance

Partner background: The project will be guided by the Scientific Advisory Committee (SAC) of the Cariboo Agricultural Research Alliance (CARA). The Cariboo Agricultural Research Alliance (CARA) was created based on the recommendations of the *Cariboo Region Adaptation Strategies Plan* to strengthen the capacity for regional agricultural research and extension. CARA is an umbrella organization, working with industry associations, local groups, government agencies, First Nation

communities and academic institutions. The Alliance was developed to provide farmers and ranchers with better access to research results, to help set regional priorities and to provide coordination for programs and projects which are important to multiple commodity sectors. CARA seeks to establish itself as a hub of agricultural research and extension in the Cariboo. To do so, it is building a network of regional and provincial researchers capable of contributing to current and future projects.

The SAC of CARA is composed of diverse expertise from the agriculture sector and academia, including: David Zirnhelt (Chair, CARA), Dr. John Church (Thompson Rivers University), Dr. David Connell (University of Northern BC), Steve Storch (College of New Caledonia), Samantha Charlton (BC Food and Agriculture Climate Action Initiative), Nicole Pressey (BC Ministry of Agriculture), Dr. John Janmaat (University of British Columbia and BC Agriculture Climate Adaptation Research Network), Mike Doherty (BC Sheep Federation), Wylie Bystead (Cariboo-Central Interior Poultry Producers Association), and Serena Black (Coordinator, CARA).

Main Objectives

Objective 1: Evaluate the effectiveness of cost-effective season extension practices (passive greenhouses, supplemental LED lighting) on regional vegetable productivity (harvestable yield). Local information on appropriate season extension methods for horticultural crops has been identified in the regional adaptation strategies as key factor for allowing agricultural producers adapt to a changing climate. Relay cropping trials for an additional late summer / early fall salad vegetable crop could significantly improve the overall productivity and profitability for market garden operations facing climate-change driven production uncertainties.

Objective 2: Evaluate the effectiveness of controlled-environment season extension practices (bed domes, supplemental LED lighting) on energy demands / carbon 'footprint' of local horticultural practices. Local information on the benefits of additional thermal capture or supplemental lighting in passively heated, controlled environments are largely undocumented. Information from this trial can be used to calculate the supplemental energy costs / carbon footprint relative to changes in vegetable yield for fall seeded crops.

The Problem Being Addressed and Connection to Increase Adaptive Capacity

Controlled growing environments (greenhouses, high tunnels, low tunnels) represent a small but increasingly important part of regional horticultural operations. Greenhouse or tunnel production, however, has potentially very wide applicability for diversifying Cariboo agriculture because it is not restricted by sub-regional variations in soils or micro-climate. These growing systems have been demonstrated elsewhere to moderate climate-change driven extremes in seasonal climatic variability. Horticulture trials in controlled environments were identified as a top strategic priority by agricultural stakeholders as part of the regional climate adaptation strategies.

Traditional greenhouse production practices can involve costly, energy intensive inputs (heating and lighting) to successfully establish and mature commercial vegetable crops. The supplemental energy inputs mayalso directly increase the release of greenhouse gases, depending on the energy source used to power the system. Season extension in field settings (i.e. outside of controlled

environments) has been challenged by highly variable spring and fall weather patterns in recent years, and the unpredictable onset and termination of the frost-free conditions.

Trials on innovative greenhouse practices will help to identify viable, cost-effect methods for horticultural season extension in an increasingly important regional production setting. The results of this project will be directly applicable to horticultural producers operating across the Cariboo, and the information generated aligns with the specific production knowledge gaps that market garden producers have identified. This research will generate results are also applicable to areas with similar production potentials in the central interior of BC (e.g. Fraser Fort George, Bulkley Nechako Regional Districts).

Additional Environmental andClimate Mitigation Co-benefits

By providing a physical barrier, greenhouses and tunnels can address some emerging pest management challenges in comparison to open-grown field crops, also originating from climate change. Research and extension support on pest management has also been identified as a top priority for regional agricultural climate change adaptation.

In addition to potential climate change adaptation and mitigation benefits, the improvements in horticultural production without heavy reliance on chemical controls for pest management can create soil water conservation and biodiversity enhancement co-benefits that extend beyond the immediate production setting.

Methods and Evaluation

The controlled environment, season extension technology will be evaluated by implementing a trial deployment of bed domes and supplemental LED lighting with scientific monitoring of key plant and environmental indicators to evaluate the implications for:

- Salad vegetable (lettuce, scallions) production;
- Length of the growing season;
- Soil and air temperature, relative humidity and light; and,
- Direct production costs.

Crop production trials have direct relevance to regional climate adaptation with regards to market garden producers' ability to increase the total seasonal productivity under increased climatic variability. The length of the growing season, as determined within the greenhouse by the onset of the first and last killing frosts, is a major concern for horticulture producers experiencing highly variable spring and fall weather patterns, and unpredictable onset and termination of the frost-free conditions. Air temperature and relative humidity influence both crop growth and the potential for some crop pests to flourish.

Data collected will be analyzed for statistical significance, using sites as treatment replicates and control areas for treatment comparisons.

Monitoring Plan

Research Sites. Research will be conducted at CNC's greenhouse facilities in Quesnel and Prince George with a full set of all treatments implemented at each site.

Treatments. Salad vegetable crops (lettuce, scallions) will be seeded at two dates (late August, mid-September) under three bed cap treatments (bed dome for full crop rotation, bed dome installed after 2 weeks, and undomed control) and two lighting treatments (natural ambient light and supplemental 75 to 225 W, full spectrum LED lighting to achieve 16 hour of full light, and 8 hours of dark per day). Six growing benches will be utilized at each location, separated into two groups of three, divided by a floor to ceiling blackout curtain to ensure no reflected or refracted light from the supplemental LED lighting treatment reaches the crops growing under natural light (Fig 1).

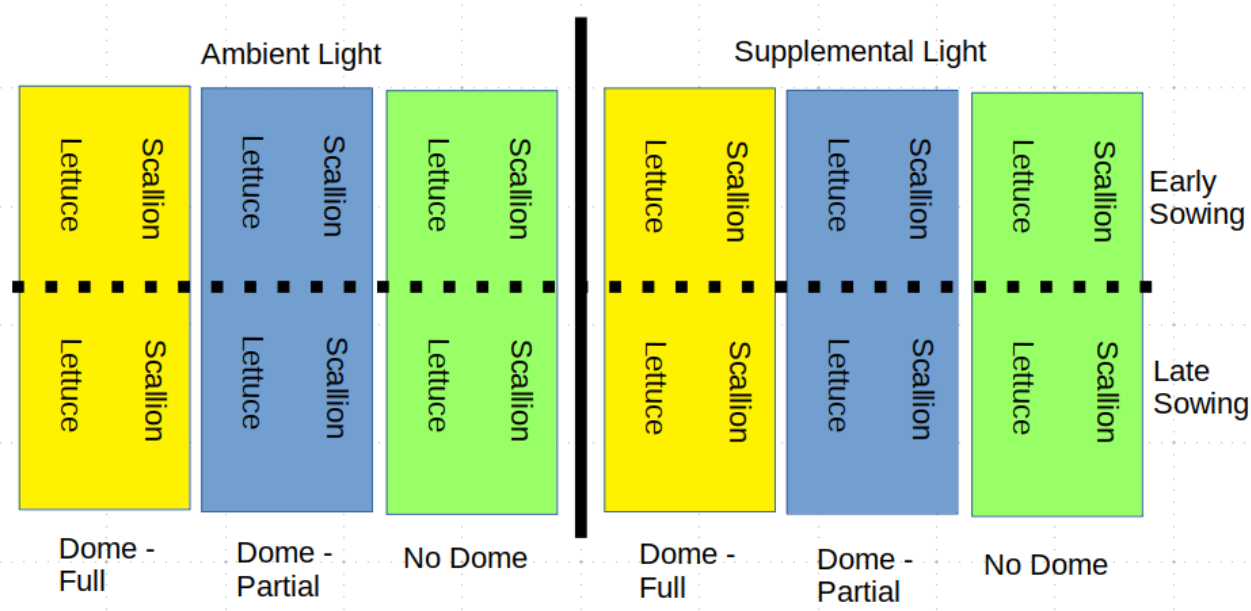


Figure 1. Representation of the treatment layout at each location.

Low cost, wooden framed domes covered with translucent bubble wrap (Fig. 2) will be tested for use as an added layer of thermal insulation above 4 of the 6 growing tables. Two of the domes will be installed at the time of the crop seeding, and two will be applied two weeks after crop seeding.

Measures. Data collected will include the averagecrop plant survival, crop yield at maturity, and daily measures of soil temperature, air temperature and relative humidity. Weekly measures of light at the crop surface will be taken at one-hour intervals from the initiation of the supplemental LED lighting (as needed) from (06:00) until the termination of the daily supplemental LED lighting period (20:00). Supplemental energy inputs will be calculated by multiplying the operating hours of the supplemental lighting by their power rating.

Additional information will be documented, including crop germination dates, crop development notes, incidence of pest organisms, or any other information potentially relevant to the outcome of the trials.

Figure 2.CNC Quesnel Campus Greenhouse with thermal domes (right).

Knowledge Transfer

A producer-focused open house will be held at the CNC Quesnel Campus, allowing agricultural producers to observe the trials and hear preliminary results. Extension materials will also be developed, including a project fact sheet on the practices demonstrated and the results, a detailed final technical report and updates on the CARA website.

All written extension and communication materials about the project will be made available on the CARA Website, social media network, and included in the Cariboo Agricultural Research Alliance database. It is expected that approximately 20-30 producers will directly participate in the field day, and that 100+ producers will be engaged with the project through the other extension channels.

Work Plan

	Activities	**Deliverables**
April 2020 – Jul 2020	- Recruitment of research assistant - Finalize research design - Secure all equipment and materials - Develop detailed work plan (with monitoring schedule, etc.) for each site.	- Research work plan with design and work schedule - News release of project throughout the Region, and to CARA mailing list subscribers
Aug 2020 – Nov 2020	- Treatments applied. - Sampling conducted - Producer open house	- Social media and newsletter updates - Open house
Dec 2020 – Mar 2021	- Data summaries and analyses - Reporting	- Project fact sheet - Final report - Social media updates