Climate Action Initiative

BC AGRICULTURE & FOOD

Priority Pests of the Cariboo-Chilcotin

Final Report

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By

George W. Powell, PhD, PAg

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The input, experience and advice from many agricultural stakeholders was instrumental in developing this report. A listing of those consulted in the preparation of this report is provided in Appendix 2, in addition to many who participated anonymously in the project survey.

Disclaimers

The Governments of Canada and British Columbia are committed to working with industry partners. Opinions expressed in this document are of the author and not necessarily those of the Governments of Canada or British Columbia, the Investment Agriculture Foundation or the B.C. Agricultural Research & Development Corporation.

Management summaries in this report contain current information on pest control options and are accurate at the time of publication. Only use chemical controls registered for use in your area of production and on the specific crops and pests for which they are registered. Follow all pesticide label directions for the prescribed storage, handling, application and disposal practices.

Summary

A changing climate is influencing agricultural pest dynamics and their impacts on agricultural production in the Cariboo region. During the Cariboo Adaptation Strategies planning process facilitated by the BC Agriculture and Food Climate Action Initiative, stakeholders identified a number of agricultural pests of concern and also highlighted a significant gap in regional support activity. This project was implemented to help regional producers begin to adapt to emerging pest management issues resulting from climate change.

Consultations were conducted with key regional stakeholders and organizations using a survey and an interview process, to develop lists of priority plant, insect, disease and other agricultural pests. A ranking was assigned to these current and emerging agricultural pest threats based on individual pest's current and potential distributions if unmanaged, the scale and severity of their impacts on various types of regional agricultural production, and the existing research, monitoring and/or management support (i.e. effective beneficial practices). Information gathered in the consultations, supplemented with a separate literature review, was used to inform this ranking.

The literature review and feedback from stakeholders was also used to identify a gaps in regional extension, monitoring and research work, with potential project partners identified. The following recommendations are put forward to support pest management in the Cariboo-Chilcotin:

1. Employ Layered Management Strategies, recognizing the different needs of endemic pests, new pests with limited regional distributions, and pests not yet in the region but with significant potential to cause harm if they establish a presence;
2. Enhance Producer Education and Connection to Information, particularly in the areas of integrated pest management, pest identification, monitoring protocols, and the full range of suitable control options;
3. Expand and Refine Regional Pest Monitoring;
4. Establish, or Link to Existing, Climate Monitoring Networks;
5. Refine the Priority Pest Ranking System to allow for more robust pest management decision making to the local, or in some cases, site/farm level; and,
6. Conduct Participatory Research and Adaptive Management Trials that avoid new pest problems from establishing, improve the understanding of non-crop/non-livestock hosts and vectors, link pest management issues to other climate-related changes, leverage existing management capabilities, and result in long-term stable control with lower-cost inputs.

Contents

Tables

Figures

1. Background

With a changing climate, agricultural operations in the Cariboo-Chilcotin[1] are expected to experience increased mean annual temperatures, growing degree days and frost-free periods together with decreased snowfall, summer precipitation and heating degree days (Pacific Climate Impacts Consortium, no date). Climate change is already influencing, and will continue to influence, agricultural pest dynamics and their impacts on agricultural production in the region. For example, warmer winter temperatures allow insects, fungi, weeds and bacteria to more easily overwinter and expand their ranges. Although, to date, these impacts in the region remain largely unquantified. New and emerging pest issues may require new management approaches, which can assist with minimizing impacts on the health, quality and productivity of livestock and crops.

Understanding the priority agricultural pests[2] in the context of climate change was suggested as a key adaptation component for the sector in the coming years. During the Cariboo Adaptation Strategies planning process facilitated by the BC Agriculture and Food Climate Action Initiative, stakeholders identified a number of agricultural pests of concern and also highlighted a perceived gap in regional support activity. A key strategy in managing new invasive pest threats is early detection and rapid response to prevent establishment. Improving the monitoring, and information available on pest identification and management options is viewed as critical to managing changes in populations and ranges of economically significant species (i.e. those that cause damage to crops or harm to livestock).

This review and analysis is intended to help regional agricultural producers begin to adapt to emerging pest management issues resulting from climate change. The overall goals of the project were the following:

1. Consult with agricultural producers and relevant organizations to identify priority pest issues;
2. Review information resources for the priority pests and increase accessibility of this information to producers; and,
3. Analyze the information from the consultations and resources to assess the gaps and priorities for managing current and future regional pest threats in consideration of climate change impacts.

The desired outcomes are to identify the needs for monitoring and other support work on priority pest issues and also build the capacity of producers to respond to these issues with appropriate management strategies through collaborative monitoring or pilot projects.

1 The geographic scope is the area within the boundaries of the Cariboo Regional District.

2 “Pests” refer to agricultural pests including insects/arachnids, pathogens, and weeds, and for the purposes of this project specifically exclude vertebrates.

2. Methods

2.1 Priority Pest Ranking System

To assist in determining the priorities for future extension, monitoring and research, a ranking was assigned to current and emerging agricultural pest threats identified for the region. Information gathered in the consultations, supplemented with a separate literature review, was used to inform this ranking. The pest ranking is composed of five elements, with variable weightings, as outlined below, creating a composite score out of 100 for each pest:

1. Current geographic scope (proportion of the agricultural land base; maximum 15)
   a. Not present (0)
   b. Local (5)
   c. Sub-regional (10)
   d. Pan-regional (15)
2. Potential geographic scope (proportion of the agricultural land base), if unmanaged and in the context of climate change projections (maximum 15).
   a. Local (5)
   b. Sub-regional (10)
   c. Pan-regional (15)
3. Scale of impacts (maximum 25; based on Tables 2 and 3). If more than one production area is impacted, the scale of impact is additive to the maximum value.
4. Severity of impacts (maximum 25)
   a. Minor loss of quantity or quality (1)
   b. Significant - potential for partial loss of yield or quality (10)
   c. Catastrophic - potential for total loss (25)
5. Existing research, monitoring and management support (i.e. effective BMPs) (maximum 20)
   a. Advanced (1)
   b. Minor (10)
   c. Limited or non-existent (20)

For all of the plant pests (i.e. weeds) and some of the insect species evaluated, an adjustment factor was applied to the current and potential geographic scope ratings based on the ecological amplitude of a given pest species and relative to the current and potential distribution of ecological zones within agricultural and rangeland areas of the region. The modeling of current and future climate distributions is described in section 2.2.

For example, baby's breath (*Gypsophila paniculata*) is an invasive weed known to impact rangelands in the bunchgrass (BG)[3] zone. The BG zone currently represents 24.1% of the regional land base in use as rangeland. The current geographic scope rating (local distribution) was therefore, multiplied by 0.241 to obtain a more accurate rating of scope.

Table 1. Scale of Production Impacts for Crops Grown in the Cariboo Region. Area in production and relative value (based on adjusted net operating income) from the Census of Agriculture (Statistics Canada, 2016).

Crop/Production Type	Area in Production (acres)	Area in Production Rating	Relative Value Rating	Overall Impact Rating[4]
Land in natural state used for range	658069[5]	10	1	2.5
Tame or seeded pasture	55219	7	2	3.5
Other forage crops (e.g. timothy, orchardgrass)	54705	7	6	10.5
Alfalfa, alfalfa mixtures	47709	7	6	10.5
Cereals (wheat, oats, barley, corn, etc.)	7397	5	8	10
Forage seed crops	369	2	6	3
Vegetables, potatoes and other field crops	244	2	10	4
Fruit, berries and nuts	48	1	7	1.8
Outdoor nursery crops	18	1	9	2.3
Greenhouse production	3.4	1	9	2.3

The area under production for various agricultural crops in the Cariboo Regional District (CRD) follows a pattern of near exponential expansion from greenhouse production at the low end, through horticultural crops, vegetable and forage seed crops, cereals to forage crops, pastures and rangeland. The relative valuation of these crops is, for the most part, inversely related to the area under production. The lowest net operating income originates from rangeland, and the highest from vegetable, horticultural and greenhouse production.

3 The biogeoclimatic zones of Cariboo agricultural areas and rangelands is provided in Appendix 1.

4 (Production area rating multiplied by production value rating) divided by 4

5 Does not include approximately 320,000 Animal Unit Months of Crown grazing tenures.

Table 2. Scale of Production Impacts for Livestock Produced in the Cariboo Region. Livestock numbers and relative value (based on adjusted net operating income) from the Census of Agriculture (Statistics Canada, 2016).

Livestock Type	Number	Relative Production Rating	Relative Value Rating	Overall Impact Rating[6]
Cattle, beef	92677	10	1	2.5
Cattle, dairy	507	4	8	8
Sheep	4696	5	3	2.5
Hogs	860	3	10	7.5
Equine	3376	6	1	1.5
Goats	374	2	3	1.5
Poultry	13510	1	9	2.3
Bees	481	1	2	0.5
Llama, alpaca	143	1	2	0.5
Bison	76	2	2	1
Rabbit	353	1	2	0.5

Regional livestock production, normalized to animal units[7] for comparative purposes, is by far, predominantly beef cattle. Nearly all of the regional livestock production (beef cattle, dairy cattle, sheep, equine, goats, llama, alpaca and bison) is highly integrated and dependent upon regional cereal crops, forage cultivation and rangeland.

2.2 Regional Climate and Pest Distribution Modeling

Regional agricultural operations are expected to experience increased mean annual temperatures, growing degree days and frost-free periods together with decreased snowfall, summer precipitation and heating degree days through mid-century (Pacific Climate Impacts Consortium, no date; Table 3). Given the high variability in existing climatic and geographic conditions in the region, however, not all areas will experience a uniform or consistent level of change.

6 (Production number rating multiplied by production value rating) divided by 4

7 One animal unit is the metabolic equivalent of a mature beef cow.

Table 3. Summary of Climate Projections for the Cariboo Region (deviation in the 2050s from 1961 to 1990 baseline, with the 10th to 90th percentile range).

Climate Variable	Deviation	Range
Mean Annual Temperature (°C)	+ 1.8	+ 1.1 to + 2.6
Precipitation (%), Annual	+ 6	- 1 to + 13
Precipitation (%), Summer	- 7	- 15 to + 5
Precipitation (%), Winter	+ 7	- 3 to + 14
Snowfall (%), Winter	- 8	- 15 to + 3
Snowfall (%), Spring	- 54	- 74 to - 12
Annual Growing Degree Days	+ 283	+ 162 to + 444
Annual Heating Degree Days	- 632	- 930 to - 398
Frost-Free Days	+ 23	+ 13 to + 34

To better understand the potential implications of future climate on agricultural pest populations, an analysis of the current and future geographic distribution of biogeoclimatic ecological classification (BEC) zones relative to regional agricultural and rangeland was conducted. BEC zones encapsulate a hierarchal classification (at regional, local and site levels) of the climate, vegetation potential and other site factors affecting productivity (Meindinger and Pojar, 1991). The system is widely used by resource managers and researchers in BC to support natural resource management. For the purposes of this project, the ecological suitability of many regional agricultural pests is known, and allows for a more refined estimation of their current and future distributions relative to the overlap of various BEC zones and agricultural production (see section 2.1). A spatial analysis was conducted to quantify these distributions.

The area represented by regional 'agriculture' and 'rangeland' was obtained from the 'Baseline Thematic Mapping Present Land Use Version 1 Spatial Layer' dataset (FLNRO, 2017a). The area considered as rangeland, only captures permanent rangeland, and does not include transient use of forestland areas following timber harvesting. Current BEC distributions were estimated from the 'Biogeoclimatic Ecosystem Classification (BEC)' data set (FLNRO, 2017b). Cariboo Regional District boundaries were obtained from the 'Regional Districts - Legally Defined Administrative Areas of BC' dataset (MAH, 2017). The projected 2050 BEC distributions were estimated from the climate envelope modeling developed at the University of BC's Centre for Forest Conservation Genetics (Hamman *et al*., 2005; Wang *et al*. 2016).

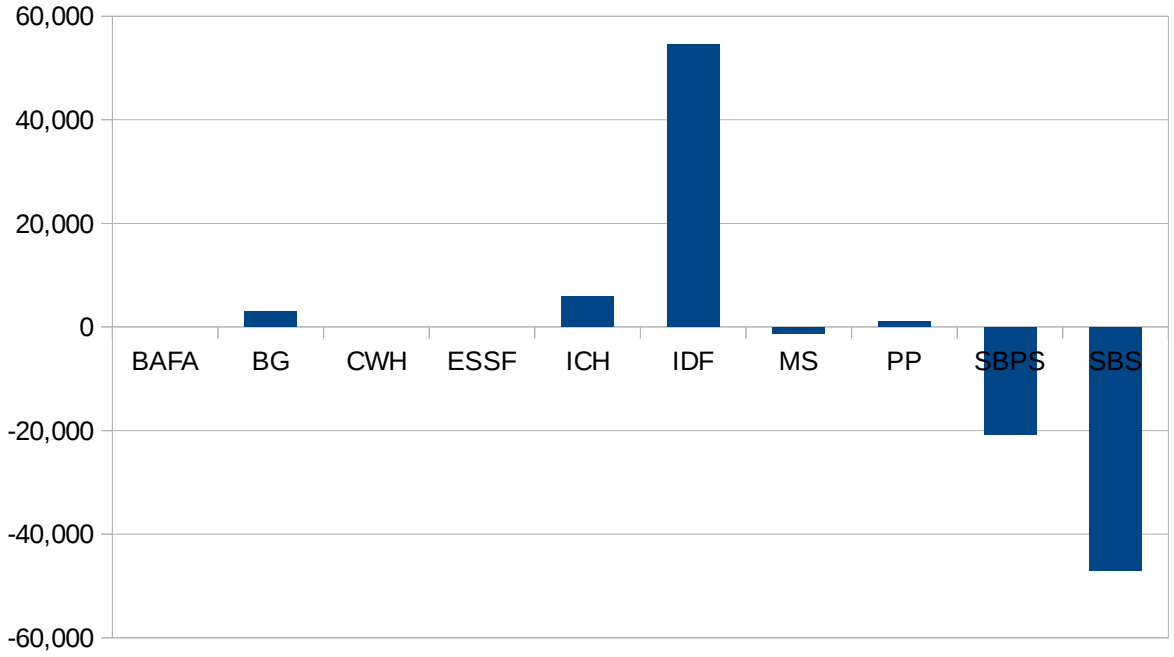
Data were analyzed at a spatial resolution of a 758-m pixel raster, with the assistance of the geospatial lab, Strengthening Farming Unit, BC Ministry of Agriculture.

The analysis projects significant changes in distribution of BEC zones relative to agricultural and rangeland areas in the CRD by the 2050s. Overall, climates suitable for Bunchgrass (BG), Coastal Western Hemlock (CWH), Interior Cedar-Hemlock (ICH), Interior Douglas-fir (IDF) and Ponderosa Pine (PP) zones will expand, while climates classified as Boreal Altai Fescue Alpine (AT), Montane Spruce (MS), Sub-Boreal Pine – Spruce (SBPS), Sub-Boreal Spruce (SBS) and

Spruce – Willow – Birch (SWB) zones will contract. There are differences, however, in how these changes will be expressed on agricultural land (i.e. cultivated land, improved pastures, hayfields) and rangeland (unimproved grazing lands on grasslands and in open forests).

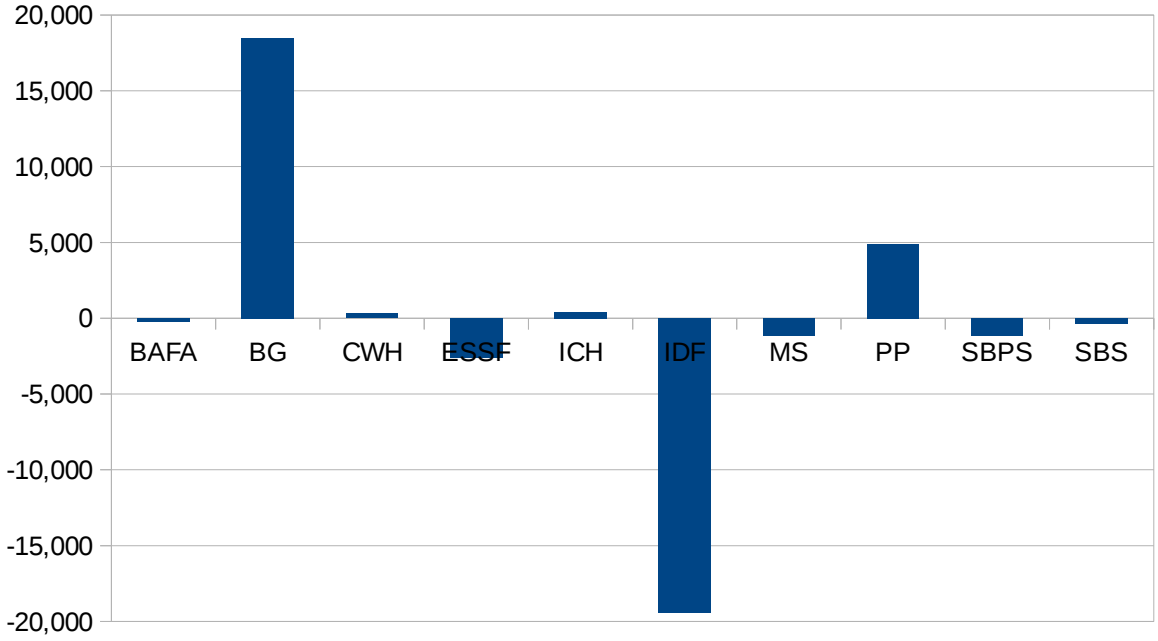
Regional agricultural lands will see a marked decline in sub-boreal climates (SBS, SBPS) and an increase in temperate zones (ICH, IDF) particularly at mid-elevations in the North, Central and South Cariboo (Fig. 1).

Figure 1. Projected Change (ha) in the Distribution of Biogeoclimatic Zones on Agricultural Land in the Cariboo Regional District Through 2050.



Cariboo-Chilcotin rangelands are projected to transition from temperate and sub-boreal forest climates (IDF, ESSF, MS, SBS, SBPS) to true grassland (BG) and dry, open forests (PP) particularly in the South Cariboo, and at lower elevations in the Chilcotin and along the Fraser and Chilcotin River benches (Fig. 2).

Figure 2. Projected Change (ha) in the Distribution of Biogeoclimatic Zones on Rangeland in the Cariboo Regional District Through 2050.



2.3 Consultations

2.3.1 Survey

The current distribution and potential impacts of invasive plants (weeds) is fairly well documented within the region by the Cariboo Chilcotin Coast Invasive Plant Council (CCCIPC ,2017). The CCCIPC's 'Priority Invasive Alien Plant' list was therefore utilized as a starting point for determining priority agricultural weeds and it was supplemented with additional information obtained in the consultations with industry and other stakeholders.

No equivalent regional scan or inventory, however exists for agricultural insects, pathogens (bacterial, fungal, viral) or other pests (e.g. mites). As first step in documenting agricultural pest problems other than weeds, a survey was distributed to agricultural stakeholders in the region to aid in identifying existing species of concern. The survey link was widely distributed through government and industry agriculturally-focused mailing lists. A total of 35 individuals completed the survey between November 5 and December 10, 2017, collectively identifying 19 insects, pathogens and other pests of agricultural production in the region. All of the producers that completed the survey, and indicated they were willing to complete a follow-up interview, were subsequently invited to participate in the more detailed consultations. Information collected in the survey was also used to help with the gap analysis and recommendations with respect to current producer knowledge about regional pest issues, management and monitoring activities.

The insect, pathogen and other agricultural pest survey questions included the following:

1. In which electoral area / municipality is your farm located?
2. What insect, disease or other non-weed agricultural pest are you reporting?
3. What crop(s) or livestock were directly impacted by this pest?
4. What was the level of impact on production quantity or quality?
   - No signifcant impact detected
   - Minor loss of quantity or quality
   - Partial loss of production or quality
   - Total loss of production or quality diminished such that it was not suitable for sale
5. Please note all actions you have undertaken to manage this insect or disease problem
   - None
   - Monitored pest levels
   - Applied chemical controls
   - Used biological controls or promoted beneficial organisms that control this pest
   - Used cultural methods, physical barriers or mechanical controls
6. Is your management of this pest problem successful?
   - No
   - Partially
   - Fully
   - Does not apply
7. Does this insect or disease impact other agricultural operations in the Cariboo Region?
   - Don't know
   - Some of my neighbours also have this pest problem
   - This pest impacts many farms or ranches in my local area
   - This pest impacts farms and ranches across the entire Region
8. Which of the following apply to your farm or ranch?
   - I follow an integrated pest management (IPM) plan and it is current
   - I can identify the major pests impacting my operation and understand their lifecycle
   - I keep records on pests, beneficial organisms, weather and crop damage / livestock health
   - I consider a combination of appropriate control methods before control action is taken
   - I keep records on pest management actions taken and their effectiveness
9. If you are willing to participate in a follow-up interview, please provide your name and contact information.

2.3.2 Interviews

Various stakeholders, including producer and support organizations and the individuals that self-identified in the regional agricultural pest survey, were invited to participate in a more detailed interview process, providing information to help refine the pest rankings. Individuals that participated in the consultations are included in Appendix 2.

Some of the individuals and groups consulted were asked to assist in answering the following questions for each of the identified pests for which they were familiar.

1. What is your estimation of the current distribution (geographic or biogeoclimatic based estimates) of this pest? Provide a level of confidence in your distribution estimate:
   - High (based on active monitoring or inventory work);
   - Moderate (based on multiple observations, limited monitoring or research); or,
   - Low (cursory evidence based on limited observation or anecdotal information).
2. How will the distribution change with the projected changes in regional climate?
   - Increase, stable or decrease
3. Do you have estimates, or measures of, regional losses and/or dimished quality of crop or livestock production directly related to this pest? Provide a level of confidence in your impact estimate:
   - High (based on direct experience, active monitoring or inventory work);
   - Moderate (based on multiple observations, limited monitoring or research); or,
   - Low (cursory evidence based on limited observation or anecdotal information).
4. Are you conducting, or are you aware of, monitoring activities related to this pest? If yes, what is the scope of the monitoring:
   - Local /site specific;
   - Subregional; or,
   - Regional.
5. Are you conducting, or are you aware of, regionally-based or -relevant research / adaptive management trials for this pest?
6. What strategies have you used, or are aware of, for managing this species to prevent establishment, control populations or mitigate damage? If you have direct experience, were the methods employed effective and what were the costs involved?
7. Do you have any potential project ideas or opportunities for collaboration to support management strategies for this species?
8. Are there other agricultural pest problems not identified here that you think pose an emerging threat? If yes, go through questions 1 to 7 for the additional pests.

2.4 Literature Review and Gap Analysis

Concurrent to the consultations, published resources and relevant information from the BC Agriculture and Food Climate Action Initiative, Environmental Farm Plan Program, academic and other technical organizations were identified through electronic searches and supplemented with recommendations from key individuals identified in the consultation plan. These references were scanned and reviewed to identify gaps and priority areas for future support and development activities, including research, monitoring, outreach and education, pilots or demonstration projects.

3. Priority Pests for the Cariboo Region

3.1 Plants

The CCCIPC's Regional Strategic Plan, formed the starting point for assessing plant pests. Eight species with negligible impact on regional agriculture were excluded from further evaluation and ten additional species were identified and added to the evaluation, based on consultations with agricultural producers and support organizations.

The agriculturally-related, priority invasive alien plants identified were then screened following methods described in Section 2.1 and the results of the screening are summarized in Table 4. A listing of all priority pests sorted by their rating is provided in Appendix 3.

Table 4. Summary of Priority Agricultural Plant Pests in the Cariboo Region.

Species	CGS[1]	PGS[2]	ScOI[3]	SeOI[4]	MMRS[5]	Rating	Page
Baby's-breath	0.1	3.4	6	10	10	29.6	12
Black henbane	0.5	9.1	6	10	10	35.5	12
Blueweed	0.5	9.4	6	10	10	35.9	12
Burdock, common	9	12.9	8.5	10	10	50.3	13
Burdock, giant	9	12.9	8.5	10	10	50.3	13
Common groundsel	4.8	5.6	25	10	1	46.4	13
Common tansy	4.2	13.3	6	10	10	43.5	14
Dalmatian toadflax	7.4	7.7	2.5	10	1	28.5	14
Field bindweed	1.6	5.6	25	10	1	43.2	14
Field scabious	0.1	5.3	3.5	10	10	28.9	15
Goat's beard	15	15	6	1	1	38	15
Hoary alyssum	0.5	9.1	4	25	10	48.5	15
Hoary cress	1	15	16.5	10	10	52.5	16
Hound's tongue	0.8	14	21.5	10	1	47.3	16
Knapweed, diffuse	2.5	7.7	2.5	10	1	23.6	17
Knapweed, meadow	0.5	9.5	6	10	1	26.9	17
Knapweed, Russian	0.5	9.4	7.5	10	10	37.4	17

Species	CGS[1]	PGS[2]	ScOI[3]	SeOI[4]	MMRS[5]	Rating	Page
Knapweed, spotted	2.4	10	6	10	10	**38.4**	18
Leafy spurge	2.3	9.8	6	10	1	**29.1**	18
Marsh arrowgrass	0.6	8.5	7.5	25	10	**51.6**	19
Mountain bluet	0	0	2.5	10	10	**22.5**	19
Mustard, field	1.7	5.6	23.5	10	1	**41.8**	19
Mustard, wild	1.7	5.6	23.5	10	1	**41.8**	20
Orange hawkweed	12.7	11.5	16.5	10	10	**60.7**	20
Oxeye daisy	12.9	11.6	16.5	10	10	**60.9**	20
Perennial pepperweed	0.6	12.9	25	10	10	**58.5**	21
Quackgrass	6.5	6.5	25	10	10	**58**	21
Scentless chamomile	5.3	4.5	2.5	10	1	**23.3**	22
St. John's wort	7.3	10	12.5	10	1	**40.8**	22
Sulphur cinquefoil	2.5	7.7	2.5	10	10	**32.7**	23
Tall yellow buttercup	12.9	11.6	12.5	10	10	**56.9**	23
Thistle, bull	12.8	14.1	19.5	10	1	**57.4**	23
Thistle, Canada	12.8	14.1	25	10	10	**71.9**	24
Thistle, marsh plume	0.3	5.9	3.5	10	10	**29.7**	24
Thistle, nodding	5.4	4.6	2.5	10	1	**23.5**	24
Thistle, plumeless	0.5	9.8	25	10	1	**46.3**	25
Wild chervil	0	0	6	10	10	**26**	25
Wild parsnip	0.1	4.9	3.5	10	10	**28.5**	25
Yellow flag iris	0.4	4.2	5	10	10	**29.6**	26
Yellow hawkweeds	10.2	10.1	6	10	10	**46.4**	26
Yellow rattle	15	15	6	10	10	**56**	27

1. Current geographic scope.
2. Potential geographic scope.
3. Scale of impact.
4. Severity of impact.
5. Management, monitoring and research support.

A brief description of each priority weed species, together with details on the potential impacts on the agricultural sector and management options used in this ranking are provided in the sections that follow.

3.1.1 Baby's-breath (*Gypsophila paniculata*)

Cariboo Priority Pest Rating: 29.6

Current Distribution: Small, localized infestations throughout the region.

Potential Distribution: Highly disturbed rangeland sites in the BG zone.

Agricultural Impacts: Forage displacement.

Description: Multi-branched perennial herb with small white flowers in diffusely branched clusters. Has a profuse, woody root system.

Management: Hand pulling and chemical controls; because of the large root system, both may only show partial success.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al.*, 2014.

3.1.2 Black Henbane (*Hyoscyamus niger*)

Cariboo Priority Pest Rating: 35.5

Current Distribution: A few localized infestations in the Chilcotin.

Potential Distribution: Unimproved pasture and rangeland in the IDF zone.

Agricultural Impacts: Forage displacement; non-preferred species by livestock.

Description: A 1-m tall annual or biennial plant. Entire plant is covered in small hairs. Long, wide leaves and tubular greenish-yellow flowers with purple veins borne on spikes.

Management: Mowing, hand pulling and burning to kill the seeds or chemical controls. Take care in handling: black henbane is poisonous to humans.

References: CCCIPC, 2017; Klinkenberg, 2017.

3.1.3 Blueweed (*Echium vulgare*)

Cariboo Priority Pest Rating: 35.9

Current Distribution: Small, localized infestations throughout the region, with greater distribution in the north Cariboo.

Potential Distribution: Rangeland and unimproved pastures, with sandy or gravelly soils, in the dry forest zone (IDF and PP).

Agricultural Impacts: Forage displacement. Seeds are barbed and can mat in livestock wool and hair.

Description: Biennial to short-lived perennial growing to 1-m tall. Stems covered in stiff hairs. Clusters of bright blue flowers grow on the upper side short stems.

Management: Avoid soil disturbance to prevent re-establishment. Repeated cutting or mowing is effective if conduced before seed head formation. Chemical control options exist.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.4 Burdock, Common (*Arctium minus*)

Cariboo Priority Pest Rating: 50.3

Current Distribution: Widely distributed throughout the region.

Potential Distribution: Rangeland, unimproved pastures and farmyards with fertile soils, in the BG, ICH, IDF, MS, PP and SBS zones.

Agricultural Impacts: Forage displacement. Barbed seed heads can mat livestock wool and hair.

Description: Biennial, growing to 1- to 3-m tall. Tap-rooted. Lower leaf stalks are hollow. Flower heads less than 2.5 cm diameter scattered along the stem. Rounded flower head with hooked spines.

Management: Avoid soil disturbance to prevent re-establishment. Herbicide control for first year plants and cutting or digging to stop seed production or spread on second year plants.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014

3.1.5 Burdock, Giant (*Arctium lappa*)

Cariboo Priority Pest Rating: 50.3

Current Distribution: Widely distributed throughout the region.

Potential Distribution: Rangeland, unimproved pastures and farmyards with fertile soils, in the BG, CWH, IDF, PP and SBS zones.

Agricultural Impacts: Forage displacement. Barbed seed heads can mat in livestock wool and hair.

Description: Biennial, growing to 1- to 3-m tall. Tap-rooted. Lower leaf stalks are solid. Flower heads greater than 2.5 cm diameter and clustered. Rounded flower head with hooked spines.

Management: Avoid soil disturbance to prevent re-establishment. Herbicide control for first year plants and cutting or digging to stop seed production or spread on second year plants.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al.*, 2014.

3.1.6 Common Groundsel (*Senecio vulgaris*)

Cariboo Priority Pest Rating: 46.4

Current Distribution: Widely distributed throughout the region.

Potential Distribution: Cultivated fields in the CWH, ESSF, IDF, PP, and SBS zones.

Agricultural Impacts: Competitor of field and horticultural crops. Consumption of large volumes can cause liver damage in cattle.

Description: Annual or biennial, growing to 60-cm tall. Highly lobed leaves. Small yellow flowers. Black-tipped seed bracts. Seeds spread in the wind.

Management: Hand pulling. Chemical controls effective, though some groundsel populations have developed resistance to triazine herbicides. Crop rotation with perennial cover for at least 2 growing seasons.

References: Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.7 Common Tansy (*Tanacetum vulgare*)

Cariboo Priority Pest Rating: 43.5

Current Distribution: Widely distributed, localized infestations, throughout the region.

Potential Distribution: Pasture and rangeland with fertile soils in the BG, CWH, ESSF, IDF and SBS zones.

Agricultural Impacts: Forage displacement.

Description: Perennial, growing to 1.8-m tall. Rhizomatous roots. Deeply divided, dark green leaves with serrated edges. Small yellow, button flowers in clusters on the top of the plant.

Management: Repeated mowing prior to seed set. Hand pulling effective if the root is removed. Wide range of effective chemical controls available.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.8 Dalmatian Toadflax (*Linaria dalmatica*)

Cariboo Priority Pest Rating: 28.5

Current Distribution: Scattered, localized infestations, throughout the region.

Potential Distribution: Rangeland in the BG, ICH, IDF and PP zones.

Agricultural Impacts: Forage displacement.

Description: Tap-rooted perennial, growing to 1.2-m tall. Waxy, heart-shaped green leaves clasp the stem. Yellow, snap dragon-like flowers grow along a spike.

Management: Repeated mowing or cutting prior to seed set. Fall application of chemical controls. Highly effective biological control, the stem weevil, *Mecinus janthinus*.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.9 Field Bindweed (*Convolvulus arvensis*)

Cariboo Priority Pest Rating: 43.2

Current Distribution: Widely distributed throughout the region.

Potential Distribution: Cultivated soils in the BG, ESSF, ICH, IDF and PP zones.

Agricultural Impacts: Competitor with field and horticultural crops.

Description: A creeping-rooted perennial, growing prostate to the ground or growing around other plants and objects with vine-like stems. Roots can extend over 5-m into the soil. Arrow-shaped leaves with sharply pointed or rounded basal lobes. Funnel shaped, white or light pink flowers.

Management: Repeated mowing and hand pulling with variable success because of extensive root system. Effective chemical controls are available.

References: Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.10 Field Scabious (*Knautia arvensis*)

Cariboo Priority Pest Rating: 28.9

Current Distribution: Scattered, localized infestations, throughout the region. Larger populations in the North Cariboo.

Potential Distribution: Cool, moist sites in the IDF, ICH and MS zones.

Agricultural Impacts: Forage displacement in pastures.

Description: Tap-rooted perennial, growing to 1.3-m tall. Stems and leaves are covered in short, stiff hairs. Violet to pale blue flowers. A highly prolific seed producer.

Management: Repeated mowing or cutting prior to seed set. Cultivation and reseeding pastures can achieve complete control. Effective chemical controls are available.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al.*, 2014.

3.1.11 Goat's Beard (*Tragopogon dubius*)

Cariboo Priority Pest Rating: 38

Current Distribution: Widely distributed throughout the region.

Potential Distribution: Widely adapted to regional climates, including BG, ESSF, ICH, IDF, MS, PP, SBPS, SBS and SWB zones.

Agricultural Impacts: Forage displacement in rangeland and pastures.

Description: Also commonly referred to as yellow salsify. A tap-rooted biennial to short-lived perennial, growing 0.3 to 1-m tall. Long, grass-like leaves. Stem swollen below the flower head which bears a single yellow, daisy-like flower with long green bracts below the petals.

Management: Mowing or cutting prior to seed set. Can be completely controlled with cultivation and reseeding pastures. Livestock will readily graze early in the growing season. Effective chemical controls are available.

References: Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.12 Hoary Alyssum (*Berteroa incana*)

Cariboo Priority Pest Rating: 48.5

Current Distribution: Scattered, localized infestations, throughout the region.

Potential Distribution: Highly disturbed sites (roadside, ditches) in the IDF zone.

Agricultural Impacts: Poisonous to horses.

Description: Annual to short-lived perennial, growing to 0.7-m tall, with slender tap root. White flowers with deeply notched petals cluster at the ends of the stems.

Management: Minimize the amount of soil disturbance to prevent spread. Hand pulling or cutting prior to seed set. Effective chemical controls are available.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.13 Hoary Cress (*Cardaria draba*)

Cariboo Priority Pest Rating: 52.5

Current Distribution: Common in the south Cariboo. Scattered, localized infestations, elsewhere throughout the region.

Potential Distribution: Occurs on a variety of soil and ecological types, but favours alkaline conditions; BWBS, CWH, ESSF, ICH, IDF, MS, PP, SBPS, SBS and SWB zones.

Agricultural Impacts: Forage displacement in rangeland, hayfields and pastures.

Description: Creeping rooted, perennial, growing 0.1 to 0.6-m tall. Lower, arrowhead-shaped leaves are covered in hairs; upper leaves are hairless. Numerous white flowers with four petals in dense clusters, giving the plant a flat top appearance.

Management: Hand pulling or cutting generally less effective due to expansive root systems. Effective chemical controls available.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al.*, 2014.

3.1.14 Hound's Tongue (*Cynoglossum officinale*)

Cariboo Priority Pest Rating: 47.3

Current Distribution: Scattered, localized infestations, throughout the region.

Potential Distribution: Dry disturbed sites in the BG, ICH, IDF, MS, PP and SBS zones.

Agricultural Impacts: Forage displacement in rangeland and pastures. Barbed seeds can mat in livestock wool and hair. Contains an alkaloid toxic to grazing animals.

Description: A biennial or short-lived perennial growing 0.5 to 1.2-m tall. Large, long leaves resembling a tongue grow first in a rosette. Dull purple flowers bear pyramid-shaped nutlets covered in hooked burs.

Management: Hand pulling or cutting prior to seed set effective. Effective chemical controls available. Biological control with the root-feeding weevil *Mogulones cruciger*.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.15 Diffuse knapweed (*Centaurea diffusa*)

Cariboo Priority Pest Rating: 23.6

Current Distribution: Scattered, localized infestations, throughout the region.

Potential Distribution: Dry rangeland in the BG, ICH, IDF and PP zones.

Agricultural Impacts: Forage displacement.

Description: A biennial to short-lived perennial, growing to 1-m tall. Overwinters as a low-growing rosette of highly divided, 15-cm long leaves, with a multi-branched stem bolting in late spring. Small white, or sometimes pinkish, flowers form on stem tips. Flower bracts have a short, stiff spine. A very prolific seed producer.

Management: Repeated mowing or cutting prior to seed set. Repeated hand pulling. Control with herbicides if applied before seed set. A number of successful biological controls available including a root boring beetle and moth, two seed head gall flies and a seed head weevil.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al.*, 2014.

3.1.16 Meadow Knapweed (Centaurea x moncktonii)

Cariboo Priority Pest Rating: 26.9

Current Distribution: Scattered, localized infestations, in the North and South Cariboo.

Potential Distribution: Disturbed, overgrazed sites in the ICH and IDF zones.

Agricultural Impacts: Forage displacement in unimproved pasture and rangeland.

Description: Deeply-rooted perennial, growing to 1.1-m tall. 10-cm long leaves of various form including entire, toothed or lobed. Small pink to purple flowers are enclosed by short bracts with tan to dark brown coloured tips are borne on erect, hairy stems.

Management: Hand pulling or cutting before seed set. Effective chemical controls available. Biological control options include a seed feeding weevil (*Larinus obtusus*), a seed feeding moth (*Metzneria paucipunctella*) and seed feeding fly (*Urophora quadrifasciata*).

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.17 Russian Knapweed (*Acroptilon repens*)

Cariboo Priority Pest Rating: 37.4

Current Distribution: Scattered, localized infestations in the South and Central Cariboo, Chilcotin.

Potential Distribution: Heavy textured soils in the drier PP and IDF zones.

Agricultural Impacts: Forage displacement in pastures and rangeland; consuming large volumes can cause neurological impairment in horses.

Description: A creeping-rooted perennial, growing up to 1.2-m tall. Many branched, erect stems with long, elliptical leaves. Branch tips bear 1-cm flower heads with green bracts and no spines. Flowers range in colour from pink, white to lavender.

Management: Repeated mowing to ground level and hand pulling. Effective chemical controls are available. Biological control options include a gall-forming nematode and a rust fungus.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.18 Spotted Knapweed (*Centaurea stoebe*)

Cariboo Priority Pest Rating: 38.4

Current Distribution: Well established in the North, South and Central Cariboo. Isolated, localized infestations in the Nazko area and Chilcotin.

Potential Distribution: Open sites with well-drained soils in the PP, IDF, ICH, MS and ESSF zones.

Agricultural Impacts: Forage displacement in unimproved pastures and rangeland.

Description: A biennial or short-lived perennial, growing up to 1-m tall. Growing from a basal rosette in the first year, a many branched stem forms with pinnately-divided, dull green leaves. Solitary flower heads with dark fringe on the bracts resembling a black spot at the tip. Flowers may be pink, purple or white.

Management: Repeated mowing to ground level and hand pulling. Effective chemical controls are available. Many biological control options including a root feeding moth (*Agapeta zoegana*), a root feeding weevil (*Cyphocleonus achates*), two seed feeding weevils (*Larinus minutus* and *L. obtusus*) and a seed feeding moth (*Metzneria paueipunctella*).

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al.*, 2014.

3.1.19 Leafy Spurge (*Euphorbia esula*)

Cariboo Priority Pest Rating: 29.1

Current Distribution: Scattered, localized infestations, throughout the region.

Potential Distribution: Disturbed, overgrazed sites in the PP, ICH and IDF zones.

Agricultural Impacts: Forage displacement in rangeland.

Description: Deeply-rooted perennial, growing 0.8- to 1-m tall. Narrow, 10-cm long leaves. Small flowers enclosed within showy, lime-green to pale yellow, heart-shaped bracts. Stems and leaves exude a milky, latex when wounded.

Management: Hand pulling or cutting generally less effective due to the extensive root systems. Effective chemical controls are available. Effective biological controls available. Sheep and goats will readily graze.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.20 Marsh Arrowgrass (*Triglochin maritima*)

Cariboo Priority Pest Rating: 51.6

Current Distribution: Widely distributed throughout the region.

Potential Distribution: Wetlands and wet meadows in the BG, BWBS, CWH, ESSF, ICH, IDF, MS, PP, SBPS, SBS and SWB zones.

Agricultural Impacts: Toxic to livestock.

Description: Aquatic or semi-aquatic perennial herb, 0.3- to 1-m tall, with extensive rhizomes. All leaves are basal, growing in a tuft and giving rise to a leafless flower spike bearing inconspicuous green-brown flowers.

Management: Hand pulling or cutting. Effective chemical controls are available, but herbicide use is generally restricted by proximity to aquatic habitats. Complete drainage of soils renders the habitat unsuitable to arrowgrass.

References: Klinkenberg, 2017.

3.1.21 Mountain Bluet (*Centaurea montana*)

Cariboo Priority Pest Rating: 22.5

Current Distribution: Scattered, localized infestations, throughout the region.

Potential Distribution: Disturbed, unshaded sites in the SBS zone.

Agricultural Impacts: Forage displacement in rangeland.

Description: Perennial, growing 0.3 to 0.8-m tall. Lance-shaped leaves with a light woolly underside. Blue to blue-purple 'cornflower' like flowers.

Management: Hand pulling or cutting before seed set to reduce reproduction; can re-bolt from cut stems. Effective chemical controls are available.

References: CCCIPC, 2017; Klinkenberg, 2017.

3.1.22 Field Mustard (*Brassica rapa*)

Cariboo Priority Pest Rating: 41.8

Current Distribution: Widely distributed throughout the region.

Potential Distribution: Cultivated fields in the BG, ICH, IDF, MS and PP zones.

Agricultural Impacts: Competes with forage and field crops.

Description: Many other common names, including wild mustard. An annual to biennial growing to 0.5-m tall. Wavy toothed leaves clasp the stalk. Terminal clusters of small yellow flowers.

Management: Hand pulling for small infestations. Zero till or minimum till cultivation to minimize the amount of soil without cover. Crop rotation with perennial crops for at least two growing seasons. Several effective chemical controls are available.

References: Klinkenberg, 2017.

3.1.23 Wild Mustard (*Sinapis arvensis*)

Cariboo Priority Pest Rating: 41.8

Current Distribution: Widely distributed throughout the region.

Potential Distribution: Cultivated fields in the BG, ICH, IDF, MS and PP zones.

Agricultural Impacts: Competes with forage and field crops.

Description: A fibrous-rooted annual growing 0.3 to 1-m tall. Thick stems with stiff hairs near the base. Under surface of leaves hairy on the mid-vein. Large oblong, wavy toothed leaves clasp the stalk. Terminal clusters of bright yellow, four-petaled flowers.

Management: Hand pulling for small infestations. Zero till or minimum till cultivation to minimize the area of soil without cover. Crop rotation with perennial cover for at least two growing seasons. Several effective chemical controls are available.

References: Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.24 Orange Hawkweed (*Hieracium aurantiacum*)

Cariboo Priority Pest Rating: 60.7

Current Distribution: Widespread infestations throughout the region, except the Chilcotin. Heavy infestation in the North Cariboo and Nazko corridor.

Potential Distribution: Low fertility hayfields, pastures and rangeland in the ESSF, ICH, IDF, PP, SBPS, SBS and SWB zones.

Agricultural Impacts: Forage displacement.

Description: A perennial, growing up to 0.3-m tall, with shallow, fibrous roots and extensive stolons. Hairy, spatula-shaped leaves are mostly basal. Flowers are orange to red-orange, with a lighter coloured centre. Stems and leaves exude a milky latex when wounded.

Management: Mowing or hand pulling before seed set may not be effective if it stimulates regrowth from the stolons. A relatively poor competitor, fertilizer application to stimulate forage growth can reduce hawkweed populations. Effective chemical controls are available.

References: CCCIPC, 2017; Dobb, 2013; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.25 Oxeye Daisy (*Leucanthemum vulgare*)

Cariboo Priority Pest Rating: 60.9

Current Distribution: Widespread infestations throughout the region.

Potential Distribution: Widely adapted to regional soils and climate; CDF, CWH, ESSF, ICH, IDF, MS, PP, SBPS and SBS zones.

Agricultural Impacts: Forage displacement in hayfields, pastures and rangeland.

Description: A perennial, growing up to 1-m tall, with rhizomatous roots. Lower leaves are spoon shaped and dissected; upper leaves are narrower and clasp the stem. Flowers are white with a yellow centre, resembling daisies.

Management: Mowing or hand pulling before seed set; may not be effective if it stimulates regrowth from the rhizomes. A relatively poor competitor, fertilizer application to stimulate forages

can reduce oxeye daisy populations. Effective chemical controls are available. Unpalatable to cattle and pigs, but will be grazed by sheep, goats and horses.

References: CCCIPC, 2017; Dobb, 2013; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.26 Perennial Pepperweed (*Lepidium latifolium*)

Cariboo Priority Pest Rating: 58.5

Current Distribution: One site in the south Cariboo.

Potential Distribution: Well-drained, often saline sites in the BG, IDF and PP zones.

Agricultural Impacts: Forage displacement in pastures and crop land.

Description: A perennial with creeping roots, growing up to 2-m tall. Leaves are lance shaped, have a prominent white mid-vein and are waxy. Small, white flowers form in dense, rounded clusters.

Management: Mowing and spring burning before seed set. Hand pulling is usually ineffective. Effective chemical controls are available.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.27 Quackgrass (*Elymus repens*)

Cariboo Priority Pest Rating: 58

Current Distribution: Widespread throughout the region.

Potential Distribution: Widely adapted to regional soils and climate; BG, BWBS, CWH, ESSF, ICH, IDF, MS, PP, SBPS and SBS zones.

Agricultural Impacts: Forage displacement in pastures and hayfields. Competes with other field crops and impedes cultivation. Quackgrass is a potential host of the Hessian fly (*Mayetiola destructor*); hay exports to some countries must be free of any host plant material of this pest, thereby limiting the market for hay infested with quackgrass.

Description: An aggressive perennial grass with profuse, white rhizomes, growing up to 1-m tall. Base of leaf blades with a claw-like appendage that clasps around the hollow stems.

Management: Vigorously regenerates from very small rhizome fragments, making mechanical control (e.g. tillage, discing) difficult. Hand pulling and mowing are ineffective. Effective chemical controls are available. Prolonged use of thick mulching on the soil surface may sometimes be effective if plants at the field margins are also controlled.

References: Dobb, 2013; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.28 Scentless Chamomile (*Tripleurospermum inodorum*)

Cariboo Priority Pest Rating: 23.3

Current Distribution: Widely distributed throughout the region.

Potential Distribution: Highly disturbed sites in the PP, IDF and ICH zones.

Agricultural Impacts: Forage displacement in rangeland.

Description: An annual to short-lived biennial, growing up to 1-m tall. Fern-like leaves on multi-branched stems end in a daisy-like flower, white petals with a yellow centre. A prolific seed producer. Sometimes confused with oxeye daisy; scentless chamomile has no odour when foliage is crushed.

Management: Repeated mowing and hand pulling. Effective chemical controls are available. A weak competitor, management to improve the vigour of desired forages will displace this weed (e.g. fertilizer, rotational grazing). Biological control options include a seed feeding weevil (*Omphalon hookeri*), a stem mining beetle (*Microplontus edentulus*) and a gall forming midge (*Rhopalomyia tripleurospermia*).

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.29 St. John's Wort (*Hypericum perforatum*)

Cariboo Priority Pest Rating: 40.8

Current Distribution: Well established throughout the region.

Potential Distribution: Overgrazed or disturbed sites in the CWH, ESSF, ICH, IDF, MS and PP zones.

Agricultural Impacts: Forage displacement in pastures and rangeland. Contains toxin that causes photo-sensitivity in livestock.

Description: A rhizomatous perennial, growing from 0.3 to 1-m tall. Oblong leaves perforated with many tiny, transparent dots. Bright yellow, five-petaled flowers grow in flat-topped clusters on rust-coloured stems. A prolific seed producer.

Management: Effective chemical controls. Highly effective biological control including a root feeding beetle (*Agrilus hyperici*), an aphid (*Aphis chloris*), leaf feeding moth (*Aplocera plagiata*) and leaf feeding beetles (*Chrysolina hyperici* and *C. quadrigemina*, *C. varians*). Take care: plant juices can also cause photo-sensitivity in humans.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.30 Sulphur Cinquefoil (*Potentilla recta*)

Cariboo Priority Pest Rating: 32.7

Current Distribution: Scattered, localized infestations, throughout the region with larger populations in the South and Central Cariboo.

Potential Distribution: Wide range of soil types in the BG, ICH, IDF, MS and PP zones.

Agricultural Impacts: Forage displacement in rangeland.

Description: A tap-rooted perennial, growing from 0.3- to 0.8-m tall. Stems and leaves have scattered, erect hairs. Leaves divided into 5 to 7 leaflets in a palm shape. Bright pale to sulphur-yellow flowers have five heart-shaped petals.

Management: Repeated mowing and hand pulling with variable success because of regrowth from the roots. Effective chemical controls are available.

References: CCCIPC, 2017; Klinkenberg, 2017; Powell, 1996; Ralph *et al*., 2014.

3.1.31 Tall Yellow Buttercup (*Ranunculus acris*)

Cariboo Priority Pest Rating: 56.9

Current Distribution: Widely distributed throughout the region.

Potential Distribution: Moist, rich soils in the BAFA, BWBS, CWH, ESSF, ICH, IDF, MS, PP, SBPS, SBS and SWB zones.

Agricultural Impacts: Forage displacement in wet meadows and pastures. Contains a toxin that can result in pain and inflammation in grazing animals.

Description: Perennial with slender fibrous roots, growing up to 0.9-m tall. Upright stems bear deeply lobed, dark green leaves divided into three leaflets in a palm arrangement. Bright yellow waxy flowers with five petals.

Management: Repeated mowing and hand pulling. Effective chemical controls are available, but herbicide use may be limited by the proximity to aquatic and riparian habitats.

References: Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.32 Bull Thistle (*Cirsium vulgare*)

Cariboo Priority Pest Rating: 57.4

Current Distribution: Widely distributed throughout the region.

Potential Distribution: Cultivated fields, pastures and rangeland. Wide adaptability to regional climates; BG, CDF, CWH, ESSF, ICH, IDF, MS, PP and SBS zones.

Agricultural Impacts: Forage displacement.

Description: Tap-rooted biennial, growing to 30- to 150-cm tall. Spiny, winged stems and long, sharp spines on upper surface of the leaves, with smaller spines on the under surface. Flowerhead bracts are tipped with small spines capped in purple flowers.

Management: Avoid soil disturbance to prevent re-establishment. Herbicide control for first year plants, and cutting or digging to stop seed production and spread on second year plants.

References: Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.33 Canada Thistle (*Cirsium arvense*)

Cariboo Priority Pest Rating: 71.9

Current Distribution: Widely distributed throughout the region.

Potential Distribution: Cultivated fields, pastures and rangeland. Widely adapted to regional climates; BG, CDF, CWH, ESSF, ICH, IDF, MS, PP, SBS and SWB zones.

Agricultural Impacts: Forage displacement.

Description: Biennial to short-lived perennial, growing to 1.2-m tall. Extensive creeping roots system. Stalkless dark-green leaves with spiny lobes. White, rose, pink or purple flowers on small, spineless flower heads.

Management: Repeated cutting or mowing to deplete root reserves. Limited success with single application of chemical controls due to the extensive root system. Prescribed grazing is effective on new foliage before spines become firm.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.34 Marsh Plume Thistle (*Cirsium palustre*)

Cariboo Priority Pest Rating: 29.7

Current Distribution: Scattered, localized infestations, throughout the region, with larger populations in the North Cariboo.

Potential Distribution: Moist soils in the ESSF, IDF, ICH and SBS zones.

Agricultural Impacts: Forage displacement in pastures.

Description: Tap-rooted, biennial, growing to 2-m tall. Narrow, spiny leaves. Large clusters of purple to pink flowers form on the end of the stem.

Management: Hand pulling or mowing before seed-set. Does not tolerate cultivation. Complete control is possible with cultivation and reseeding of pastures. Effective chemical controls are available. Biological controls are available with variable success.

References: CCCIPC, 2017; Klinkenberg, 2017.

3.1.35 Nodding Thistle (*Carduus nutans*)

Cariboo Priority Pest Rating: 23.5

Current Distribution: Widespread infestations throughout the region.

Potential Distribution: Disturbed, overgrazed rangeland in the ICH, IDF, MS and PP zones.

Agricultural Impacts: Forage displacement in rangeland.

Description: A biennial, growing up to 2.1-m tall. Long dark-green leaves with a light green midrib, is spiny and deeply lobed. Flowers are solitary, lightly spiny and deep rose to violet in colour. Flower heads tilt or 'nod' at an angle from the stem.

Management: Mowing, cutting or hand pulling is effective if done before seed set; if the root crown is not removed, the thistles may re-bolt. Effective chemical controls are available. Biological control options include two weevils (*Rhynocyllus conicus* and *Trichosirocalus horridus*) and a seed feeding fly (*Urophora solstitialis*).

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al.*, 2014.

3.1.36 Plumeless Thistle (*Carduus acanthoides*)

Cariboo Priority Pest Rating: 46.3

Current Distribution: Scattered, localized infestations, in the Central Cariboo and Chilcotin.

Potential Distribution: Moist, rich soils in the PP, IDF and ICH zones.

Agricultural Impacts: Forage displacement in pastures and crop land.

Description: A tap-rooted biennial, growing up to 1.2-m tall. Stems and flower heads have spiny wings. Narrow, highly dissected leaves. Pink to purple flowers are solitary on the end of branches.

Management: Repeated mowing and hand pulling. Effective chemical controls available. Biological control options include two weevils (*Rhynocyllus conicus* and *Trichosirocalus horridus*).

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.37 Wild Chervil (*Anthriscus sylvestris*)

Cariboo Priority Pest Rating: 26

Current Distribution: Localized infestation in the North Cariboo.

Potential Distribution: Moist, rich soils in the CWH and SBS zones.

Agricultural Impacts: Forage displacement in pastures and rangeland.

Description: A tuberous-rooted biennial to perennial, growing from 0.3 to 1.2-m tall. Roots can extend up to 1.8-m deep in the soil. Stems are hollow with a fringe of hairs. Leaves are fern-like. White flowers form in clusters.

Management: Repeated mowing and hand pulling has variable success because of the deep root system. Effective chemical controls are available.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.38 Wild Parsnip (*Pastinaca sativa*)

Cariboo Priority Pest Rating: 28.5

Current Distribution: Localized infestation in the North and Central Cariboo.

Potential Distribution: Wide range of soil conditions, though typically associated with past disturbance in the IDF zone.

Agricultural Impacts: Forage displacement in pastures and rangeland.

Description: A tap-rooted biennial, growing up to 1.5-m tall. A single stems with toothed leaves in pairs. Yellow-green flowers form in umbrella-shaped clusters. Narrow, highly dissected leaves. Pink to purple flowers are solitary on the end of branches.

Management: Repeated mowing and hand pulling. Effective chemical controls are available.

References: CCCIPC, 2017; Klinkenberg, 2017.

3.1.39 Yellow Flag Iris (*Iris pseudacorus*)

Cariboo Priority Pest Rating: 29.6

Current Distribution: Localized infestations in the Chilcotin, South and Central Cariboo.

Potential Distribution: Aquatic and riparian soils in the IDF zone.

Agricultural Impacts: Minor forage displacement in rangeland; toxic to cattle.

Description: A perennial growing from bulbs, 1- to 1.5-m tall. Erect, flat, sword-like leaves, 0.5- to 1-m long. Large, yellow flowers with petal divided into 3.

Management: Hand pulling or digging. Chemical control options are limited because this plant only grows in riparian and aquatic habitats.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al.*, 2014.

3.1.40 Yellow Hawkweeds (*Hieracium spp.*)

Cariboo Priority Pest Rating: 46.4

Current Distribution: Widely distributed throughout the region. More prominent in North Cariboo and Nazko subregions. Includes closely related species often conflated in identification: meadow hawkweed, also known as, yellow king devil (*H. caespitosum*), queen devil, also known as, yellow devil (*H. glomeratum*), tall hawkweed (*H. piloselloides*), and others.

Potential Distribution: Drier, disturbed phases in the IDF, ICH and SBS zones.

Agricultural Impacts: Forage displacement in pastures and rangeland.

Description: Shallow-rooted perennials, growing up to 1-m tall. Fibrous roots and stolons. Leafless stems branch into multiple flower heads each with a bright yellow, dandelion-like flower. Stems and leaves exude a milky latex when wounded.

Management: Repeated mowing and hand pulling has variable effect because these plants can vigorously re-sprout from underground stolons. Effective chemical controls are available.

References: CCCIPC, 2017; Klinkenberg, 2017; Ralph *et al*., 2014.

3.1.41 Yellow Rattle (*Rhinanthus minor*)

Cariboo Priority Pest Rating: 56

Current Distribution: Widely distributed throughout the region.

Potential Distribution: Wet meadows and moist soils in the BG, BWBS, CWH, ESSF, ICH, IDF, MS, PP, SBPS, SBS and SWB zones.

Agricultural Impacts: Forage displacement in pastures and rangeland.

Description: An annual growing 0.2 to 0.5-m tall. A mottled green-purple stem with opposite, simple leaves, with a serrated margin. Yellow-hooded flowers form in clusters on the end of branches. The seeds are borne in an inflated capsule, which rattles when ripened and dry. Yellow rattle is considered hemi-parasitic, meaning it takes some of its nutrients by tapping into the roots of neighbouring plants.

Management: Hand pulling before seed set. Effective chemical controls are available, though treatment may be restricted due to proximity of yellow rattle habitat to aquatic or riparian zones.

References: Klinkenberg, 2017.

3.2 Insects and Arachnids

The agriculturally-related, priority insect and arachnid (e.g. mites, ticks) pests were identified from the Cariboo Adaptation Strategies plan, producer survey and follow-up interviews. The insect and arachnids identified were screened following methods described in Section 2.1 and the results are summarized in Table 5. A listing of all priority pests sorted by their rating is provided in Appendix 3. A brief description of each species together with details on the potential impacts on the agricultural sector and management options are provided in the sections that follow.

Table 5. Summary of Priority Agricultural Insect and Arachnid Pests in the Cariboo Region.

Species	CGS[1]	PGS[2]	ScOI[3]	SeOI[4]	MMRS[5]	Rating	Page
Alfalfa weevil	5	15	10.5	25	1	**56.5**	29
Apple aphid	10	10	1.8	1	1	**23.8**	29
Apple maggot	0	10	1.8	25	10	**46.8**	30
Black army cutworm	5	15	25	25	10	**80**	30
Brown marmorated stink bug	0	15	25	25	10	**75**	31
Cabbage maggot	15	15	4	25	10	**69**	31
Carrot rust fly	15	15	4	10	10	**54**	32
European fire ant	0	5	6.5	25	1	**37.5**	32
Face fly	15	15	2.5	1	1	**34.5**	33
Grasshopper, clear-winged	15	15	25	25	10	**90**	33
Grasshopper, migratory	15	15	25	25	10	**90**	33
Grey tortrix moth	5	15	10.5	10	10	**50.5**	34
Horn fly	15	15	2.5	1	1	**34.5**	35
Horse bot fly	0	15	1.5	10	1	**32.5**	35
Japanese beetle	0	10	8.1	25	10	**53.1**	36
Large yellow underwing moth	15	15	4	25	10	**69**	36
Onion root maggot	15	15	4	25	10	**69**	37
Rocky Mountain wood tick	10	15	6.5	10	1	**42.5**	37
Spotted wing drosophila	0	10	4.1	25	10	**49.1**	38
True army worm	0	5	25	25	10	**65**	38
Varroa mite	15	15	0.5	25	1	**56.5**	39
Western cherry fruit fly	10	10	1.8	25	1	**47.8**	39
Western corn rootworm	0	10	14	25	10	**59**	40
Western flower thrips	15	15	6.3	10	10	**56.3**	40

1. Current geographic scope; 2. Potential geographic scope; 3. Scale of impact; 4. Severity of impact; 5. Management, monitoring and/or research support.

3.2.1 Alfalfa Weevil (*Hypera postica*)

Cariboo Priority Pest Rating: 56.5

Current Distribution: Isolated pockets throughout the region.

Potential Distribution: All areas.

Agricultural Impacts: One of the most destructive pests of alfalfa crops in Canada. Larvae feed on the young growing tips and then on opened leaves and flower buds.

Description: A snout beetle, approximately 5-mm long, with a stripe down the middle of the back. Larvae have a black head, yellow-green body with three white stripes down the back. Adults overwinter under plant debris and soil, in and around, alfalfa fields.

Management: Monitor fields for signs of feeding damage. Consider applying registered chemical controls at the following crop heights and larval densities:

30 cm height - 1 larvae/stem;

40 cm height - 2 larvae/stem; or,

Any height - 3 larvae/stem.

Timely harvest of the first hay cut interrupts this weevil's development and destroys eggs and larvae. Chemical controls may be required for larger infestations.

References: Goplen *et al*., 1982; Government of Saskatchewan, 2017.

3.2.2 Apple Aphid (*Aphis pomi*)

Cariboo Priority Pest Rating: 23.8

Current Distribution: All areas.

Potential Distribution: All areas

Agricultural Impacts: A common pest of vegetables, ornamental and tree fruit crops. Aphids damage leaves or new growth which may weaken or deform plants. Some spread plant viruses and most secrete honeydew as they feed, which leaves a sticky coating on leaves and fruit and may attract secondary pests. Only reported as a regional agricultural issue on tree fruits.

Description: There are a large number of species in the aphid family can impact agricultural crops. Apple aphids are yellowish-green to light green, winged or wingless. They overwinter as eggs on water sprouts and shoot terminals. Hatching begins as apple leaf buds open in the spring. Females can produce many generations over the summer.

Management: Monitor orchards for infestations starting at flowering. Prevent new infestations by avoiding excessive nitrogen fertilization that promotes succulent growth. A variety of effective control options exist, including biological controls, dormant oil sprays, insecticidal soaps and registered chemical products.

References: BC Ministry of Agriculture, 2016a; BC Tree Fruit Production Guide, 2017.

3.2.3 Apple Maggot (*Rhagoletis pomonella*)

Cariboo Priority Pest Rating: 46.8

Current Distribution: Not in the region, but has been detected in the Prince George area.

Potential Distribution: All areas of the region capable of growing apple (*Malus* spp.).

Agricultural Impacts: A serious pest of apple, crabapple and hawthorn crops. Heavily infested fruit can become mushy and drops prematurely. Light infestations result in rotted fruit in storage.

Description: A black bodied fly with yellowish head and legs, and green eyes. Larvae are white, legless and with no distinct head. Overwinters as pupae under host trees. Adults emerge in late June to early July, through until early October. Females are attracted to ripening fruit to lay eggs. Small depressions appear on the fruit surface where females have inserted eggs. Fruit infested early in the growing season may have a lumpy surface as it matures. Larval damage appears as brown tunnels winding through the fruit flesh. Larvae mature in 13 to 50 days, depending on temperature.

Management: Monitor orchards using sticky traps in host trees prior to June. Sticky traps may also provide a measure of control. Use registered chemicals if presence is confirmed. Do not store fruit bins under host trees to avoid risk of contaminating the bins with larvae or pupae. Clean up all fallen fruit and remove any unmanaged, wild or unsprayed trees within 500 m of the orchard to eliminate outside sources and alternate hosts of this pest.

References: BC Ministry of Agriculture, 2017a.

3.2.4 Black Army Cutworm (*Actebia fennica*)

Cariboo Priority Pest Rating: 80

Current Distribution: Eastern Cariboo around Quesnel and Horsefly Lakes, south to Horse Lake.

Potential Distribution: All areas of the region.

Agricultural Impacts: A serious forest pest, black army cutworms sporadically impacts a variety of forage, cereal, vegetable and horticultural crops.

Description: A brownish black moth with approximately 40-mm wingspan. Eggs hatch in the fall and overwinter in the soil as larvae. Larvae are velvety black on the top with two fine, white lines running the full length of each side; the underside is gray. Feeding on new vegetative growth begins soon after snow melt in the spring. Pupation and moth emergence occurs in July through September, depending on the weather.

Management: Monitor for larval emergence in early spring. A variety of control options exist including registered chemicals and biological agents. Provide adequate irrigation; plants with drought stress are more susceptible to cutworm impacts. Arid, drought-prone sites, with sparse vegetation cover are most vulnerable to this insect.

References: Ross and Ilnytzky, 1977.

3.2.5 Brown Marmorated Stink Bug (*Halyomorpha halys*)

Cariboo Priority Pest Rating: 75

Current Distribution: Not currently in the region.

Potential Distribution: All areas capable of supporting field and horticultural crops.

Agricultural Impacts: A highly damaging pest, feeding on a wide variety of berries and tree fruits, vegetables and ornamentals.

Description: Shield-shaped, 13- to 17-mm long, brown marbled appearance, alternating brown and white markings on the outer edge of the abdomen. Distinguished from other stinkbugs by smooth shoulders and white bands on the antennae.

Management: There are currently few registered chemical controls. This insect moves easily in shipping containers, wood products, wood packing material, shipping boxes and vehicles. Inspect any items or vehicles coming from infested areas. Report any sightings immediately to the BC Ministry of Agriculture.

References: BC Ministry of Agriculture, 2017b; Philip and Jesperson, 2008.

3.2.6 Cabbage Maggot (*Hylemya brassicae*)

Cariboo Priority Pest Rating: 69

Current Distribution: Widely distributed throughout the region.

Potential Distribution: All horticultural operations of the region.

Agricultural Impacts: A destructive pest of cabbage, cauliflower, broccoli, Brussels sprouts, radish and turnip**.**

Description: This fly overwinters as pupae and emerges from late May through June. Adults are gray with black stripes on the thorax, and resemble houseflies. Eggs are laid in the soil near plants. Larvae emerge and feed on the roots, creating multiple tunnels. Root injury by the larvae results in stunted growth or death of the plants.

Management: Monitor for adult emergence with sticky traps. Treatments must be applied before eggs hatch. Registered insecticides incorporated into the soil prior to planting or seeding, or applied at regular intervals to the foliage and soil surface thereafter. Some cabbage maggot populations are resistant to organophosphate insecticides.

References: Alberta Agriculture Food and Rural Development, 1996.

3.2.7 Carrot Rust Fly (*Psila rosae*)

Cariboo Priority Pest Rating: 54

Current Distribution: Widely distributed throughout the region.

Potential Distribution: All horticultural operations of the region.

Agricultural Impacts: Damage and dis-form carrots.

Description: A fly that overwinters in the soil in the pupal stage. Adults begin to emerge in late May, after an accumulation of 250 degree-days. Adult are slender, shiny black, about 6-mm long, with a small reddish head and long, yellow legs. Eggs are deposited into the soil around the base of carrots. Larvae feed on root hairs and small roots, progressing to their third moult, when they enter the main carrot root to complete their development.

Management: Adults can be monitored with yellow sticky traps and they also provide a measure of control. A low flier, high perimeter soil berms around carrot crops may interrupt adults from finding egg laying locations. Registered chemical controls can be applied after confirmation of adult presence.

References: Borsato, 2017; Stevenson and Chaput, 1993.

3.2.8 European Fire Ant (*Myrmica rubra*)

Cariboo Priority Pest Rating: 37.5

Current Distribution: Not present in the region.

Potential Distribution: Can persist in areas with greater than 680 mm annual precipitation and a mean annual temperature above 6ºC. Currently no areas in the region meet this profile. With climate change, all agricultural areas may surpass the temperature level, but none will have the required precipitation. This species, therefore, is only a future threat to irrigated pastures.

Agricultural Impacts: Painful stings on livestock; it can swarm and attack aggressively if disturbed. Pastured livestock are at risk, with the potential for young animals to be killed.

Description: A small (5-mm long) red to brownish-red coloured ant with two waist segments (native ant species have only one). Creates no visible mounds, but rather nests are formed below the soil surface with a small entry hole hidden by vegetation, debris or stones.

Management: Prevent new infestation through careful inspection of soil, mulch or plants imported from known areas of infestation. European fire ants primarily forage for food within 1-m of their nests. Locate nest sites by placing apple slices on the ground in a grid pattern and monitor ant density. Fire ants can also be baited to a 2% boric acid in sugar solution. Once nest sites are located, ants can be eradicated by treating the soil with registered insecticides. Reduce or eliminate irrigation and remove anything from the soil surface that will trap and hold heat and moisture.

References: Higgins, 2017; Invasive Species Council of BC, 2014.

3.2.9 Face Fly (*Musca autumnalis*)

Cariboo Priority Pest Rating: 34.5

Current Distribution: All areas of the region.

Potential Distribution: All areas of the region.

Agricultural Impacts: Adults feed on secretions from the eyes, nose and lips of livestock. Face flies are bloodsuckers, but unable to pierce the skin, they are attracted to open wounds or sores. They distress cattle, resulting in less grazing time and lower weight gains or milk production. Blindness can result from flies feeding around the eyes.

Description: Face flies overwinter as adults, emerging in March to early April. Females lay eggs in cow dung or other excrement, where they hatch into larvae and feed within hours. Larvae are off-white, 8- to 19-mm long. They pupate in the ground. Adults resemble the common housefly, though slightly larger. Face flies prefer moist, shaded pastures and may be seen in large numbers resting on rocks or fence posts. Several generations per year are possible.

Management: There are several repellents to discourage the feeding activities and registered topical insecticides are available, providing complete control. Keep barn and livestock confinement areas clean of manure. Rotational grazing systems will move animals away from infected fields. Promptly treat livestock injuries and sores to eliminate feeding sites on the animals.

References: Clark, 2015; Pickens and Miller, 1980.

3.2.10 Grasshoppers (*Camnula pellucida; Melanoplus sanguinipes*)

Cariboo Priority Pest Rating: 90

Current Distribution: Grasslands and openings in the dry forest (BG, PP and IDF zones); occasional outbreaks elsewhere when conditions are optimal.

Potential Distribution: All agricultural areas in the region.

Agricultural Impacts: The most destructive insect pest of forages in the region, impacting rangeland, pastures and field crops of all types. Normally light damage every year; episodic outbreaks can result in extensive damage. Large-scale grasshopper outbreaks have been recorded in the Chilcotin since the 1890s and have reoccured within every decade since. The oldest range reference area in the region was established at Riske Creek in 1923 for grasshopper monitoring.

Description: Clear-winged grasshopper (*Camnula pellucida*); the first instar is very small, dark brown-black with a clearly visible white stripe around the body. Adults have yellow-orange hindlegs. Migratory grasshopper (*Melanoplus sanguinipes*); adult forewings have rows of small, dark rectangular spots that look like aircraft windows. Eggs look like brown rice and are laid in the fall in pods, about 2-cm deep in the soil. Clear-winged grasshoppers tend to lay their eggs in around sloughs and depressions in rangelands, as well as unbroken sod along roadsides, fences and pastures. Migratory grasshoppers tend to lay egg pods on drier hillsides and in weedy areas, especially where the sod has been disturbed and the vegetation is sparse. Grasshoppers have only one generation per year in Canada, however, hatching may be turned on or off by periods of warmer or cooler weather, giving the appearance of multiples hatches. Larvae pass through five stages of maturation (instars) before mature adults form.

Management: Overgrazing and poor range condition contribute to favorable habitat for grasshopper development; use appropriate stocking and rotational grazing systems to retain plant

cover in susceptible areas. Tillage of stubble land in the fall can destroy eggs beds of migratory grasshoppers.

Note where grasshoppers lay eggs in the late summer and fall to identify the hatching locations to begin monitoring the following spring. Weather conditions play a major role in grasshopper population increases. Monitor grasshopper density following the Agriculture and Agri-food Canada guidelines and apply chemical controls when threshold levels of 13 nymphs or 10 feeding adults per m^2 are exceeded. Grasshoppers that appear lethargic and hang on vegetation in mid to late summer may be infected with naturally occurring pathogens that can help reduce their numbers. Encouraging healthy bird populations may also provide a measure of control, though past efforts to promote mountain bluebird nesting in the Chilcotin as natural grasshopper control were deemed to have been difficult to quantify results.

References: BC Ministry of Agriculture, 2015a; BC Ministry of Agriculture, Fisheries and Food, 1994; Benn, 2016; Cannings and Scudder, 2005; Johnson, 2008; McLean, 1982; Thistle, 2008; Tisdale *et al*., 1954.

3.2.11 Grey Tortrix Moth (*Cnephasia stephensiana*)

Cariboo Priority Pest Rating: 50.5

Current Distribution: Isolated, localized populations in the Central and North Cariboo.

Potential Distribution: All areas capable of growing an alfalfa crop.

Agricultural Impacts: Feeding damage on alfalfa.

Description: A grayish-white moth with an 18-to 22-mm wing span. Larvae vary in colour from brownish-black to yellowish. Overwinter as young larvae in cocoons. Emerges in the early summer, larvae feed on alfalfa leaves and also spin and fold leaves together.

Management: Monitor alfalfa fields and harvest the hay crop before extensive feeding damage occurs. There are no registered chemical controls in Canada for this moth. Biological control can be provided by a parasitic wasp (*Scambus canadensis*).

References: Acheampong, 2016.

3.2.12 Horn Fly (*Haematobia irritans*)

Cariboo Priority Pest Rating: 34.5

Current Distribution: Present throughout the region.

Potential Distribution: All livestock producing areas.

Agricultural Impacts: Blood sucking from cattle.

Description: Small, gray flies (about one-half the size of house flies) that aggregate densely on the backs, sides, bellies and polls of cattle. They can feed on blood up to 20 to 30 times per day. Females deposit eggs in fresh manure; larvae migrate into the soil beneath the manure to mature. Adults emerge in 10 to 20 days and are capable of flying long distances in search of a host. Multiple generations are possible per season.

Management: Monitor fly numbers on cattle weekly in season and provide back rubbers, dust bags, insecticidal ear tags, pour-ons, oral larvicides and sprays when numbers reach more than 200 flies per animal. Keep barns and livestock confinement areas clean of manure. Rotational grazing systems will move animals away from infected fields. Patch burning of pastures has also been effective at reducing horn fly populations.

References: Clark, 2015.

3.2.13 Horse Bot Fly (*Gasterophilus intestinalis*)

Cariboo Priority Pest Rating: 32.5

Current Distribution: Isolated occurrences in the region.

Potential Distribution: All equine are at risk.

Agricultural Impacts: Internal parasite of horses and donkeys. Loss of appetite, weight loss, and distress.

Description: A small fly, between 1.5- to 2-cm long; it resembles a bee with black and yellow hairs covering the body. Females lay yellow-colored eggs onto horse's legs, neck and around the nose and muzzle. The eggs hatch within five days, stimulated by the horse biting or licking them. Maggots either crawl into the mouth or are ingested and subsequently bury themselves in the tongue and gums. They remain in the oral cavity for approximately one month before migrating to the stomach where they attach to the lining with their hooked mouths. The larvae dig into the stomach tissue and can cause many gastric problems for the next 8 to 10 months. The larvae pass in the horse's manure and pupate in the excrement.

Management: Regularly clean manure from barn and livestock confinement areas. An insecticide can be applied weekly during the peak egg laying season to the areas of the body covered with bot eggs. Seek guidance from a veterinarian for treatments once the larvae are inside the horse.

References: University of Florida, 2017.

3.2.14 Japanese Beetle (*Popillia japonica*)

Cariboo Priority Pest Rating: 53.1

Current Distribution: Not in the region.

Potential Distribution: All areas with horticultural production are at risk.

Agricultural Impacts: Turf is the favoured host, but the roots of other plants are also attacked. Adults are heavy feeders, attacking both foliage and fruit of more than 250 different host species. Adult beetles consume the tissue between leaf veins, removing large, irregularly shaped portions or leaving a 'skeleton' of vein tissue.

Description: Oval-shaped beetles, approximately 10-mm long and 6-mm wide; the abdomen, thorax and head are metallic green with metallic copper-brown wing coverings and contrasting white tufts of hair along the sides and rear of the abdomen. There is only one generation per year. Adults appear in summer and are very active for about 6 to 8 weeks. Larvae are 'C'-shaped, creamy white with a yellowish-brown head.

Management: Monitor for infestations and report any sightings immediately to the BC Ministry of Agriculture. Start spraying affected plants with an approved insecticide at the first sign of attack.

References: CFIA, 2017.

3.2.15 Large Yellow Underwing Moth (*Noctua pronuba*)

Cariboo Priority Pest Rating: 69

Current Distribution: Occurs throughout the region.

Potential Distribution: All areas of the region.

Agricultural Impacts: The larvae, commonly referred to as a cutworm, are a common pest of many vegetable crops. Larvae chew through the main stem of seedlings, 'cutting' them off at ground level.

Description: The adult moth is relatively large, with a wingspan of 50- to 60-mm. Fore wings vary in colour from light brown to brown-black; hind wings are bright orange-yellow with a black band. Moths are active at night from the early summer to September. Larva are green or brown with two rows of black markings along the back. Underwing moths overwinter as larvae.

Management: Monitor for damage in the spring. The majority of cutworm damage occurs to vegetables early in the growing season and when plants are small seedlings. If fresh damage is noted, digging the soil in the immediate vicinity to a depth of 2 to 5-cm will expose the larvae for hand picking or applying a registered insecticide. Cutworms often overwinter in weedy areas, pastures or other vegetation in the field margin; control weeds, particularly in the late summer and autumn. Cutworm larvae have many natural predators including parasites, wasps and birds; preserve habitat for beneficial organisms in and around vegetable fields.

References: Chaput, 2000.

3.2.16 Onion root maggot (*Delia antiqua*)

Cariboo Priority Pest Rating: 69

Current Distribution: Occurs throughout the region.

Potential Distribution: All areas of the region.

Agricultural Impacts: Onion maggots are the most damaging insect pest of onions throughout Canada. Larval feeding can destroy an entire onion crop, because maggots continually move to new plants after they kill the host plants they start on.

Description: This fly overwinters as a brown, oval pupae, slightly larger than a grain of wheat. Gray-coloured adults, similar in appearance to a house fly, but with a narrower abdomen, emerge in the spring. In May and June, egg laying occurs coinciding with new onion growth. Adults may also be observed on dandelion stems. The 1-cm long, white maggots emerge and feed on onions at any stage of development. Three generations are possible per year.

Management: Onion root maggot can be very difficult to control and they have developed resistance to many insecticides. Sanitation of onion production fields is very important: regularly remove all dead onions and onion culls from the field. Adult files have many natural predators including wasps and birds; preserve habitat for beneficial organisms in and around vegetable fields. Granular application of registered insecticides can provide control of maggots if timed properly, or by planting onion seed treated with insecticides. Excessive spraying of adults has contributed to this pest building resistance, therefore it is very important to alternate control methods.

References: Ritcey and Chaput, 1998.

3.2.17 Rocky Mountain Wood Tick (*Dermacentor andersoni*)

Cariboo Priority Pest Rating: 42.5

Current Distribution: Widespread throughout the region.

Potential Distribution: All dry, open forests and grasslands with tall ground vegetation.

Agricultural Impacts: Can excrete a toxin causing paralysis in livestock and stock dogs (also rarely in humans). Also a vector for livestock diseases.

Description: An arachnid, this common 5-mm long tick has four sets of legs and lacks antenna. Females have a semi-circular shield on the back. Rocky Mountain tick is a three-host tick; feeding on animal blood and then falling to the ground at each stage of development. Eggs are laid on the ground and larva, with only three sets of legs, emerge to feed on the blood of animals hosts. Nymphs also feed on blood and then develop into adults. Between March and early May, adults perch on the ends of tall grass waiting for a host to pass by. Once attached, females engorge themselves with blood, enlarging up to 10 times their original size to feed egg development.

Management: Regular grooming of horses and stock dogs during tick season. Care should be taken to properly remove ticks with a tick comb or forceps, without squeezing the tick body. Topical application (pour-on, sprays, dust) of a registered chemicals provides excellent control.

References: Higgins, 1999.

3.2.18 Spotted Wing Drosophila (*Drosophila suzukii*)

Cariboo Priority Pest Rating: 49.1

Current Distribution: Not currently in the region.

Potential Distribution: All areas capable of supporting berry or tree fruit production; preferring summer temperatures of 20 to 30ºC.

Agricultural Impacts: Infests a wide variety of soft fruits and berries, including cherry, plum, strawberry, blueberry, blackberry, raspberry, thimbleberry, grape, Oregon grape, currant, and honeysuckle/honey berry. Fruit contaminated with larvae soften, decay and become unmarketable.

Description: Adults flies are light yellow or brown with red eyes, about 2- to 3-mm long. Males have a single black spot on the end of each wing. Females have no spots, but have a distinctive saw-like appendage for depositing eggs. Females lay eggs inside intact ripening fruit leaving a small pin-hole dimple on the surface. Small, white larvae hatch and feed within the fruit; pupa are 3-mm long, legless and a dull brown colour.

Management: Good sanitation practices are key to controlling this fly. Clean up culls and fallen fruit and seal them in plastic bags or freeze for at least 48 hours before disposal; composting the fruit will not kill this fly. Monitor for flies from mid-May onward using apple cider vinegar traps. If detected in the trapping, spraying with registered insecticides provides adequate control.

References: Acheampong and Hueppelsheuser, 2013.

3.2.19 True army worm (*Mythimna unipuncta*)

Cariboo Priority Pest Rating: 65

Current Distribution: Not in the region.

Potential Distribution: Warm, high precipitation subregions.

Agricultural Impacts: Cereals, forage grasses and corn are the primary hosts. When populations are high this insect will feed on broad-leaved plants as well, including many vegetable crops.

Description: Brown delta-shaped, large-bodied moths, about 30-mm long, are only active at night. Adults lay dense egg masses on new growth beginning in April. Larvae, up to 35-mm long, hatch and feed on leaves, and less frequently, seed heads, mostly at night or during cool mornings. Once a crop area is defoliated, the larvae move on mass to adjacent stands.

Management: Outbreaks are unpredictable and extensive crop damage can occur quickly. Field scouting for larvae should being in mid to late June, just after sunset or early in the morning. Apply registered chemical controls if more than 54 larvae per m^2 are detected. Consider cutting, baling, or grazing forage crops earlier to limit crop loss. Don't move crops from infected farms to other locations. Army worm larvae have many natural predators including parasites, wasps and birds; preserve habitat for beneficial organisms in and around production fields.

References: Hueppelsheuser, 2017.

3.2.20 Varroa Mite (*Varroa destructor*)

Cariboo Priority Pest Rating: 56.5

Current Distribution: All agricultural areas in the region.

Potential Distribution: All agricultural areas in the region.

Agricultural Impacts: Parasitizes honey bees. Can cause total colony loss if unmanaged.

Description: Varroa mite was introduced into BC in the early 1990s and rapidly spread to all beekeeping areas of the province. Here, as elsewhere in the world, it remains the most virulent pest of European honeybee production. Mites feed on bee brood and adult honeybees.

Management: Mite eradication is not feasible due to the complex and dynamic interactions between bee and mite populations. Individual chemical and non-chemical controls are usually insufficient on their own for control and mites can re-invade hives quickly after treatment. Successful management of requires integrated approaches, including:

1. Coordinated use of different controls, where none are sufficient on their own;
2. Frequent monitoring of mite population levels;
3. Recording monitoring results to analyze mite population trends; and
4. Application of registered chemical, including oxalic acid, and non-chemical controls (screen floors over sticky traps) to keep mites at manageable levels instead attempting eradication.

References: BC Ministry of Agriculture, 2015b; van Westendorp, 2017.

3.2.21 Western Cherry Fruit Fly (*Rhagoletis indifferens*)

Cariboo Priority Pest Rating: 47.8

Current Distribution: Isolated pockets throughout Central and South Cariboo.

Potential Distribution: All areas capable of growing sour or sweet cherry.

Agricultural Impacts: Larvae feeding on cherry flesh renders them unmarketable.

Description: Adult flies are slightly larger than a house fly, with a black body and yellow markings near the wing base, and white stripes across the abdomen. Wings have black bands. Adults are weak fliers and attack the first cherry tree they encounter. Females deposit eggs into ripening fruit leaving a small shot-hole. Tiny, 5-mm long, white maggots hatch and feed within the cherry for 1 to 2 weeks before dropping to the ground to pupate in the soil.

Management: Good orchard sanitation is key. Remove all fruit from the orchard floor and destroy. Monitor for adult flies with yellow sticky traps; these traps may also provide a low level of control. When presence is noted apply a registered chemical control within 6 days of first detection. For heavy infestations, harvest and destroy the cherry crop to prevent recurrence the following year.

References: BC Tree Fruit Production Guide, 2017.

3.2.22 Western Corn Rootworm (*Diabrotica virgifera*)

Cariboo Priority Pest Rating: 59

Current Distribution: Not in the region.

Potential Distribution: All areas capable of growing field or sweet corn.

Agricultural Impacts: Damages or destroys the root systems of corn, leading to crop loss.

Description: This beetle overwinters as an egg, hatching in the spring, where the tiny, white football-shaped larvae feed on corn roots for 1 month. Larvae pupate in the soil, and adults emerge in July. Adults feed on corn foliage and pollen. The adult beetles are active fliers and will feed on many plants and move to new fields. Adult beetles are 6-mm long, with very long antenna, yellowish-brown in colour with a black stripe on each wing cover.

Management: This pest can be disrupted by crop rotation out of corn every 2 to 4 years. Field scouting should be conducted throughout the growing season. In-furrow sprays of registered chemical controls at planting, or foliar sprays for adults in July or August provide good control.

References: BC Ministry of Agriculture, 2017c.

3.2.23 Western Flower Thrips (*Frankliniella occidentalis*)

Cariboo Priority Pest Rating: 56.3

Current Distribution: Isolated pockets, associated with greenhouse production.

Potential Distribution: All areas of the region.

Agricultural Impacts: Feeds on the blossoms of over 500 different plants, including fruit, vegetable and ornamental crops; most problematic for greenhouse flower growers.

Description: Thrips go through six developmental stages: egg, two larval stages, a pre-pupal and pupal stage, and an adult. At the end of the second larval stage, thrips drop to the ground to pupate on or just below the soil surface. Emerging adults are small, 1-mm long, and vary in colour from yellowish to dark brown. Adults have small feather-like wings and a highly segmented abdomen.

Management: Take preventative measures to keep thrips out; inspect transplants for thrips before introducing them into a greenhouse or other production areas. Cover greenhouse openings with 0.16-mm mesh to prevent insects from entering. Eliminate weeds that may serve as alternate hosts. Monitor greenhouse and production areas with yellow or blue sticky traps; one trap for every 100 m^2. If detected, apply a registered chemical control; rotate between classes of chemical controls to avoid the thrips from developing resistance. There are a number of commercially available biological agents to control thrips in a greenhouse setting.

References: BC Ministry of Agriculture, 2016b.

3.3 Pathogens

The priority diseases of crops and livestock were identified from the Cariboo Adaptation Strategies plan, producer survey and follow-up discussions. These species were screened following methods described in Section 2.1 and the results are summarized in Table 6. A listing of all priority pests sorted by their rating is provided in Appendix 3. A brief description of each species together with details on the potential impacts to the agricultural sector and management options are provided in the sections that follow.

Table 6. Summary of Priority Agricultural Disease Pests in the Cariboo Regional District.

Species	CGS[1]	PGS[2]	ScOI[3]	SeOI[4]	MMRS[5]	Rating	Page
Anaplamosis	0	15	2.5	25	10	52.5	42
Apple scab	10	10	1.8	10	1	32.8	42
Botrytis blight	15	15	4	25	1	60	43
Botrytis neck rot	15	15	4	25	10	69	43
Brown root rot	5	15	10.5	10	1	41.5	44
Ergot	15	15	25	25	1	81	45
Fusarium head blight	0	15	16.5	10	1	42.5	45
Late blight, potato & tomato	5	15	4	25	1	50	46
Phytophthora root rot	5	15	10.5	25	1	56.5	46
Rhizoctonia	5	15	4	10	1	35	47
Verticilium wilt	5	15	10.5	10	1	41.5	47
West Nile virus	0	15	1.5	25	10	51.5	48

1. Current geographic scope
2. Potential geographic scope
3. Scale of impact
4. Severity of impact
5. Management, monitoring and/or research support

3.3.1 Anaplasmosis (*Anaplasma marginale, A. ovis*)

Cariboo Priority Pest Rating: 52.5

Current Distribution: not present in the region.

Potential Distribution: all cattle, sheep, goats and bison at risk.

Agricultural Impacts: ruminant production; impact on animal health ranges from mild anemia in young animals to sudden death in older animals.

Description: Anaplasmosis is an infectious disease of the red blood cells caused by bacteria. It may cause mild to severe impacts in cattle, sheep, deer and goats, and is spread by ticks.

Management: Monitor and report to the Provincial Veterinarian. Outbreaks are usually seasonal and occur during or immediately after the tick breeding season, from March to mid-May in interior BC. Test livestock before importing them from endemic regions: tropical and subtropical regions of the southern United States, Australia, central and south America, Africa and southern Asia. Control the tick vectors: *A. marginale* can be transmitted by Rocky Mountain wood tick (*Dermacentor andersoni*), American dog tick (*D. variabilis*) and winter or moose tick (*D. albipictus*). Examine and treat livestock coming off rangeland with a registered pesticide.

References: Lew-Tabor, 2016; Sharma, 2015.

3.3.2 Apple Scab (*Venturia inaequalis*)

Cariboo Priority Pest Rating: 32.8

Current Distribution: All areas of the region capable of growing apples (*Malus* spp.).

Potential Distribution: All areas of the region capable of growing apples.

Agricultural Impacts: Fruit lesions resulting in skin ruptures and malformed apple crops. Infected fruit may only be suitable for processing, not the fresh market, with reduced yield and value.

Description: Apple scab is a common fungal disease of BC apple crops, particularly with wetter, more humid growing areas. Fruit is the most susceptible when young. As apples mature and the skin thickens, it becomes more resistant to scab, requiring increasingly longer wet periods for infection. Apple scab generally does not kill the trees outright but it can cause premature defoliation, which may weaken the tree and influence its winter survival. The fungi overwinter in infected leaves on the orchard floor. Spores are produced in these dead leaves in the spring when new growth appears on the trees (the green tip stage). The spores are discharged during rainy periods and can be carried long distances by the wind.

Management: Monitor for new scab lesions throughout the growing season, but particularly at green tip stage of leaf growth and ending about two weeks after fruit-set. Plant scab-resistant varieties; minimize overhead sprinkler irrigation to prevent leaf wetting; use pruning, spacing and row orientation to ensure good airflow through the orchard to speed drying of trees when wet; chop, shred, burn or remove infected leaf litter from the orchard floor in the autumn. Apply fungicides after the first sign of new infections; alternate between registered fungicide groups to prevent fungicide-resistant populations from developing. Fungicides may need to be applied every 7 to 14 days during the primary scab season.

References: BC Tree Fruit Production Guide, 2017; Carisse and Jobin, 2006.

3.3.3 Botrytis Blight (*Botrytis cinerea*)

Cariboo Priority Pest Rating: 60

Current Distribution: All agricultural areas in the region.

Potential Distribution: All agricultural areas in the region.

Agricultural Impacts: Wide range of hosts, including tomato, pepper and lettuce crops. Partial to full crop loss in greenhouses, outdoor hoop houses or covered crop tunnels.

Description: Botrytis blight, also known as gray mold, is a fungal disease that appears as a white to smoky-gray coloured dusting that forms lesions, which can result in withering and death of tissues or the entire plant. Infection can occur on all parts of the plant. Stem infections often lead to stem canker, the most destructive form of the disease. Botrytis needs a source of nutrients prior to infection, usually in the form of fluids leaking from plant injuries or dying tissues, such as withering flowers. The mold grows under conditions of high relative humidity (>80%) and is spread by air flow, irrigation or sprays, tools and horticultural workers.

Management: Sanitation is important. Remove dead or dying tissue from plants and the soil surface and dispose of it away from the growing area. If possible, avoid injuring plants and do not leave large stubs on plant stocks when taking cuttings or pruning. Avoid pruning on cool, high humidity days and sanitize pruning equipment before and during work. Provide adequate heat and air flow (e.g. fans) to prevent prolonged high humidity conditions and do not overcrowd plants. Monitor for early signs of infection. Spore formation and spread can be stopped with a spray solution of household dish soap in water. Infections can be treated with registered fungicides or biological controls. Note that some *Botrytis* populations are resistant to certain chemicals.

References: Catherall, 2017; .Holz *et al.*, 2007; Sabaratnam, 2016a.

3.3.4 Botrytis Neck Rot (*Botrytis allii*)

Cariboo Priority Pest Rating: 69

Current Distribution: All agricultural areas in the region.

Potential Distribution: All agricultural areas in the region.

Agricultural Impacts: A post-harvest disease of onion and garlic causing the bulb to rot in storage.

Description: Fungi which can be found on allium crops (onion and garlic) all over the world. Infected bulbs may have a sunken or depressed appearance due to the dried up tissue and feel spongy soft in the neck area. Infections occur during the growing season in the field, residing mainly in the soft, green tissue of the plant 'necks'. Generally the pathogen remains dormant until bulbs start rotting one to two months after they go into storage. Spores are produced on infected, dry leaf tissue or fungal tissue in the soil (viable for up to 2 years) and spreads with the wind.

Management: Prevent spread by burying or disposing of cull plants off-site; infected tissue can provide a source of spores for two or more years. Rotation to non-allium crops for at least 3 years can also decrease soil reservoirs. Plant only uninfected or treated bulbs or seeds. Do not apply nitrogen fertilizers after bulbs have formed to minimize late season green neck tissue. Apply registered fungicides if harvest conditions are anticipated to be wet or humid. Properly dry bulbs

prior to placing in storage. Infections and impacts are worst under storage conditions of high humidity, temperatures above 4ºC and poor ventilation.

References: Holz *et al*., 2007; Nischwitze *et al.*, 2013.

3.3.5 Brown Root Rot (*Phoma sclerotioides*)

Cariboo Priority Pest Rating: 41.5

Current Distribution: isolated pockets, mainly in eastern and northern subregions of the Cariboo.

Potential Distribution: all cultivated forage fields.

Agricultural Impacts: Brown root rot (BRR) can kill single forage plants or patches, or weaken the plants, reducing yields or making them more susceptible to winter damage or other pests. BRR can infect alfalfa, sweet clover, alsike clover, perennial grasses and winter cereal crops.

Description: A low-temperature tolerant, soil-borne fungi that can destroy forage roots. Sometimes referred to as a "snow mold" because it can grow rapidly when the ground is not yet frozen but is covered by snow. Infections appear as dark-brown, circular lesions that expand until the entire root is covered. Dead, shrunken roots may become gray. and brittle, or under prolonged wet conditions, dark and mushy. BRR infections occur sporadically and are highly weather dependent. The fungi becomes active when the ground cools in the fall. Development stops during the coldest parts of winter, but resumes with warmer spring conditions.

Management: Plant winter-hardy cultivars with root crowns set lower into the soil profile, or plant a mixture of forage species in the same crop to minimize exposure to susceptible species. BRR builds up in the soil over time, making older field more susceptible. Rotate crops to non-susceptible species at least every 3 years in infected fields.

References: Goplen *et al*., 1982; Friesen, 2013.

3.3.6 Ergot (*Claviceps purpurea*)

Cariboo Priority Pest Rating: 81

Current Distribution: All agricultural areas in the region.

Potential Distribution: All agricultural areas in the region.

Agricultural Impacts: Fungi fruiting bodies in the seed heads of grass species displace grain production and is also highly toxic to livestock, resulting in weight loss leading to death.

Description: A fungus infecting many grass crops, including forages (bromegrass, orchardgrass, wild rye, wheat grasses, fescues, timothy and reed canary grass) and cereals, including wheat, rye, barley and triticale. Oats are rarely affected. The fungus forms a black body (sclerotia) in the seed head of similar size to the seed kernel. Symptoms of ergot poisoning in livestock include lameness, excitability, belligerence, loss of appetite and weight loss. It can take up to 8 weeks for symptoms to become evident. Pregnant, breeding and lactating animals are the most sensitive to ergot.

Management: Scout fields for early signs of infection and do not allow infected crops to be used as livestock feed. Plant seeds treated with a registered fungicide. Rotate between grasses or cereal crops with broadleaf crops. Deep tillage can be used to bury infected material at the time of seeding. Cut hay or silage before grasses form seed heads to prevent formation of the fungal sclerotia. Do not feed infected forages to livestock. The sclerotia are only capable of infecting other crops for one year but remain toxic to livestock indefinitely.

References: Bailey *et al*., 2003; Manitoba Agriculture, no date.

3.3.7 Fusarium Head Blight (*Fusarium graminearum*)

Cariboo Priority Pest Rating: 42.5

Current Distribution: Not in the region.

Potential Distribution: All agricultural areas in the region, particularly where high humidity occurs in the spring and early summer.

Agricultural Impacts: A disease of wheat, barley, oats and other small cereal grains and corn causing small yield reductions. Contains a mild toxin resulting in weight loss in livestock.

Description: Fungi, recognized in the crops by the premature bleaching of infected spikelets and the production of orange, spore-bearing structures called sporodochia at the base. Infected grains may be chalky white and shrunken, or encrusted in an orange or black coating.

Management: Scout fields for early signs of infection and do not use infected crops as livestock feed. Plant seed treated with a registered fungicide to prevent the disease from establishing. Rotate between grasses or cereal crops with broadleaf crops. Use deep tillage to bury infected material at the time of seeding or on heavily impacted crops in lieu of harvest.

References: Calpas *et al*. 2003.

3.3.8 Late Blight of Potato and Tomato (*Phytophthora infestans*)

Cariboo Priority Pest Rating: 50

Current Distribution: isolated pockets, mainly in eastern and northern subregions of the Cariboo.

Potential Distribution: All agricultural areas in the region.

Agricultural Impacts: The most destructive disease of potato in BC, can result in total crop loss. It can also infect other plant species in the nightshade family, such as tomato.

Description: Late blight is caused by an oomycete (a fungal-like organism). Development depends on wet weather conditions, high humidity and cool to moderate temperatures. It first appears on leaves as small, circular or irregularly shaped, dark lesions. As the infection progresses, the entire plant may decay. Infected potato tubers turn brown and rot from the outside. On tomato, leaf infections are similar, spreading onto the fruit, and eventually destroying it before it ripens. A white, fuzzy mold may develop on the underside of leaves.

Management: Scout fields for early signs of infection and monitor weather conditions. Plant blight resistant varieties. Do not over irrigate with overhead sprinklers. Infections require leaves to be wet for longer than 10 hours and under moderate temperatures favorable to spore production. Do not over fertilize crops with nitrogen; early succulent plant growth is most susceptible to infection. Remove culls and volunteer plants for destruction or deep burial. Avoid replanting fields previously infected with late blight. Control weeds in the night shade family. Selectively use registered fungicides as part of an integrated pest management strategy. Late blight is developing fungicide resistance; rotate controls between different families of fungicides.

References: Philip and Jesperson, 2008; Sabaratnam, 2016b; Smith, 2016.

3.3.9 Phytophthora Root Rot (*Phytophthora megasperma* f.s. *medicagensi*)

Cariboo Priority Pest Rating: 56.5

Current Distribution: Isolated pockets, mainly in eastern and northern subregions of the Cariboo.

Potential Distribution: All agricultural areas in the region.

Agricultural Impacts: Alfalfa roots rot below the soil surface resulting in plant death.

Description: This oomycete disease occurs primarily under wet conditions, on poorly drained soils when temperatures are cool. Yellowish-brown patches form on the root surface, extending to the root crown and may eventually kill the plant, or result in spindly, yellowed plants with poor nodulation.

Management: Plant resistant cultivars. Scout fields for early signs of infection and monitor weather conditions. Drain fields or use other water management (interception ditches, irrigation scheduling) that prevents soils from becoming saturated for prolonged periods.

References: Bailey *et al*. 2003; Goplen *et al*., 1982; Philip and Jesperson, 2008.

3.3.10 Rhizoctonia (*Rhizoctonia solani*)

Cariboo Priority Pest Rating: 35

Current Distribution: Isolated pockets throughout the region.

Potential Distribution: All agricultural areas in the region.

Agricultural Impacts: Reduces potato tuber quality and can also kill potato and other crop seedlings.

Description: A common fungi infecting potato crops. It causes misshapen tubers and a black scurf on the surface, reducing yields and decreasing quality for sale. *Rhizoctonia* can prevent seeds from germinating (pre-emergent damping off), or it can infect and kill very young seedlings (post-emergent damping off). Infected seeds have reddish-brown lesions and seedlings have cankers on the stems and roots.

Management: Plant certified seed, free of infection into warm soil (>8ºC). Harvest crops as soon as the tubers have set; late harvest allows additional time for onset of infection. Increasing the soil organic matter tends to reduce *Rhizoctonia.* The fungi can survive in the soil for many years in the form of sclerotia. Treat tubers with a registered fungicide to prevent scurf from spreading.

References: Ontario Ministry of Agriculture, Food and Rural Affairs, no date; Syngenta Canada, 2017.

3.3.11 Verticillium Wilt of Alfalfa (V*erticillium albo-atrum*)

Cariboo Priority Pest Rating: 41.5

Current Distribution: All agricultural areas in the region.

Potential Distribution: All agricultural areas in the region.

Agricultural Impacts: Kills or weakens alfalfa, making them susceptible to winter damage or other pests. Can cause major yield reductions by the end of the second and third year after planting.

Description: Verticilium wilt is caused by a fungus. The first signs of infection are temporary wilting of the upper leaves and is followed by a general wilting of the entire plant. The affected leaves and stems generally turn white or yellow in colour and the base of the stems may turn gray, dark brown or black.

Management: Early detection and isolation of infected fields is key to slowing dispersal. Wilt can survive on volunteer alfalfa plants and some broad-leaf weeds at the margins of fields and these plants should be treated when alfalfa fields are reseeded. Plant resistant cultivars. The wilt fungi can spread in plant material moved from field to field (such as during winter feeding), or in contaminated hay or manure. Wilt is most severe under irrigation. Reducing irrigation on infected fields can slow the spread.

References: Dobb, 2013; Goplen *et al*. 1982; Manitoba Agriculture, no date.

3.3.12 West Nile Virus

Cariboo Priority Pest Rating: 51.5

Current Distribution: Not present in the region.

Potential Distribution: All equine and avian species.

Agricultural Impacts: Domestic geese, horses, mules and donkeys have the greatest potential to be severely affected, though others may be carriers. Infections can result in impairment or mortality.

Description: West Nile Virus (WNV) is a mosquito-transmitted disease that can cause inflammation of the brain and spinal cord. Horses with WNV can exhibit a range of signs including stumbling, confusion, listlessness, head pressing, lack of appetite, inability to stand, seizures and weakness. In severe cases animals will die. Some horses may have permanent neurological impairment and will need to be euthanized.

Management: There is no treatment for WNV infections. Management centres on prevention through control of the vectors that spread the disease. WNV is transmitted by mosquitoes and can be carried in wild birds including crows and other corvids (ravens, magpies, jays). These species can be used as an early warning of its presence in an area. Only specific mosquitoes spread WNV. In Western Canada, *Culex tarsalis* is the main species of concern, therefore, livestock exposure to mosquitoes should be minimized with insect repellents or smudges, using screened housing and avoiding outdoor activities during dawn and dusk, the peak times of this mosquito's feeding. *C. tarsalis* breeds in small bodies of warm water. Poorly drained eaves troughs, bird baths, discarded rubber tires, mud puddles or any other source of pooled water should be eliminated.

WNV infection in horses, mules and donkeys is a provincially "Notifiable Disease" in BC, requiring a report be made to the Chief Veterinarian within 24 hours if you have reasonable grounds to suspect it has occurred.

References: BC Ministry of Agriculture, 2016c; Office of the Chief Provincial Veterinarian, 2012.

4. Analysis and Recommendations

4.1 Summary of Issues

Overview of Regional Pest Concerns

Consultations with regional stakeholders, together with a scan of relevant information, identified 77 priority agricultural pests, including 41 weed species, 24 insects and arachnids and 12 pathogens. While there are differences in the expression of various pest problems, there was a high degree of overlap in the pest species identified in the Cariboo-Chilcotin, with those in other major farming regions of the province (Eisen, 2016; Jesperson, 2017; RDNO, 2012; Scholefield *et al*. 2016; van Westendorp, 2017). And, indeed, there are no agricultural pest problems unique to the Cariboo Regional District.

The pests identified can be classified into three groupings to inform the regional management strategy (Table 7):

1. Endemic pests, with existing wide or pan-regional distribution, and variable impacts on production;
2. Pests with limited regional distribution, but potentially for expansion; and,
3. Pests not known to be within the region, but which would cause significant impacts if they arrive.

Pests can also be grouped by their relative priority rankings (Table 7). The agricultural pests evaluated had an average priority ranking of 46.9/100 with a standard deviation of 15.2. In consideration of the relative risks, the following categories were established:

- High: Pests with ranking greater than 1 standard deviation above the average;
- Average: Plus or minus 1 standard deviation from the mean rank; and,
- Low: Those with a rating less than 1 standard deviation below the mean.

Most of the agricultural pest problems in the Cariboo Regional District are endemic and of average relative risk (Table 7). Contrary to other areas where climate change is implicated in the northward migration and elevated risk from warm-season (C4) weeds (Holm, 1997; Patterson *et al*., 1999; Walthall et *al*., 2014), the regional weeds identified are overwhelmingly cool-season (C3) adapted. The projected regional climate shifts appear to have a more pronounced effect on extending the ranges of some established weed problems, rather than making conditions suitable for new entrants.

In contrast, the warming temperatures and extended growing seasons evidenced in the climate envelope modeling (Section 2.2), suggests that new, and potentially very damaging, insect and pathogen problems could establish in the region. This is in agreement with the climate change forecasting for expansion in the ranges of insects, arachnids and pathogens across North America (Bale and Hayward, 2010; Hartley *et al*., no date; Scholefield *et al*. 2016; Walthall et *al*., 2014).

Table 7. Priority Pest Groupings for Management

Rating	Endemic	Limited Distribution	Not in the Region
High	Thistle, Canada Orange hawkweed Oxeye daisy Botrytis neck rot Ergot Grasshoppers Cabbage maggot Large yellow underwing moth Onion root maggot	Black army cutworm	Brown marmorated stink bug True army worm
Average	Burdock, common Burdock, giant Common groundsel Common tansy Field bindweed Goat's beard Knapweed, spotted Marsh arrowgrass Mustard, field Mustard, wild Quackgrass St. John's wort Tall yellow buttercup Thistle, bull Yellow hawkweeds Yellow rattle Carrot rust fly Face fly Horn fly Rocky Mountain wood tick Varroa mite Western flower thrips Botrytis blight Brown root rot Verticilium wilt	Black henbane Blueweed Hoary alyssum Hoary cress Hound's tongue Perennial pepperweed Russian knapweed Sulphur cinquefoil Thistle, plumeless Alfalfa weevil Grey tortrix moth Horse bot fly Western cherry fruit fly Late blight, potato & tomato Phytophthora root rot Rhizoctonia	Apple maggot European fire ant Japanese beetle Spotted wing drosophila Western corn rootworm Anaplamosis Fusarium head blight West Nile virus
Low	Dalmatian toadflax Knapweed, diffuse Leafy spurge Scentless chamomile Thistle, nodding Aphids Apple scab	Baby's-breath Field scabious Knapweed, meadow Mountain bluet Thistle, marsh plume Wild chervil Wild parsnip Yellow flag iris	

Integrated Pest Management

Integrated pest management (IPM) is a decision-making process that contributes to effective, economically and environmentally responsible decisions (BC Ministry of Agriculture, 2010). IPM practices are universally recommended as beneficial to adapting agriculture to a changing climate (BC Ministry of Agriculture, 2010 ; Scholefield *et al*., 2016; Walthall *et al*., 2012; Wolfe *et al*., 2014). The primary steps and information needed in an IPM plan are:

1. Planning and managing production to avoid pest problems;
2. Being able to identify and understand pests life cycles, preferred foods and environments;
3. Monitoring pests and beneficial organisms, pest damage and environmental conditions;
4. Using economic thresholds and past experience in making pest control decisions;
5. Choosing appropriate control methods from the full suite of biological, cultural, mechanical and chemical options; and,
6. Evaluating the effects and efficacy of the management undertaken.

As evidenced by the results of the producer survey and interviews, IPM planning is not widely practiced in the region, nor are the elements of an IPM system used extensively. Only one respondent to the survey indicated they follow a formal IPM plan. While 70% indicated they could identify the pest impacting their operation and understood their life cycles, only 29% consider a range of management options before taking action, and less than 15% keep records of their pest control actions and formally evaluate the effectiveness of their management.

Regional Pest Management Support

Regional support for education, monitoring, research and adaptive management are recognized throughout the province and elsewhere as contributing to an effective and efficient agricultural pest management response (Benn, 2016; CCCIPC, 2017; CAI, 2012a; CAI, 2012b; Nadler, 2014; Scholefield and Dessureault, 2016; Scholefield *et al*., 2016).

Producers and producer groups identified a lack of adequate programmatic support for agricultural pest management in the region as a barrier to addressing new and existing pest issues. There are, however, many programs available to the agricultural community, although the producer awareness and connection to these resources appears highly variable. Support includes:

1. BC Ministry of Agriculture provides information and technical support at many levels, based within and outside the region, including,
    a. Regional Agrologists provide information and help producers connect to services within the region and throughout the province, including dedicated provincial Ministry specialists with expertise in integrated pest management for livestock, crops, and apiculture; organic production, biological controls and pesticides;
    b. Plant Health Laboratory [https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/plant-health/plant-health-laboratory] provides diagnostic services for a modest fee covering crop pests including insects, diseases and non-pathogenic disorders; and,

   c. Animal Health Lab [https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/animal-health] provides veterinary diagnostic services for livestock production.

2. Cariboo Agricultural Research Alliance (CARA). This newly launched initiative does not yet have programs or other support in place for pest management, though their mandate of producer focused research and extension support aligns with the intent;
3. Cariboo Coast Chilcotin Invasive Plant Council (CCCIPC) provides robust extension of information for invasive plant identification, monitoring and control [http://cccipc.ca/]. The Council provides direction on invasive plant species for control, inventory and monitoring work, and supports regional education, coordination and strategic planning (CCCIPC, 2017). The CCCIPC has supported research and adaptive management, including follow-up monitoring of biological controls released in the region, and targeted grazing of weeds ('Cows eat weeds'). The CCCIPC is linked to, and supplies information into, a provincial, inter-agency weeds database;
4. Cariboo Regional District [http://www.cariboord.ca/services/invasive-plants/invasive-plants-2] provides information and support for noxious weed control, including cost-share funding on herbicides, equipment loans for applying pest control products, and limited treatment service for weed infestations on private property (typically for small land parcels);
5. Environmental Farm Plan (EFP) and Beneficial Management Practices (BMP) Programs, [http://ardcorp.ca/programs/environmental-farm-plan/] delivered by the BC Agricultural Research and Development Corp, provides all agricultural producers with free, confidential, on-farm risk assessment and education, which includes basic education on IPM methods. Qualifying producers who complete an EFP are eligible for funding support for professional development of an IPM plan for their farm or ranch;
6. Forage Council of BC [http://www.farmwest.com/] has weather-based calculator tools for determining pest degree days, temperature and degree days in support of IPM. Farmwest maintains a library of extension articles and other resources related pest management;
7. Invasive Species Council of BC [http://bcinvasives.ca/] has extensive resources online to assist with the identification and management of non-native, invasive plants and insects; the Council hosts research forums and webinars; and, offers training programs for the identification, reporting, inventory and management of invasive species;
8. Ad hoc support in pest management has been provided regionally on many levels from many organizations, several of which have expressed interest in future partnerships or collaboration on research and extension projects, as their time and resources permit:
   a. BC Cattlemen's Association, regional and local associations;
   b. Certified Organic Associations of BC;
   c. College of New Caledonia, Horticulture Program;
   d. Kersley Farmers' Institute;
   e. Thompson Rivers University.

Complexity and Cumulative Impacts

Climate change can underpin complex, multi-factored and cumulative pest impacts in agricultural production (Crawford and Beveridge 2013; Walthall, 2012). In the Cariboo-Chilcotin, several producers emphasized that forest pest outbreaks have had direct and indirect impacts on their agricultural operations. Mountain pine beetle (*Dendroctonus ponderosae*), Douglas-fir beetle (*D. pseudotsugae*) and spruce bark beetle (*D. rufipennis*) have directly impacted farm and ranch timber resources, elevated fire hazards, damaged fencing and other infrastructure, blocked roads and trails and changed regional hydrology and micro-climates.

Forest pest outbreaks, coupled with an increased frequency in drought and wildfire, and changes in wildlife distributions (which are also likely responding to forest pests, drought and fire), are contributing to cumulative impacts being expressed in regional farming and ranching. Examples include:

- In the south Cariboo, drought and mountain pine beetle impacts have significantly reduced surface water sources for stock watering on rangeland. The decrease in traditional water sources has impacted livestock distributions with a greater risk of localized overgrazing within trailing distance of water, often coupled with greater foraging competition from wild ungulates in these same areas. And these factors, cumulatively, have created habitat favourable to grasshopper outbreaks, which through a negative feedback, accelerates the forage losses and deterioration of the range condition.
- In the central Cariboo, changes in surface water and wind patterns resulting from beetle-killed forests, have altered the spring soil moisture, temperature and humidity profiles for market garden operations. The supplemental irrigation that is now required to keep seed beds suitable for germination, also elevates the risk of some fungal and insect pests.

Other Issues Identified

In the course of the consultations, stakeholders identified other climate- and non-climate related impacts affecting regional agriculture, that are outside the scope of this review and analysis. These factors, though sometimes only peripheral to pest management, may factor into the decisions around future support for pest-related support in the region.

The issues identified include the following:

- The fate of native pollinators in relation to pesticide use, drought and wildfire smoke and degree to which they are impacted by climate change;
- Native plants, not considered noxious or invasive, but that are poisonous to livestock (e.g. pine needles causing abortion in cattle, water hemlock causing livestock poisoning) and their relationship to climate variables (e.g. whether the potency increases with drought);
- Perception that crops damaged or consumed by black bears, wild ungulates and waterfowl generally exceeds all losses attributed to insects, weeds and pathogens combined;
- Perception that livestock killed or maimed by wild predators (notably wolves) generally exceeds all losses to livestock insect pests and diseases;
- An observed decrease in bat populations with potential consequences for increased disease conveyed by mosquitoes and flies, or direct impacts from insect pests;
- An observed increase in corvids, including mag pies and crows, with the risk of increased incidence of disease (e.g. West Nile virus) carried by these wild birds.

4.2 Gap Analysis and Recommendations

Based on the review of literature and input from agricultural stakeholders, the following knowledge or management gaps are noted with recommendations for supporting agricultural pest management activities in the Cariboo-Chilcotin.

1. Employ Layered Management Strategies

An effective and comprehensive management approach is in place for some of the agriculturally-related, regional weeds (CCCIPC, 2017), but none exists for the full spectrum of agricultural pests identified in this review. It is recommended, conforming to the regional strategy for invasive plants in the regional (CCCIPC, 2017) and pest management activities in other jurisdictions (Wolfe *et al*. 2014), that a layered management approach be employed, based on the relative risks and existing distribution of the priority pest species (Table 7):

Endemic pests, with wide or pan-regional distribution; support should focus on extending beneficial practices information to producers to manage an ongoing presence within their production setting, and where possible, to direct efforts to manage species into an equilibrium using cultural methods or biological controls;

Pests with limited regional distribution; support should focus on containment or eradication to prevent their spread and impacts in other areas of the region; and,

Pests not known to be within the region; support should primarily be directed to helping producers and the general public identify and report any incidence of these pests to allow for a rapid response to contain and eradicate, if and when they are detected.

Most of the agricultural pest problems in the region are endemic, and can be managed in the current and future climate scenarios with producer education on beneficial management practices, with an emphasis on IPM. Special emphasis should be given to extending identification and reporting protocols for the high priority pests, not yet in the region: brown marmorated stink bugs and true army worms. Both potentially impact a wide range of agricultural crops across the spectrum of regional production and are very destructive once established.

2. Enhance Producer Education and Connection to Information

Existing producer knowledge regarding many pest management issues and management options is insufficient. Agricultural producers are at the front line of all pest management issues, and their ability to effectively address existing and emerging pest management issues hinges on key information in the areas of:

1. Integrated pest management concepts and planning;
2. Identification of priority agricultural pests and their damage patterns;
3. Scouting and monitoring protocols, particularly for insect and pathogens; and,
4. The full range of cultural, biological, mechanical and chemical control options suited to individual pest problems.

Producer education should start by improving the connection of regional producers to existing free or low cost, and sometimes underutilized, support programs that are already in place:

1. CCCIPC education resources for weed identification and management options;
2. EFP and BMP Programs for IPM education and planning support. No regional producers have accessed support cost-share funding for IPM planning or activities in the past 8 years;
3. Invasive Species Council of BC for education and training resources; and,
4. BC Ministry of Agriculture Plant and Animal Health Laboratories. The plant diagnostic lab in Abbotsford notes that they receive very few samples for identification from the Cariboo - Central Interior which limits their ability to prepare support responses (Jesperson, 2017).

3. Expand and Refine Regional Pest Monitoring

Existing regional support for monitoring and managing plant pests is far more advanced than for either insects or pathogens. Moreover, for weeds, greater emphasis has been placed on regional monitoring and extension activity related to species invading rangelands and natural areas, than on either cultivated fields or improved pastures.

A pan-agricultural, monitoring network should be established that is focused on early detection and is linked to a rapid response protocol for new and emerging pest issues. This would enable improved access and sharing of pest information across the region. Options for the monitoring network include:

- Resourcing a standalone system under the direction of CARA with responsibility for keeping this strategy up-to-date, and coordinating information from the CCCIPC, BC Ministry of Agriculture and individual agricultural producers; and,
- Resourcing an expanded role for the CCCIPC (transitioning it to an invasive species organization) to include a broadened range of plant pests (to include weeds impacting agricultural operations that may not be invasive) as well as insects, arachnids and pathogens.

With any option for pest monitoring, there needs to be increased emphasis on making the information available to individual producers, in a format they can readily understand, allowing them to make better informed IPM decisions.

Existing protocols for scouting and monitoring insects and pathogens, such as Agriculture and Agri-Food Canada's insect monitoring protocols should be employed when available (Benn, 2016).

4. Establish, or Link to Existing, Climate Monitoring Networks

Insect and disease problems are generally more dynamic than plant pests and rely more heavily on annual weather patterns and local conditions before they manifest. There is, therefore, a more acute need for reliable local or sub-regional climate information to forecast pest problems and recommend IPM actions. As in other jurisdictions (Nadler, 2014), there are few agriculturally-related weather information providers, and none dedicated to supporting this region. The large geographic area covered by the Cariboo-Chilcotin, and relatively sparse network of existing networked climate stations, however, present major challenges.

It is recommended that a network of sub-regional agricultural climate stations be established. The $2,000 to $3,000 cost of these stations will be prohibitive for many individual producers to participate. Resourcing should be directed to subsidizing climate station establishment until a representative distribution is present across the major agricultural areas in the region. Individual agricultural producers can also access cost-share funding for climate monitoring equipment through the BMP Program if they have completed an EFP, and it is current.

All individual climate stations should be networked, when possible, to share data into existing provincial climate information networks, such as the BC Forage Council - Farm West Climate Station Network [http://www.farmwest.com/node/938].

As added benefits, the climate station network would also be of utility in forecasting agricultural water use, for adjusting irrigation schedules, and also in predicting the hazard ratings for wildfires.

5. Refine the Priority Pest Ranking System

The pest rankings used in this analysis should be revisited and updated periodically, as many of the variables involved in the ranking process are dynamic (e.g. species distributions) and subject to revision as new information on impacts and management outcomes, future climate projections, or other relevant information becomes available.

The mapping of agricultural pests to the regional climates and habitats (e.g. level of disturbance, shade, other host species) both in current and projected climate scenarios should be expanded and refined. The current modeling was conducted at the biogeoclimatic zonal level, and is suitable for making strategic decisions at a regional level. Reworking the model to a biogeoclimatic subzone and variant level, and making this information available as a GIS spatial layer, would allow for more robust pest management decision making to the local, or in some cases, at the farm level. This modeling would also benefit from an expansion and updating of the agricultural land use inventory (ALUI) dataset for the Cariboo Regional District.

6. Conduct Participatory Research and Adaptive Management Trials

There are many basic pest management gaps that would benefit from regional information and experiences. For example, for many of the pest issues, the organic control options are limited or non-existent (Eisen, 2016). There is also a wealth of relevant research and experience from other agricultural regions that could be demonstrated regionally. Current research and development support is limited, but emphasis should be given to work that addresses information gaps that:

- Avoids new pest problems from establishing, e.g. through trialling pest-resistant crops and crop varieties;
- Improves the understanding of non-crop/non-livestock hosts and vectors;
- Links pest management issues to other climate-related changes, e.g. water supply, wildlife populations, wildfire;
- Leverages existing management capabilities and resources to lower or eliminate the treatment costs, e.g. targeted grazing for weed control (e.g. 'cows eat weeds'), or changing cultivation methods to decrease fungal pests;
- Results in long-term stable control with lower-cost inputs, e.g. testing, establishing and monitoring regionally-adapted biological controls.

It is recommended that research and adaptive management work should be coordinated through resourcing the Cariboo Agricultural Research Alliance (CARA). Regional support partnerships could be leveraged to expand producer driven research and adaptive management trials, though none currently have significant core funding for this work, and activities need to be framed within their existing mandates.

For weeds, there are many partnership options including the CCCIPC, Cariboo Regional District, cattle producer organizations, Thompson Rivers University and the Forage Council of BC.

For greenhouse and horticultural crops, expansion of ongoing trials by the College of New Caledonia, Horticulture Program is a logical starting area.

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Appendix 1. Biogeoclimatic Zones of the Cariboo Regional District

Boreal Altai Fescue (BAFA)

Bunchgrass (BG)

Boreal White and Black Spruce (BWBS)

Coastal Western Hemlock (CWH)

Interior Cedar-Hemlock (ICH)

Interior Douglas-fir (IDF)

Engelmann Spruce - Subalpine Fir (ESSF)

Ponderosa Pine (PP)

Montane Spruce (MS)

Sub-Boreal Pine – Spruce (SBPS)

Sub-Boreal Spruce (SBS)

Spruce Willow Birch (SWB)

Appendix 2. Consultation Participants

The following individuals, and those who wished to remain anonymous, are thanked for providing information and advice for this review.

Susanna Acheampong, Entomologist, BC Ministry of Agriculture

Lynda Archibald, Fraser Bench Farm

Duncan Barnett, Cariboo Cattlemen's Association; BC Cattlemen's Association Director

Serena Black, General Manager, BC Forage Council; Cariboo Agriculture Research Alliance

Kevin Boon, General Manager, BC Cattlemen's Association

Rob Borsato, District H Farmers' Institutes, Quesnel Farmer's Market

Diane Brown, Range Officer, 100 Mile House Resource District, Ministry of Forests, Lands, Natural Resource Operations and Rural Development

Jennifer Catherall, Instructor, College of New Caledonia, Quesnel Campus

Rob Dinwoodie, Range Officer, Okanagan Shuswap District, Ministry of Forests, Lands, Natural Resource Operations and Rural Development

Gus Friedenberger, Quesnel Beekeeper's Association

Robert and Kathryn Hettler, Pilgrims' Produce

Grant Huffman, Cariboo Cattlemen's Association; BC Cattlemen's Association Director

Gayle Jesperson, Plant Pathologist, BC Ministry of Agriculture

Sandra Latin, Range Officer, Quesnel Natural Resource District, Ministry of Forests, Lands, Natural Resource Operations and Rural Development

Lavona Liggins, Regional Agrologist, Prince George, BC Ministry of Agriculture

Gene Pascuzzo, Cloverleaf Farm

Nicole Pressey, Regional Agrologist, Quesnel and Williams Lake, BC Ministry of Agriculture

Lorne Smith, Richbar Honey

Emily Sonntag, Invasive Plant Management Coordinator, Cariboo Regional District / Cariboo Chilcotin Coast Invasive Plant Council

Ruth Robinson, South Cariboo Regional Cattlemen's Association

Paul van Westendorp, Provincial Apiculturist, BC Ministry of Agriculture

Appendix 3. All Priority Pests Sorted by Pest Ranking

Rating	Pest		Rating	Pest
90	Grasshopper		42.5	Rocky Mountain wood tick
81	Ergot		42.5	Fusarium head blight
80	Black army cutworm		41.8	Mustard, field
75	Brown marmorated stink bug		41.78	Mustard, wild
71.9	Thistle, Canada		41.5	Brown root rot
69	Cabbage maggot		41.5	Verticilium wilt - alfalfa
69	Large yellow underwing moth		40.8	St. John's wort
69	Onion root maggot		38.4	Knapweed, spotted
69	Botrytis neck rot		38	Goat's-beard
65	True army worm		37.5	European fire ant
60.9	Oxeye daisy		37.4	Knapweed, Russian
60.7	Orange hawkweed		35.9	Blueweed
60	Botrytis blight		35.5	Black henbane
59	Western corn rootworm		35	Rhizoctonia
58.5	Perennial pepperweed		34.5	Face fly
58	Quackgrass		34.5	Horn fly
57.4	Thistle, bull		32.8	Apple scab
56.9	Tall yellow buttercup		32.7	Sulphur cinquefoil
56.5	Alfalfa weevil		32.5	Horse bot fly
56.5	Varroa mite		29.7	Thistle, marsh plume
56.5	Phytophthora root rot		29.6	Baby's-breath
56.3	Western flower thrips		29.6	Yellow flag iris
56	Yellow rattle		29.1	Leafy spurge
54	Carrot rust fly		28.9	Field scabious
53.1	Japanese beetle		28.5	Dalmatian toadflax
52.5	Anaplasmosis		28.5	Wild parsnip
52.5	Hoary cress		26.9	Knapweed, meadow
51.6	Marsh arrowgrass		26.0	Wild chervil
51.5	West nile virus		23.8	Aphids, apple
50.5	Grey tortrix moth		23.6	Knapweed, diffuse
50.3	Burdock, giant		23.5	Thistle, nodding
50.3	Burdock,common		23.3	Scentless camomile
50	Late blight of potato and tomato		22.5	Mountain bluet
49.1	Spotted wing drosophila			
48.5	Hoary alyssum			
47.8	Western cherry fruit fly			
47.3	Hound's-tongue			
46.8	Apple maggot			
46.4	Common groundsel			
46.4	Yellow hawkweeds			
46.3	Thistle, plumeless			
43.5	Common tansy			
43.2	Field bindweed			