


TOWN OF BLACK DIAMOND &
TOWN OF TURNER VALLEY

CLIMATE RESILIENCE ACTION PLAN

- MARCH 2016 -

> *"A resilient* [community] *is one that has developed capacities to help absorb future shocks and stresses to its social, economic, and technical systems and infrastructures so as to still be able to maintain essentially the same functions, structures, systems, and identity."*
>
> [Working Definition, ResilientCity.org]

This Climate Resilience Action Plan (Action Plan) has been produced through the **Climate Resilience Express** project with financial support from The Calgary Foundation, Natural Resources Canada, All One Sky Foundation, the Municipal Climate Change Action Centre, and Alberta Ecotrust Foundation.

The goal of Climate Resilience Express is to produce a streamlined ("express") process for developing a climate resilience action plan for smaller communities through a one-day workshop process, and to subsequently prepare a 'self-help' toolkit to support these communities in working through the process. Four smaller communities from across Alberta were selected to pilot the workshop process and aspects of the toolkit. The Towns of Black Diamond and Turner Valley were one of the selected communities.

Climate Resilience Express is a collaboration between All One Sky Foundation, the Municipal Climate Change Action Centre, the Miistakis Institute and the Alberta Biodiversity Monitoring Institute.

For more information on the Climate Resilience Express visit: http://allonesky.ca/climate-resilience-express-project/ or mccac.ca/programs/climate-resilience-express.

March 2016

Summary

The effects of climate change are already apparent in the Black Diamond and Turner Valley area, with observable changes in temperature, precipitation, and extreme weather events over the last century. The impacts of climate change could be numerous and diverse, giving rise to uncertain consequences, for infrastructure and services, property, the local economy and environment, and the health and lifestyles of citizens. To better prepare for these potential impacts, the Towns of Black Diamond and Turner Valley have prepared this Action Plan, which identifies a number of anticipatory measures to manage priority risks and opportunities expected to result from climate change over the next several decades.

In total, 13 climate-related risks, and three climate-related opportunities were identified, of which three risks and one opportunity were judged to be priorities requiring immediate action, and are the focus of this Action Plan:

1. Wildfire (risk);
2. Loss of wetlands (risk);
3. Water supply shortage (risk); and
4. Increase in summer tourism (opportunity).

Starter action plans are developed for each of these priority impacts.

The Towns of Black Diamond and Turner Valley are already committed to numerous actions that help manage the above priority risks, including: • a FireSmart program and mutual aid agreements with the Government of Alberta and nearby municipalities to manage wildfire risk; • support for effective wetland management such as requirements for on-site water retention in new developments; and • the management of water to mitigate water supply shortages, including a water conservation bylaw, community education, universal water metering, and a leakage detection program. The Towns also have actions currently in place to promote existing summer tourism opportunities, such as local recreation facilities and regional marketing initiatives.

In addition to existing actions that help mitigate priority climate risks, 15 actions are identified for consideration to help Black Diamond and Turner Valley better prepare for climate change. A number of actions can be implemented quickly with minimal investment, whereas other actions have longer-term timeframes and require a higher level of investment. Implementation of these actions will ensure that both Towns remain resilient under a wider range of potential future climate conditions.

This Action Plan is a living document and should be periodically reviewed and updated to ensure it remains relevant and effective.

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1. INTRODUCTION

The effects of climate change are already apparent in Black Diamond and Turner Valley, with observable changes in temperature, precipitation, and extreme weather events over the last century. The average annual temperature in the Black Diamond and Turner Valley area has increased by about +1.5°C since the early 1900s, with winter months seeing greater warming than summer months. Over the same period, the amount and timing of precipitation in the area have also changed.

We are sure to experience further changes to our climate in the decades ahead—the result of past greenhouse gas (GHG) emissions. There is a time lag between GHG emissions and when we see the impacts, as the planet takes a while to respond. How much the climate will change beyond the next few decades depends on how far and how fast global GHG emissions are reduced from current levels.

> **Mitigation** will help avoid the unmanageable … **adaptation** is essential to manage the unavoidable.

The impacts of climate change on communities across Alberta will be numerous and diverse, giving rise to potentially significant, though uncertain consequences for municipal infrastructure and services, private property, the local economy and environment, and the health and lifestyles of citizens. Potential impacts may include changing patterns of precipitation with increased risk of flooding and drought, increased strain on water resources, rising average temperatures and more common heatwaves, more frequent wildfires, or more intense ice, snow, hail or wind storms. Climate change may also present opportunities for communities.

Alberta communities are at the forefront of these impacts—both because extreme weather events can be especially disruptive to urban systems and because they are where much of our population live, work and raise their families. Smaller communities with limited resources are particularly vulnerable and may lack the capacity to adequately respond to increasing impacts. It is therefore essential that communities take steps now to anticipate and better prepare for future climate conditions, to ensure they continue to prosper as a desirable place to live and work for generations to come.

The Towns of Black Diamond and Turner Valley, through the preparation of this Action Plan, are taking steps towards a safe, prosperous and resilient future. The Action Plan identifies a number of anticipatory measures to manage priority risks and opportunities anticipated to result from climate change in the area over the next several decades.

2. Developing the Action Plan

The overall approach to developing climate resilience action plans through Climate Resilience Express is grounded in existing standards for risk management based on the International Organization for Standardization's (ISO) 31000, Risk Management – Principles and Guidelines. It follows a four-step, iterative process (shown in Figure 1):

Step 1: Establish the local context for climate resilience action planning;

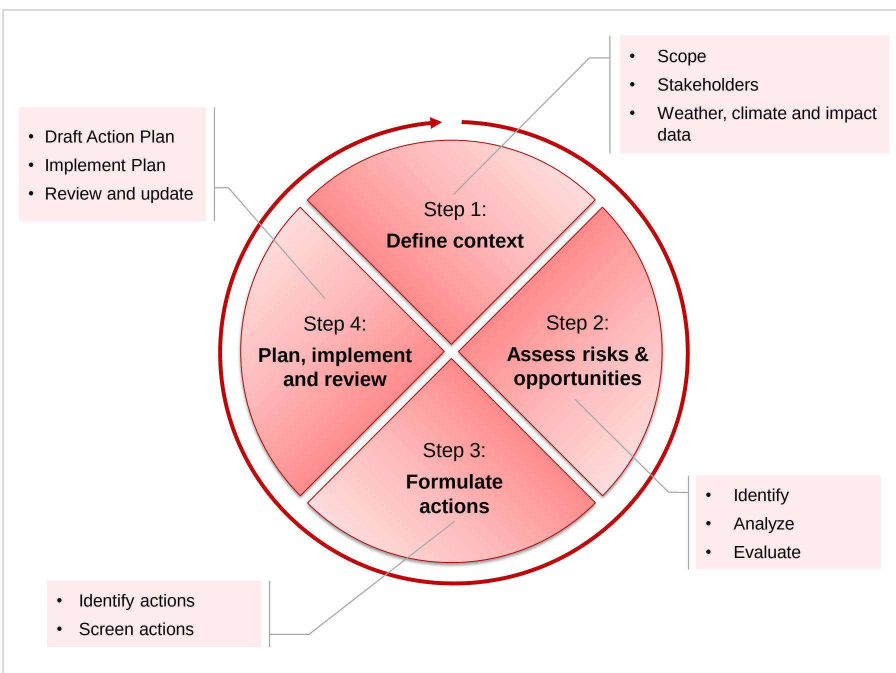
Step 2: Assess potential climate-related risks and opportunities to establish priorities for action;

Step 3: Formulate actions to manage priority risks and opportunities; and

Step 4: Prepare and implement an Action Plan, review progress, and update the Plan to account for new information and developments.

Step 2 and Step 3 of the process are the focus of the one-day workshop with local stakeholders, which is at the heart of Climate Resilience Express. Step 1 is undertaken in advance of the workshop; preparing the Action Plan and Step 4 takes place after the workshop.

Figure 1: Climate Resilience Express — action planning process



BEFORE THE WORKSHOP: STEP 1

Prior to the workshop the context for climate resilience action planning in Black Diamond and Turner Valley is established. This involves:

- **Defining the spatial scope**

  The spatial scope is focused on impacts within the geographic boundaries of the Towns of Black Diamond and Turner Valley, with consideration also given to important climate impacts that occur outside the municipal boundaries, which affect life within the Towns—e.g., changes in the regional ecosystem.

- **Defining the operational scope**

  The assessment of risks and opportunities considers potential community-wide impacts, which includes impacts to municipal infrastructure, property and services, as well as impacts to private property, the local economy, the health and lifestyle of residents and the natural environment.

- **Defining the temporal scope**

  The assessment considers impacts arising from projected climate and associated environmental changes out to the 2050s. This timeframe looks ahead to the types of changes and challenges, which decision-makers and residents might face within their lifetimes. It also reflects a planning horizon that, although long in political terms, lies within the functional life of key public infrastructure investments and strategic land-use planning and development decisions.

- **Compiling climate and impact data**

  Climate projections for the 2050s are compiled for the Black Diamond and Turner Valley area and historical weather data is analyzed to identify observed trends in key climate variables. Information is also compiled on the main projected environmental changes for the area by the 2050s. This activity is discussed further in Section 3.

- **Developing scales to score risks and opportunities**

  Scales are required to establish the relative severity of impacts in order to determine priorities for action. The scales used in the risk and opportunity assessment at the workshop are provided in Appendices.

AT THE WORKSHOP: STEP 2 AND STEP 3

The one-day workshop used to generate the information underpinning this Action Plan comprises four main sessions. Workshop participants are listed in Appendix A.

- **Session 1: Exploring local weather and impacts**

  The session objective is to explore the relationship between weather, climate and key aspects of Black Diamond and Turner Valley in relation to past weather-related impacts. Outcomes from this session at the workshop are presented in Section 3.

- **Session 2: Introduction to climate science and impacts**

  The session objective is to present information about climate science, local climate trends and projections, projected environmental changes, and potential impacts for the area. This information is also presented in Section 3.

- **Session 3: Assess future risks and opportunities**

  The session objective is twofold; first, to determine how projected climate or environmental changes could impact the Towns of Black Diamond and Turner Valley, and second, to prioritize the identified impacts in order to establish priorities for action planning. Outcomes from this session at the workshop are presented in Section **Error! eference source not found.**.

- **Session 4: Action planning**

  The session objective is to determine what actions are necessary to increase resilience to priority risks and to capitalize on priority opportunities. Outcomes from this session at the workshop are presented in Section 5.

AFTER THE WORKSHOP: STEP 4

Outcomes from the workshop are used as the basis for this Action Plan. Building resilience to climate change is not a static process, however, but rather needs to be monitored and reviewed to both check progress on implementation and to take account of changing scientific knowledge about the physical impacts of climate change. Implementing this Action Plan, reviewing progress, and updating the Plan to keep it relevant are discussed in Section 6.

3. Observed Impacts, Climate Trends and Projections

Observed Local Weather and Climate Impacts

Session 1 at the workshop invited participants to identify how Black Diamond and Turner Valley have been affected by weather-related events in the recent past, considering impacts on the local economy, property and infrastructure, the natural environment, and residents' health and lifestyles. A selection of observed weather-related impacts on the community identified by participants is provided in Box 1.

Box 1: Summary of observed weather events and impacts

- ✓ Less snowfall.
- ✓ Fewer extreme cold events.
- ✓ Weather seems to be more extreme and variable.
- ✓ Several major hailstorms have caused damage to property and negatively impacted residents and local businesses.
- ✓ Extreme events, including hailstorms and floods can have positive benefits for local restoration and repair businesses.
- ✓ Floods in 2005 and 2013 led to major impacts on local infrastructure including loss of major transportation routes, communications and water lines. These floods also had significant negative impacts on local quality of life and mental health.
- ✓ Longer, hotter summers have been observed with some benefits for tourism and agriculture.
- ✓ Lower late summer flows in the Sheep River have led to increased water treatment requirements.
- ✓ Major rainstorms have overwhelmed the storm sewers and caused flooding.
- ✓ Wildlife migratory patterns appear to be changing with some species staying longer and new and different species appearing.
- ✓ Berry production is changing, and seems less consistent.
- ✓ There appear to be fewer mosquitoes and more wasps.

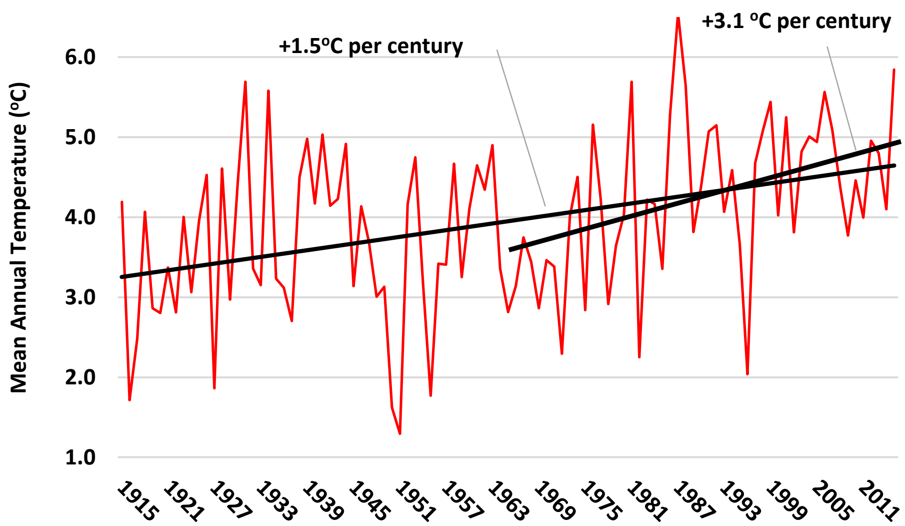
LOCAL CLIMATE TRENDS

To provide a perspective of historic climate trends in the Black Diamond and Turner Valley area, data is collected and analyzed from six climate stations in the region (Olds, Kananaskis, Calgary, Lethbridge, High River and Pincher Creek)[i]. These climate stations were selected because the data cover multiple decades, are high quality, and the stations span an area that is comparable to the same area for which climate projections are available. Climate records of temperature and precipitation for Black Diamond and Turner Valley are assembled by averaging the individual records from the five climate stations and applying appropriate statistical techniques[ii].

➡ Temperature records

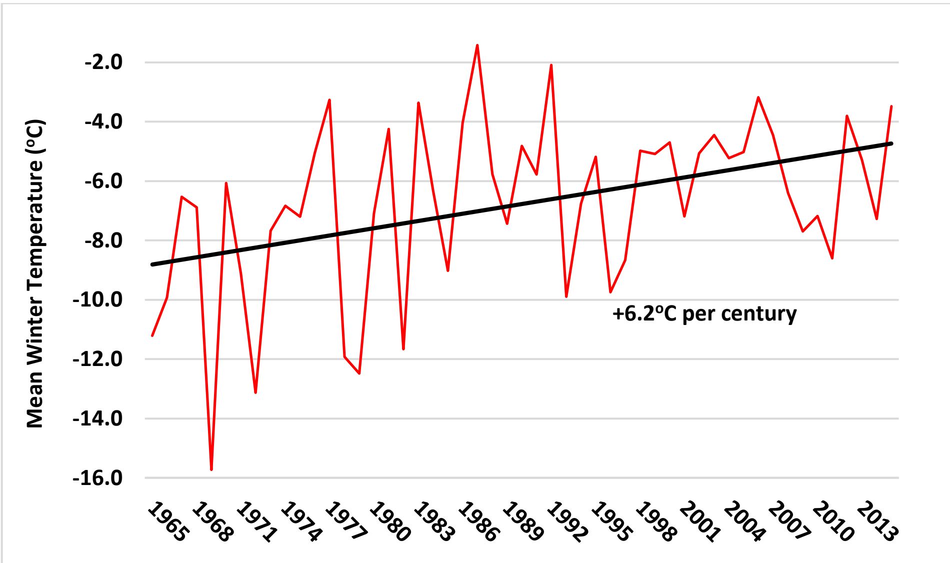
Temperature records for the area over the period 1915-2015 show that mean annual temperature has increased at a rate of +1.5°C per century (Figure 2), which is approximately 1.7 times faster than the observed global rate of warming over the same time period. The rate of warming observed over the last 50 years is higher still at +3.1°C per century.

Figure 2: Mean annual temperature in the Black Diamond and Turner Valley area (1915-2015)



Over the last 50 years, the largest seasonal increase in temperature in the Black Diamond and Turner Valley area occurred during the winter (December-February). The observed rate of warming in winter since 1965 is +6.2°C per century (Figure 3), which is substantially greater than the annual rate of +3.1°C per century. In contrast, warming during the summer (June-August) since 1965 occurred at a slower rate of +1.5°C per century. Trends in mean spring and fall temperature are also positive over the last 50 years, but the statistical confidence of these trends is less robust.

Figure 3: Mean winter temperature in the Black Diamond and Turner Valley area (1965-2015)



Precipitation records

Mean annual precipitation in the Black Diamond and Turner Valley area has not changed significantly over the last century. Further, changes in seasonal precipitation since 1915 and since 1965 show no significant trends with one exception; winter precipitation has decreased at a rate of 19mm per century over the last 100 years and 71mm per century over the last 50 years (Figure 4). Also, since 1965, the amount of precipitation falling as snow has been declining at a rate of 103 mm per century (Figure 5), which is consistent with the observed warming in the region over this time frame.

Figure 4: Mean winter precipitation in the Black Diamond and Turner Valley area (1915-2015)

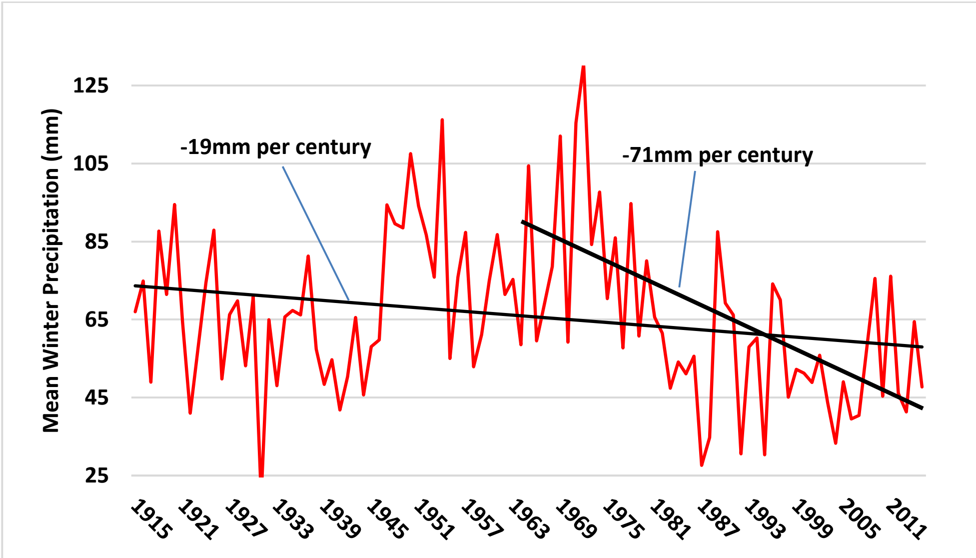
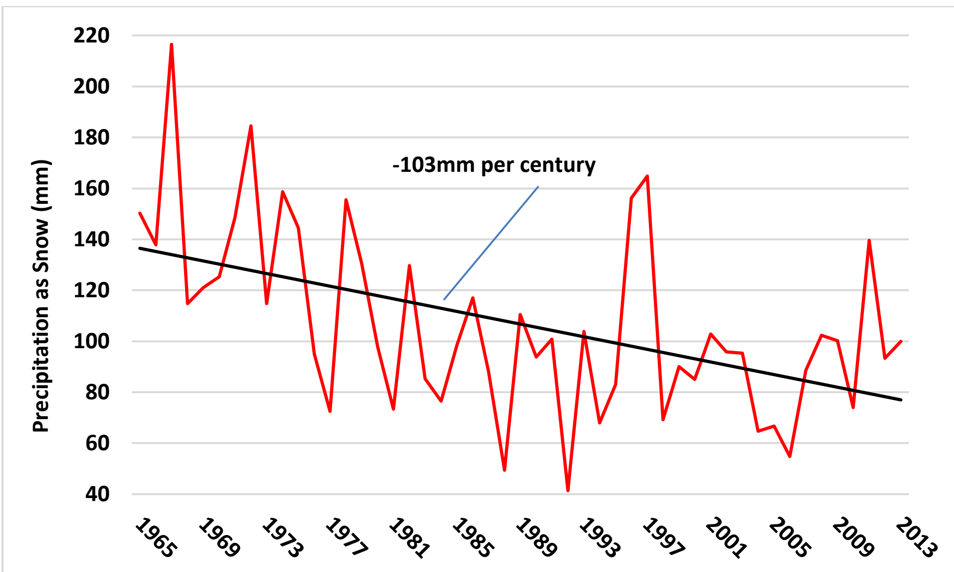


Figure 5: Mean annual precipitation falling as snow in the Black Diamond and Turner Valley area (1965-2013)



Source: CWNA[iii]

Climate Projections for Area

Climate projections for the Black Diamond and Turner Valley area, for the 2050s, were derived using the Pacific Climate Impacts Consortium's (PCIC) Regional Analysis Tool[iv]. The projections are based on results from 15 different Global Climate Models (GCMs). Each model generates output for one high and one low GHG emission scenario. Projected climate change within the models is primarily driven by assumed increases in concentrations of GHGs in the atmosphere. The results from all 15 GCMs for both GHG emission scenarios are averaged.

> "Since the mid-20th century human activities, including the burning of fossil fuels and changes in land use patterns have been the dominant cause of climate change… This trend is expected to continue through the present century and beyond, leading to rates of global warming that will exceed any experienced during the past several thousand years." [v]

Climate projections for the 2050s in the Black Diamond and Turner Valley area are summarized in Table 1. The mean annual temperature is anticipated to increase by +1.9°C above the 1961-1990 baseline which will increase the absolute mean annual temperature in the 2050s to about +5.9°C. This projected increase in temperature is consistent with the rate of change in mean annual temperature that has been observed in the Black Diamond and Turner Valley area over the last 50 years. The projected increase in mean annual temperature is expected to be accompanied by an increase in mean annual precipitation of approximately 5%.

Table 1: Summary of climate projections for the Black Diamond and Turner Valley area by the 2050s

Climate Variable	Season	Baseline (1961-1990)	Projected Change	
			Mean	Range
Average temperature	Annual	+4.0°C	+1.9°C	(+1.2 to +2.8)
Average precipitation	Annual	509 mm	+5%	(-3% to +11%)
Average temperature	Summer	+15.0°C	+2.2°C	(+1.5 to +3.2)
Average precipitation	Summer	199 mm	-5%	(-15% to +7%)
Average temperature	Winter	-7.4°C	+1.9°C	(+1.0 to +3.4)
Average precipitation	Winter	74 mm	+10%	(-1% to +19%)
Average temperature	Spring	+3.7°C	+1.5°C	(+1.0 to +2.5)
Average precipitation	Spring	135 mm	+10%	(+3% to +19%)
Average temperature	Fall	+4.7°C	+1.9°C	(+1.2 to +2.7)
Average precipitation	Fall	101 mm	+8%	(-1% to +13%)

Notes: The mean projected change is the average value over the 30-year period 2040-2069. The range is defined by the 10th and 90th percentile values. Summer includes Jun-Aug, fall includes Sep-Nov, winter includes Dec-Feb, and spring includes Mar-May.

The projected increases in mean summer temperatures (+2.2°C) exceed the mean annual projection and it is anticipated that this increase in summer temperature will be accompanied by a decline in summer precipitation (5%). Mean winter temperature is expected to increase by +1.9°C with a 10% increase in mean winter precipitation. Mean temperatures are also expected to rise in the spring and fall (+1.5°C and +1.8°C, respectively); precipitation is projected to increase by 10% in the spring and 8% in the fall.

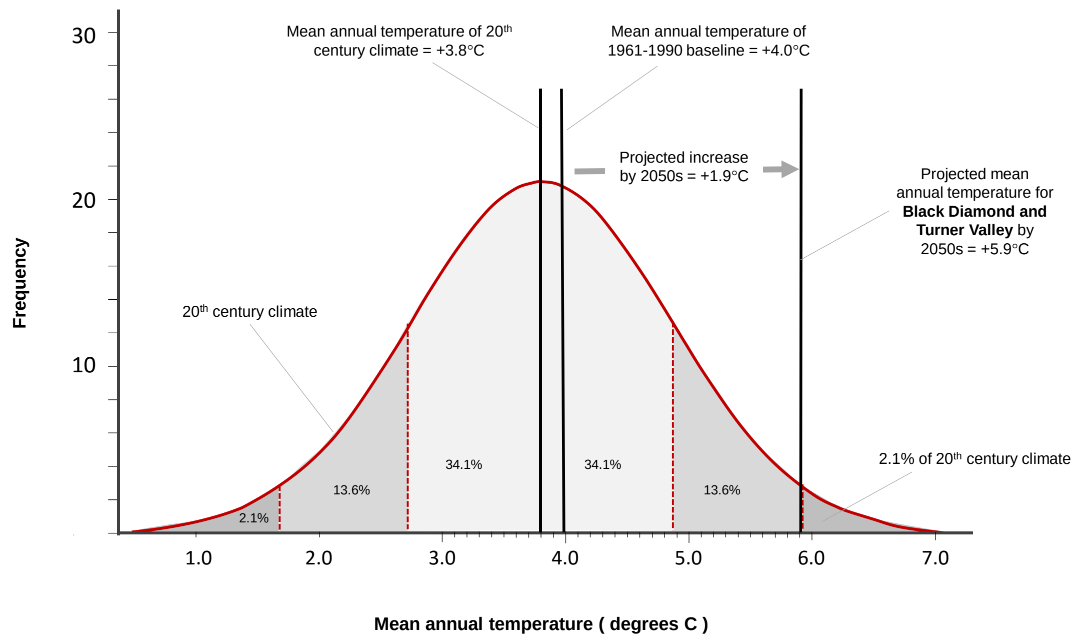
➡ Precipitation extremes

In recent years, numerous extreme precipitation events have occurred at various locations globally at monthly, daily and sub-daily timescales; several have occurred in western Canada with serious consequences. Recent studies have demonstrated that extreme rainfall intensity increases by about 7% for every degree increase in global atmospheric temperature[vi]. Model projections of short-duration precipitation is an emerging area of research and presents challenges due to—among other things—difficulties in modelling convective storms and the limited availability of hourly climate data for establishing long-term trends. However, as global temperatures increase, the capacity of the atmosphere to carry water vapor also increases. This will supply storms of all scales with increased moisture and produce more intense precipitation events[vii]. Consequently, it is very likely that Black Diamond and Turner Valley will see more extreme precipitation events as the climate continues to warm in the coming decades.

Box 2: Putting projected changes in mean annual temperature in context

In order to place the magnitude of the projected temperature changes in the 2050s into context, a normal distribution (bell curve) was fitted to the 20th century climate of the Black Diamond and Turner Valley area (1915-1999). The mean of the probability distribution is then shifted by the projected temperature increase of +1.9°C above the 1961-1990 baseline. This increase in mean annual temperature represents a shift of more than two standard deviations above the 20th century mean temperature. In other words, the climate projections indicate that the mean annual temperature of the 2050s in the Black Diamond and Turner Valley area will be similar to the warmest 2-3% of 20th century climate.

Although a change in mean annual temperature of +1.9°C may not appear to be a large absolute shift in climate, when compared with the probability distribution of 20th century climate in the Black Diamond and Turner Valley area, a shift of this magnitude is substantial. By analogy, the projected shift in mean annual temperature will be similar to replacing Black Diamond and Turner Valley climate over the period 1961-1990 with that of Conrad, Montana (94 km south of the Alberta-US boarder at Coutts).



PROJECTED ENVIRONMENTAL CHANGES

Projected changes in average temperature and precipitation in the Black Diamond and Turner Valley area will have broad consequences across the natural environment, including for moisture availability, growing season, regional ecosystems, invasive plants, streamflow, wetlands, and wildfires.

Available moisture and growing season

Although mean annual precipitation is projected to increase in the Black Diamond and Turner Valley area, the region is projected to become drier overall because warmer temperatures will increase the rate of evaporation from vegetation and soils, such that overall moisture loss will exceed the projected increase in mean annual precipitation (reflected by the projected decline in the Climate Moisture Index in Figure 6)[viii]. In addition, while mean annual precipitation is projected to increase, the slight projected decline in precipitation during the warm summer months will likely contribute to moisture stress[ix].

The projected increases in average temperatures in spring, summer and fall will result in increases in both the length and the warmth of the growing season in the region around the Towns of Black Diamond and Turner Valley. Growing degree days are a measure of the length and warmth of the growing season[x]. By the 2050s, the Black Diamond and Turner Valley area (indicated with the black rectangle in Figure 7) is projected to experience an increase of approximately 290 degree days, on average; put another way, the growing season in the area will become more similar to the growing season experienced around Vulcan, Alberta in today's climate.

A reduction in available moisture and an extended growing season are projected consequences of climate change common to most of the prairie region[xi]. The consequences for agriculture in the Black Diamond and Turner Valley area will depend on the balance between the advantage construed by a longer growing season, and the potential negative impacts of a reduction in available moisture.

Figure 6: (A) Historic (1961-1990) and (B) projected distribution of available moisture in Alberta by the 2050s (2041-2070)[xii]

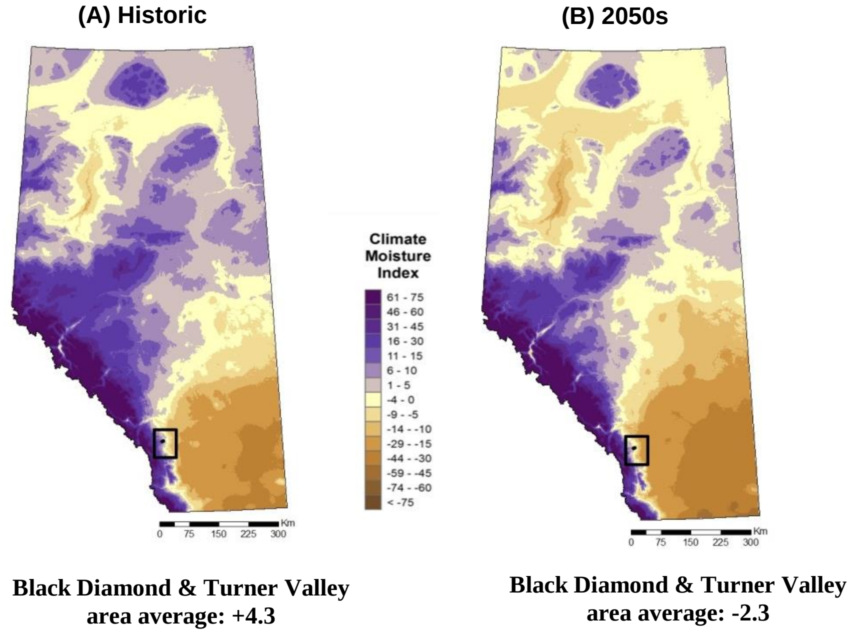
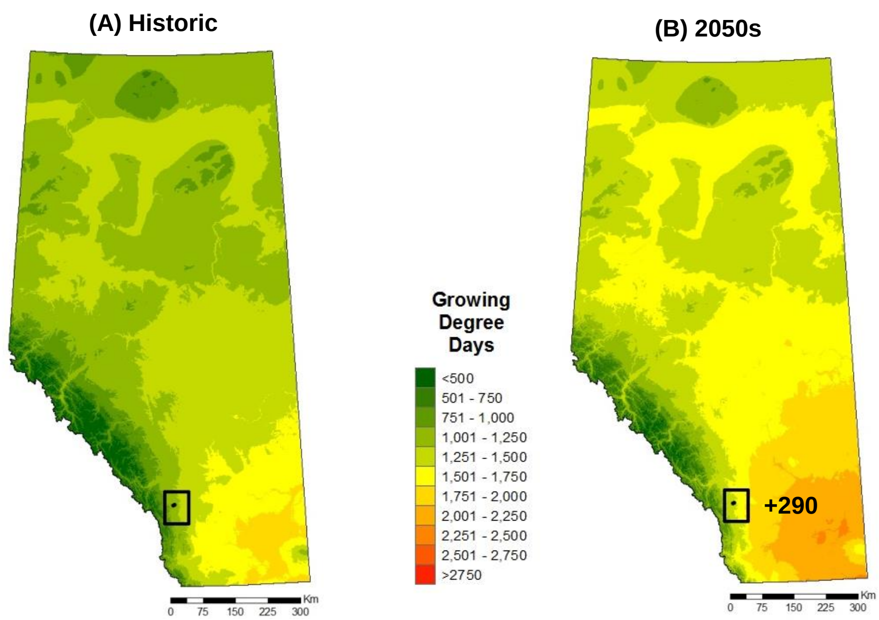


Figure 7: (A) Historic (1961-1990) and (B) projected distribution of growing degree days in Alberta by the 2050s (2041-2070)[xiii]



Regional ecosystems

Alberta's natural sub-regions, which are defined by unique combinations of vegetation, soil and landscape features, represent the diversity of ecosystems in the province. The Towns of Black Diamond and Turner Valley are currently located in the Foothills Parkland region (indicated in Figure 8), characterized by a mosaic of aspen forests and foothills fescue grasslands[xiv]. The towns are bordered on the west by the higher-elevation Montane ecosystem, where aspen forests become more dominant and lodgepole pine and Douglas fir stands appear, and on the east by the Foothills Fescue grassland ecosystem[xv].

The warmer and drier conditions projected for the Black Diamond and Turner Valley area by the middle of the century will have consequences for these regional ecosystems: the projected climate for the 2050s will be more favourable for grassland ecosystems and less favourable for the forested ecosystems of the Montane and Foothills Parkland. Although specific projections for ecosystem change in this region are challenging because of the diversity of ecosystems across a relatively small region, some general patterns of change can be anticipated. At lower elevations in the Montane ecosystem, forest stands will likely be more susceptible and less likely to recover from disturbances like insect outbreaks, fire, and drought, leading to a gradual transition of this ecosystem to one that resembles the Foothills Fescue grasslands of today[xvi]. In the east, drier conditions may encourage a shift in the composition of the Foothills Fescue grassland community towards the more drought-tolerant grasses common in the Mixedgrass ecosystem[xvii]. Immediately around the Towns of Black Diamond and Turner Valley, the hilly topography is likely to continue to support the mosaic of aspen forests and grasslands of the Foothills Parkland Ecosystem[xviii].

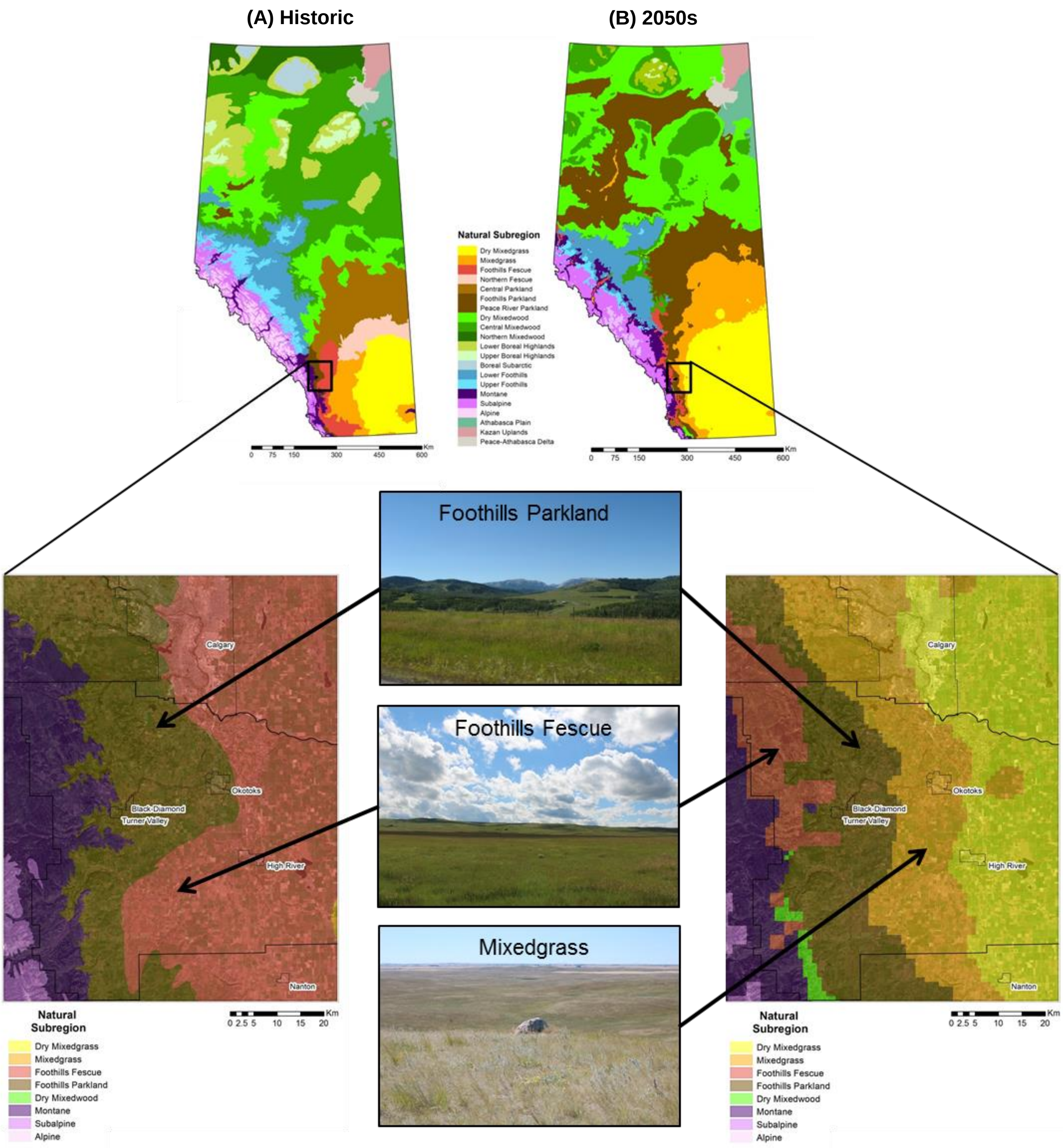
Wetlands

Wetlands in the Black Diamond and Turner Valley area and in the prairie region more broadly, are highly sensitive to climate variability[xix]. Projected declines in summer precipitation and overall available moisture, and more frequent drought conditions in the future will lead to reductions in wetland area and depth, and will reduce wetland permanence[xx,xxi].

Wildfire

The warmer and drier climate projected for the Black Diamond and Turner Valley area by the 2050s will create conditions more favourable for wildfires. In particular, a longer fire season with more severe fire weather conditions in the future is likely to result in fires that are more difficult to control and to an increase in the average area burned[xxii, xxiii].

Figure 8: (A) Historic (1961-1990) and (B) projected (2050s) distribution of natural sub-regions in Alberta and around the Towns of Black Diamond and Turner Valley[xxiv, xxv]



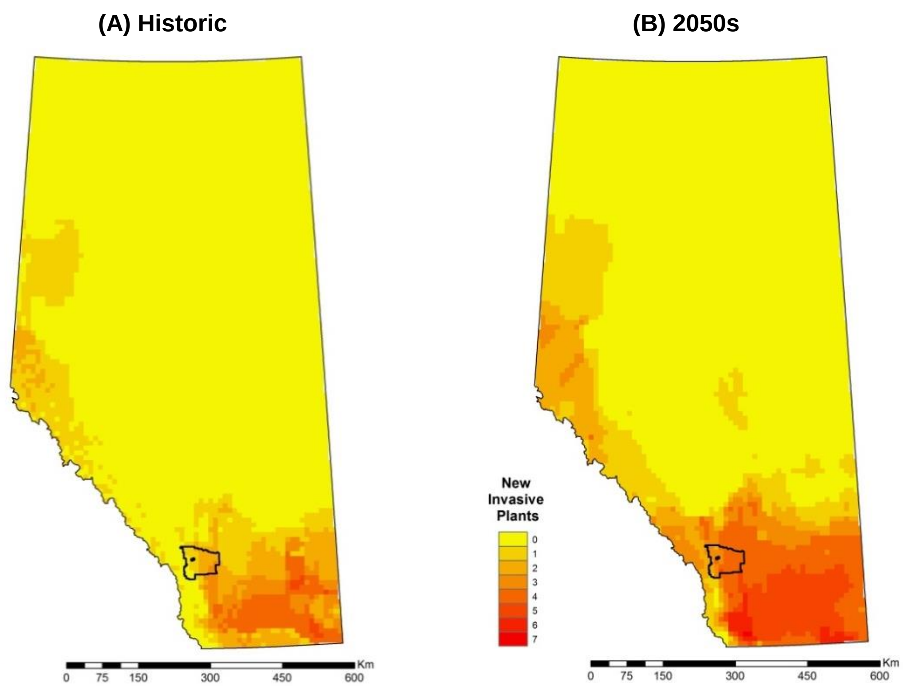
➡ Streamflow

Streamflow volume and timing in the headwater creeks on the eastern slopes of the Canadian Rockies around the Towns of Black Diamond and Turner Valley depend primarily on snowmelt, in addition to groundwater[xxvi]. An increased proportion of rain versus snow in winter months, and earlier snowmelt driven by warmer spring temperatures are projected to increase winter streamflow, earlier spring peak flow, and earlier in the spring, and decrease in the summer[xxvii]. Stream temperatures in the region are projected to increase during the summer months, as a result of projected warming, with potential consequences for aquatic wildlife habitats and recreation opportunities[xxviii].

➡ Invasive plants

The warmer and drier conditions projected for the Black Diamond Turner Valley area by the middle of the century, and in southern Alberta more broadly, are likely to be more favourable for invasive plants that are not currently found in the region. As a result, the region is likely to be at risk from a greater number of invasive plants in the middle of the century compared to today (see Figure 9).

Figure 9: (A) Historic (1961-1990) and (B) projected (2050s) suitable climate for potential new invasive plant species to Alberta[xxix]



4. Climate Risks and Opportunities for Towns of Black Diamond and Turner Valley

Session 3 at the workshop invited participants to:

1. Identify how projected climate or environmental changes for the 2050s could impact Black Diamond and Turner Valley; and

2. Translate the identified impacts into risks and opportunities in order to establish priorities for action planning.

Potential Climate Impacts

Workshop participants identified a range of climate-related impacts for the local economy, property and infrastructure, the natural environment, and residents' health and lifestyles. The list of identified impacts is provided in Table 2.

Table 2: Potential climate change impacts with mainly negative (-) or positive (+) consequences for the Towns of Black Diamond and Turner Valley

• Water supply shortage and drought (-)	• Snow storm (-)
• Loss of wetlands (-)	• Reduced winter recreation (-)
• Wildfire (-)	• Ice storm / freezing rain (-)
• Increased cooling costs (-)	• Deforestation (-)
• Tornado (-)	• River flooding (-)
• Heat wave (-)	• Increased stock grazing (+)
• Hailstorm (-)	• Increased in local food opportunities (+)
• Storm-water flooding (-)	• Increase in summer tourism/recreation (+)

PRIORITY CLIMATE RISK AND OPPORTUNITIES

The potential impacts listed in Table 2 served as a starting point for the risk and opportunity assessment. Following plenary discussion at the workshop, some impacts were merged and the descriptions modified. Other impacts were deemed not particularly relevant to the Town, or had positive and negative consequences that were judged to cancel out; these are not considered further. This produced a smaller list of the most important potential impacts for Black Diamond and Turner Valley.

Workshop participants were invited to translate these impacts into risks (impacts with mainly negative consequences) and opportunities (impacts with mainly positive consequences), and to simultaneously prioritize the risks and opportunities. Priorities are assigned to impacts by scoring, first, the severity of potential consequences for the area, and second, the likelihood of those consequences being realized. Participants assigned scores to impacts using the consequence scales found at Appendix B (for risks) and Appendix C (for opportunities), and the likelihood scale found at Appendix D.

➡ Potential risks

Table 3 provides a description of the potential climate change risks facing the Towns of Black Diamond and Turner Valley. The description includes a selection of key consequences, along with the label used to identify the impact in the “risk map” shown in Figure 10. The risk map is a two-dimensional representation of adverse consequences plotted against likelihood. Impacts in the upper right corner of the map have larger adverse consequences combined with a high likelihood of occurrence. These impacts are priorities for action.

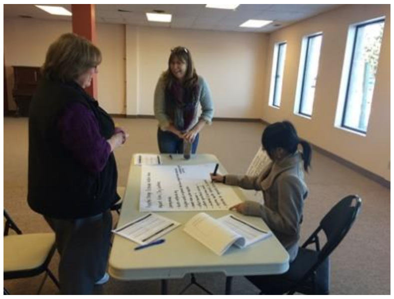


Table 3: Climate change risks facing the Towns of Black Diamond and Turner Valley by the 2050s

Potential local risks		Key consequences for Black Diamond and Turner Valley
Label for risk map	**Description**	
"Loss of wetlands"	Deterioration or loss of local wetlands caused by shifting ecosystems, warmer summer temperatures, or long-term drought.	• Change in groundwater levels–less surface water/retention • Impact on bird/wildlife habitat • Landscape change – drier conditions, trees affected, etc. • Increased costs for agricultural irrigation • Possibly fewer mosquitos • New opportunities for land use
"Water supply shortage"	Inability to meet water demand of town due to decrease in summer stream flows and less available moisture.	• Water restrictions required – unhappy residents • Impacts to economy and businesses if water not available • Warmer rivers impact fish • Lifestyle changes required to promote water conservation • Disappearance of wetlands and riparian areas • Potential loss of water-based recreation • Economic and quality of life impacts for agriculture industry
"Wildfire"	Increased interface wildfire risk caused by increased summer temperatures and heat waves, less precipitation in summer, less available moisture and a longer fire season.	• Negatively affects tourism • Negatively affects agriculture industry • Potential loss or damage to residential and commercial buildings • Negative health impacts from smoke • Negative impact on landscape and wetlands
"Deforestation"	Loss of local forests due to long-term regional shift toward grassland-dominated ecosystem.	• Less water production and carbon dioxide uptake • Reduction in air quality • Change in appearance of the landscape
"Tornado"	Destructive tornado caused by more extreme heat and an increase in intensity of summer storms.	• Damage to property and infrastructure • Higher insurance costs • High stress levels and reduced quality of life • Loss of communication lines
"Hail"	Destructive hail storm caused by more extreme heat and an increase in intensity of summer storms.	• Damage to property and infrastructure • Damage to agricultural crops • Potential for injury • Higher insurance costs • High stress levels and reduced quality of life

Potential local risks		Key consequences for Black Diamond and Turner Valley
Label for risk map	**Description**	
"River flooding"	Increased frequency and intensity of flooding from extreme precipitation events.	• Damage to property and infrastructure • Potential injuries and fatalities • Interruption to businesses and economic activity • Reduced water quality and damage to aquatic habitat
"Storm-water flooding"	Localized 'flash' flooding caused by extreme precipitation capacity of storm-water system exceeded.	• Road closures and transportation delays – potential economic impacts • Damage to property and infrastructure
"Snow storm"	Major snowstorm / blizzard caused by an increase in winter precipitation and in the number of extreme precipitation events.	• Transportation disruption – stranded travellers • Damage to trees • Damage to property and infrastructure (snow loading) • Road maintenance costs
"Ice storm/ Freezing rain"	Freezing rain event caused warmer winter temperatures and increased proportion of winter precipitation falling as rain.	• Disruption to electricity service and communication systems • Transportation disruption – stranded travellers • Damage to property and infrastructure • Potential injuries (slips and falls) • Road maintenance costs
"Loss of winter recreation"	Fewer opportunities for local winter recreation due to warner winter temperatures and less precipitation falling as snow.	• Economic impacts – fewer tourists • Negative impact on quality of life for residents
"Increased cooling costs"	Increased space cooling costs (air conditioning) due to warmer summer temperatures and more periods of extreme heat	• Increased costs for residents, businesses and municipality
"Heat wave"	Extreme heat event caused by warmer summer temperatures and more periods of extreme heat.	• Public health impact, particularly for vulnerable populations (infants and elderly)

Figure 10: Risk map for climate change impacts facing the Towns of Black Diamond and Turner Valley

CONSEQUENCES	(1) Low	(2) Low-moderate	(3) Moderate	(4) Moderate-high	(5) High
(5) Major	Tornado				Higher priorities for action
(4)	Heat wave		Water supply shortage River flooding Wildfire		
(3) Moderate			Ice storm / freezing rain	Storm-water flooding Hail storm Snow storm Loss of wetlands	
(2)			Loss of winter recreation Deforestation		
(1) Negligible	Lower priorities for action			Increased cooling costs	
	LIKELIHOOD				

Impacts in the red and yellow zones are priorities for further investigation or management. Impacts in the red zone are the highest priorities for action. Impacts in the green zone represent broadly acceptable risks; no action is required now for these impacts beyond monitoring of the risk level as part of periodic reviews (see Section 6).

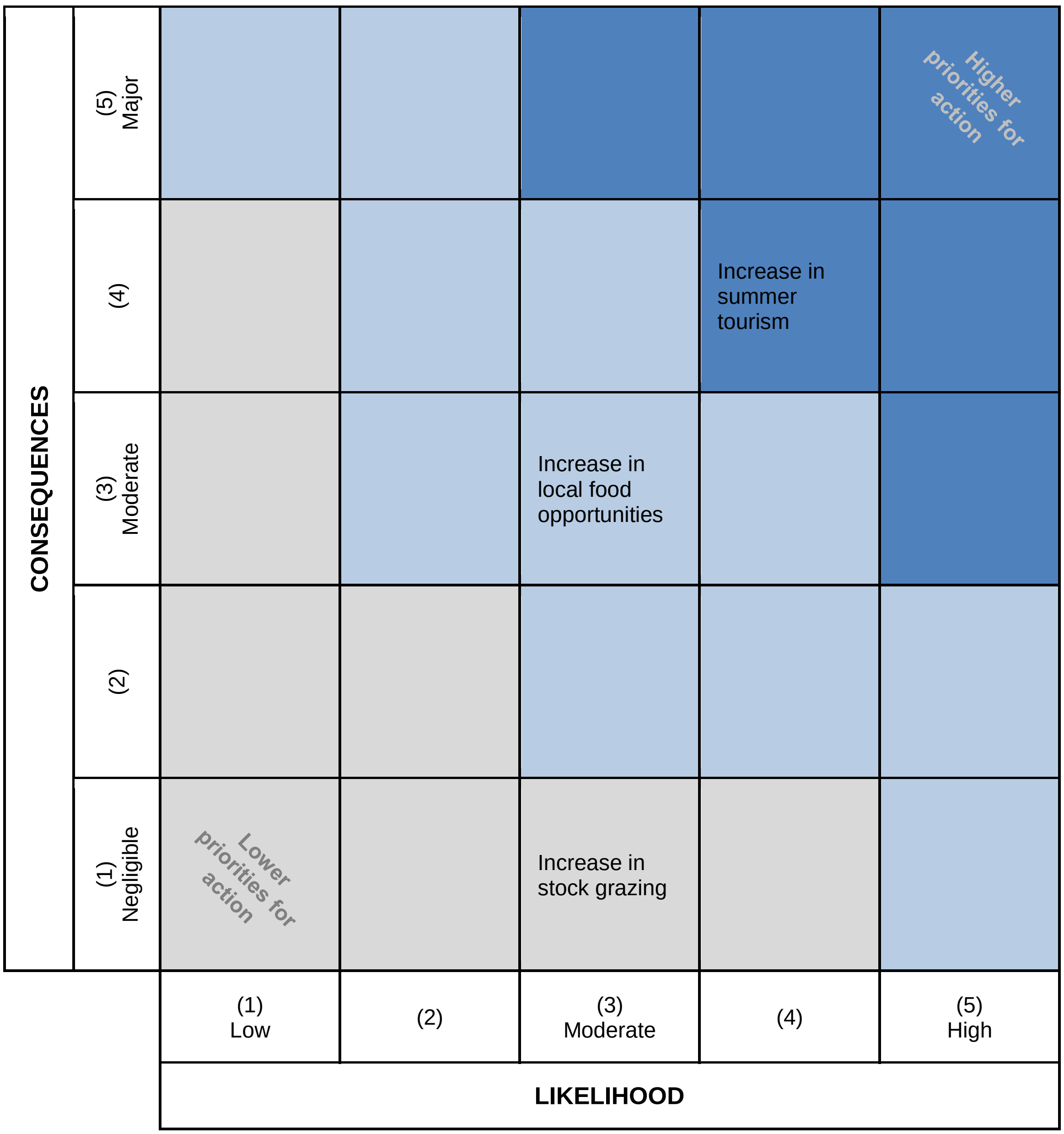
➡ Potential opportunities

Table 4 provides a description of the potential climate change opportunities for Black Diamond and Turner Valley. The description includes a selection of potential benefits, along with the label used to identify the impact in the opportunity map shown in Figure 11. Impacts in the upper right corner of the map have greater potential benefits combined with a high likelihood of occurrence. These impacts are priorities for action.

Table 4: Climate change opportunities for the Towns of Black Diamond and Turner Valley by the 2050s

Potential local opportunities		Key consequences for Black Diamond and Turner Valley
Label for opportunity map	**Description**	
"Increase in summer tourism"	Increase in opportunities for summer recreation for both residents and tourists as a result of warmer temperatures.	• Economic benefits – potential to attract more tourists • Increased use of outdoor amenities/activities (pool, paths, spray park) • Quality of life benefits
"Increase in local food opportunities"	Additional opportunities for food growing for both local gardens and agricultural producers from warmer summer temperatures and an extended growing season.	• Economic benefits • Increase in access to local produce • Increase in water conservation • Community development • Increased water usage • More local food available (farmers market) • Improved economy
"Increase in stock grazing"	Additional land available for stock grazing due to long-term regional shift toward grassland-dominated ecosystem.	• Economic benefits from increased beef and grain production

Figure 11: Opportunity map for climate change impacts facing the Towns of Black Diamond and Turner Valley



Impacts in the dark blue and light blue zones are priorities for further investigation or promotion. Impacts in the dark blue zone are the highest priorities for action. Impacts in the grey zone represent marginal opportunities; no action is required now for these impacts beyond monitoring of the level of opportunity as part of periodic reviews (see Section 6).

5. Climate Resilience Actions

The next step is to formulate actions (a) to increase resilience to priority risks and (b) to increase capacity to capitalize on priority opportunities.

For the priority risks and opportunities plotted in Figure 10 and Figure 11 respectively, Session 4 at the workshop invited participants to devise a list of recommended adaptation actions. Ideally, actions should be devised for all priority risks and priority opportunities. However, within the time constraints of the one-day workshop used by Climate Resilience Express, action planning focuses on a subset of priority risks and opportunities, chosen by workshop participants. The four priorities selected for action planning are:

1. Wildfire (risk);
2. Loss of wetlands (risk);
3. Water supply shortage (risk); and
4. Increase in summer tourism (opportunity).

For each of these four priorities, a starter action plan is developed by, first, addressing the following two questions:

1. What actions are currently being taken to manage the risk or opportunity?
2. What new actions, or improvements to existing actions, are needed to more effectively manage the risk or opportunity in the future?

Second, the resulting long-list of potential actions is screened to identify, for each priority risk or opportunity, three to five of the most promising actions for inclusion in the climate resilience plan. When screening actions, participants should consider • the likely effectiveness of the action in mitigating the risk, • how feasible it would be to implement, • how generally acceptable it would be to stakeholders, including elected officials, and • how equitably spread are the costs and benefits of the action across the community.

To support the successful implementation of recommended actions, workshop participants also provided information on:

1. Total implementation costs;
2. The timeframe for implementation; and
3. The lead department or organization.

These three factors are key inputs to the development of an implementation strategy. Table 5 was used to help participants provide approximations for (1) and (2).

Table 5: Climate resilience actions – definitions for total implementation costs and implementation timeframe

Information	Descriptor	Description
Total implementation costs	Low	Under $10,000
	Moderate	$10,000 to $49,999
	High	$50,000 - $99,999
	Very high	$100,000 or more
Timeframe to have action implemented (operational)	Ongoing	Continuous implementation
	Near-term	Under 2 years
	Short-term	2 to 5 years
	Medium-term	5 to 10 years
	Long-term	10 years or more

Starter action plans for each of the four selected priorities are provided below. It is important that the other priority risks and opportunities are put through a similar action planning exercise as soon as it is practical to do so.

Of note, the Towns of Black Diamond and Turner Valley are already committed to numerous actions that will help manage the risks and opportunities of climate change identified in Section **Error! Reference source not found.**. Some of these actions were identified during Session 4 f the workshop and include measures to:

- Manage wildfire risk, such as implementation of a FireSmart program, mutual aid agreements with the Government of Alberta and nearby municipalities, fire bans when necessary and training for firefighters;
- Support effective wetland management such as requirements for on-site water retention in new developments, municipal storm-water retention ponds, a streambank restoration education program and riparian repair systems;
- Manage water to mitigate water supply shortages including a water conservation bylaw, community education, universal water metering, and a leakage detection program; and

- Increase opportunities for summer tourism, including local facilities like the swimming pool, spray park and pathway system, promotion of specialty shopping and dining, and regional marketing initiatives.

It is important that both Towns continue to support the implementation of these important climate resilience activities.

Loss of Wetlands

Action	Implementation Cost	Implementation Timeframe	Implementation Lead
Update Municipal Develop Plan and subdivision standards to ensure retention of wetlands in new developments	High	Short-term	Planning
Develop a Master Drainage Strategy that promotes retention of natural drainage systems and incorporates a low-impact-develop approach to storm-water management	High	Near-term	Planning
Develop a wetland and riparian area education program	Moderate	Medium-term	Planning
Develop a wetland monitoring and maintenance program to track wetland loss and restore natural wetlands	Very high	Long-term	Planning

WILDFIRE

Action	Implementation Cost	Implementation Timeframe	Implementation Lead
Identify a defensible space around the Town boundaries	Low	Near-term	Fire / Planning
Enhance community education efforts about wildfire risks and mitigation	Low	Ongoing	Fire / Communications
Improve response times by cross-utilizing firefighting equipment and personnel	Moderate	Ongoing	Fire / Budget

WATER SUPPLY SHORTAGE

Action	Implementation Cost	Implementation Timeframe	Implementation Lead
Implement automatic water restrictions throughout the summer season	Low	Near-term	Council / administration
Develop water conservation education materials targeted at recreational users	Low	Near-term	Administration
Encourage water users to utilize non-potable water for all permitted uses	High	Near-term	Council / users
Encourage use of drought-tolerant landscaping on public and private property	Moderate	Short-Term	Planning / Parks & Recreation

Increase in Summer Tourism

Action	Implementation Cost	Implementation Timeframe	Implementation Lead
Increase the number of cultural and activity-based events offered (e.g. folk festival)	Moderate	Short-term	Partnership between municipality, businesses, chamber, cultural groups
Improve communications with potential event hosts and organizations to enhance event offerings	Moderate	Near-term	
Explore opportunities to enhance summer tourism through local food sales and agri-tourism	Moderate	Short-term	
Invest in facilities and infrastructure targeted at the travelling public such as parking, washrooms and new attractions	High	Medium-long term	Municipality

6. Implementation and Next Steps

> Writing a plan and leaving it on the shelf, is as bad as not writing the plan at all. If this Action Plan is to be an effective tool, it must be implemented and reviewed periodically.

Acting

The recommended actions listed in Section 5 serve as a 'shopping-list'. Town staff should establish priorities from the listed actions, and begin implementation as soon as practical. Consideration should be given to forming a cross-departmental and cross-community implementation team from among workshop participants to oversee implementation of the Action Plan. A number of actions can be implemented quickly with minimal investment, whereas other actions have longer-term timeframes, require a higher level of investment, and may require a more detailed implementation strategy with specific budgets and funding sources, timelines and milestones for specific activities, and defined roles and responsibilities for specific stakeholders and groups.

Effective communication with the public and other community stakeholders about climate change impacts can be valuable in helping them understand why certain measures are needed. Community outreach, for example through the Town websites or at public events can be an effective way to both:

- Gather input from community members on the content of the Action Plan; and
- Promote the Towns' efforts to become more resilient.

Mainstreaming

This Action Plan is developed as a 'stand-alone' document. However, it is important that climate resilience generally is integrated (i.e., 'mainstreamed')—as a matter of routine—into the Town's strategies, plans, policies, programs, projects, and administrative processes. For example:

- Climate resilience should be considered in all future land use and development decisions, including administrative processes such as bids, tenders and contracts for planning and development work;

- Strategic plans (e.g., the Municipal Development Plan and Parks, Open Spaces and Trails Master Plan) and neighborhood scale plans should consider potential future climate change impacts; and
- Decisions related to the design, maintenance, and upgrading of long-life infrastructure assets and facilities should likewise consider future climate changes and impacts.

REVIEW AND UPDATE

Building resilience to climate change is not a static process. The priority risks and opportunities identified in this Action Plan, along with the recommended actions to address them, should be viewed as the first step in Black Diamond and Turner Valley's journey towards a climate resilient future.

The climate resilience action planning process is dynamic. For a start, the rapidly changing scientific knowledge about the physical impacts of climate change means that climate change risk and opportunity assessments are not one-off activities, but rather need to be reviewed and updated regularly. This Action Plan should be reviewed and updated every 5 years to ensure it remains relevant and effective, taking account of:

- Lessons learned from the implementation of actions;
- New scientific information about climate projections and corresponding impacts; and
- Changes to the Town's goals and policies.

Keeping the Action Plan relevant may only involve a few minor adjustments, or it may require revisiting some of the steps in the climate resilience planning process and preparing a new Action Plan.

7. APPENDICES

Appendix A: Workshop participants

Name	Title
Town of Black Diamond	
Sharlene Brown	Mayor
Tom Dougal	Public Works Foreman
Ellyn DuMont	GIS Coordinator
Les Quinton	Parks & Recreation Manager
Mike Ross	Councillor
Rod Ross	Planning & Development Officer
Verna Staples	Legislative Services Manager
Erin Welk	Urban Systems (Engineering Consultant)
Dusty Williams	Chair, Black Diamond Sustainability Committee
Town of Turner Valley	
Matthew Atkinson	Planning and Development Coordinator
Monique LeBlanc	Community Services and Business Development Manager
Judy Mackenzie	Planning and Development Assistant
Stephanie Ruddock	Community Services Coordinator
Gerry Rooke	Director of Emergency Management
Ellyn DuMont	GIS Coordinator
Kelly Tuck	Mayor
Barry Crane	Councillor
John Waring	Councillor

Appendix B: Scale for scoring the consequences of risks

Score	Description
(1) **Negligible**	• Negligible impact on health & safety and quality of life for residents • Very minimal impact on local economy • Insignificant environmental disruption or damage • Slight damage to property and infrastructure, very short-term interruption of lifelines, or negligible cost to municipality
(2)	
(3) **Moderate**	• Some injuries, or modest temporary impact on quality of life for some residents • Temporary impact on income and employment for a few businesses, or modest costs and disruption to a few businesses • Isolated but reversible damage to wildlife, habitat or and ecosystems, or short-term disruption to environmental amenities • Damage to property and infrastructure (including critical facilities and lifelines), short-term interruption of lifelines to part of community, localized evacuations, or modest costs to municipality
(4)	
(5) **Major**	• Many serious injuries or illnesses, some fatalities, or long-term impact on quality of life for most residents • Long-term impact on businesses and economic sectors, major economic costs or disruption • Widespread and irreversible damage to wildlife, habitat and ecosystems, or long-term damage, disruption to environmental amenities • Widespread damage to property & infrastructure (including critical facilities and lifelines), extensive and long-term interruption of services, widespread evacuations, or major cost to municipality

Appendix C: Scale for scoring the consequences of opportunities

Rating	Description
(1) **Low**	• Increase in income / jobs for a *few* businesses • Lifestyle improvement for *some* residents • Cost savings for municipality, businesses or residents
(2)	
(3) **Moderate**	• Increase in income / jobs for a *sector* • Lifestyle improvement for a *select group* of residents • Cost savings for municipality, businesses or residents • *Short-term* boost to reputation and image of municipality
(4)	
(5) **High**	• Increase in income / jobs for *key sectors* of local economy • Lifestyle improvement for a *majority* of residents • Cost savings for municipality, businesses or residents • *Long-term* boost to reputation of municipality

Appendix D: Scale for scoring the likelihood of consequences

Rating	Recurring Impact	Trending Impact
(1) **Low**	Once in 50 years or more	*Very unlikely* – less than 5% chance of occurrence in next 50 years
(2)	Once in 10 to 50 years	*Unlikely* – 5% to 35% chance of occurrence in next 50 years
(3) **Moderate**	Once in 5 to 10 years	*Possible* – 35% to 65% chance of occurrence in next 50 years
(4)	Once in 1 to 5 years	*Likely* – 65% to 90% chance of occurrence in next 50 years
(5) **High**	Up to once per year	*Almost certain* – 95% or greater chance of occurrence in next 50 years

8. ENDNOTES

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[i] Environment Canada's Adjusted and Homogenized Canadian Climate Data (AHCCD) are quality controlled climate data that incorporate a number of adjustments applied to the original meteorological station data to addresses any inaccuracies introduced by changes in instruments and observing procedures.

[ii] The significance of the trends was determined using the Mann-Kendall test after removing lag-1 autocorrelation with the Zhang (1999) method (described in Wang and Swail, 2001).

[iii] Wang, T., Hamann, A. Spittlehouse, D.L. and Murdock, T.Q. 2012. ClimateWNA – High-resolution spatial climate data for western North America. *Journal of Applied Meteorology and Climatology* **51**:16-29.

[iv] The Pacific Climate Impacts Consortium (PCIC) is a regional climate service centre based at the University of Victoria. PCIC provides a number of tools that support long-term planning for climate change including the model projections derived from the Regional Analysis Tool.

[v] Warren, F.J. and Lemmen, D.S., editors (2014): Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation; Government of Canada, Ottawa, ON, 286p.

[vi] Westra, S., Alexander, L.V., Zwiers, F., 2013. Global increasing trends in annual maximum daily precipitation. J Clim 26(11) 3904–3918.

[vii] Trenberth, K.E., 2011. Changes in precipitation with climate change. Clim Res., 47, 123-138.

[viii] Schneider, R.R. 2013. Alberta's Natural Subregions under a changing climate: past, present and future. Biodiversity Management and Climate Change Adaptation Project, Alberta Biodiversity Monitoring Institute, Edmonton, AB. Available at: http://www.biodiversityandclimate.abmi.ca/

[ix] Ibid.(same as previous reference)

[x] Specifically, they are a measurement of heat accumulation, calculated by determining the total number of degrees by which average daily temperature exceeds a threshold temperature (in this case 5°C) over the course of a growing season.

[xi] Sauchyn, D. and S. Kulshreshtha. 2008. Prairies; *in* From Impacts to Adaptation: Canada in a Changing Climate 2007, *edited by* D.S. Lemmen, F.J. Warren, J. Lacroix, and E. Bush; Government of Canada, Ottawa, ON. pp. 275-328.

[xii] Maps created with climate data available at http://ualberta.ca/~ahamann/data/climatewna.html (Hamann et al. 2013). The mid-century climate moisture index projection is based on the German ECHAM5 global climate model and the A2 emissions scenario (IPCC 2000). Climate moisture index represents the balance between annual precipitation and annual evapotranspiration; it is positive when precipitation exceeds evapotranspiration (Hogg 1997).

- Hamann, A. T. Wang, D.L. Spittlehouse, and T.Q. Murdock. 2013. A comprehensive, high-resolution database of historical and projected climate surfaces for western North America. *Bulletin of the American Meteorological Society* 94:1307–1309.
- IPCC. 2000. Special Report on Emissions Scenarios - Summary for Policy Makers. Intergovernmental Panel on Climate Change Working Group III.
- Hogg, E.H. 1997. Temporal scaling of moisture and the forest-grassland boundary in western Canada. Agricultural and Forest Meteorology 84:115-122.

[xiii] Maps created with climate data available at http://ualberta.ca/~ahamann/data/climatewna.html (Hamann et al. 2013). The mid-century growing degree days projection is based on the German ECHAM5 global climate model and the A2 emissions scenario (IPCC 2000).

- Hamann, A. T. Wang, D.L. Spittlehouse, and T.Q. Murdock. 2013. A comprehensive, high-resolution database of historical and projected climate surfaces for western North America. *Bulletin of the American Meteorological Society* 94:1307–1309.
- IPCC. 2000. Special Report on Emissions Scenarios - Summary for Policy Makers. Intergovernmental Panel on Climate Change Working Group III.

[xiv] Natural Regions Committee. 2006. Natural Regions and Subregions of Alberta. Compiled by D.J. Downing and W.W. Pettapiece. Government of Alberta. Pub. No. T/852. Edmonton, AB.

[xv] Ibid.

[xvi] Schneider, R.R. 2013. Alberta's Natural Subregions under a changing climate: past, present and future. Biodiversity Management and Climate Change Adaptation Project, Alberta Biodiversity Monitoring Institute, Edmonton, AB. Available at: http://www.biodiversityandclimate.abmi.ca/

[xvii] Ibid.

[xviii] Ibid.

[xix] Liu, G. and F.W. Schwartz. 2012. Climate-driven variability in lake and wetland distribution across the Prairie Pothole Region: from modern observations to long-term reconstructions with space-for-time substitution. *Water Resources Research* 48:W08526.

[xx] Ouyang, Z., R. Becker, W. Shaver, and J. Chen. 2014. Evaluating the sensitivity of wetlands to climate change using remote sensing techniques. *Hydrological Processes* 28:1703-1712.

[xxi] Johnson, W.C., B. Werner, G.R. Guntenspergen, R.A. Voldseth, B. Millett, D.E. Naugle, M. Tulbure, R.W.H. Carroll, J. Tracy, and C. Olawsky. 2010. Prairie wetland complexes as landscape functional units in a changing climate. *BioScience* 60:128-140.

[xxii] de Groot, W.J., M.D. Flannigan, and A.S. Cantin. 2013. Climate change impacts on future boreal fire regimes. *Forest Ecology and Management* 294:35-44.

[xxiii] Flannigan, M.D., M.A. Krawchuk, W.J. de Groot, B.M. Wotton, and L.M. Gowman. 2009. Implications of changing climate for global wildland fire. *International Journal of Wildland Fire* 18:483-507.

[xxiv] Maps created with data available at http://www.biodiversityandclimate.abmi.ca. The mid-century Natural Subregion projection from Schneider (2013) is based on the German ECHAM 5 global climate model and the A2 emissions scenario (IPCC 2000).

- Schneider, R.R. 2013. Alberta's Natural Subregions under a changing climate: past, present and future. Biodiversity Management and Climate Change Adaptation Project, Alberta Biodiversity Monitoring Institute, Edmonton, AB. Available at: http://www.biodiversityandclimate.abmi.ca/
- IPCC. 2000. Special Report on Emissions Scenarios - Summary for Policy Makers. Intergovernmental Panel on Climate Change Working Group III.

[xxv] Photo credits (top to bottom): ABMI; Monica Kohler; Monical Dahl.

[xxvi] Byrne, J.M., D. Fagre, R. MacDonald, and C.C. Muhlfeld. Climate Change in the Rocky Mountains. *In:* Impact of Global Changes on Mountains: Responses and Adaptation. Grover, V.I., A. Borsdorf, J.H. Breuste, P.C. Tiwari, and F.W. Frangetto eds. CRC Press, New York, NY.

[xxvii] Ibid.

[xxviii] MacDonald, R.J., S. Boon, J.M. Byrne, M.D. Robinson, and J.B. Rasmussen. Potential future climate effects on mountain hydrology, stream temperature, and native salmonid life history. Canadian Journal of Fisheries and Aquatic Sciences 71:189-202.

[xxix] Maps from Chai, S.L., A. Nixon, J. Zhang, and S. Nielsen. 2014. Predicting invasive plant responses to climate change: prioritization and mapping of new potential threats to Alberta's biodiversity. Prepared for the Biodiversity Management and Climate Change Adaptation Project, Alberta Biodiversity Monitoring Institute, Edmonton, AB. Available at: http://www.biodiversityandclimate.abmi.ca/.

The projected future distribution of each potential new invasive plant species is based on the CSIRO-Mk3.0 global climate model, A2 emissions scenario (IPCC 2000).

- IPCC. 2000. Special Report on Emissions Scenarios - Summary for Policy Makers. Intergovernmental Panel on Climate Change Working Group III.

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FOUNDATION

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