


MACKENZIE COUNTY

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. Mackenzie County was 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: 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 Mackenzie County, with observable changes in temperature, precipitation, and extreme weather events over the last century. The impacts of climate change on the County 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, Mackenzie County has 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 four climate-related opportunities were identified, of which four risks and one opportunity were judged to be priorities requiring immediate action. Priority climate change risks for Mackenzie County include:

1. Wildfire;
2. Transport and access disruption;
3. Crop and forage loss; and
4. Freezing rain / ice storm.

Starter action plans are developed for each of these priority risks. The potential for a greater variety of crops to be grown in the region was identified as a significant opportunity, though no new actions to take advantage of this opportunity are formulated at this time.

Mackenzie County is already committed to numerous actions that help manage the above priority risks, including: wildland urban interface planning and other actions to manage wildfire risk; agricultural education and experimentation with new crops through the Mackenzie Applied Research Association; and installation of backup generators at most County offices and water treatment facilities. It is important that the County follow through on these and other standing commitments, as part of its effort to be prepared for weather and climate impacts now, and in the future.

In addition to existing actions that help mitigate priority climate risks, 16 actions are identified for consideration to help Mackenzie County 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 Mackenzie County remains 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 Mackenzie County, with observable changes in temperature, precipitation, and extreme weather events over the last century. The average annual temperature in the Mackenzie County area has increased by about +2.7°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—be it through 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.

Mackenzie County, through the preparation of this Action Plan, is 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;

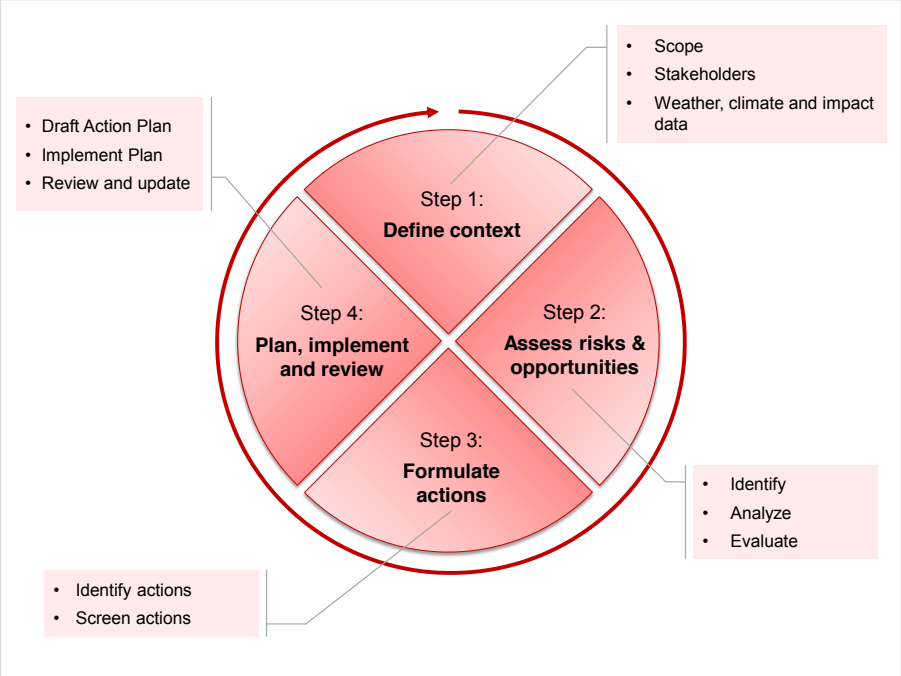
Step 2: Assess potential climate-related risks and opportunities to establish priorities for action;

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 Mackenzie County is established. This involves:

- **Defining the spatial scope**

  The spatial scope is limited to direct impacts within the geographic boundaries of Mackenzie County.

- **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 Mackenzie County 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 Mackenzie County 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 Mackenzie County, 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 4.

- **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 Mackenzie County has 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

- ✓ Extreme dryness and high temperatures led to severe fires in the early 1980's, 2012 and 2015, affecting air quality and forestry operations.
- ✓ Major windstorm in January 2014, leading to power outages across the County.
- ✓ Freezing rain events have started to occur more often over the last 10-15 years.
- ✓ Fewer cold spells in winter.
- ✓ Extreme rain events happening more frequently.
- ✓ Flooding of Peace River in 1934 (due to ice jams) and in 1986.
- ✓ Earlier and faster snow melt is increasing spring flood risk in some areas.
- ✓ Forestry operations and oil and gas sector have a shorter operating season (starting later, finishing earlier) due to shorter winters and less reliable winter access roads.
- ✓ Food growing season is longer.
- ✓ Access to some communities and areas of the County is restricted due to less reliable winter access roads (e.g., ice bridges over the Peace River).

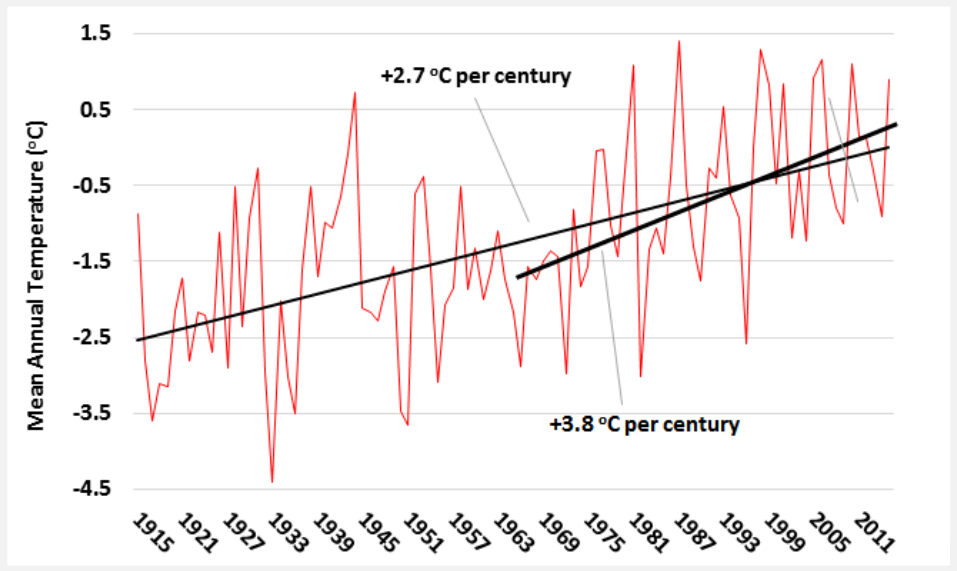
LOCAL CLIMATE TRENDS

To provide a perspective of historic climate trends in Mackenzie County, data is collected and analyzed from eight climate stations in the region (Ft. Nelson, Ft. Chipewyan, Hay River, High Level, Peace River, Ft. Smith, Ft. McMurray and Ft. Vermilion)[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 Mackenzie County are assembled by averaging the individual records from the five climate stations and applying appropriate statistical techniques[ii].

➡ Temperature records

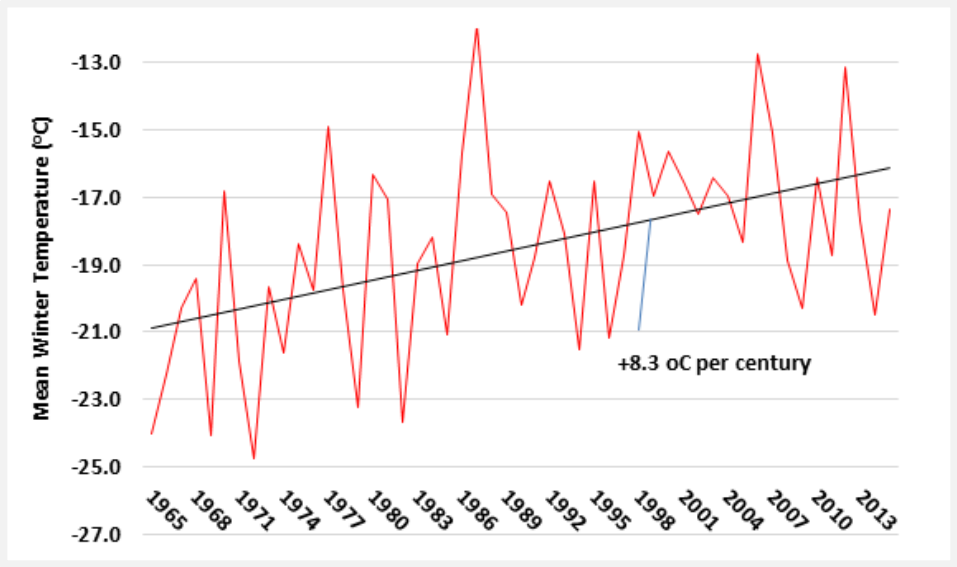
Temperature records for the area over the period 1915-2015 show that mean annual temperature has increased at a rate of 2.7 °C per century (Figure 2), which is approximately 2.4 times faster than the observed global rate of warming over the same time period. The rate of warming observed over the last 50 years is higher still at 3.8°C per century.

Figure 2: Mean annual temperature in Mackenzie County (1915-2015)



Over the last 50 years, the largest seasonal increase in temperature in Mackenzie County occurred during the winter (December-February). The observed rate of warming in winter since 1965 is +8.3°C per century (Figure 3), which is substantially greater than the annual rate of +3.8°C per century. In contrast, warming during the summer (June-August) since 1965 occurred at a slower rate of +3.0°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 Mackenzie County (1965-2015)

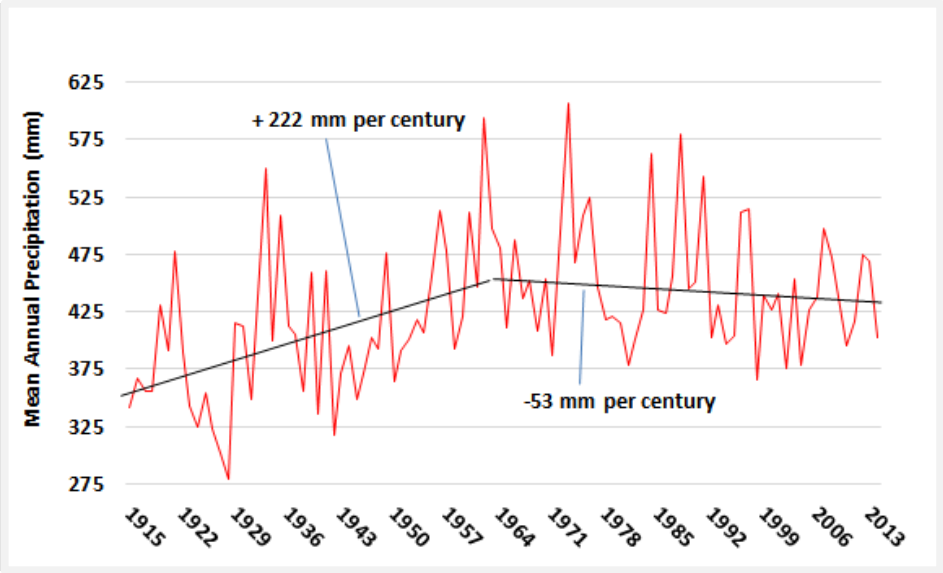


➡ Precipitation records

Mean annual precipitation in Mackenzie County increased by 80 mm over the last century (Figure 4), although this was largely driven by a rapid increase in the first half of the 20th century (+222 mm per century). Since 1965, mean annual precipitation has declined at a rate of 53 mm per century, but this latter trend is not statistically robust.

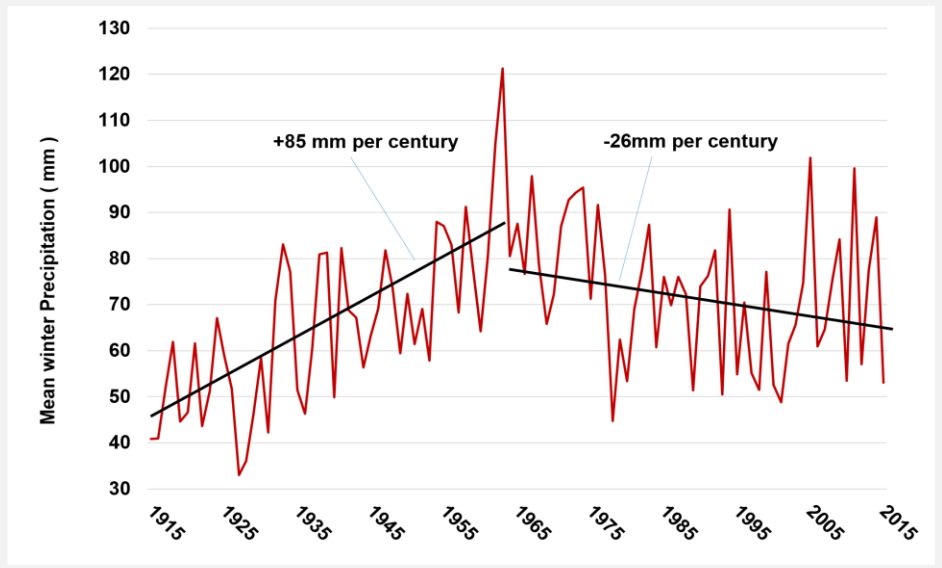
Changes in seasonal precipitation since 1965 show no significant trends with one exception: winter precipitation (December-February) has decreased at a rate of 30mm per century over the last 50 years.

Figure 4: Mean annual precipitation in Mackenzie County (1915-2014)



Source: CWNA[iii]

Figure 5: Mean winter precipitation in Mackenzie County (1915-2014)



CLIMATE PROJECTIONS FOR AREA

Climate projections for Mackenzie County, 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 Mackenzie County are summarized in Table 1. The mean annual temperature is anticipated to increase by +2.1°C above the 1961-1990 baseline, which will increase the absolute mean annual temperature in the 2050s to about +0.9ºC. This projected increase in temperature is consistent with the rate of change in mean annual temperature that has been observed in Mackenzie County 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 +6%.

Table 1: Summary of climate projections for Mackenzie County by the 2050s

Climate Variable	Season	Baseline (1961-1990)	Projected Change	
			Mean	Range
Average temperature	Annual	-1.2˚C	+2.1˚C	(+1.5 to +3.0)
Average precipitation	Annual	464 mm	+6%	(0% to +17%)
Average temperature	Summer	15.1˚C	+1.7˚C	(+1.1 to +2.8)
Average precipitation	Summer	189 mm	+5%	(-6% to +16%)
Average temperature	Winter	-19.5˚C	+3.1˚C	(+0.9 to +4.2)
Average precipitation	Winter	78 mm	+12%	(-5% to +23%)
Average temperature	Spring	-0.3˚C	+1.8˚C	(+1.0 to +2.6)
Average precipitation	Spring	83 mm	+8%	(0% to +20%)
Average temperature	Fall	-0.2˚C	+2.1˚C	(+1.4 to +2.9)
Average precipitation	Fall	113 mm	+8%	(-1% to +20%)

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 increase in mean winter temperature (+3.1°C) exceeds the mean annual projection and it is anticipated that this increase in winter temperature will be accompanied by an increase in winter precipitation of +12%. Mean summer temperature is expected to increase by +1.7°C with a +5% increase in mean summer precipitation. Mean temperatures are also expected to rise in the spring and fall (+1.8°C and +2.1°C, respectively); precipitation is projected to increase by 8% in both the spring and fall.

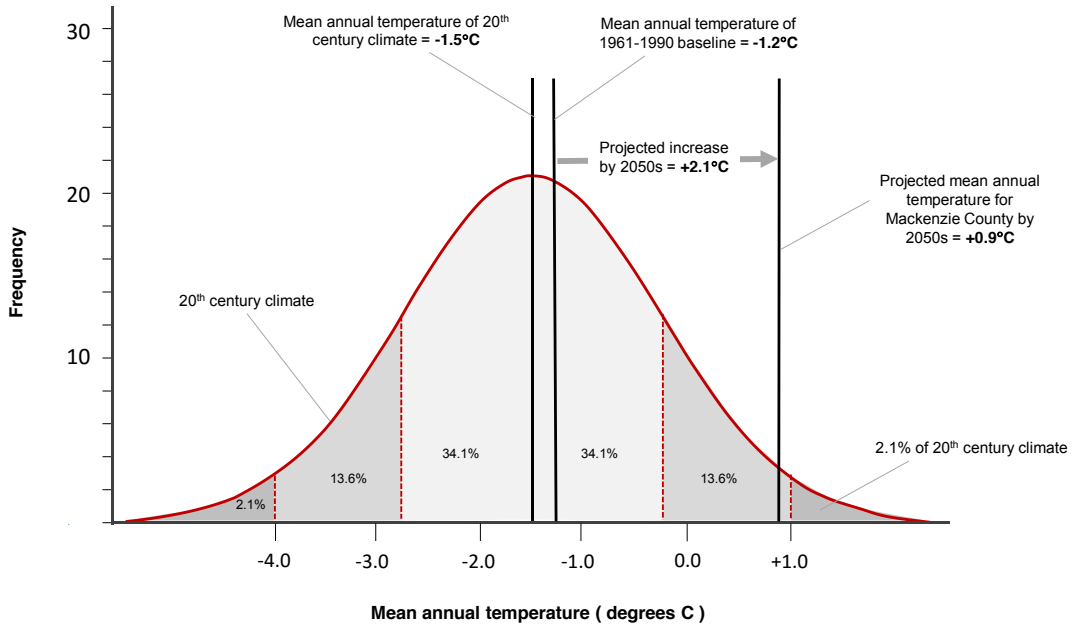
While annual and winter precipitation declined by 6% and 29%, respectively, over the last 50 years (recall Figure 4 and Figure 5), both variables are projected to increase by the 2050s. This may be explained by the higher uncertainty associated with projections of future precipitation compared with those for temperature. In contrast to temperature projections, precipitation projections: (a) often include individual GCM model runs that provide opposite signs (as evident within the range of projected changes shown in Table 1); and (b) are relatively small in magnitude compared with the variability in observed precipitation values during the 20th century.

The high variability of the regional precipitation record is, in part, a consequence of the relatively high degree of spatial variability of the individual precipitation records across the region. In contrast, historical temperature records across the region are remarkable consistent.

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, the 20th century climate of Mackenzie County (1915-1999) was fitted to a normal distribution (bell curve). The mean of the probability distribution is then shifted by the projected temperature increase of +2.1°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 Mackenzie County will be similar to the warmest 2-3% of 20th century climate.

Although a change in mean annual temperature of +2.1°C may not appear to be a large absolute shift in climate, when compared with the probability distribution of 20th century climate in Mackenzie County, a shift of this magnitude is substantial. By analogy, the projected shift in mean annual temperature will be similar to replacing the climate in Ft Vermilion over the period 1961-1990 with that of the Whitecourt region.



➡ 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 Mackenzie County will see more extreme precipitation events as the climate continues to warm in the coming decades.

PROJECTED ENVIRONMENTAL CHANGES

Projected changes in average temperature and precipitation in Mackenzie County will have broad consequences across the natural environment, including for moisture availability, growing season, regional ecosystems, wildfire, river flows and river ice, and permafrost.

➡ Available moisture and growing season

Although mean annual precipitation is projected to increase in Mackenzie County by the middle of the century, 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[viii].

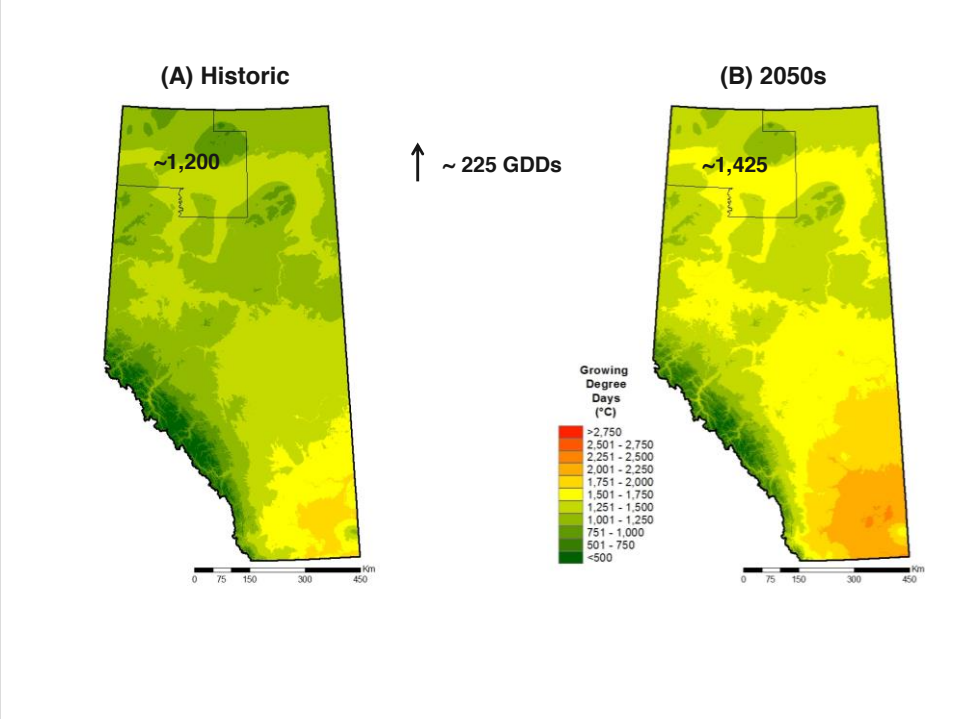
The projected increases in average temperatures in spring, summer and fall will result in increases in both the length and the warmth of the growing season in Mackenzie County. By the 2050s, Mackenzie County is projected to experience an increase of approximately 225 (growing) degree days, on average (see Figure 6); growing degree days are a measure of the length and warmth of the growing season[ix]. Put another way, the average growing season in Mackenzie County by the middle of the century will be more similar to the growing season experienced around Edmonton 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 Alberta boreal and prairie regions[x]. Because of its northern location, where agriculture is typically heat- rather than moisture-limited, the benefit for agriculture of the projected longer growing season in Mackenzie County may be greater than the potential negative impacts of the projected reduction in available moisture[xi].

➡ Regional ecosystems

Mackenzie County is a diverse region that includes upland forest, lowland forest and peatlands, and major topographic features like the Caribou Mountains (see Figure 7). Natural ecosystems in this region reflect the boreal climate and the elevational gradients: • the Dry Mixedwood Forest ecosystem that occupies the lower elevation areas along the Peace River is typically comprised of aspen forests; • the Central and Northern Mixedwood Forest ecosystems further north, and the Lower Boreal Highlands ecosystem, are cooler and have more moisture—in these ecosystems forests are typically spruce forests mixed with some aspen, and black spruce bogs and fens dominate the lowlands; • in the Caribou Mountains and Cameron Hills, the Boreal Subarctic ecosystem on the high plateaus is comprised of expansive peatlands and stunted black spruce forests[xii].

Figure 6: (A) Historic (1961-1990) and (B) projected distribution of Growing Degree Days in Alberta by the 2050s (2041-2070)[xiii]



The warmer and drier conditions projected for Mackenzie County by the middle of the century will have consequences for these regional ecosystems. In the upland forests of the Central Mixedwood and Lower Boreal Highlands ecosystems, the warmer and drier conditions will be more favourable for aspen than for spruce forests (as shown by the expansion of the Dry Mixedwood ecosystem in Figure 7). As a result, spruce forests may be less likely to recover from disturbances like fire or insect outbreaks, leading to a gradual transition to aspen-

dominated forests[xiv]. The bogs and fens at lower elevations in these regions will be more resilient to the warming and drying conditions, however, and are likely to persist through the middle of the century[xv]. In what is currently the Dry Mixedwood ecosystem along the Peace River, the warming and drying conditions will likely promote the expansion of grasslands in natural areas as aspen forests increasingly succumb to drought, fire, and insect disturbance. The emerging ecosystem will resemble the Parkland ecosystem – a mosaic of deciduous forest patches and grasslands (see Figure 7)[xvi]. In the Caribou Mountains and Cameron Hills, changes in the Boreal Subarctic ecosystem will be driven by the consequences of permafrost degradation. For example, as permafrost melting progresses, the black spruce forests that currently exist on frozen ground will transition to bogs and fens[xvii].

These predicted changes in regional ecosystems in Mackenzie County in response to projected climate change will also have consequences for the diversity of species that occupy these ecosystems, including by altering migration patterns and timing, and species ranges.

➡ Wildfire

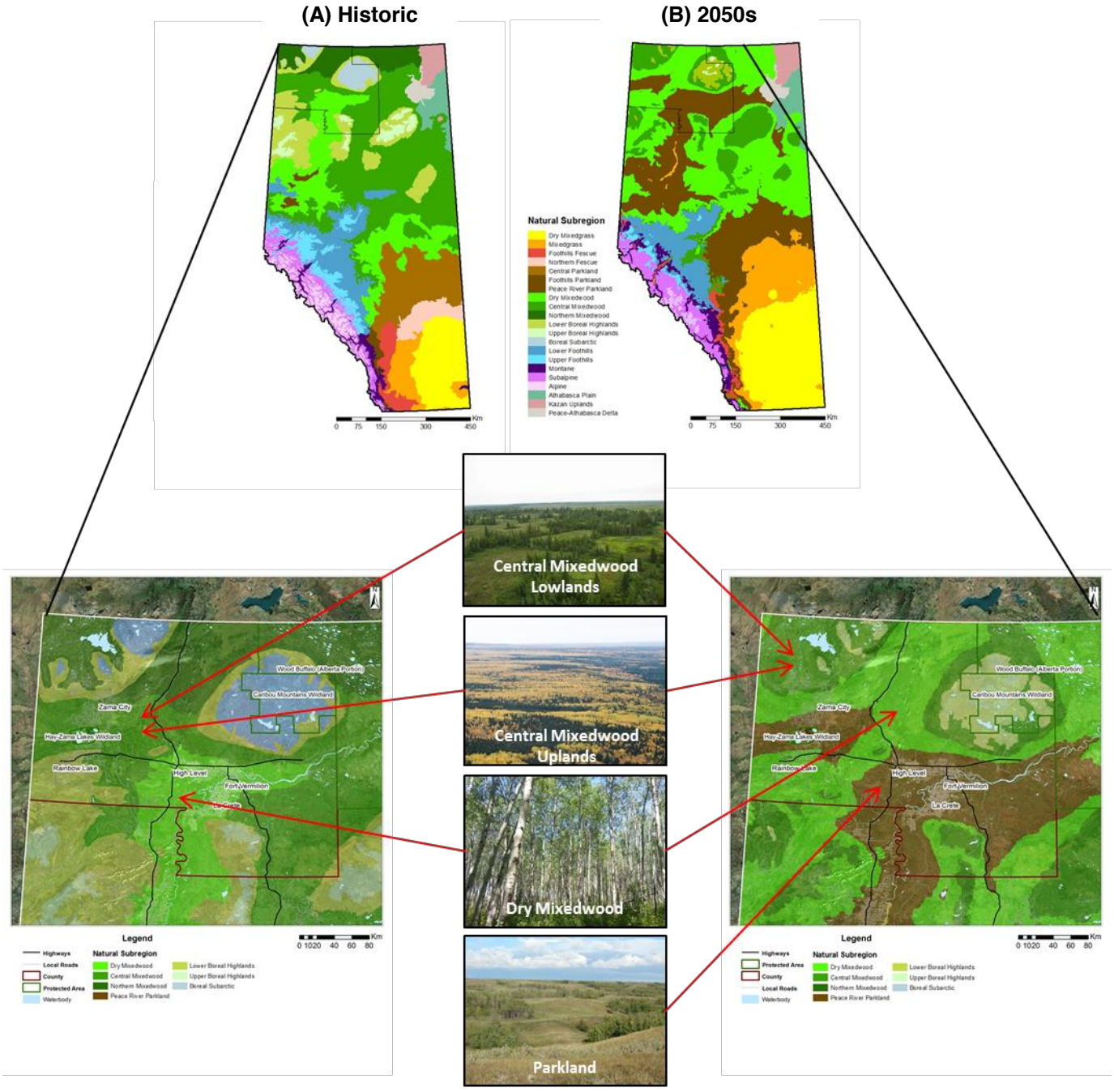
The warmer and drier climate projected for Mackenzie County by the 2050s will create conditions more favourable for wildfires. In particular, a longer fire season with more severe fire weather conditions in the future is likely to result in fires that are more difficult to control and in an increase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

➡ River Flows and River Ice

Warmer winter temperatures, an increased proportion of rain versus snow in winter months, and earlier snowmelt will all influence winter snow pack, and consequently the pattern of streamflow in the Peace and Hay Rivers[xx]. For example, in the upper Peace River, streamflow is projected to increase in the winter months, peak earlier in the spring, and decrease in the summer[xxi]. On average across the year, however, streamflow in the Peace River may increase, reflecting the overall projected increase in annual precipitation[xxii].

Warming winter temperatures will impact the ice regime on the Peace and Hay Rivers. For example, on the Peace River the duration and extent of ice cover are projected to decline, with freeze-up occurring as much as two weeks later, and spring break up occurring as much as two weeks earlier by the middle of the century[xxiii, xxiv]. In addition, warmer winter temperatures will potentially reduce the thickness of river ice and increase the likelihood of mid-winter thaws[xxv].

Figure 7: (A) Historic (1961-1990) and (B) projected (2050s) distribution of natural sub-regions in Alberta and in Mackenzie County[xxvi, xxvii]



➡ Permafrost

Mackenzie County includes areas of discontinuous permafrost, patches of ground that remain frozen throughout the year, which formed during the Little Ice Age (1550-1850) and persist in peatlands due to the insulation provided by peat[xxviii]. The remaining permafrost in Mackenzie County is highly dynamic, and has already undergone degradation in response to warming over the last 100 years[xxix]. This melting will continue with the projected climate warming, with consequences for the forested ecosystems that can exist on frozen, but not waterlogged soils, and for carbon storage in the extensive network of peatlands in Mackenzie County[xxx,xxxi].

4. CLIMATE RISKS AND OPPORTUNITIES FOR MACKENZIE COUNTY

Session 3 at the workshop invited participants to:

1. Identify how projected climate or environmental changes for the 2050s could impact Mackenzie County; 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 mainly positive (+) consequences for Mackenzie County

• Overland flooding (-)	• Transportation / access disruption (-)
• Freezing rain (-)	• Stress on wildlife (-)
• Blizzard / winter storm (-)	• Wildfire (smoke) (-)
• Reduced winter precipitation (-)	• Pest infestation (-)
• Increased frost penetration (-)	• Increased crop growth (+)
• Water supply shortage (-)	• Increase in crop types (+)
• Wind storm (-)	• Reduced energy consumption / heating (+)
• Crop loss (-)	• Increased recreation / tourism (+)
• Reduced quality / supply of timber (-)	

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 Mackenzie County, 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 Mackenzie County.

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

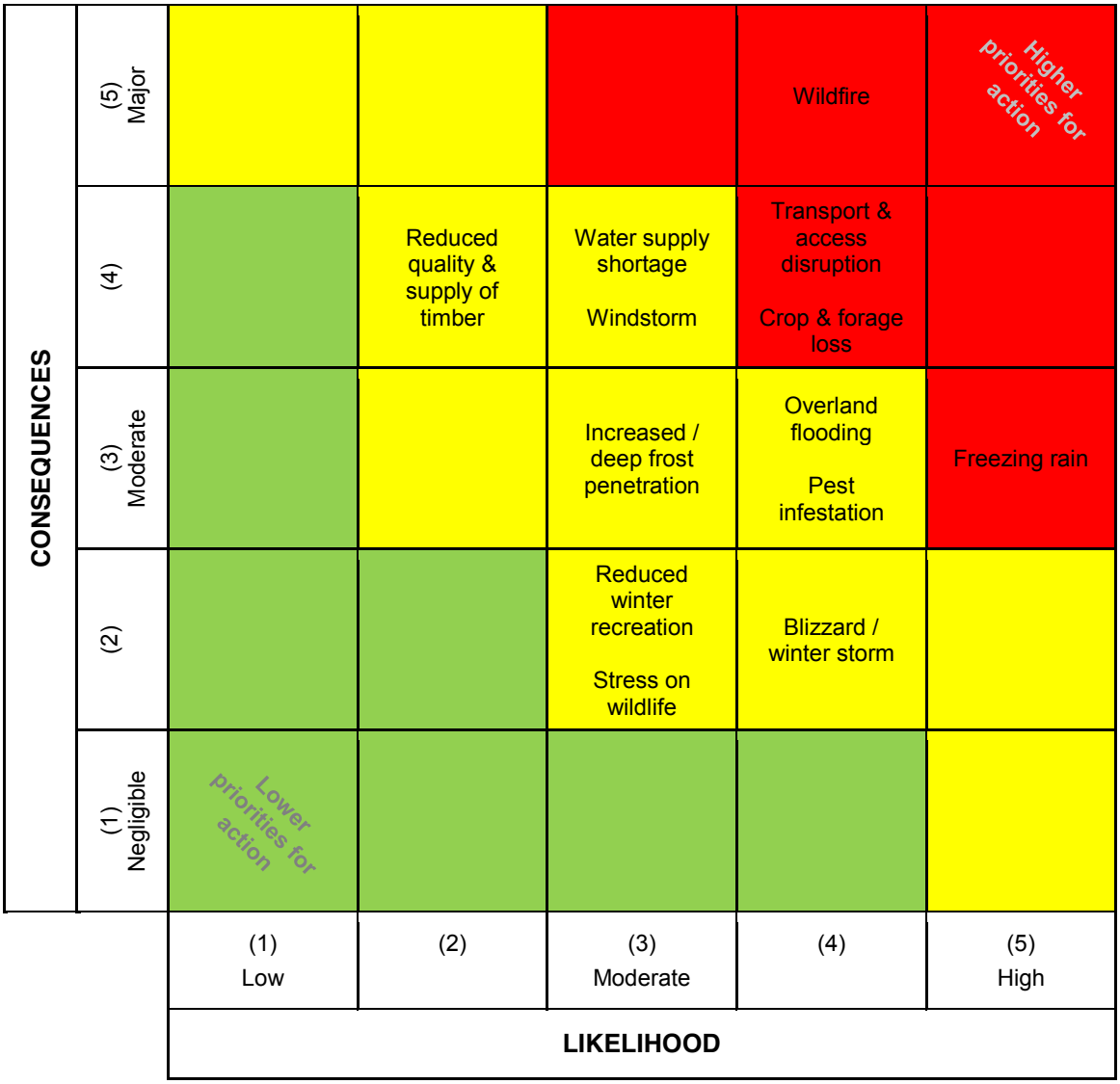
Table 3 provides a description of the potential climate change risks facing Mackenzie County. The description includes a selection of key consequences, along with the label used to identify the impact in the “risk map” shown in Figure 8. The risk map is a two-dimensional representation of adverse consequences 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 Mackenzie County by the 2050s

Potential local risks		Key consequences for Mackenzie County
Label for risk map	**Description**	
"Wildfire"	Increased interface wildfire risk caused by increased summer temperatures and heat waves, less precipitation in summer, and a longer fire season	• Loss of fibre • Health risks (smoke) • Increased cost for reforestation • Diversion of labour • Cut-off of transportation routes • Evacuations • Expensive to fight, but positive for some local businesses • Loss of wildlife • More mushroom picking opportunities
"Reduced quality & supply of timber"	Reduced quality and supply of local timber due to regional ecosystem shifts towards deciduous forest and parkland	• Increased haul distances and operation cost (must travel further to access timber) • Coniferous timber will specifically decline in quality • Increased opportunities for biofuel
"Transport & access disruption"	Warmer winters and shorter ice covered period on rivers will disrupt transportation and access to certain areas	• Increased transportation time and cost for essential supplies such as bulk goods and fuel, and access to and from communities and medical facilities • Increased isolation (e.g., Fox Lake)
"Overland flooding"	Increased frequency and intensity of local spring flooding from increased winter stream flow and earlier spring peak flow	• Property damage • Delayed planting of crops • Road washouts and access disruption, with water on roads and airport runways • Potential crop damage from increased fungi disease for plants • More river sediment, with negative impact on fish
"Water supply shortage"	Inability to meet water demand for drinking, irrigation, livestock and transportation (ferries) due to decreased summer streamflow	• Decreased water supply for rural fire operations, with increased fire risk • Reduced water quality • Economic impacts on crops (reduced plant growth) and farmers • Potential loss or delays in transportation if ferries are affected • Negative impact on wildlife and wetlands

Potential local risks		Key consequences for Mackenzie County
Label for risk map	**Description**	
"Crop and forage loss"	Loss of some crops due to increased winter temperatures (loss of snow cover) and more extreme heat	• Economic and livelihood impacts for crops and forage land • Reduced crop yield and forage availability leading to reduced family income
"Stress on wildlife"	Negative impacts and stress on wildlife caused by increased winter temperatures and lack of snow	• Negative for ungulate survival
"Pest infestation"	Increased risk of pests such as pine beetle and grasshoppers from more extreme heat or fewer cold extremes	• Economic and livelihood impacts for crops and forage land
"Increased / deep frost penetration"	Increased deep frost penetration and water line breaks from less precipitation falling as snow, and less ground insulation	• Pipe maintenance and repair costs
"Reduced winter recreation"	Fewer opportunities for local winter recreation due to warmer winter temperatures and less precipitation falling as snow	• Negative consequence for local quality of life
"Blizzard / winter storm"	Major snowstorm / blizzard caused by an increase in the number of extreme precipitation events	• Potential building collapse • Transportation and access disruptions • Benefits for winter sports and for road maintenance crews
"Freezing rain"	Freezing rain event caused by warmer winter temperatures and an increase in the number of extreme precipitation events	• Power outage, with impact on economy and quality of life • More vehicle accidents, dangerous roads and potential access disruptions
"Windstorm"	Destructive windstorm caused by increased intensity of summer storms	• Building damage • Damage to roads and other infrastructure • Soil erosion • Tree damage and increased spread of forest fire

Figure 8: Risk map for climate change impacts facing Mackenzie County



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).

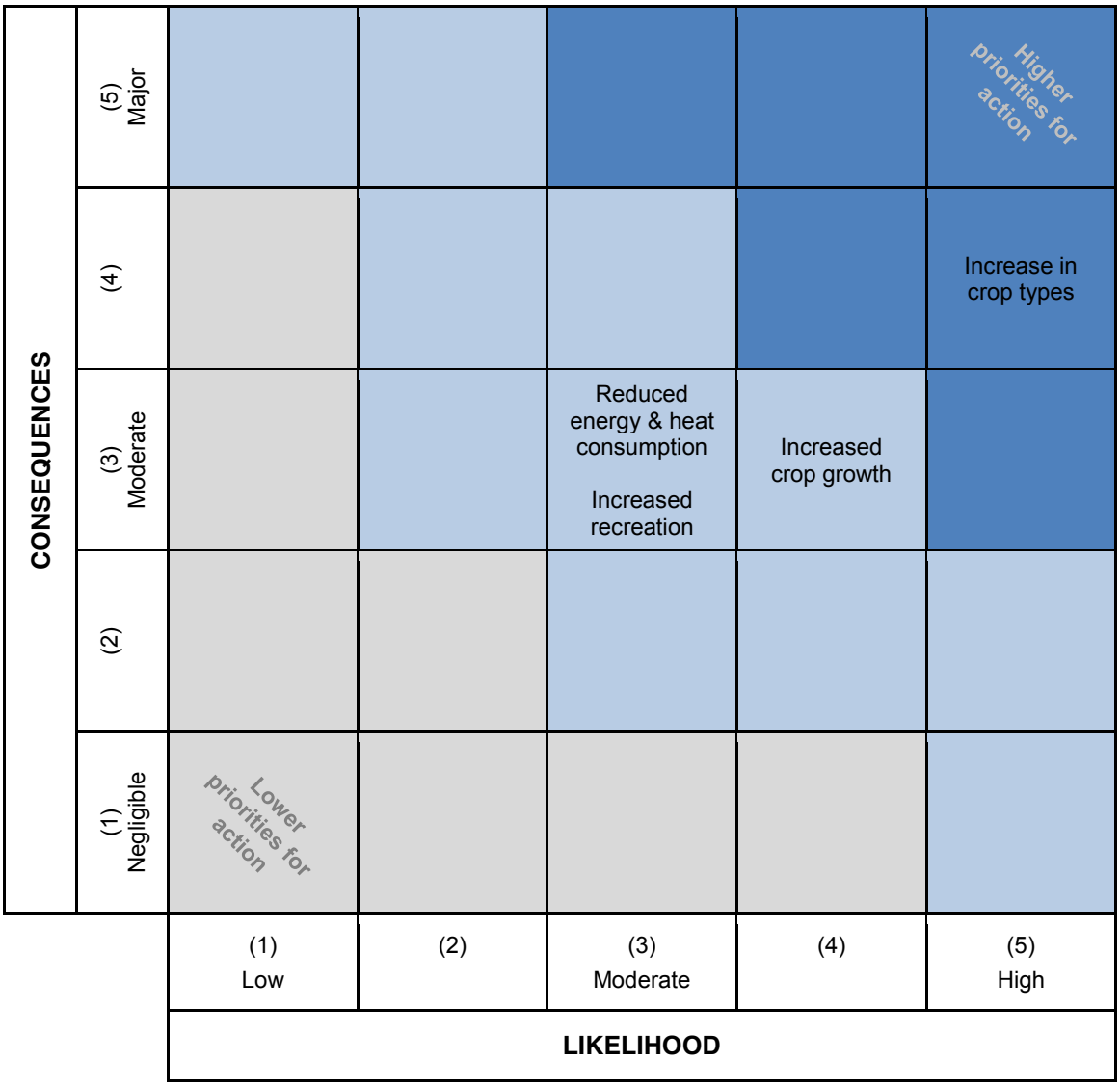
➡ Potential opportunities

Table 4 provides a description of the potential climate change opportunities for Mackenzie County. The description includes a selection of potential benefits, along with the label used to identify the impact in the opportunity map shown in Figure 9. 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 Mackenzie County by the 2050s

Potential local opportunities		Key consequences for Mackenzie County
Label for opportunity map	**Description**	
"Increased recreation"	Increase in opportunities for both summer and winter recreation as a result of warmer temperatures	• Economic benefits, with potential to attract more visitors to area • Quality of life benefits
"Reduced energy & heat consumption"	Reduced costs of energy and heat due to increased winter temperatures	• Cost savings to County, residents and businesses
"Increased crop growth"	Improved crop growth due to warmer temperatures and a longer growing season	• Economic benefits for local farmers • Additional transportation infrastructure demands • Increased demand for water for irrigation
"Increase in crop types"	Increase in the number of crops available for growth in the region due to warmer temperatures and a longer growing season	• New marketing opportunities • Economic opportunity to finish livestock locally • Additional transportation infrastructure demands • Increased demand for water for irrigation • New crop diseases and pests

Figure 9: Opportunity map for climate change impacts facing Mackenzie County



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 8 and Figure 9 respectively, Session 5 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;
2. Transport & access disruption;
3. Crop and forage loss; and
4. Freezing rain / ice storm.

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	More than 10 years

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, Mackenzie County is already committed to numerous actions that will help manage the risks and opportunities of climate change identified in Section 4. Some of these actions were identified during Session 5 of the workshop and include measures to:

- Manage wildfire risk, such as wildland urban interface planning, regional emergency planning and Incident Command System training, mutual aid agreements, public awareness campaigns about FireSmart principles, the supply of basic equipment for fighting wildfires, and communications through a Wildfire app and the Alberta Emergency Alert system;
- Mitigate transport and access disruptions caused by shorter ice covered periods on rivers, such as a snow maker for ice bride construction, the use of equipment to ‘drive in’ frost, and improved air access to communities;
- Reduce crop and forage loss through initiatives such as zero tillage minimums, experimentation with subsoiling, agricultural education and experimentation with new

crops through the Mackenzie Applied Research Association, including hemp, radish, corn, soy beans, fava beans, alfalfa and sainfoin; and

- Protect against freezing rain and ice storms, including the installation of backup generators at most County offices and water treatment facilities, stockpiling supplies of sand and salt at strategic locations across the County, and emergency response planning.

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

WILDFIRE

Action	Cost	Timeframe	Lead
Hold additional table top exercises with all agencies to plan for large-scale wildfire	Low	Near-term	Municipalities
Update the Land Use Bylaw with FireSmart planning principles such as vegetation management and construction materials	Moderate	Ongoing	County
Improve vegetation management in high risk fire areas	Very high	Near-term	County, agriculture and forestry sectors
Purchase additional firefighting equipment specific to wildland firefighting	Very high	Short-term	Municipalities
Upgrade local airport runways to facilitate landing of larger fixed-wing aircraft for water bombing	Very high	Long-term	Municipalities, County, Government of Alberta
Enhance the Regional Municipal Emergency Plan to deal with increasing wildfire risk	Moderate	Ongoing	Municipalities

TRANSPORT & ACCESS DISRUPTION

Action	Cost	Timeframe	Lead
Purchase new and better products for road maintenance and de-icing	High	Ongoing	County public works
Improve ferry infrastructure and cross-river access	Very high	Long-term	Alberta Transport, County public works
Obtain remote monitoring technology to increase awareness of potential transport and access disruptions	High	Short-term	County with private contractors, Alberta Transport, industry
Improve local medical facilities, to avoid patients being stranded by transportation and access disruptions	Very high	Long-term	Alberta Health Services

CROP & FORAGE LOSS

Action	Cost	Timeframe	Lead
Conduct research and experimentation with trapping spring runoff for irrigation to avoid crop and forage loss	Moderate	Ongoing	Alberta Agriculture and forestry, MARA
Identify wetlands to preserve, and develop techniques for temporary water storage using wetlands	Low	Ongoing	Mackenzie County

FREEZING RAIN / ICE STORM

Action	Cost	Timeframe	Lead
Complete installation of backup generators at all County offices and water treatment plants	Very high	Near-term	County
Increase the supply of sand and salt at strategic locations across the County	High	Ongoing	County
Increase the number of County staff on standby to respond to major storm events and emergencies	Moderate	Ongoing	County
Through the emergency response plan, ensure a qualified lineman is on call at all times to deal with downed power lines,		Ongoing	ATCO

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'. County 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 County website 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 County's efforts to make the community more resilient.

MAINSTREAMING

This Action Plan is developed as a 'stand-alone' document. However, it is important that climate resilience is integrated (i.e., 'mainstreamed')—as a matter of routine—into the County'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 infrastructural 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 Mackenzie County'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 County'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
Terry Batt	Agriculture Service Board
Alexandra Codispodi	Municipal Intern
Adam Clarkson	Town of High Level
Joe Dolling	Tolko
Paul Hewitt	Tolko
Eric Jorgenson	Agriculture Service Board
Josh Knelsen	Agriculture Service Board
Jacob Marfo	Mackenzie Applied Research Association
Chris McLeod	Deputy Mayor High Level
Bill Neufeld	Reeve
Greg Neuman	Mackenzie Applied Research Association
Byron Peters	Mackenzie County
Len Racher	Mackenzie County
Rodney Schmidt	Disaster Fire Services – High Level
Grant Smith	Mackenzie County
Sabrina Westra	Mackenzie Applied Research Association
Joulia Whittleton	Chief Administrative Officer
John Zylstra	Agriculture Land Management Specialist

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

Score	Description
(1) **Negligible**	• 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) **Major**	• 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 the scoring the likelihood of consequences

Score	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

[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. Inadequate data in the Fort Chipewyan and High Level precipitation records precluded their use in the reconstruction of historical precipitation.

[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] 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.

[x] 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.

[xi] Nyirfa, W.N. and B. Harron. 2004. Assessment of Climate Change on the Agricultural Resources of the Canadian Prairies. Prepared for the Prairies Adaptation Regional Collaborative, Regina, SK. 27p. Available at http://www.parc.ca/

[xii] 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.

[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 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] 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/

[xv] Schneider, R.R., K. Devito, N. Kettridge, and E. Bayne. 2015. Moving beyond bioclimatic envelope models: integrating upland forest and peatland processes to predict ecosystem transitions under climate change in the western Canadian boreal plain. Ecohydrology doi: 10.1002/eco.1707.

[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] 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.

[xix] 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.

[xx] Ibid.

[xxi] Zwiers F.W., M.A. Schnorbus, and G.D. Maruszeczka. 2011. Hydrologic impacts of climate change on BC water resources: summary report for the Campbell, Columbia and Peace River watersheds. Pacific Climate Impacts Consortium, University of Victoria, Victoria, BC. 24p.

[xxii] Ibid.

[xxiii] Andrishak, R., and F. Hicks. 2008. Simulating the effects of climate change on the ice regime of the Peace River. Canadian Journal of Civil Engineering 35:461-472.

[xxiv] Andrishak, R. and F. Hicks. 2005. Impact of climate change on the winter regime of the Peace River in Alberta. Prepared for: Climate Change Research Users Group, Alberta Environment. Pub No. I/103. 75pp.

[xxv] Beltaos, S. and T.D. Prowse. 2001. Climate impacts on extreme ice-jam events in Canadian rivers. Hydrological Sciences 46:157-181.

[xxvi] 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.

[xxvii] Photo credits (top to bottom): ABMI; V. Liefers; Sara Venskaitis; Jonathan Bennet.

[xxviii] Smith, S. 2011. Trends in permafrost conditions and ecology in northern Canada. Canadian Biodiversity: Ecosystem Status and Trends 210, Technical Thematic Report No. 9. Canadian Council of Resource Ministers. Ottawa, ON. 22p.

[xxix] Vitt, D.H., L.A. Halsey and S.C. Zoltai. 2000. The changing landscape of Canada's western boreal forest: the current dynamics of permafrost. Canadian Journal of Forest Research 30:283-287.

[xxx] Smith, S. 2011. Trends in permafrost conditions and ecology in northern Canada. Canadian Biodiversity: Ecosystem Status and Trends 210, Technical Thematic Report No. 9. Canadian Council of Resource Ministers. Ottawa, ON. 22p.

[xxxi] Smith, S.L, and M.M. Burgess. 2004. Sensitivity of permafrost to climate warming in Canada. Geological Survey of Canada Bulletin 579. Natural Resources Canada, Ottawa, ON. 24p.

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