Moving Toward Prairie Agriculture 2050



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Climate and weather: a common discussion topic in coffee shops across the Prairies. Discussions tend to be driven by our experiences, and these are influenced by recent events, especially extreme or catastrophic ones. Record heat, record cold, record snowfall, record flood, record drought – all invoke some desire to attribute extremes to driving factors. A changing climate, caused by increases in atmospheric greenhouse gases, may be driving some events but attribution of any event is not possible. As Agrologists, we have a responsibility to consider climate and weather effects on our agricultural production systems, irrespective of causes. The best advice we can offer will consider future resilience so that agricultural systems have capacity to cope with the current climate, as well as potential future conditions.

This report addresses the question of ***Climate and Food: Is There a Future?*** through the eyes of 23 experts with thoughts on our Prairie agricultural systems over the next 35 years. Many of the contributors are Professional Agrologists, who discuss the need for us to adapt in response to likely scenarios for our future climate while considering the uncertainty in any future prognosis. The contributors come from all three Prairie Provinces and work in government (federal, provincial), industry and university. As in any discussion of the future, the relative impact of change or of new technology cannot be predicted with accuracy. Consider what has happened in the past 35 years, and that the 1980 reality was no internet, no cell phones, no GPS, and the start of canola! Our history is one of technological advances arising from adversity. But to charge forward expecting as-yet undiscovered technologies to save us from the potential ills of climate change is a risky approach. Our best strategy for preparedness is ongoing dialogue based on what we know now, evolving as we learn more. The goal for this report is to generate discussion so that we can prepare ourselves to better adapt to an uncertain future.

We choose the year 2050 as our horizon. We summarize the current state of knowledge of future climate and present 14 essays on specific topics. The topics are not fully inclusive because of the diverse nature of climate effects on agriculture; but they provide a diversity of outlooks. We conclude with some aspects of preparedness, whereby we aim to strengthen the capacity of the Prairie agri-food sector to adapt and thrive. Our bottom line is that we are fortunate to be engaged with a fantastic industry; one that has already demonstrated good resilience to adapt to a changing climate. Future resilience will be affected by the many variables that impact agriculture's ability to adapt, with climate perhaps being one of the more predictable variables. It is likely there will be many surprises and we will need to be aggressive in addressing a broad range of coping strategies.

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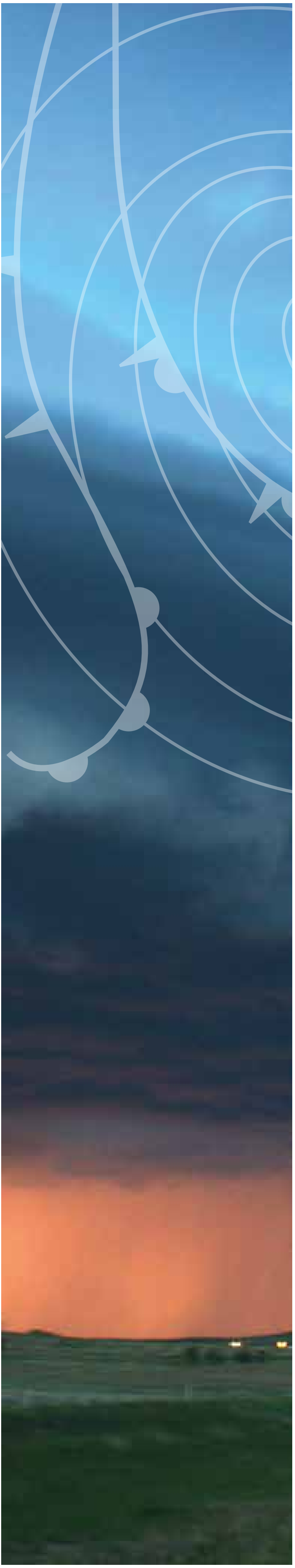

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Moving Toward the Year 2050

Why 2050?

The year 2050 approximates when the atmospheric carbon dioxide concentration is expected to double compared to pre-industrial times. This doubling has been a baseline for many simulations of future climates so that an extensive dataset exists. 2050 is also within the timeframe that today's young generation of agricultural producers will be operating. Finally, 2050 marks just over 200 years of agriculture activity across the Prairies, with the more intensive crop and livestock production practices primarily developed in the last century.

There is extensive literature on the potential impacts of a warming climate on agriculture with some excellent summaries for both Canada[1] and the U.S.[2]. While overall warming trends are statistically significant for Canada[3,4] and globally[5], identifying the impact of climate change on the Prairies is difficult because of substantial climate variability among years. There is also a high degree of uncertainty in predicting the future of drivers beyond climate change that will continue to impact production, processing and distribution systems supporting agriculture in Canada. For example, changes in policy, politics, trade, transportation and technology development are key global drivers of future change to the Canadian agri-food sector. More locally, change with respect to infrastructure support,

> *"young farmers will... be the main drivers of our food system over the next 35 years"*

(credit: M. Gaudry)

domestic market demand, land and water demand, and economics are equally important. In fact, it is proposed that climate warming and population growth are better understood and thus present less uncertainty compared to these many other factors. None-the-less, we still **need to plan for change to be competitive and to ensure that Prairie agriculture continues to thrive in 2050 and beyond.**

Canada's Food System and Today's Climate

The current Canadian food system has developed based on our resources. This includes the influence of climate over the past thousands of years during which our soils developed, and the past few decades during which our production strategies have adapted to the present climate. Currently, primary agriculture occupies only about 7% of Canada's land base, with the Prairie Provinces accounting for 82% of the total[6]. About 55% of this agricultural land base is cropland, 31% is pasture land, with the other 14% classified as woodlands and wetlands (8%), summerfallow (3%) and other (3%; this represents cropland that is temporarily out of production due to excess moisture). **Changes in climate have the potential to increase or decrease this agricultural landbase.** For example, the areas of pasture land and wetlands are usually dictated by soil moisture.

Canada's agriculture and agri-food industry encompasses primary agriculture, farm input and service suppliers, food and beverage processing, food distribution, retail, wholesale and food service. Agriculture has become increasingly internationally focused and makes a significant contribution to the gross domestic product (8% of total) while directly providing one in eight jobs in the Canadian economy. Our relatively high production capacity with the low national demand of our small population is also a function of our climate. This provides export opportunities that are critical to continued growth of agriculture. Canada is the sixth-largest exporter ($40B) of agriculture and agri-food products globally. Canola, non-durum wheat, canola oil, soybeans and frozen pork represented the top five agri-food exports in 2011[6]. Our current climate supports all of these, and is especially conducive to canola and small grain production. We could argue that the development of canola by Canadian scientists was a direct response to an opportunity in our current climate!

Our temperature regime on the Prairies dictates much of our production capability. This sets the stage for our seasonal differences, pests and diseases, grain storage, and heating/cooling requirements for buildings. However, water is equally important. Agricultural activities account for 10% of gross water withdrawals in Canada, well behind thermal power generation and domestic use[7]. However, agriculture is looked on as the largest consumer of water because it is lost through evapotranspiration and infiltration. Water supporting irrigation, livestock production

(credit: D. Flaten)

and food processing competes with drinking water use, urban, industry and hydropower needs, as well as its role in maintaining healthy ecosystems. This is especially true in Alberta, which has the greatest amount of irrigation. Currently, governance and management of Canada`s water resources are complex with limited monitoring or valuation of its use. Even under our current climate, water is critical: either too much or too little. An expert panel on water and Canadian agriculture has highlighted needs to improve water monitoring information and data interpretation, develop more efficient and sustainable methods and technologies for water management, improved governance, and to consider adoption of beneficial management practices that employ conservation agriculture and ecosystems services[8]. This is urgent in the present climate, with the urgency likely increasing in a changing climate.

On the socio-economic side, our tenure system has evolved in the present climate. Owned land as a proportion of total farm area has been decreasing steadily every census since 1976, with 62% owned by those who farm it in 2011. Other tenure arrangements include rentals, leasing of crownlands and crop sharing arrangements. The 2011 Census reported 205,730 farms in Canada, down 10% from 2006[6]. This also marked the first time the 55-and-over age category represented the highest percentage (48%) of total operators. Of equal interest was the observation that young farmer enterprises, managed solely by operators between the ages of 18 and 39 years, accounted for 7.5% of Canadian farms, but earned more from both farm and non-farm sources as compared with older farm enterprises. These young farmers will likely still be producers by the year 2050, or at least be the main drivers of our food system over the next 35 years. We may also expect that they will be large users of developing technologies, maintain an entrepreneural focus, and be in touch with global market drivers.

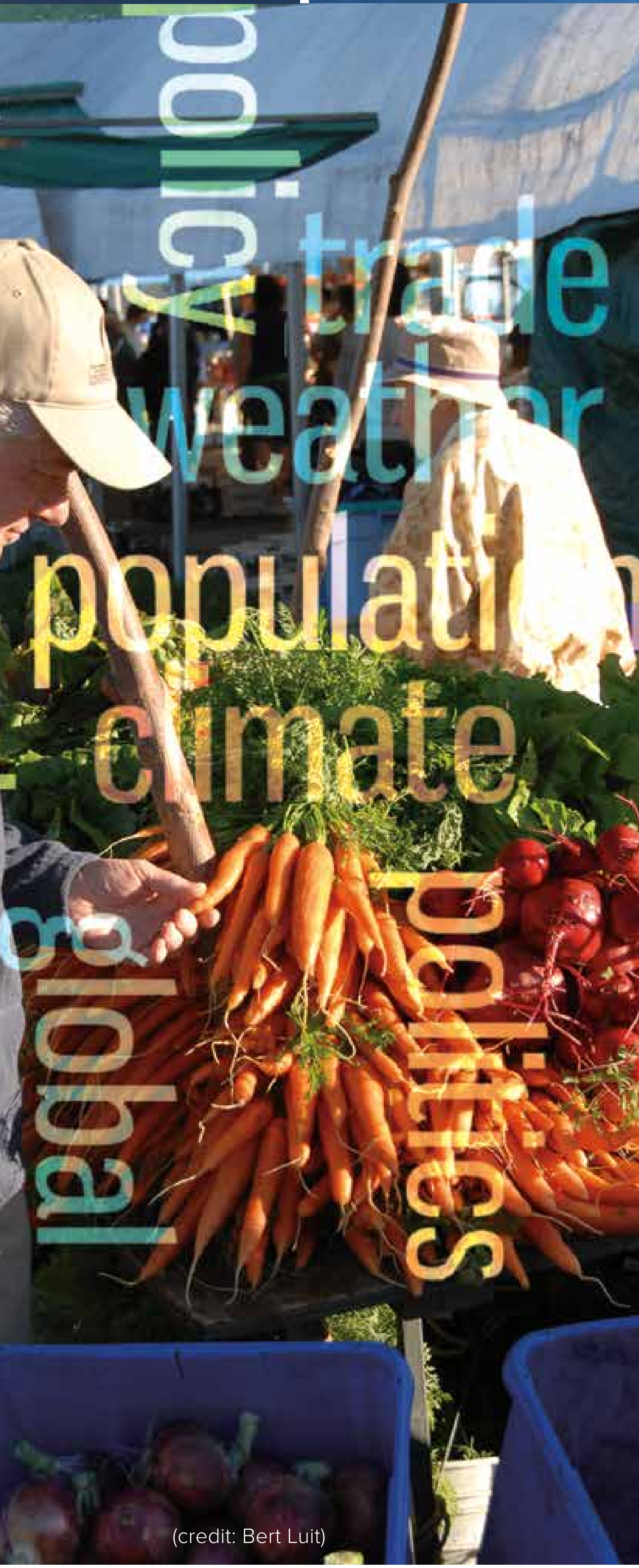
The food distribution, retail, wholesale and food service industries interact most directly with consumers. As such they have become increasingly important in conveying consumer trends and demands with respect to food ethics, and food safety, quality, value and convenience to the rest of the food value chain. Public awareness of climate change and environmental health is reflected in the retail industry`s interests in carbon footprint or ecological footprint labeling. While the complexity of monitoring and reporting environmental impact has slowed adoption of labeling policies in Canada`s food and beverage sectors to date, further development of accountability labelling is anticipated if consumer pressures continue. The impact of social media has also increased in importance conveying messages about sustainable food production, a feature that will likely increase in impact. The interaction between known climate drivers, such as emissions of greenhouse gases, and the potential to change production methods to reduce climate impacts (mitigation) will also likely increase in importance as consumers are more actively involved in food choices.

The Science of Climate Change

“Greenhouse gas” is a term for atmospheric gases that have radiative effects, resulting in the capture of long-wave (thermal) radiation that is emitted by the Earth. For simplicity, we will keep our discussion to those gases that have increased in our atmosphere as a result of human activities. Evidence for increases in these gases is clear from decades of measurements of atmospheric concentrations, as well as measurements in long-term storage media such as ice cores. The sources of these gases are also known, with the combustion of fossil fuels being the largest new contributor. The radiative forcing caused by these gases has been calculated as an average global energy addition, expressed in radiative units of $W\ m^{-2}$. The Intergovernmental Panel on Climate Change (IPCC) periodically reports on the science associated with climate change and has recently updated the information in their 5^{th} assessment report[5]. They estimate future radiative forcing based on potential scenarios for global emissions of greenhouse gases. Here we use a scenario that has a representative concentration pathway that assumes a medium growth rate of greenhouse gas emissions resulting in a radiative forcing of about 4.5 $W\ m^{-2}$ in the year 2100[9]. This assumes that greenhouse gas emissions will start declining at about 2050 when mitigation becomes more effective. While this scenario may be optimistic, it is important to note that most scenarios have similar outcomes by the year 2050, with larger differences thereafter because different levels of continuing emissions drive different endpoints over the last part of this century.

Figure 1 illustrates the radiative forcing estimates relative to the pre-industrial period (about 1765). Estimates up to 2010 are based on current measurements and the future is based on climate model projections. For this scenario, today’s radiative forcing caused by humans is slightly less than halfway to the peak. However, the climate effect is more complicated and temperature changes do not scale linearly with radiative forcing for a given year or scenario. The global temperature increase by 2050 for this scenario is estimated to be about 1.4°C (likely range of 0.9 to 2°C) compared to the 1986 to 2005 period. This is in addition to the estimated 0.6°C increase in global temperature that has already occurred from about 1850 to the 1986-2006 period. Scenarios with higher emissions project global temperature increases of about 2°C by 2050. Differences among scenarios become greater at about 2100; for example, a different scenario projects 3.7°C warming by 2100.

So what does this mean for agriculture in the Prairies and globally? IPCC uses the radiative forcing information to project the climate in 2050[5]. For the Canadian prairies, we can extract estimates of the change based on the coarse resolution of the global climate models. Potential changes are compared to one standard deviation of the current 20-year variability. If the projected change is less than one standard deviation, we estimate



(credit: Bert Luit)

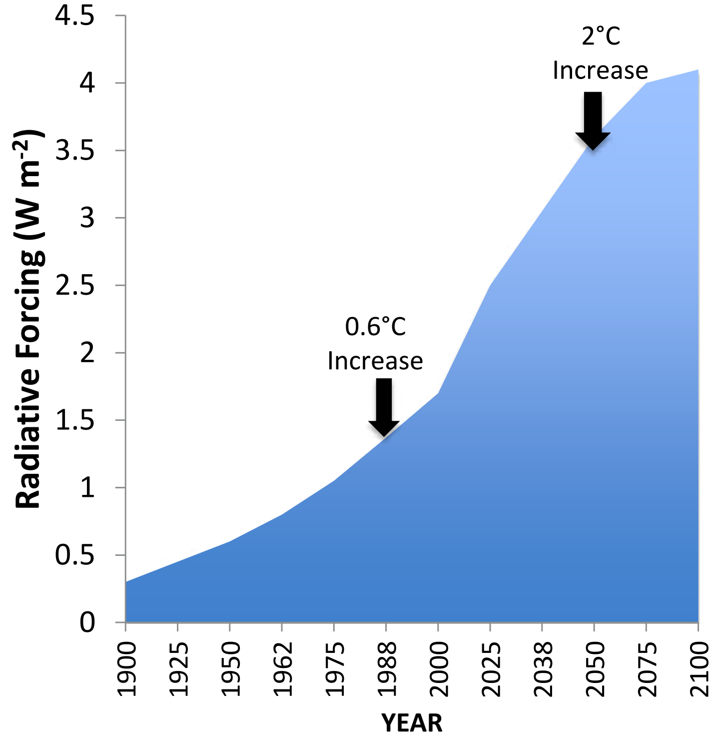


Figure 1: *Global radiative forcing from all human-caused sources based on the representative concentration pathway RCP4.5 medium emissions scenario of IPCC relative to 1765*[5]*. This scenario assumes that emissions will be mitigated and start decreasing after about 2050. Estimated temperature increases are shown.*

that no change will occur. Note that agricultural production currently copes with changes within this variability range. Table 1 indicates that both summer and winter temperatures will increase, with the increase being greatest in winter. To put this in perspective, the year-to-year variability in annual mean temperature across the Prairies typically has a standard deviation of about 1°C based on a 30-year record. However, short-term or year-to-year variability would distribute around a higher average temperature. Precipitation is projected to have little change, with likely no change in summer and perhaps a slight increase in winter. Yet precipitation can vary widely among and within years under our current climate.

Based on some older climate projections, the Prairie Adaptation Research Collaborative assessed possible changes in agricultural land capability[1]. They estimated that a changing climate by 2050 would remove many of the heat limitations for agriculture across most of the currently cropped area, but that aridity issues would increase across the Prairies (Table 1). An important aspect is that suitable climates for agriculture will be available northward, although there may be soil limitations.

Table 1: *Projected climate changes by 2050 for the Canadian Prairies and globally, compared to the 1985 to 2005 period[5].*

	Changes by 2050
The Prairies	
Summer Temperature	Increase by 1 to 4°C; median 2 to 3°C
Winter Temperature	Increase 2 to 4°C; median 3°C; warmest in east
Summer Precipitation	No change; possible increase by 10%
Winter Precipitation	0 to 10% increase; possible 20% increase
Agriculture land capability[1]	Class 1 climate increases from 8% of area to 19% with less heat limitation; aridity increases to affect 80% of currently cropped land.
Population[12]	Increase from 5.5 to 7 million
Global	
Heavy precipitation intensity & frequency	Increase
Frequency of warm days & nights	Increase
Frequency of cold days & nights	Decrease
1 in 20 year extreme daily temperature	Increase by 1 to 3 °C
Heat waves	Increase
Drought	Increase in some regions (medium confidence)
Population[13]	Increase from 7.2 to 9.6 billion

Agriculture on the Prairies responds to average conditions, variability around the average, and extreme conditions in any given year. The IPCC projections have higher uncertainty in change related to extremes for a specific region of the Earth, such as the Prairies. However, there will likely be global increases in temperature related impacts such as heat waves, extreme warm temperatures, drought, and perhaps heavy precipitation events. Our expectation is that the Prairies could be affected by these global trends.

Adaptation for the Prairies

Looking to 2050, let's assume that Prairie agriculture remains an important resource in the global food system, and that international trade has many of the same features that we have witnessed over the past decade. Within this context, how will we adapt to a changing climate? Adaptive management is part of standard operations for Prairie producers, who respond quickly to changes in weather events each year. Slower changes in average conditions are actually easier for producers to adjust to; the extremes present the larger challenges. Currently, local adaptation within cropping systems appears to be occurring: for example, maize crops have regional adaptations to extreme heat in the U.S. that help to mitigate yield losses[10]. This is in addition to breeding developments and management strategies that have agronomists asking questions like: *Is Manitoba the new Iowa?*[11]. Asking such a question is important for climate adaptation, where we have opportunities to look at current production strategies further south. Generally, a warming climate is expected to increase stresses on the U.S. agricultural sector, although the vulnerability will depend on the measures taken by the agricultural industry[2]. In most cases, at least with moderate warming, **we expect that the Prairies will gain opportunities** that presently occur further south. Despite this, there is likely not a direct analogue that we can copy because our industry will be evolving in response to many pressures, only one of which is climate.

Often our immediate concern is how a changing climate will affect our Prairie production and food systems. The global nature of climate change caused by increased greenhouse gases may well have greater effects related to how climates change in other parts of the world, especially where food production is already limited by excess heat. This effect, coupled with an additional 2.4 billion people to feed, could create opportunities for Prairie agriculture. This assumes that other global and local factors, such as disease or social unrest, are not limiting.

In the following sections, we provide some points on a range of topics that affect the agricultural industry on the Prairies. These topics provide a framework for further discussion as we adapt our management to ensure a strong Prairie agriculture industry into the future.

Essays on Climate Change and Prairie Agriculture

The issue of a changing climate poses an ongoing challenge for planning Prairie agriculture over the next few decades. Past dialogues have made it clear that given identical data or prognosis for the future, individuals will provide a wide array of interpretations. This is especially true for analyses of our recent climate and for concepts on what could be experienced over the next 35 years. When discussing the future, it is unlikely that anyone will be able to anticipate all factors, or even correctly pinpoint all of the governing variables. So there is an advantage to create a dialogue with a diversity of viewpoints to help us prepare for the unknown. Everyone has an opinion on the climate and the weather!

Here, we have asked several agricultural scientists to consider what climate change could mean for Prairie agriculture in 2050, based on their field of expertise. We solicited scientific viewpoints from a wide range of disciplines such as meteorology, crop science, animal science, and economics. The topics are not exhaustive, nor were they chosen to reflect the relative importance of potential impacts. Instead, they form a sample of thoughts. We present the current status; what is likely to be forthcoming; describe the importance; and provide some guidance around what is being done or should be done. The following 14 essays aim to provide a basis for further discussion.

(credit: K. Blair)