



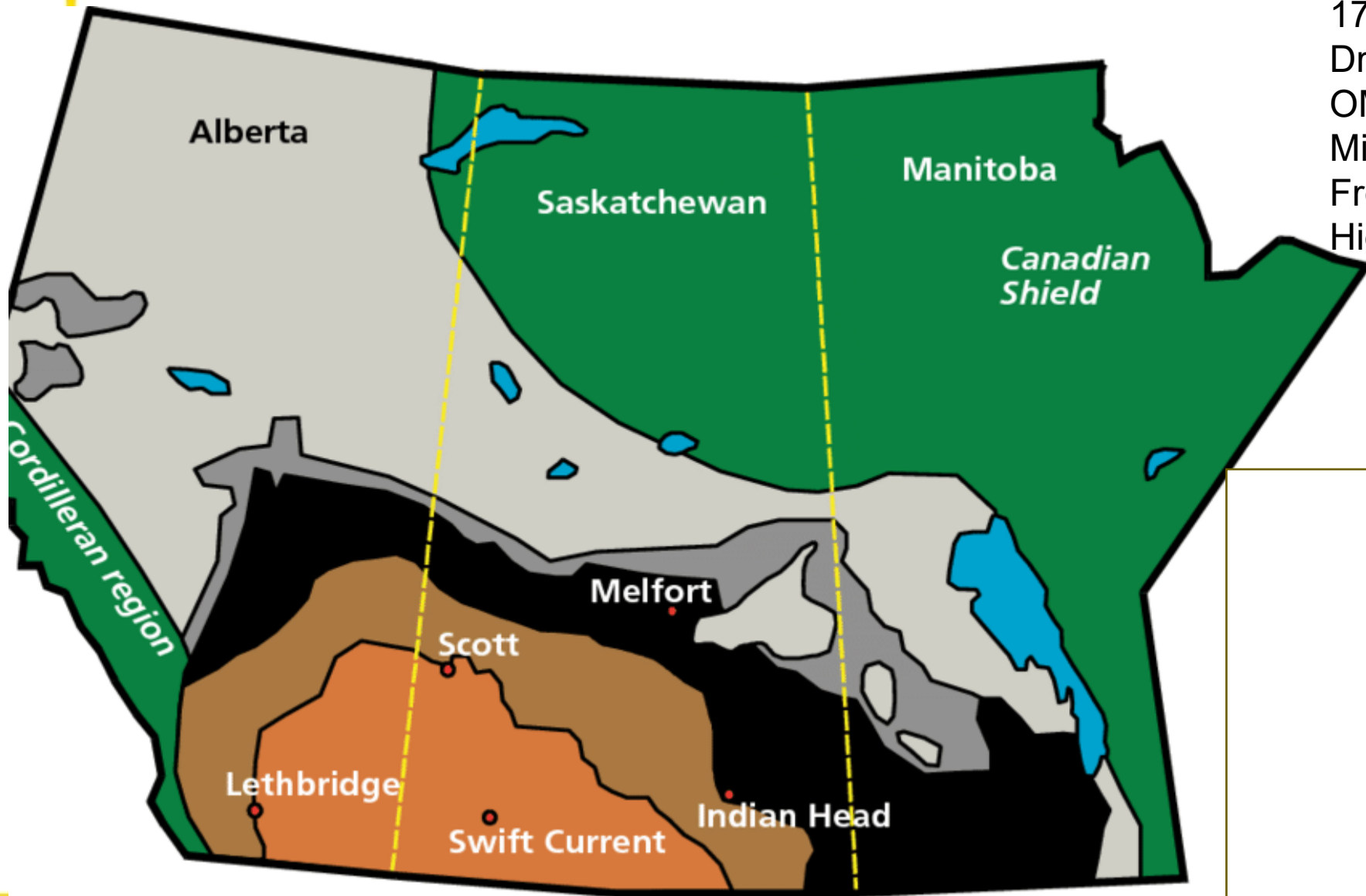
# Impact of changing climate on canola yield and quality in the brown soil zone of western Canada

Rempel C, Dickson T, Bullock P, Mkhabela M,  
Barthet V, Belanger J, Basu S, Sauchyn D

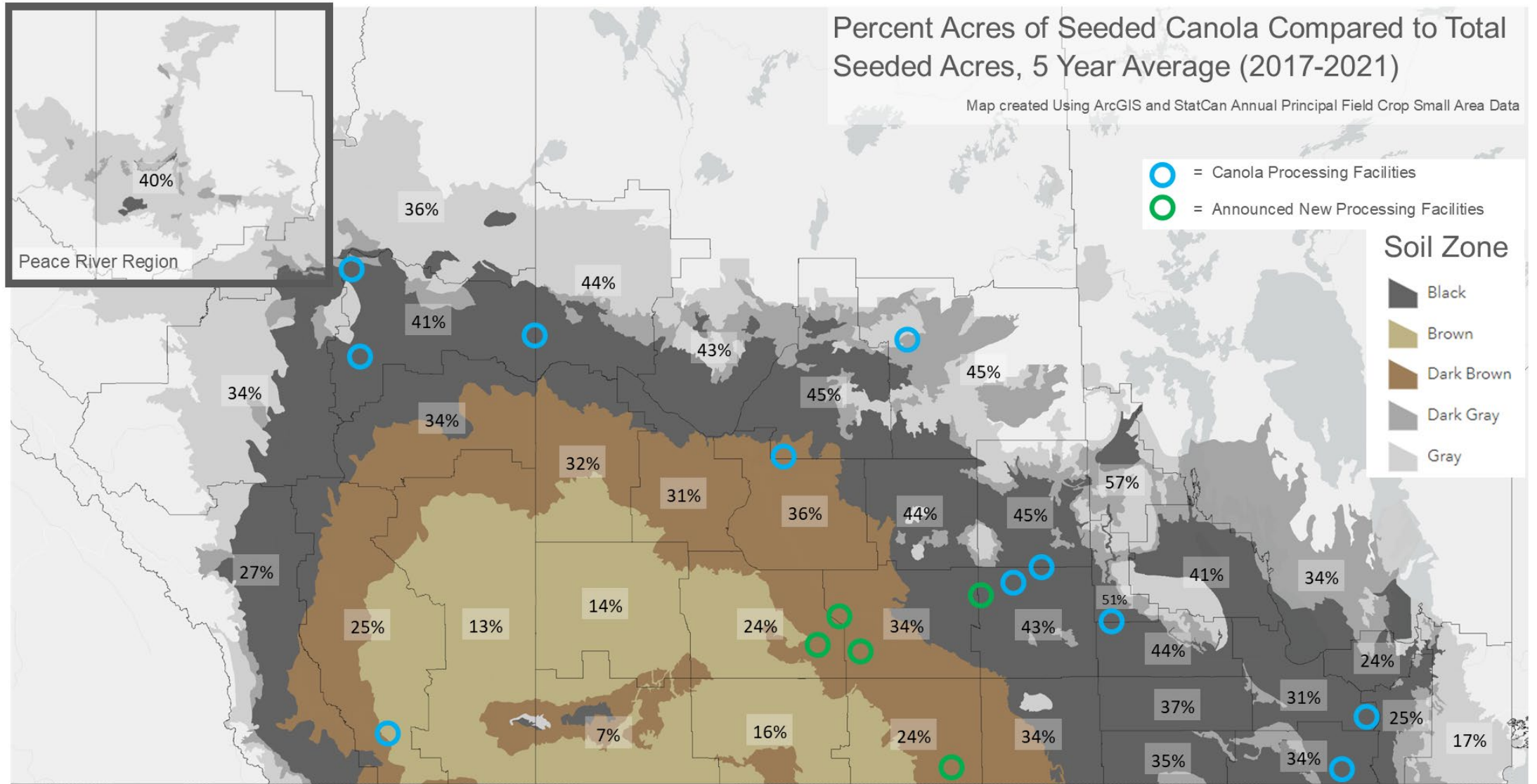
IRC September 25, 2023



# Brown Soil Zone (Palliser's Triangle)

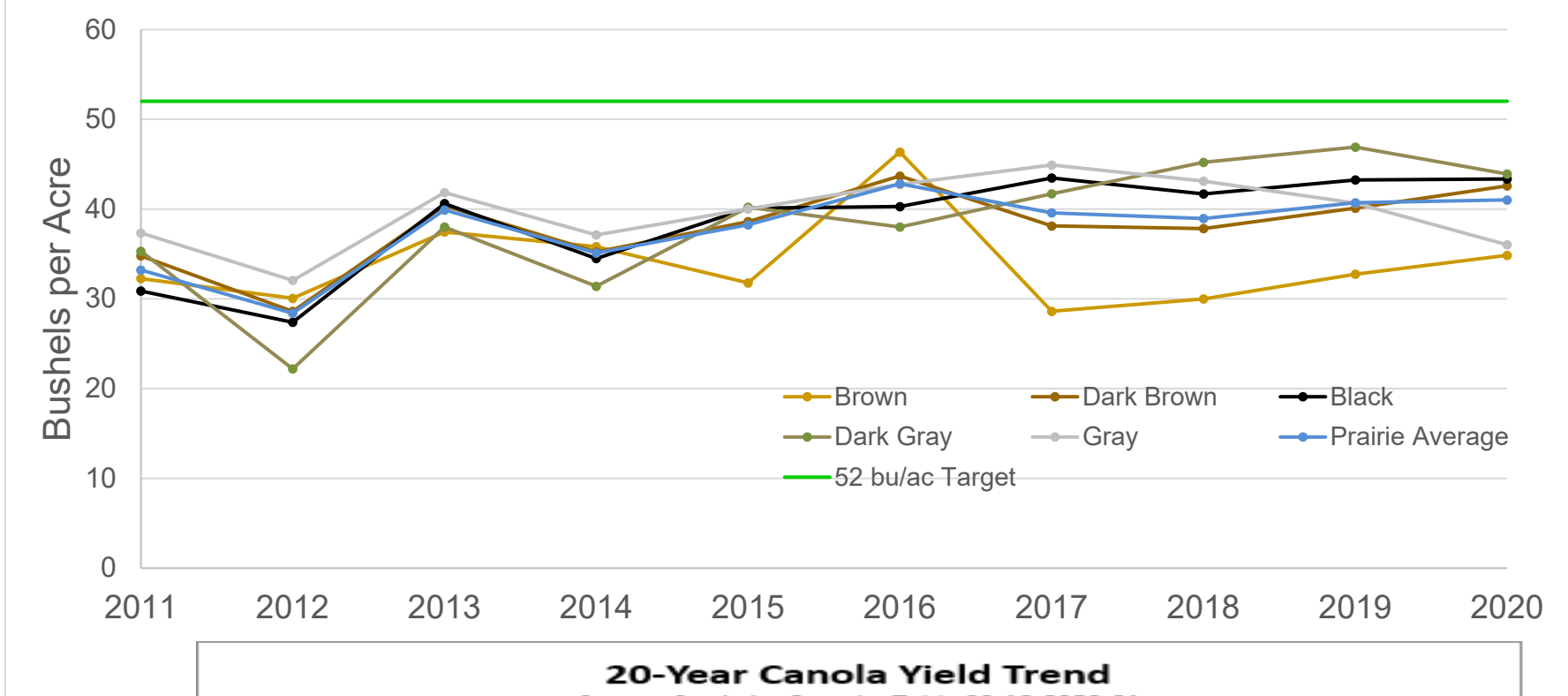


Annual precipitation: 275-330 mm  
Growing season precipitation:  
170 – 180 mm  
Driest month: Feb; Wettest: June  
OM: 2-3%  
Mixed grass prairies  
Frequent droughts, hot dry winds  
High evapotranspiration



Historic High Rates of Summerfallow

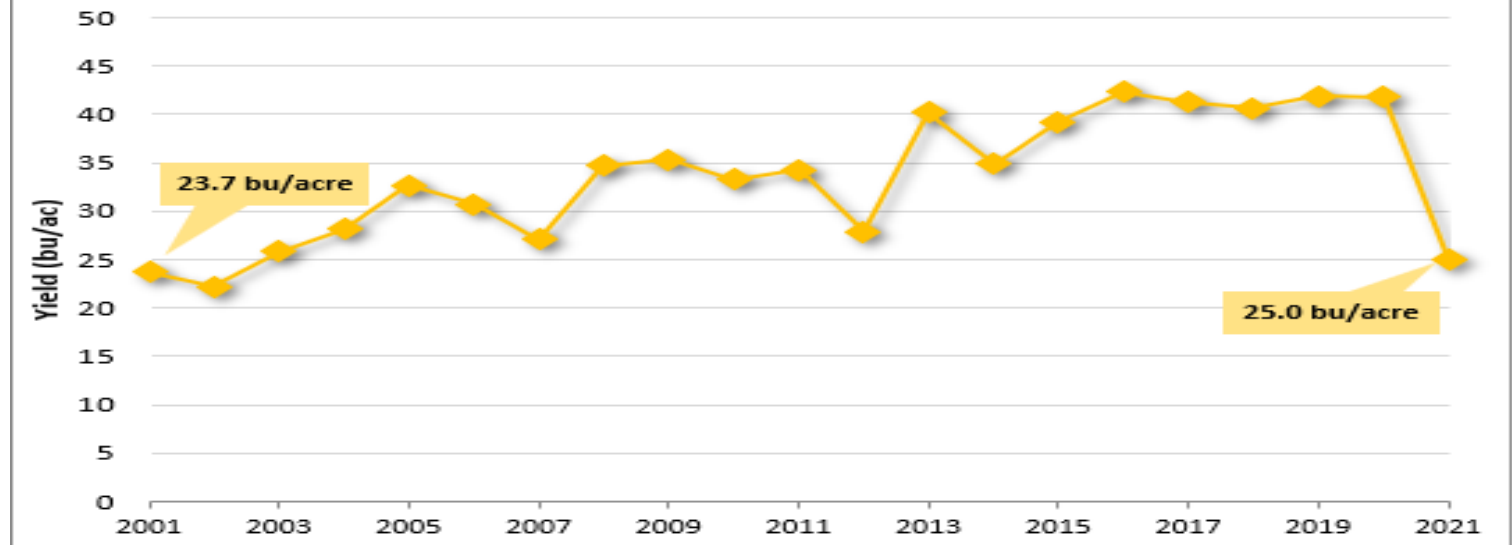
Historical Yields from Each Soil Zone (2011-2020)



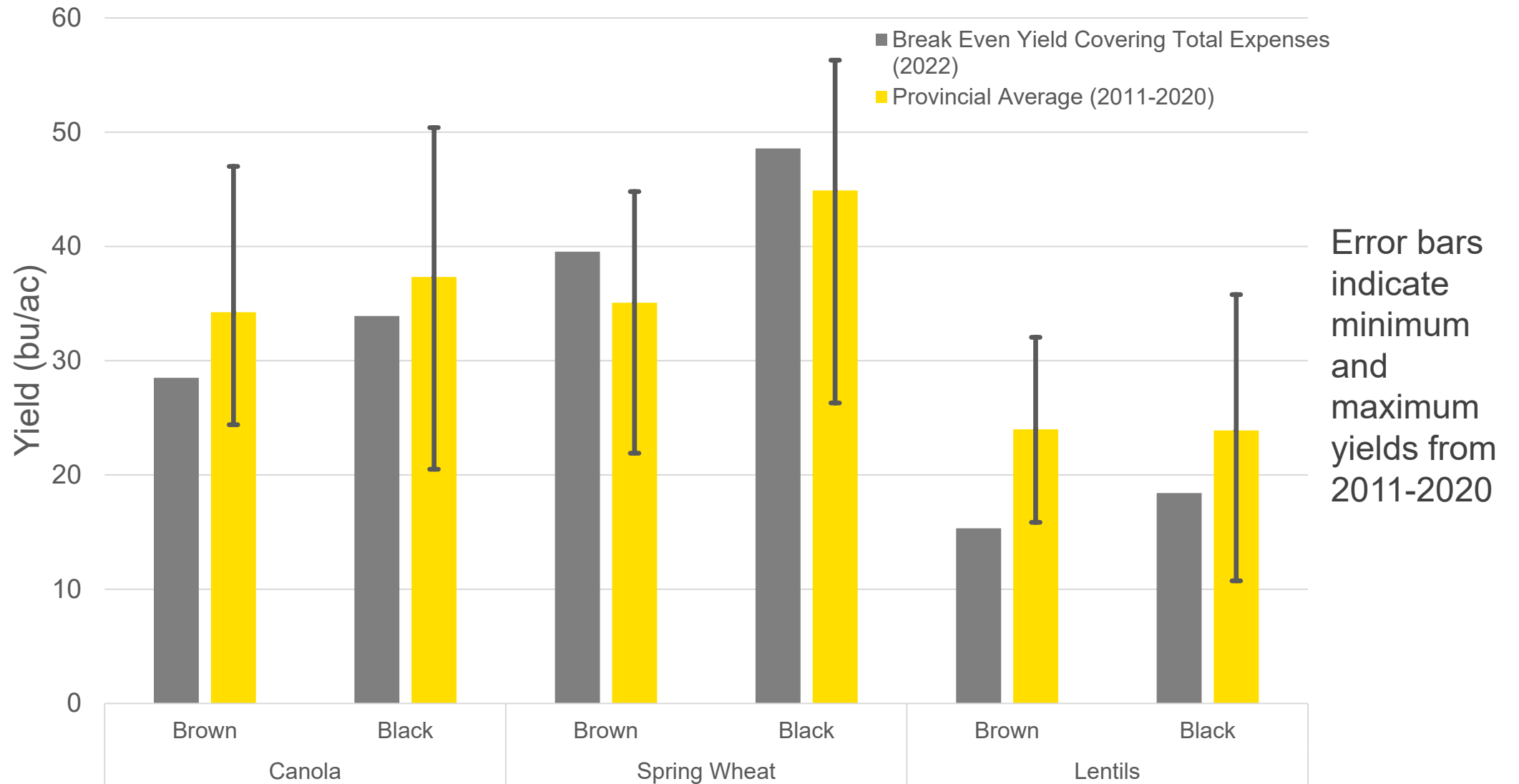
**Drought:**  
 2002  
 2012  
 2021

20-Year Canola Yield Trend

Source: Statistics Canada, Table 32-10-0359-01



# Break Even Yield and Saskatchewan Yield Averages of Crops Across Brown and Black Soil Zones

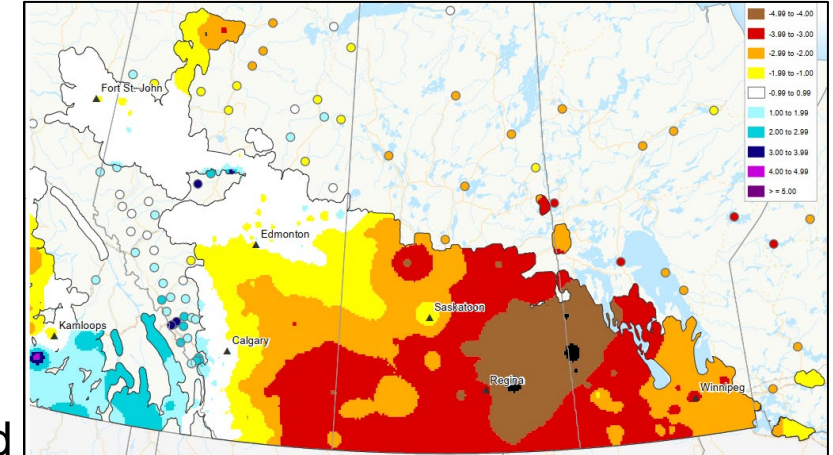


# 2021 Most Severe & Widespread Drought in Past 50 Year

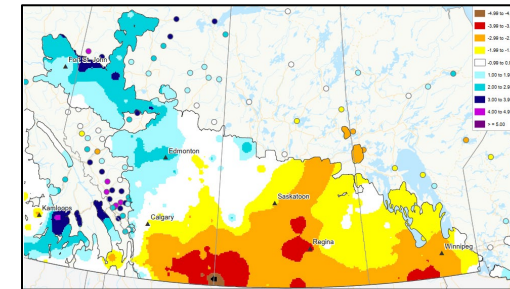
## Comparisons to Past Drought Years

- The **1961 drought** was one of the most severe droughts on record. Low precipitation, record monthly temperatures led to wide scale crop failures. Losses to Prairie wheat production alone totaled \$668 million.
- The **1988 drought** represents another significant drought period on the prairies which caused canola production to be reduced by 20-25% in Alberta, Saskatchewan and Manitoba.
- The **2001 -2002** represented a longer period of moderate drought highlighted by severe drought in 2001 and 2002. Despite single-year droughts being less severe, the cumulative impacts over 4 to 5 years resulted in significant impacts 25% reductions in yield in Saskatchewan and Manitoba in 2002.
- The **2021** drought is the most wide spread and severe drought. Overall yields have been higher than in previous severe droughts as a result of improvements in agricultural practices.

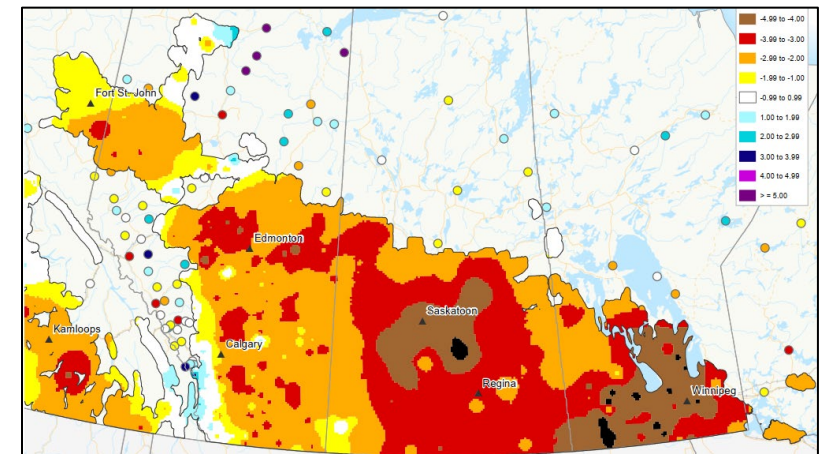
August 17, 1961



August 17, 1988

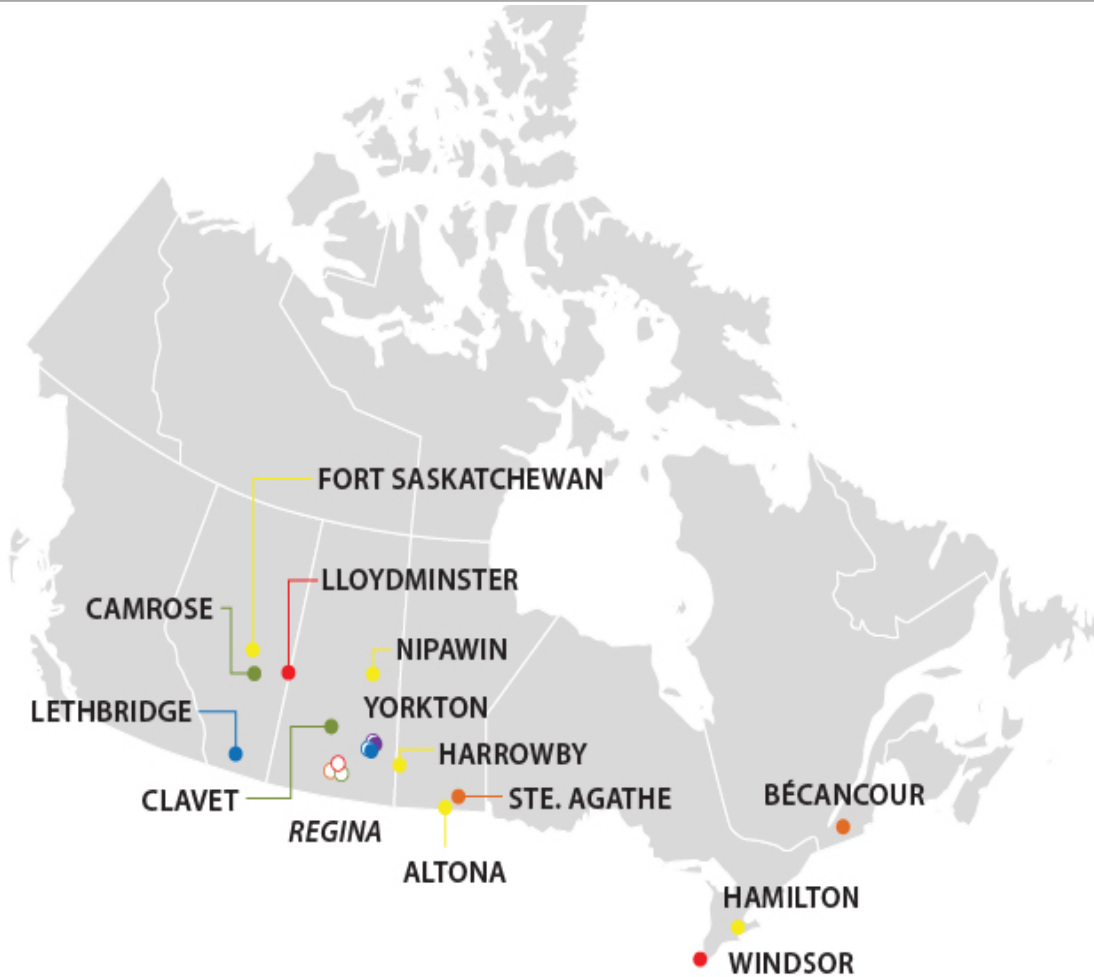


August 17, 2021



# NA biofuels a catalyst for canola processing

**5 new investments = +6.7 MMT crush capacity**



## Canola Processing Facilities in Canada

- ADM (2)
- BUNGE (5)
- CARGILL (2)
- LDC
- RICHARDSON (2)
- VITERRA (2)

## ANNOUNCED NEW PROCESSING INVESTMENTS

- CARGILL
- FCL AND AGT FOODS
- LDC
- RICHARDSON
- VITERRA



More competition for canola seed raises the overall value of canola



Increased delivery options and flexibility for farmers

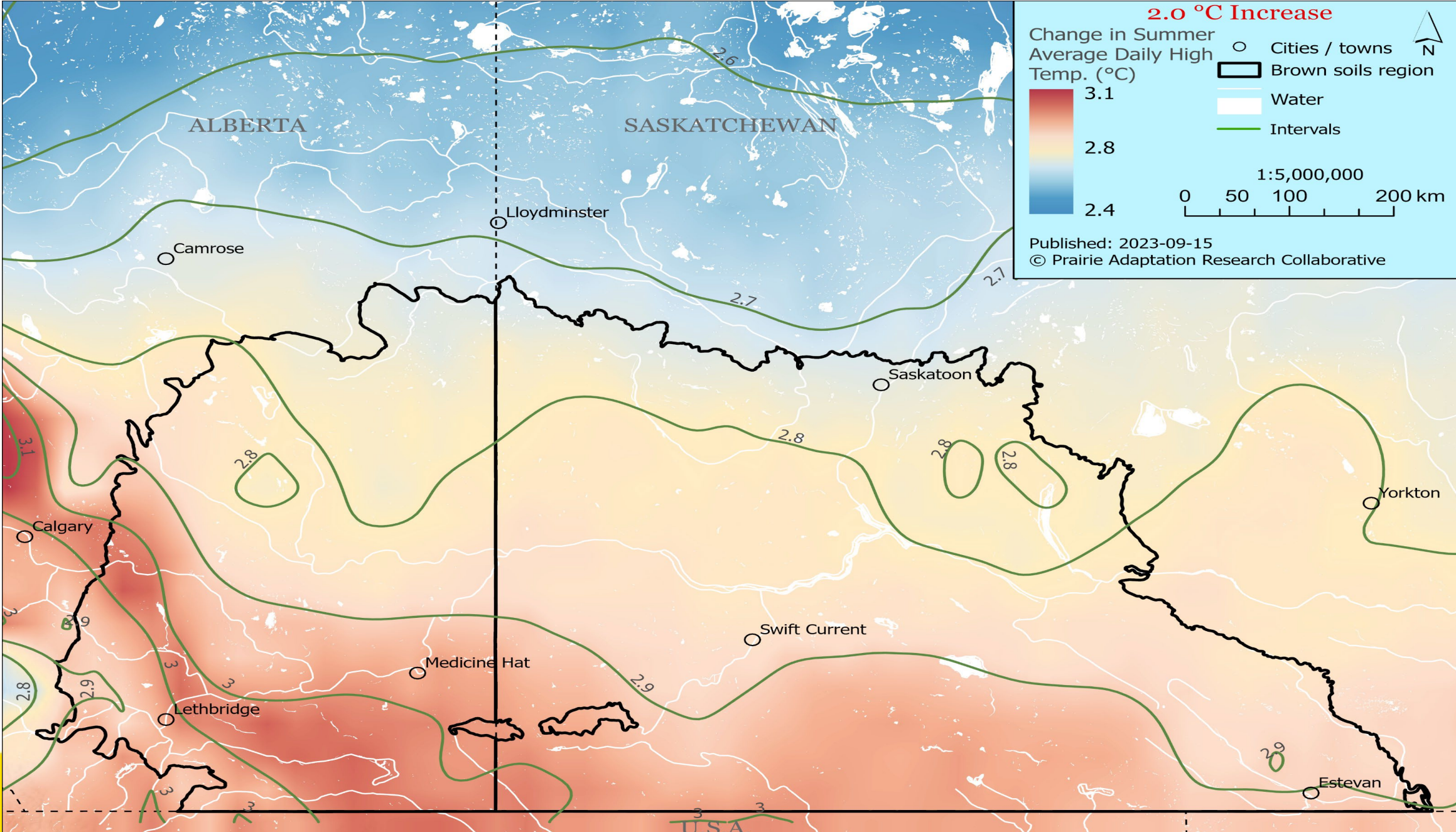
## Global Mean Surface Air Temperature (GMSAT):

- Whole globe Earth System Models
- RCP 8.5 GHG forcings - IPCC
- Historical Baseline 1976 – 2005
- 2 temp scenarios: 1.5 C, 2.0 C
- 11 models run, bootstrapped
- Scenarios mean of 11 models
- 16 Climate Variables, 4 seasons
- Yield, oil, protein, fatty acid, glucs

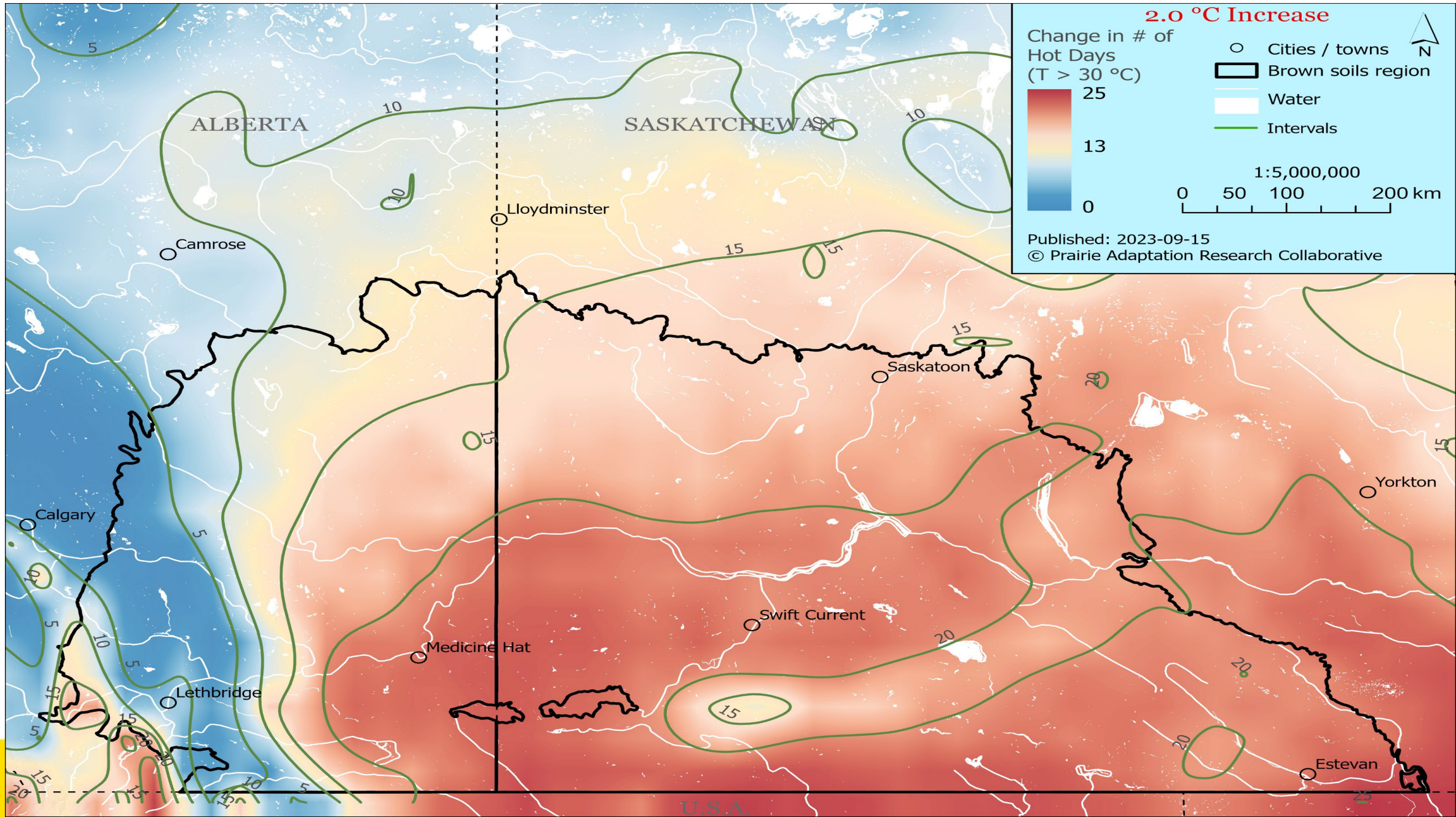
Under a relatively high GHG emissions scenario, such as RCP 8.5, the southern prairies are expected to see an increase in average temperature of 2.4 °C by 2021-2050 relative to the 1976-2005 average (Prairie Climate Centre, n.d.). This high emissions scenario is often regarded as the most likely among the climate modeling community based on current emission trends and will bring more than just changes in temperature.

NA-CORDEX Model Name	Driver Earth System Model & Regional Climate Model
CanESM2.CanRCM4	Canadian Earth System Model second generation Canadian Regional Climate Model version 4
CanESM2.CRCM5-UQAM	Canadian Earth System Model second generation Canadian Regional Climate Model-University of Montreal
GEMatm-Can.CRCM5-UQAM	Global Earth Model Atmosphere- CanESM2 Canadian Regional Climate Model-University of Montreal
GEMatm-MPI.CRCM5-UQAM	Global Earth Model – MPI Canadian Regional Climate Model-University of Montreal
GFDL-ESM2M.RegCM4	Geophysical Fluid Dynamics Laboratory – Earth System Model Regional Climate Model
GFDL-ESM2M.WRF	Geophysical Fluid Dynamics Laboratory – Earth System Model NCAR Weather Research and Forecasting Model
HadGEM2-ES.WRF	Hadley Centre Global Environment Model version 2 NCAR Weather Research and Forecasting Model
MPI-ESM-LR.CRCM5-UQAM	Max Planck Institute – Earth System Model – Low Resolution Canadian Regional Climate Model-University of Montreal
MPI-ESM-LR.RegCM4	Max Planck Institute – Earth System Model – Low Resolution Regional Climate Model
MPI-ESM-LR.WRF	Max Planck Institute – Earth System Model – Low Resolution NCAR Weather Research and Forecasting Model
MPI-ESM-MR.CRCM5-UQAM	Max Planck Institute – Earth System Model – Medium Resolution Canadian Regional Climate Model-University of Montreal

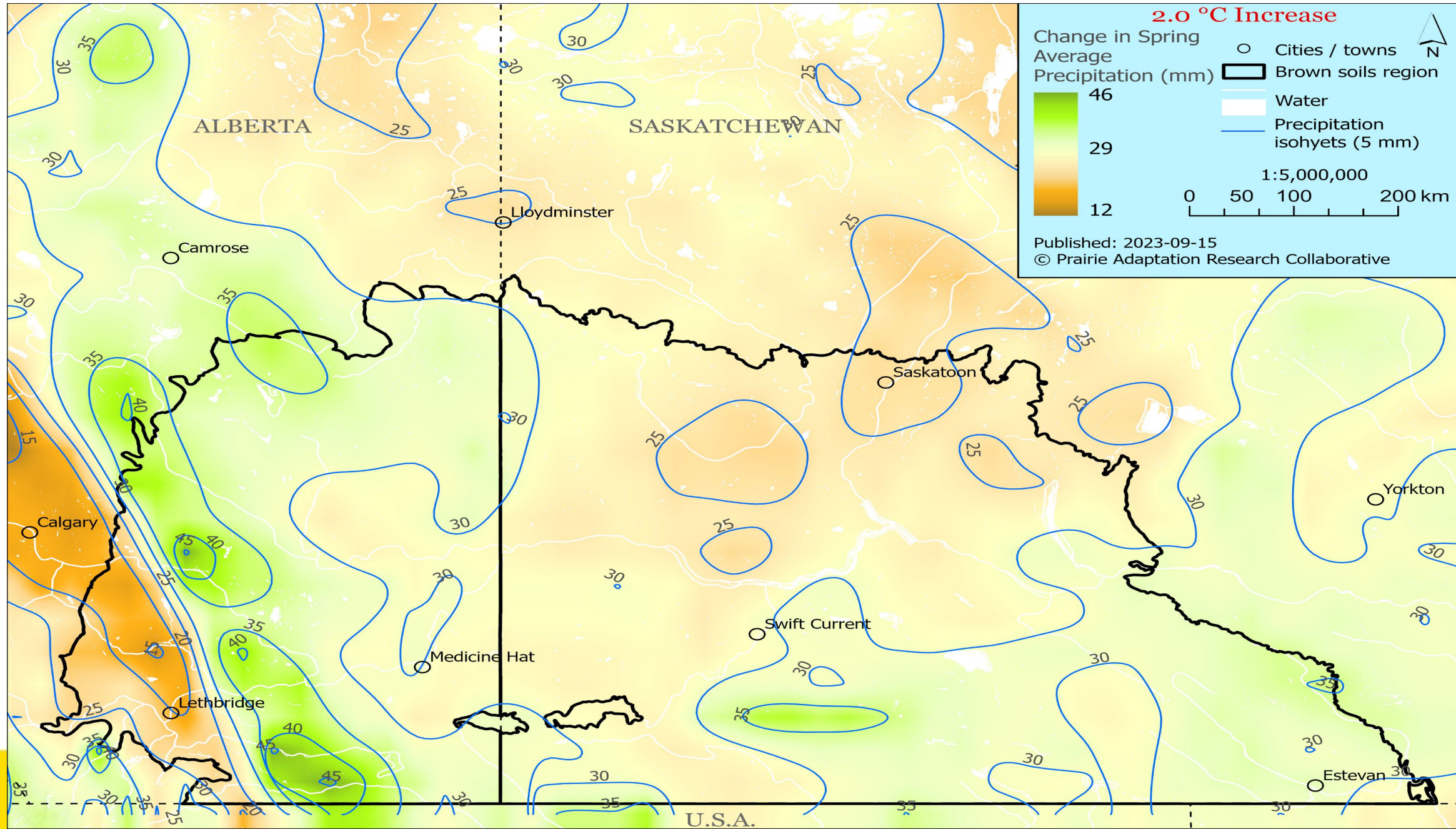
# Summer Average Daily High Temp - 2.0 C Increase



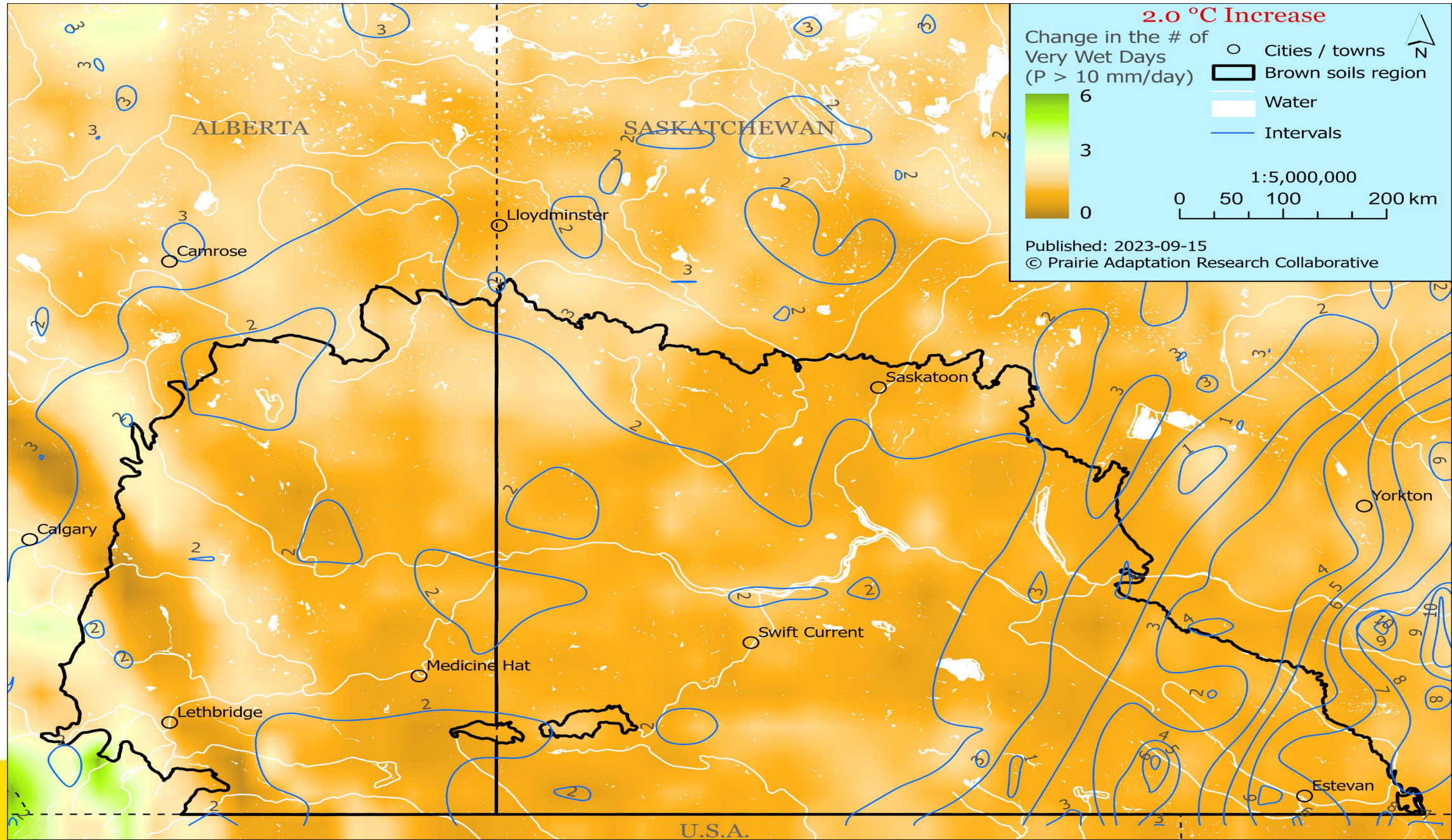
# # Hot Days ( $T > 30\text{ C}$ ) – 2 C Increase



# Spring Precipitation - 2.0 C Increase



# Change in # of Very Wet Days - 2.0 C Increase



S1 = 1.5 C; S2 = 2 C

# Key Findings

## Precipitation

- There is a dramatic increase in projected spring (March, April, May) precipitation – as much as 45.7 mm under S2 and at least an increase of 7.7 mm (S1).
- Number of Dry Days decreases by up to 12 days under both S1 and S2 – Spring (MAM).
- Spatial pattern of a drier south and wetter north is persistent across spring and summer seasons.
- An increase in the number of Wet Days ( $P > 5$  mm) and Very Wet Days ( $P > 10$  mm) is observed under S1 and S2, but with the distinction that the increase in Wet Days is spread out over the BSZ while the increase in Very Wet Days is isolated to the southwest.
- Less moisture winter, summer; increase spring and fall

## Temperature

- Warming is observed in the spring and summer months with up to 3.5 °C increase in Spring Minimum Temperature anticipated under S2. Summer projections offer little relief with projections of 3.1 °C increase in both minimum and maximum temperatures under S2.
- Warming during the growing season coincides with increases in the number of days where temperature is expected to exceed 30 °C.
  - 21 and 25 additional days are expected under S1 and S2, respectively.
- An additional 13 and 15 days are anticipated where the temperature will exceed 35 °C under S1 and S2, respectively.
- **30 C Threshold Temp Canola; Have not modelled night temp likely more NB**

# What Is the IMPACT? - YIELD

Climate variable	Influence on yield	Direction of change	Result
Spring Minimum Temperature	Positive	↑	Favourable
Spring Maximum Temperature	Positive	↑	Favourable
Summer Minimum Temperature	Positive	↑	Favourable
Summer Maximum Temperature	Both	↑	More research required
Growing Season Minimum Temperature	Positive	↑	Likely favourable
Growing Season Maximum Temperature	Both	↑	More research required
Growing Degree Days	Positive	↑	More research required
Number of Hot Days	Negative	↑	Unfavourable
Number of Very Hot Days	Negative	↑	Unfavourable
Spring Precipitation	Positive	↑	Likely favourable
Summer Precipitation	Positive	↑	Likely favourable
Growing Season Precipitation	Positive	↑	Likely favourable
Number of Wet Days	Both	↑	More research required
Number of Very Wet Days	Negative	↑	Favourable
Number of Dry Days	Negative	↑	Favourable
3-month Standardized Precipitation Evapotranspiration Index	Positive	↓	More research required

Yield Loss (bu/ac)	Flowering	
	0 – 10 Days	21 – 35 Days
Temp > 30 C; < 50% available water	25 - 28	15 - 18
Temp > 30 C; 80% available water	7 – 12	4 – 8

**Baseline Yield: 35 bu/ac**

Climate Models into APSIM; DSSAT

- 5 day temperature event >30 C
- 50 bu/ac canola crop needs 12 inches (305 mm) available moisture
- Timing of moisture critical
- 30 C critical temp for pollen viability
- Nocturnal temp < 24 C; yield loss much less severe

**Table 3.15. Weather-based models for canola quality.**

Quality Parameter	Predictive Model <sup>†</sup>
<b>Oil</b>	$40.19353106 + (E\_CD<14*0.29558084) + (CF\_CD<14*0.01006754) + (BD\_CD<11*0.02063818)$
<b>Glucosinolates</b>	$8.550831821 + (CD\_SDD>22*0.042183175) + (CD\_AVET*-0.12563818) + (BF\_CDD<17*-0.00121146) + (B\_SDD>31*-0.410755207) + (F\_SD>22CUM*0.021179128)$

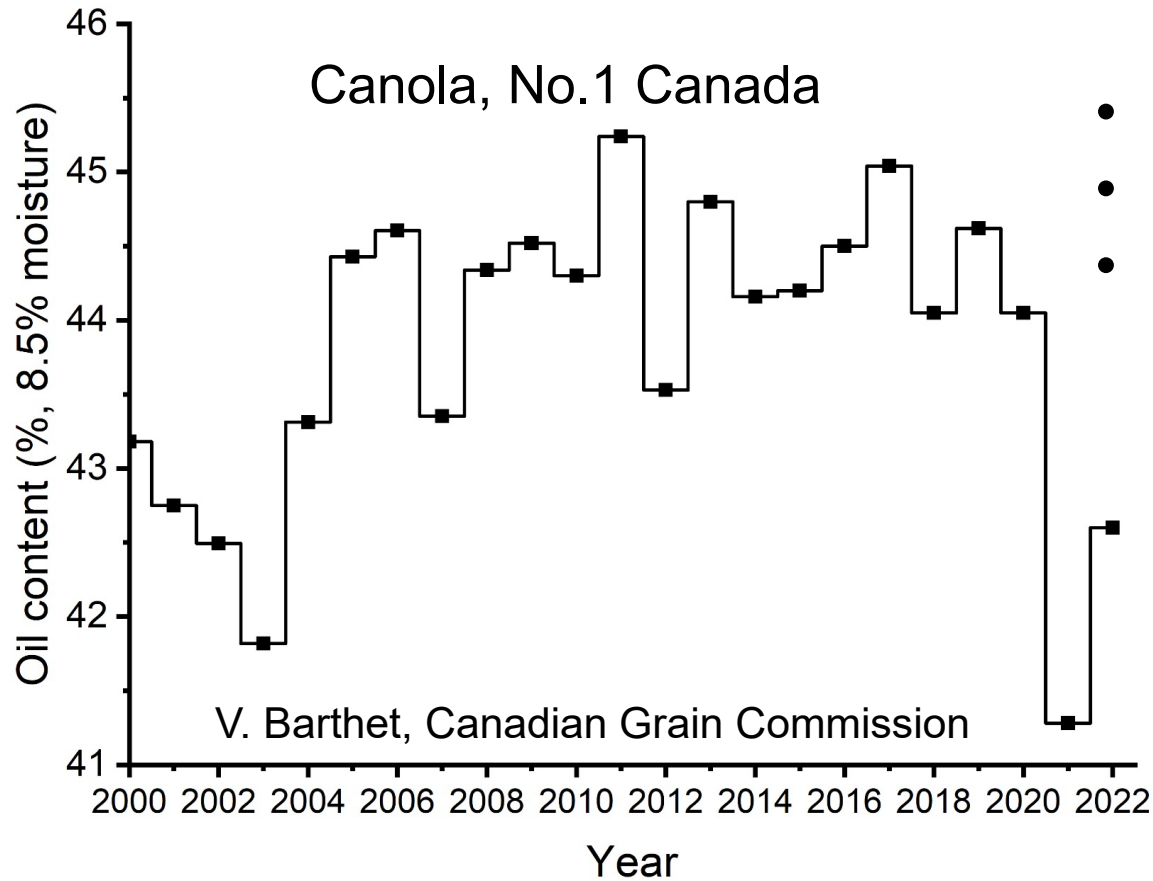
A = phenological stage 3.2, B = phenological stage 4.2, C = phenological stage 4.3, D = phenological stage 4.4, E = phenological stage 5.2, F = phenological stage 5.4

Percentage of variance explained by predictors in the final model:

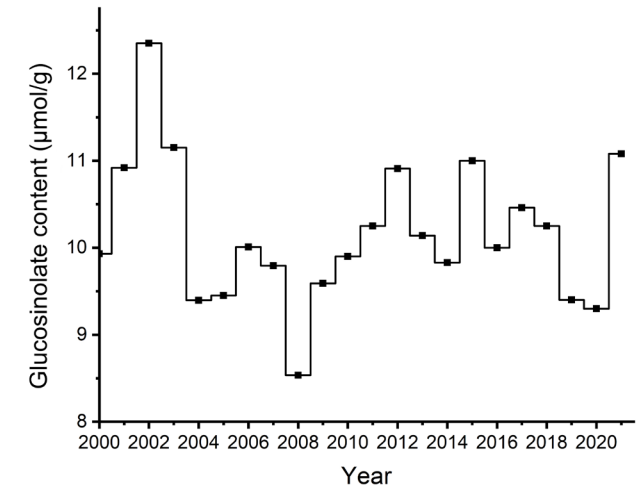
Oil	25.5
Glucosinolates	43.5

T. Dickson, Canola Council of Canada

# Seed Oil Content Since 2000



- Low Yield = Low Oil?
- 5 day temp > 30 C = 2% seed oil loss?
- Glucosinolates – Late Season Temp Stress INCREASE?



**Table 3.14. Canola quality by the latitude of the sample site.**

Quality parameter	Latitude T. Dickson, Canola Council of Canada					
	49°	50°	51°	52°	53°	54° +
Oil	44.15 <sup>B</sup>	44.64 <sup>AB</sup>	45.77 <sup>A</sup>	45.61 <sup>A</sup>	45.39 <sup>A</sup>	44.97 <sup>AB</sup>
Protein	20.61 <sup>A</sup>	20.51 <sup>AB</sup>	19.36 <sup>B</sup>	19.65 <sup>AB</sup>	20.32 <sup>AB</sup>	20.91 <sup>AB</sup>

# Long Term: Progress With Promising Genes

- ***DRO1*, *Pstol1* & *PP1*** control larger root systems.
- ***TOR*** overexpression increases performance under **drought**, increases **NUE** and **PSE**.
- **ABA response genes** increase **drought** resilience and **PSE** (***AIL7***)
- Overexpression of ***PDAT*** increases heat and **drought resilience**.
- Suppression of ***Kanghan 1* (*KH1*)** confers improved **drought resilience**.

## Short Term: Adaptation

### Have to Beat the Heat...

- Increased Spring Moisture, Temp = **Early Planting**
- **Selection of Short Season, High Yielding Varieties**
- Highest yielding hybrids = long season > 110 Days to Maturity



**canolacouncil**  
OF CANADA

Thank you

