Agriculture et Agroalimentaire Canada | Agriculture and Agri-Food Canada

Canada

Spring barley yield and potential northward expansion under climate change in Canada

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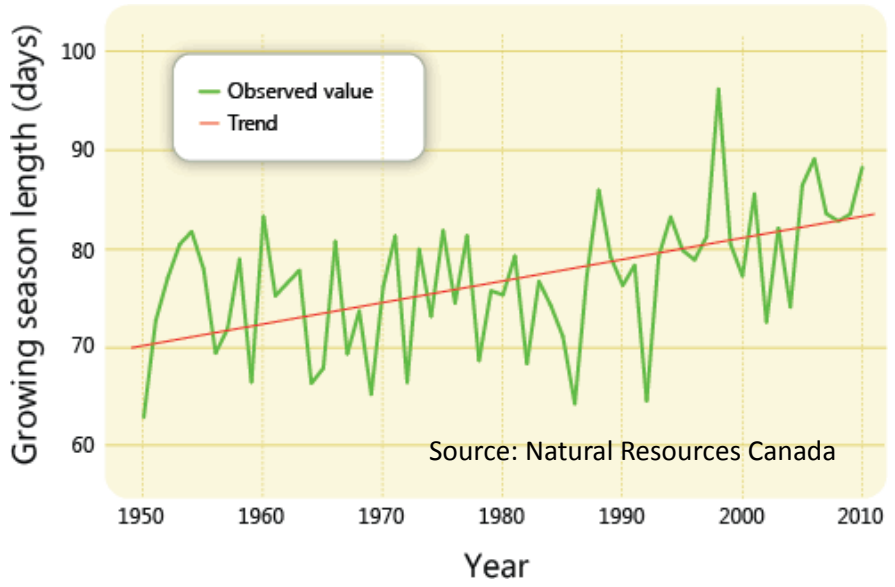
XIII séminaire STICS, 13-16 novembre 2023, Bordeaux, France

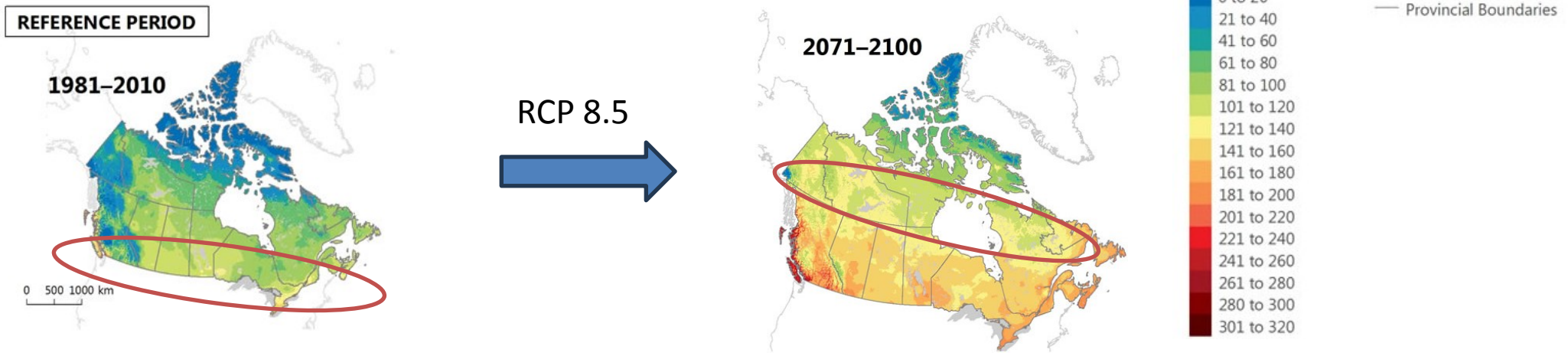
Background

- In Canada, growing season length is increasing with climate change

Past trends in growing season length for Canada (1950 to 2010)



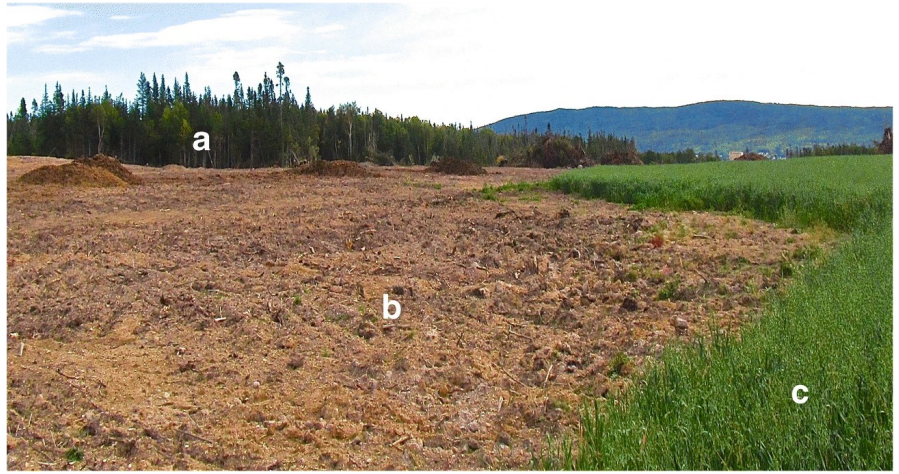
- Possible northward expansion of crop



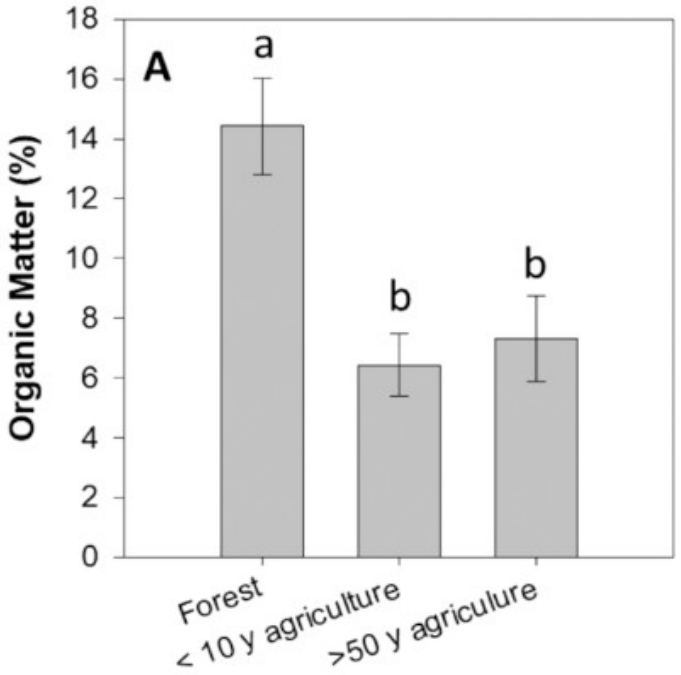
Source: Natural Resources Canada

Background

- Impact of land conversion from boreal forest to agriculture on soil organic matter:



Altdorff et al., 2021



The impact of land conversion from boreal forest to agriculture on soil health indicators

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→ Evaluation of the potential of crop growth before land conversion.

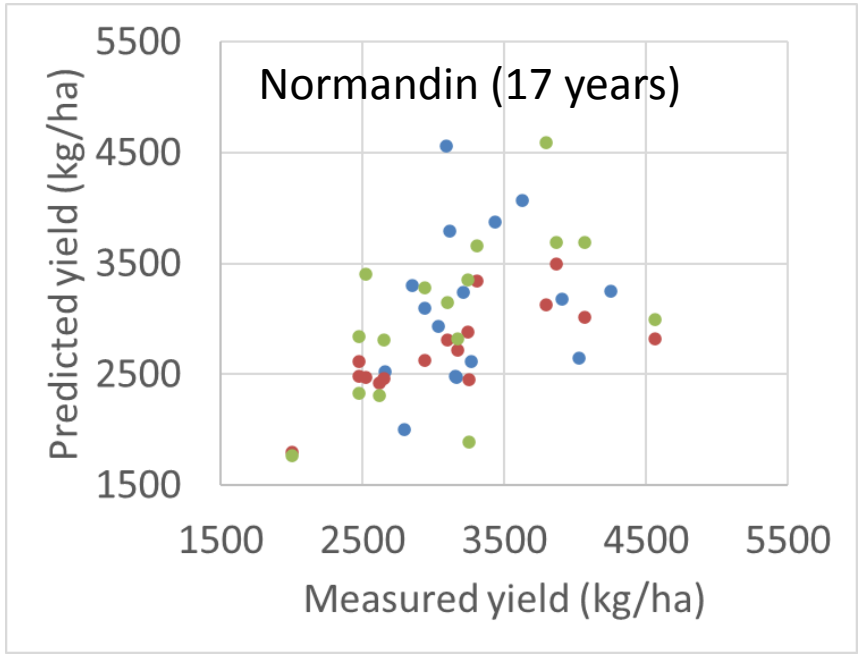
Objectives

- Global objective of the project: to assess the potential impacts of climate change (CC) on the main crops grown in Canada (spring barley, spring wheat, corn, soybean, canola, alfalfa and potato) and their possible northward expansion
- Specific objectives of this presentation: impact of CC on **spring barley** growth:
    1. in **regions** where barley is **currently produced**
    2. in **northern regions** where it may be grown **in the future**.

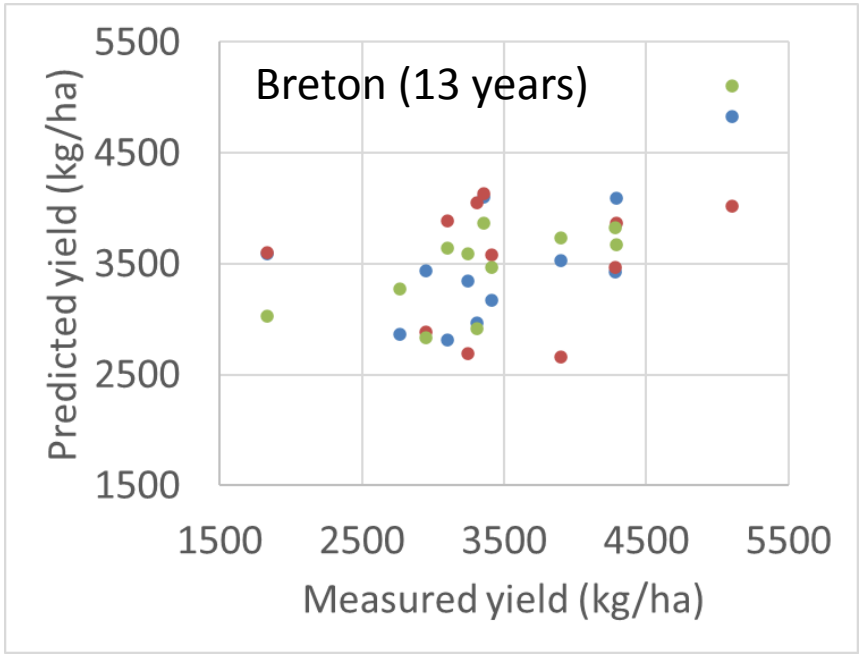
Methodology: calibration / valid

- Two datasets : Normandin (Quebec) and Breton (Alberta)
- For STICS, calibration of parameters from the proto_barley_plt.xml file
- Three crop models:
  - **STICS** (V10 beta)
  - **DNDC** (DNDCv.CAN)
  - **DSSAT** (V. 4.7.5)

Model validation for harvested grain yield:



NRMSE (%): 24.5 / 22.2 / 20.7



NRMSE (%): 21.5 / 28.9 / 17.8

Methodology: climate change simulations

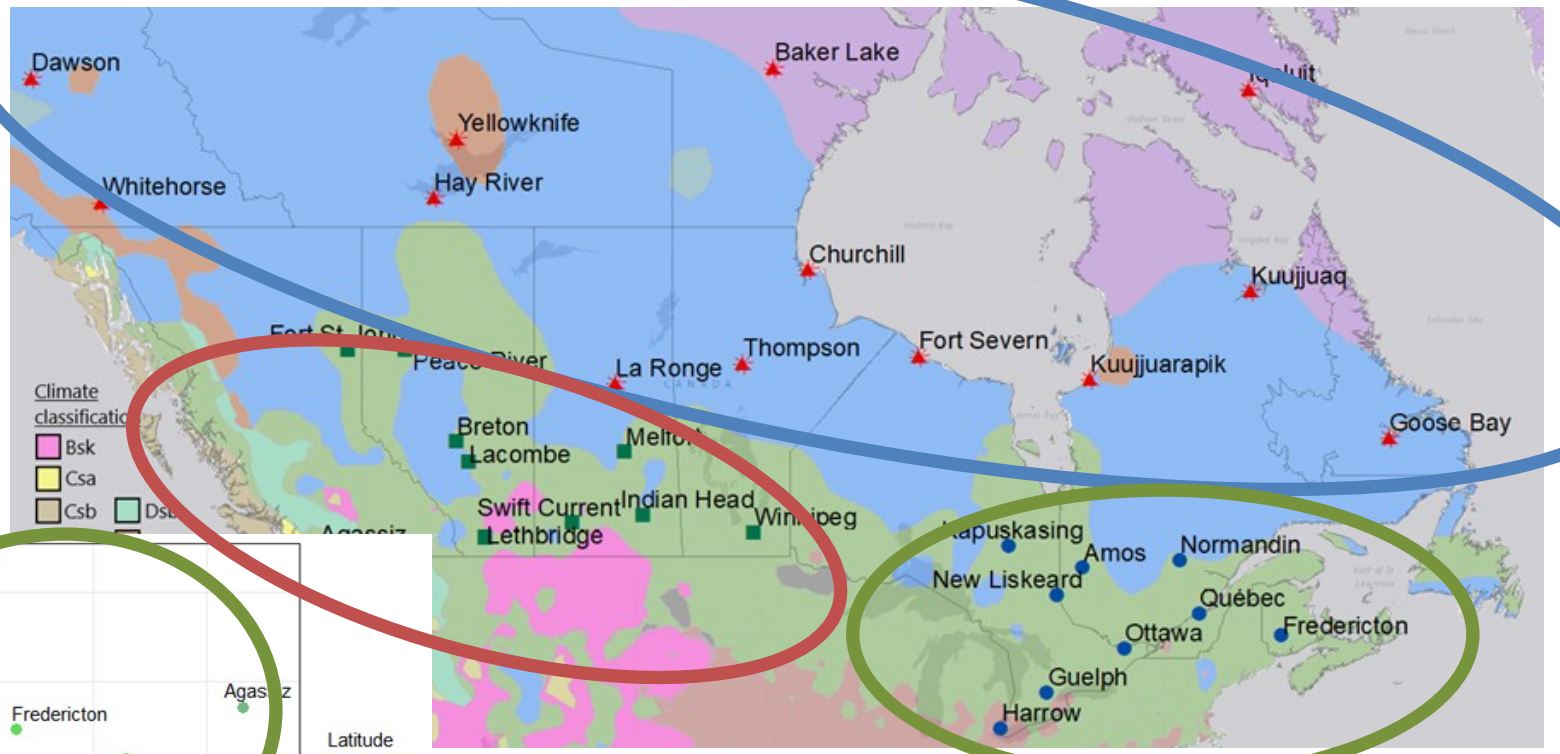
- 3 soil-crop models : STICS DSSAT DNDC
- 6 climate models : CanESM5, GFDL-ESM4, IPSL-CM6A, MPI-ESM1-2, MRI-ESM2 and UKESM1
- 3 SSPs : SSP1-2.6, 3-7.0 and 5-8.5

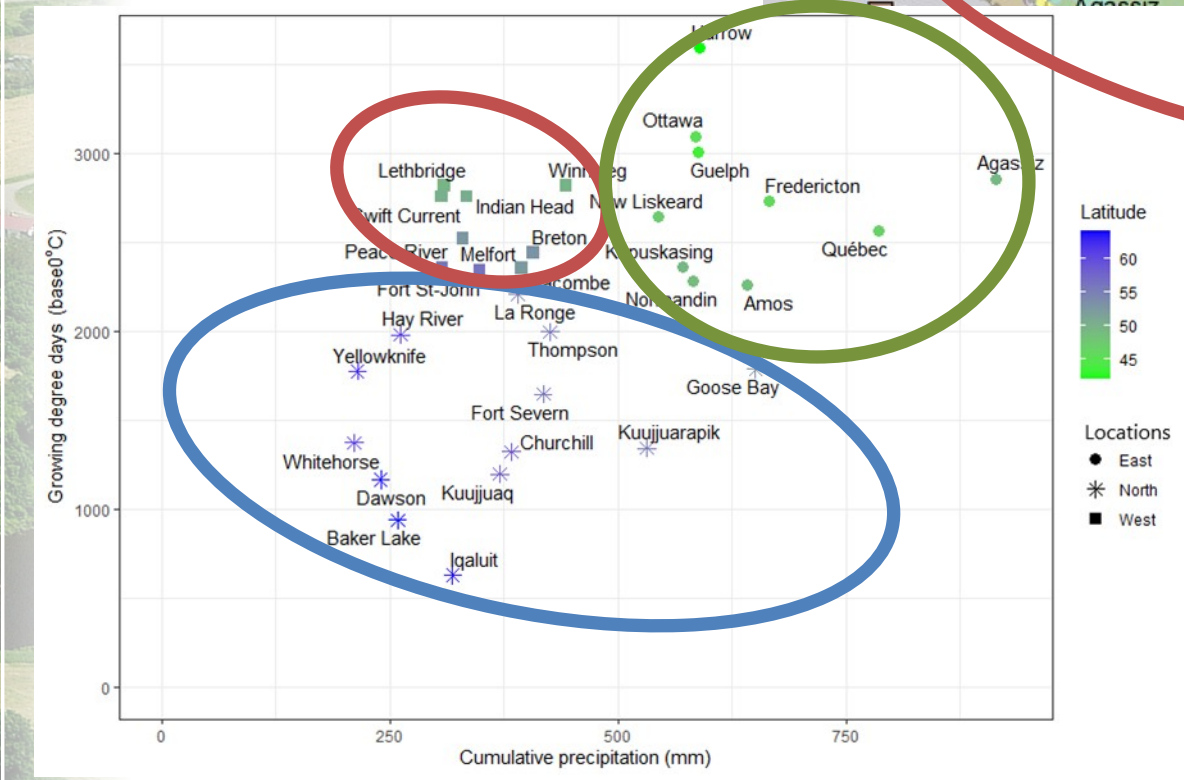
18 climate scenarios

- 120 years (1981-2100) per climate scenario
- 2 types of simulation: potential (no N and water stress) and rainfed (no N stress)

Methodology: Climate change simulations

32 locations across Canada





Cold continental climate with short growing season

Humid continental climate

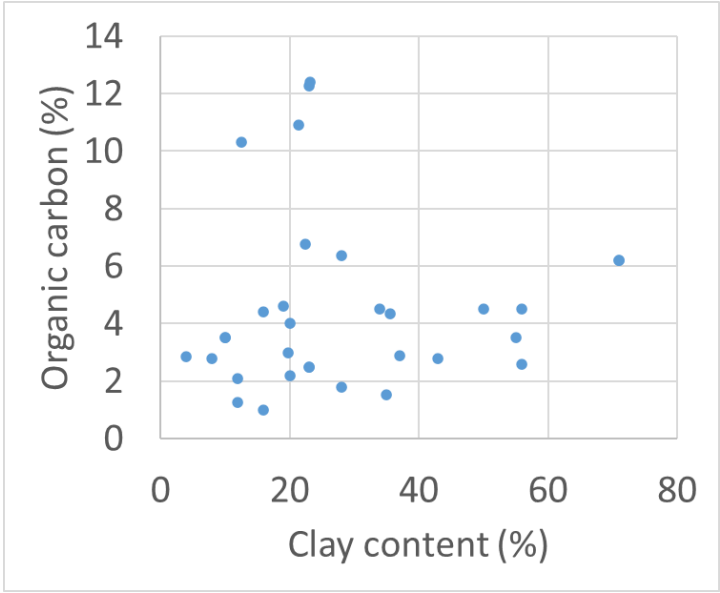
Dry continental climate

Locations where spring barley is currently grown

Methodology: climate change simulations

- Crop management:
  - Seeding date adjusted for each year following the criteria developed by Bootsma and De Jong (1988)
  - Harvest at maturity
  - Continuous simulations (no reset)

- Soil properties = most common soil around each location



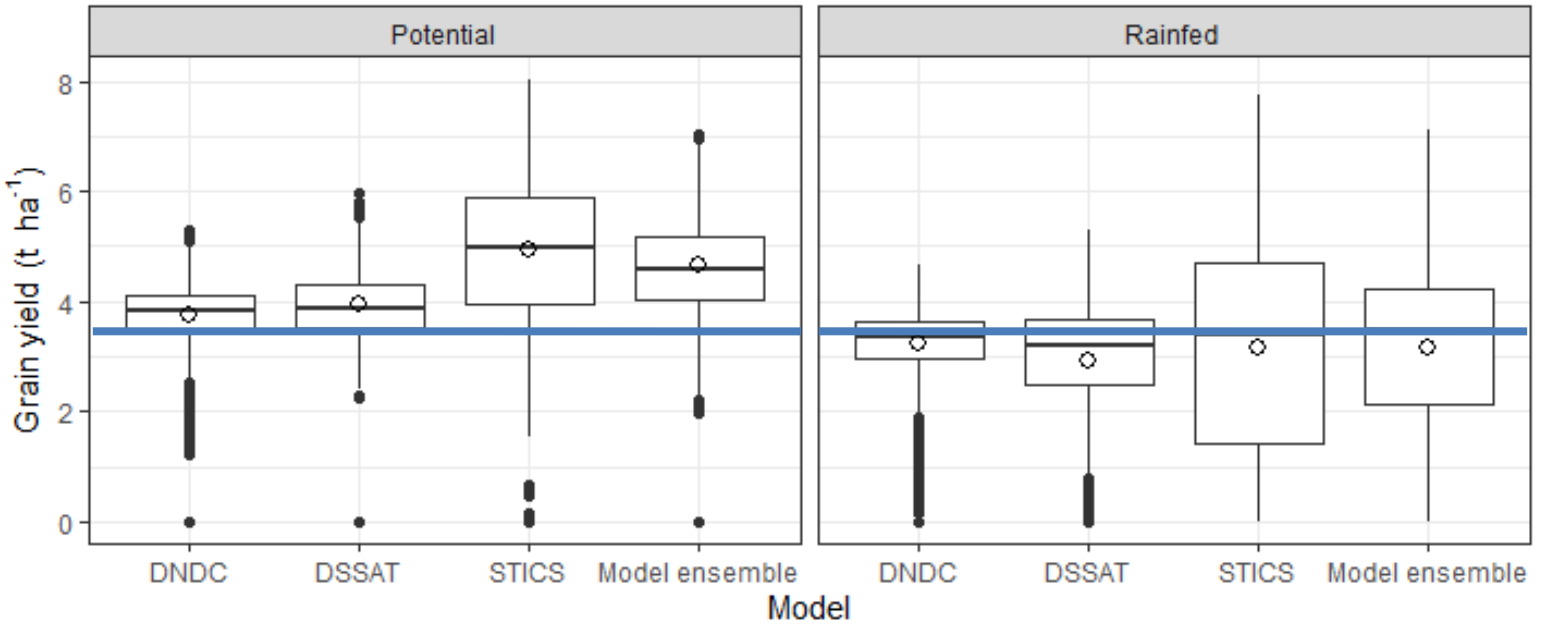
Methodology: climate change simulations

- Output analysis:
  - Three time periods:

  - Crop yield
  - Crop failure:
    - Yield <1 t ha^{-1} (≈2 times below the profitability threshold)
    - Or flowering later than day 250

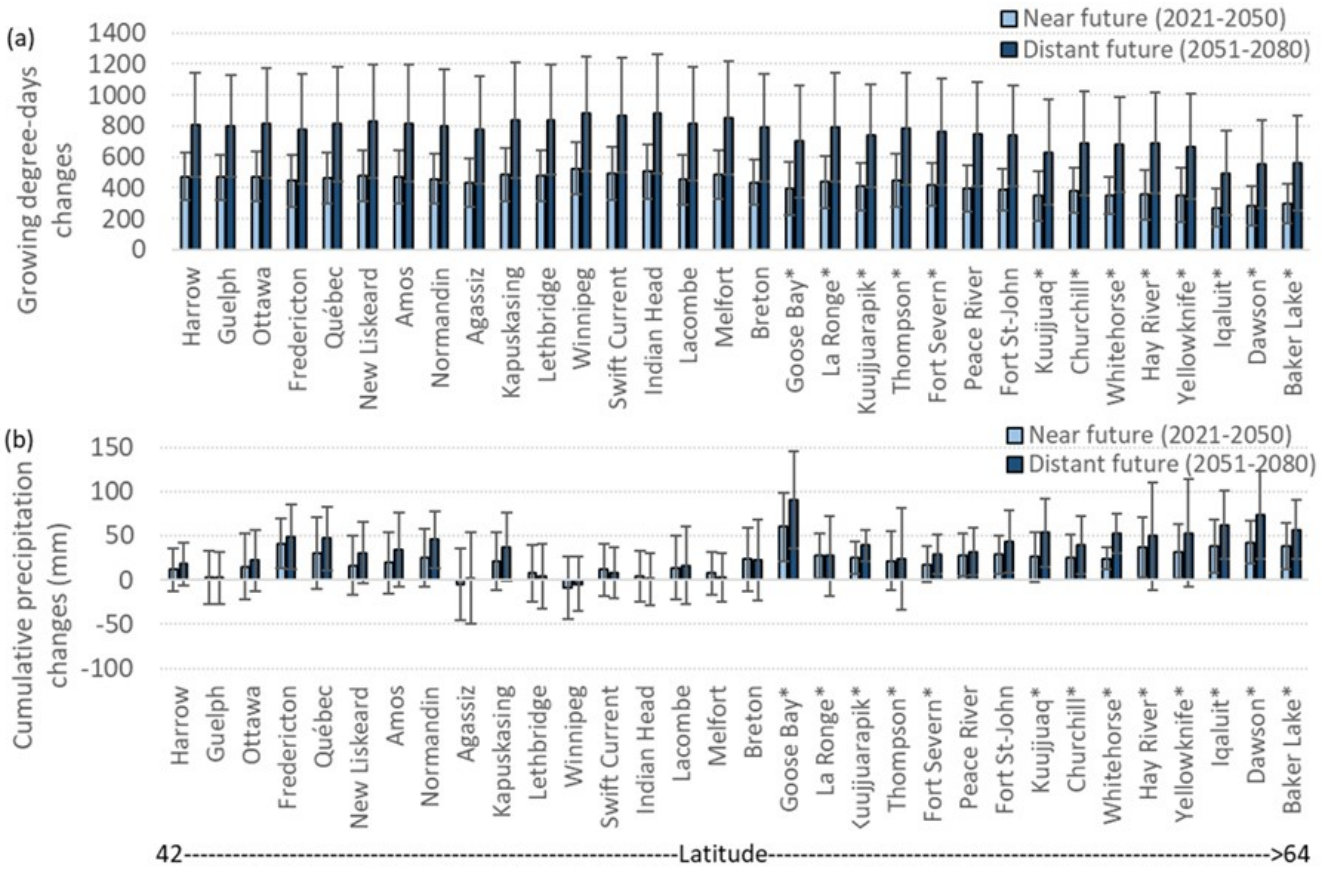
Results – Yield prediction in the reference period

Average potential and rainfed yields predicted by the three models for all locations and climate scenarios



- Yield predictions for the reference period are close to the average observed yield in Canada (3.5 t ha^{-1})
- Results are averaged across the three models for the rest of the presentation

Results – Climate change projections



- Projected GDD* increases from 300 to 500 in NF and 600 to 900 in DF.
- Small projected increases of precipitation in eastern and northern locations

*GDD base temperature = 0°C

Results – Seeding and harvest dates changes

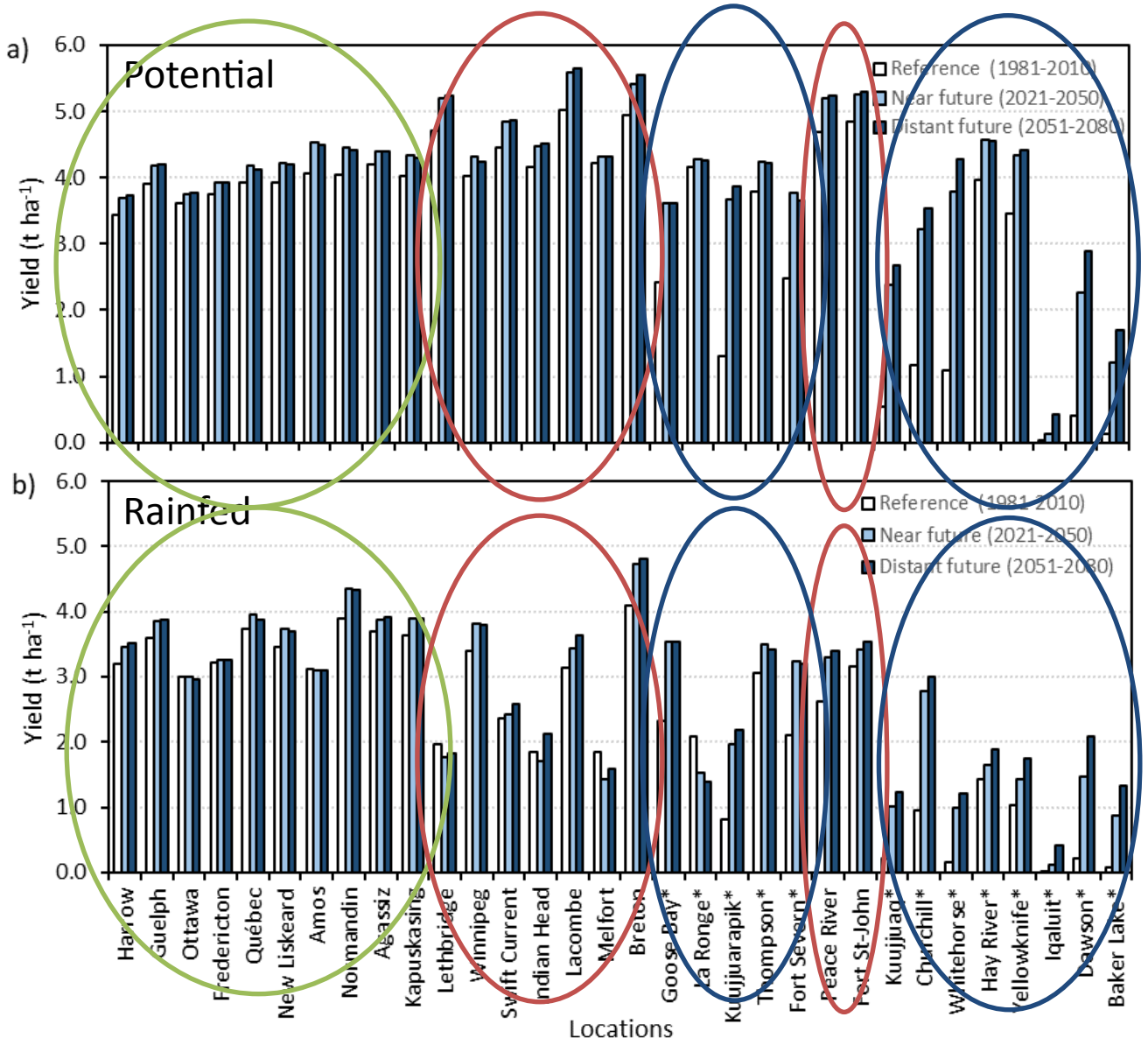
	Sowing (Julian Day)		
	Ref	NF	DF
Western locations	129 ±8	121 ±8	117 ±9
Eastern locations	143 ±9	136 ±9	133 ±10
Northern (Cold) locations	157 ±11	155 ±12	153 ±13

- Seeding dates are expected to be **2** to **8** days earlier in **NF** and **4** to **12** days earlier in **DF** compared to the reference period

	Maturity (Julian Day)		
	Ref	NF	DF
Western locations	218 ±14	205±11	198±2
Eastern locations	224 ±15	213±13	206±13
Northern (Cold) locations	254 ±25	248±27	239±27

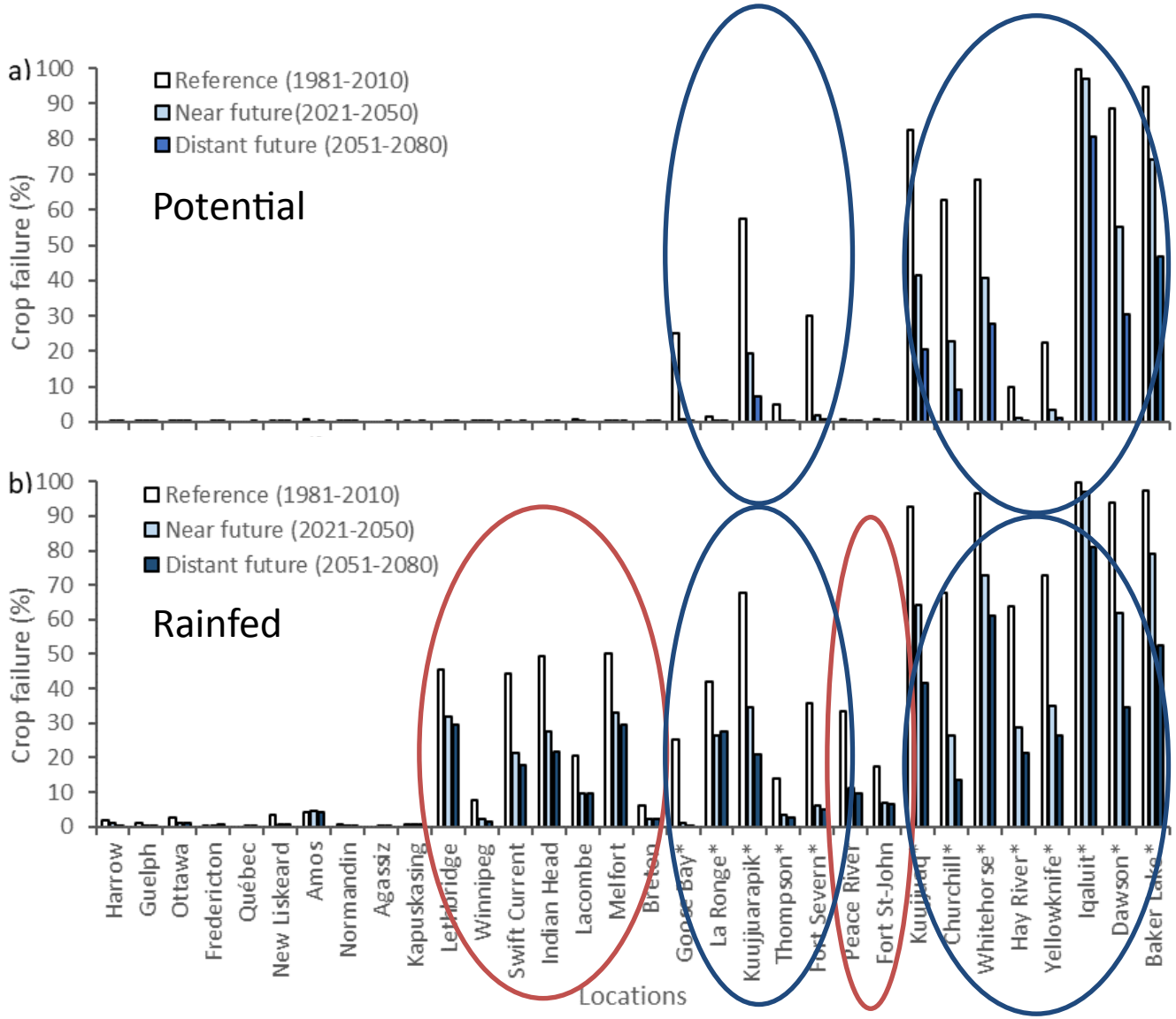
- Maturity dates are expected to be **6** to **13** days earlier in **NF** and **15** to **20** days earlier in **DF** compared to the reference period

Results – Yield prediction in the NF and DF



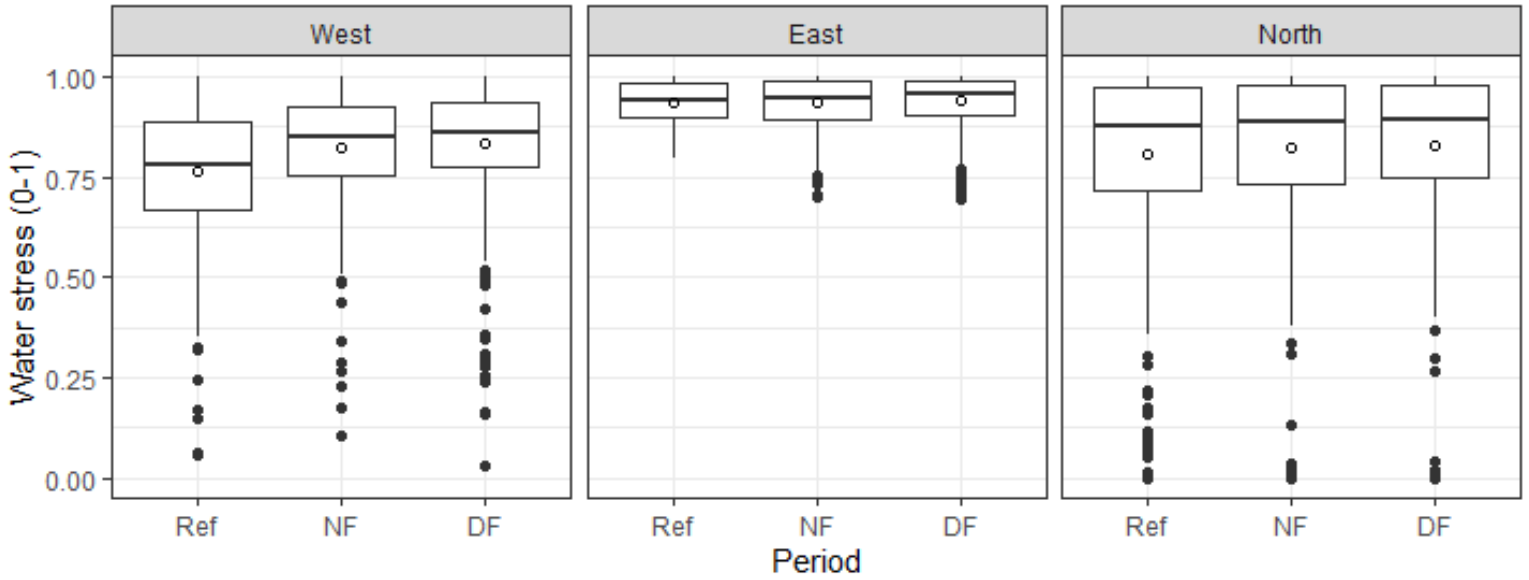
- Small yield variations in eastern locations
- Slight yield increases in most western locations
- Large yield increases in most northern locations

Results – Crop failure in the NF and DF



- Crop failures are low in regions where spring barley is currently grown.
- Except in western locations in the rainfed simulations with a tendency to decrease in the future
- Crop failures are projected to decrease in northern locations in the future due to longer the growing season.

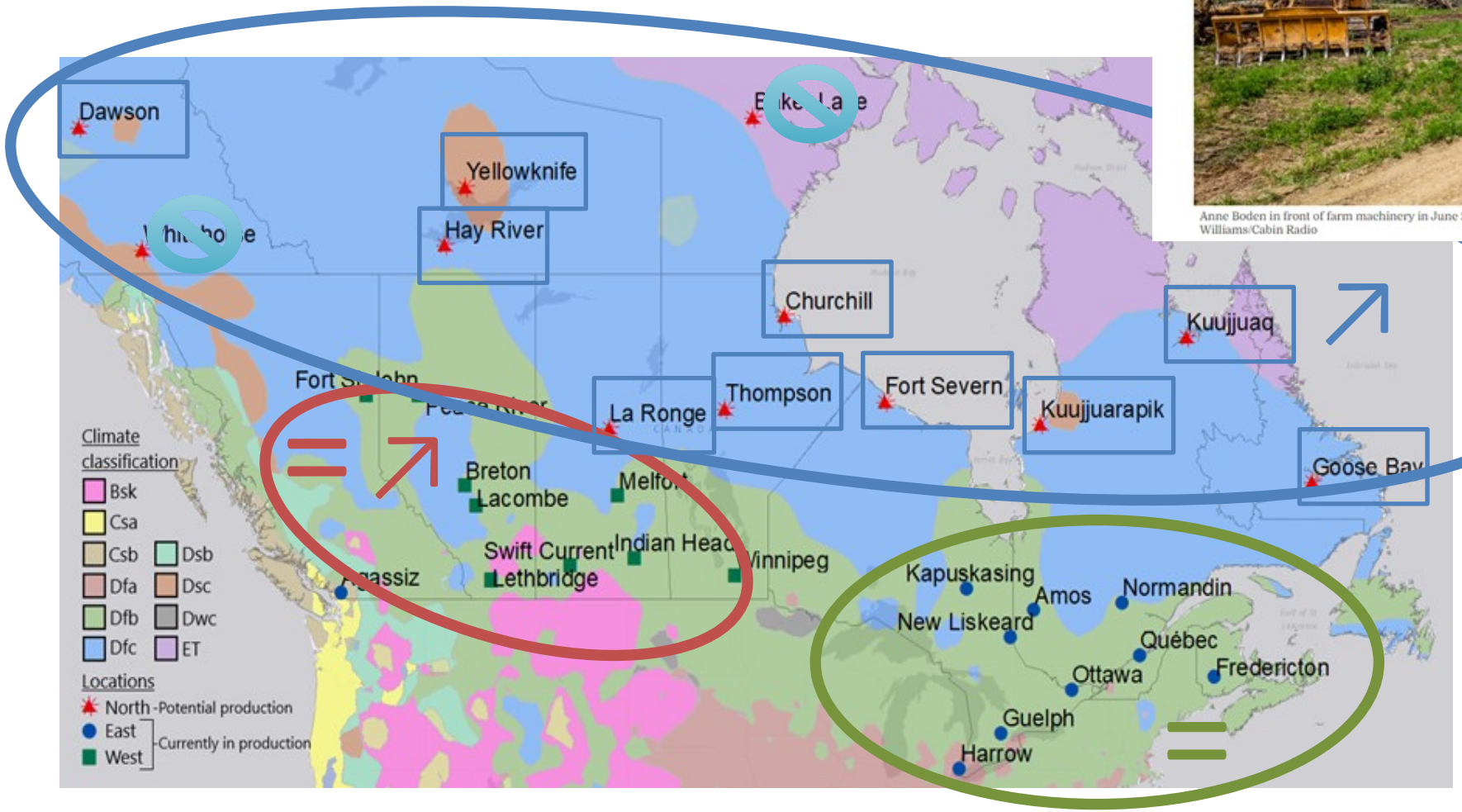
Results – Crop water stress in Ref, NF and DF



Average water stress predicted by the three crop models in Ref, NF and DF

- Almost no water stress in eastern locations
- Decrease of water stress in the future in western locations → increased water use efficiency due to increased [CO_2]
- Small variations in northern locations with great variability between locations

Conclusion



Hay River family plans 'NWT's largest commercial farm'

Ollie Williams - June 19, 2018

Anne Boden in front of farm machinery in June 2018, as she worked to establish a potato farm. Ollie Williams/Cabin Radio

Source : https://cabinradio.ca/7241/news/economy/hay-river-family-plans-nwts-largest-commercial-farm/

Conclusion / perspectives

- **Northward expansion of crops can cause environmental issues when natural areas (like boreal forest) are converted into agricultural land**
- **Studies are being done to limit these negative effects**
- **Limitations of this study**
  - Nutrient (N, P, K) limitation not considered
  - Pests and diseases not considered
  - No genetic improvement
- **Next step**
  - Simulation of crop rotations to better account for the effect of CC on C and N cycles → Considering environmental variables in addition to yield

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Thank you !
Questions?

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ORIGINAL ARTICLE

Crop Economics, Production, and Management

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