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Forecasting species distribution and abundance under current and future climates

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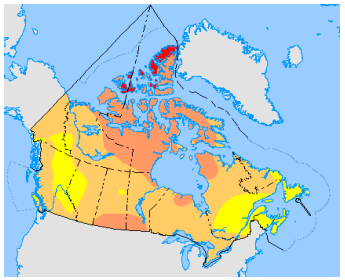


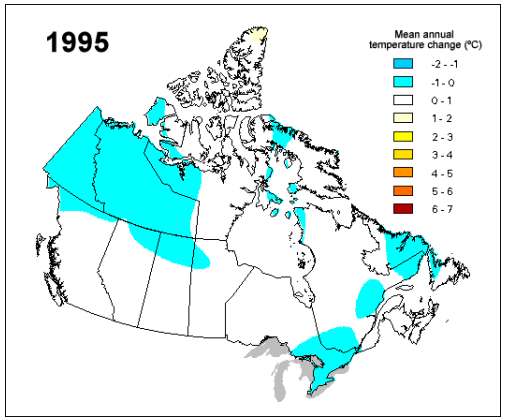
Discussion Topics

- Introductory comments
  - Climate change predictions
  - Potential impact of climate change on agriculture

- Approaches to study species distribution and abundance
  - Current climate
  - Future climates

- Case studies

- Where next?



Climate Change

- Effects of climate change:
  - Increasing temperatures
    - Low emission (B1) suggest increases of 1-3 ^{0}C. High emission (A2) scenarios predict increases of 3.5-7.5 ^{0}C
    - Even low emission scenarios are predicting temperatures that greatly exceed temperatures that have been experienced in the last 100 years
    - Increased temperature variability
  - Changes in precipitation are uncertain. Most agree that precipitation will be highly variable
  - Effects of climate change are expected to be most noticeable in northern latitudes

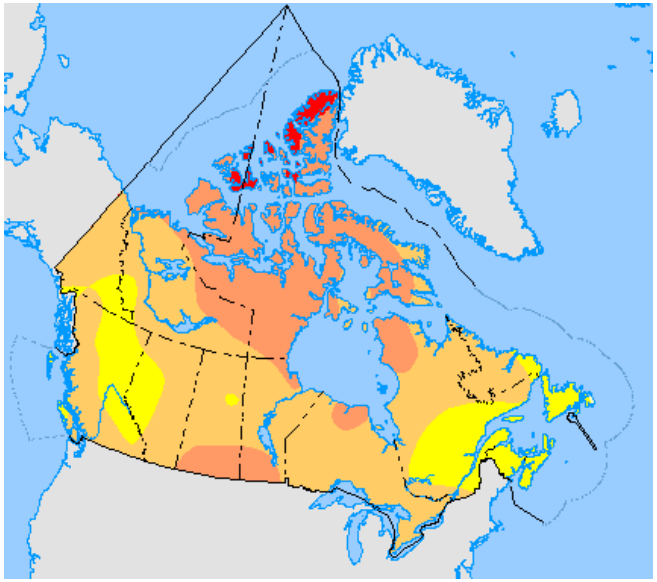
Observed Changes in Climate: Potential Impacts on Agriculture

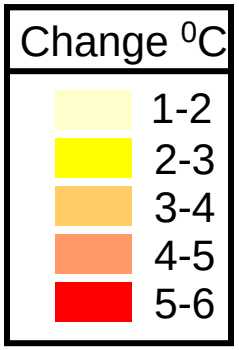
- Surface temperature in the northern hemisphere has increased more in the 20th century than any other century in the last 1000 years and the 1990's were the warmest decade in the millennium
- Mean surface temperature has increased by 0.4 to 0.8C over the last 100 years
- Largest temperature increases have occurred at the mid and high latitudes of the northern hemisphere
- There have been observed changes in extreme weather events
- There has been an increase in continental drying and risk of drought
- During the last 40 years, the growing season has increased by 1-4 days
- The number of frost free days has increased
- Night time temperatures have warmed more than daytime temperatures.

Source: IPCC – 2001, 2002

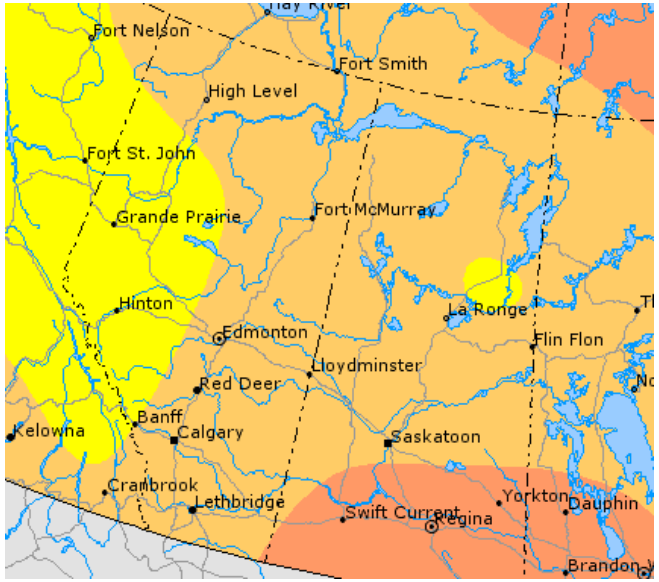
Annual Temperature Change from 1961-90 to 2040-60 (℃) based on CGCM2

Temperatures are predicted to increase by 4-6 ^{0}C in the high arctic





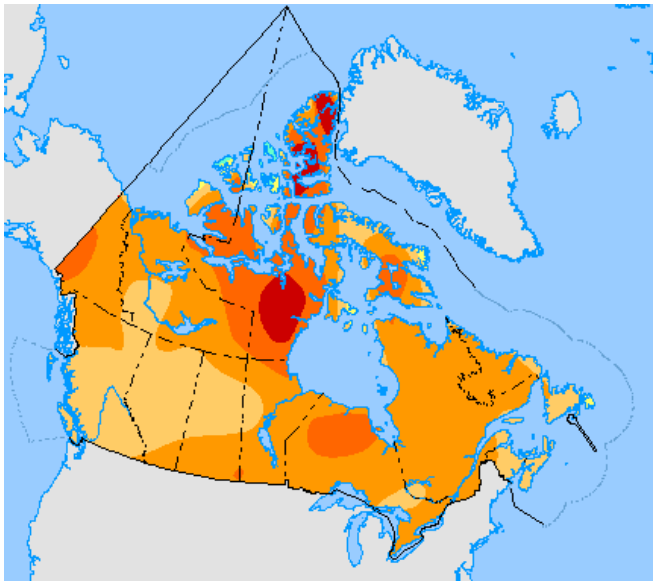
In AB and SK temperatures are predicted to increase by 2-5 ^{0}C

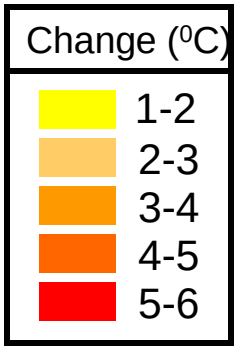


http://atlas.gc.ca/site/english/maps/climatechange/scenarios

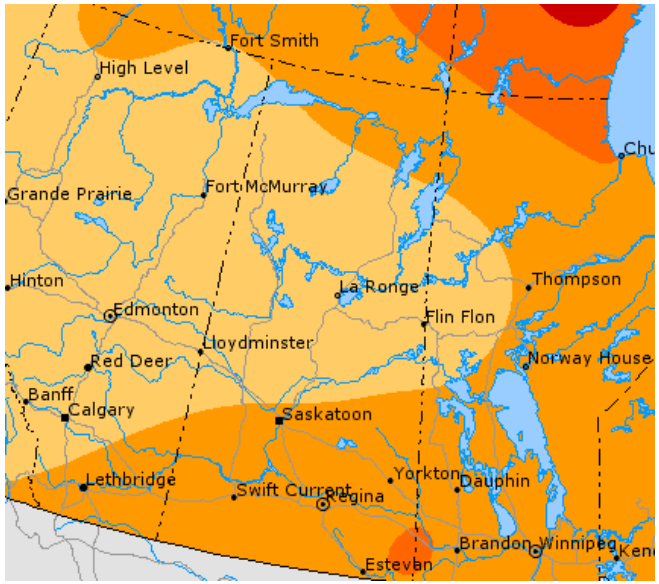
Summer Temperature Change from 1961-90 to 2040-60 (℃) based on CGCM2

Temperatures are predicted to increase by 3-6 ^{0}C in the high arctic





In AB, MB and SK temperatures are predicted to increase by 2-4 ^{0}C



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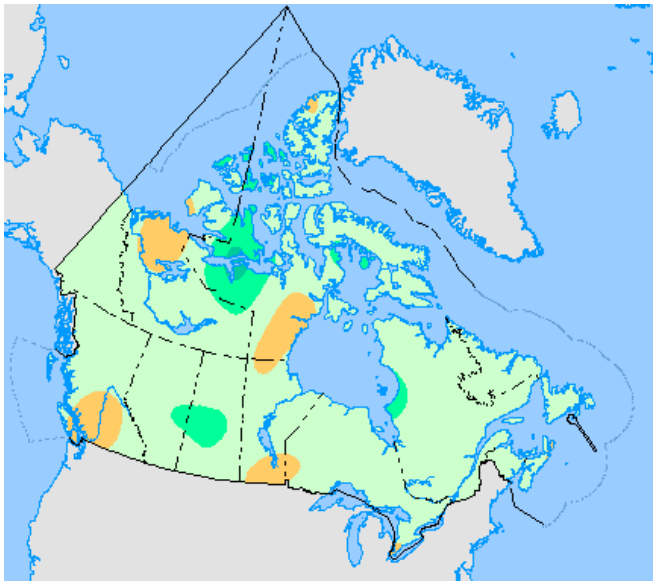
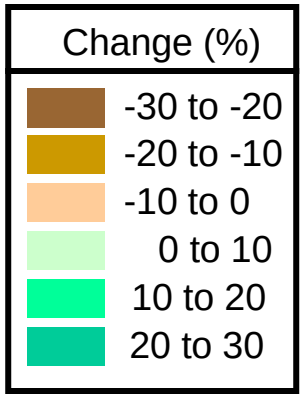
Annual and Summer Precipitation Change from 1961-90 to 2040-60 (℃) based on CGCM2

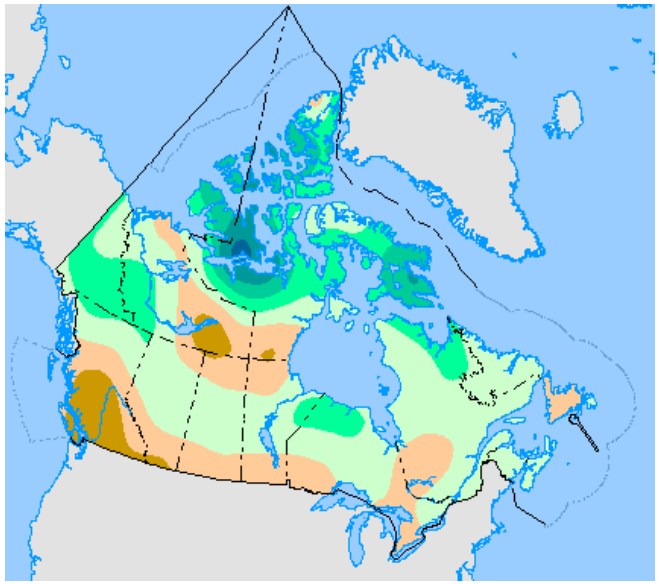
Precipitation changes will be less than for temperature. Conditions are predicted to be dry in the summer.

Annual





Summer



http://atlas.gc.ca/site/english/maps/climatechange/scenarios

Potential Impacts of Climate Change on Agriculture

- Longer growing season
- Alter timing of emergence of insects, weeds and pathogens
- Increased growth, developmental rates and shorter generation times
- Increased insect feeding rates
- Reduced overwintering mortality rates

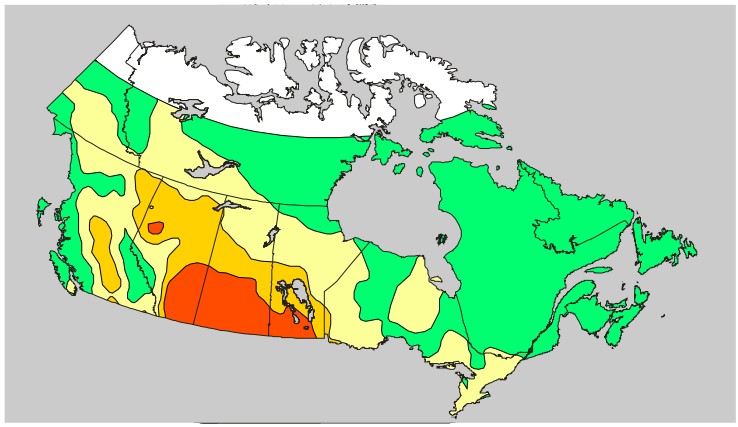
Impact of Climate Change on Agriculture (cont.)

- Warming conditions and changing precipitation patterns could affect potential distribution and relative abundance of insect, weed and pathogen populations
- Changing climate may influence the ability of species to colonize new habitats
- Reduced biodiversity

Modelling Biological Systems

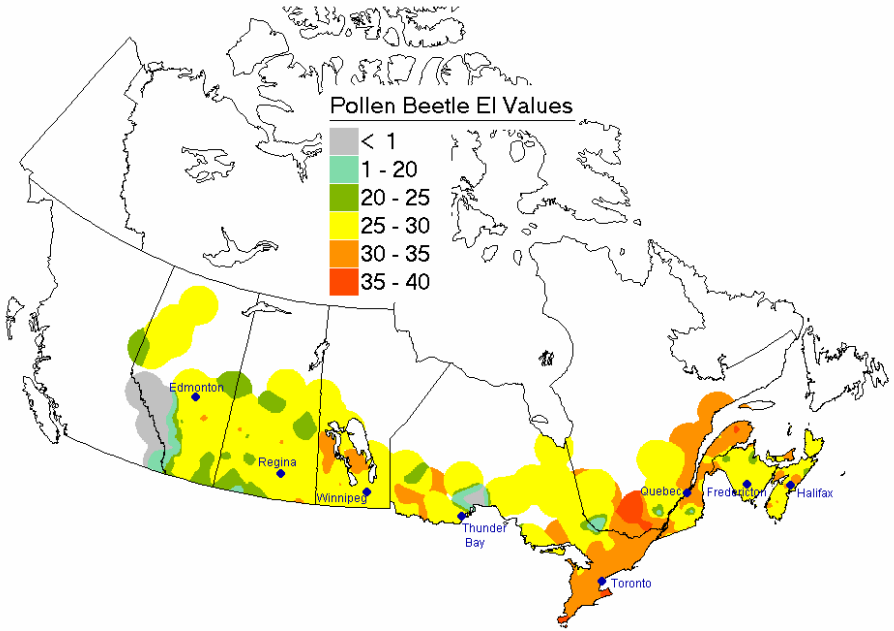
- Models are species specific
- Bioclimatic models are used to predict potential range and relative abundance

Migratory Grasshopper

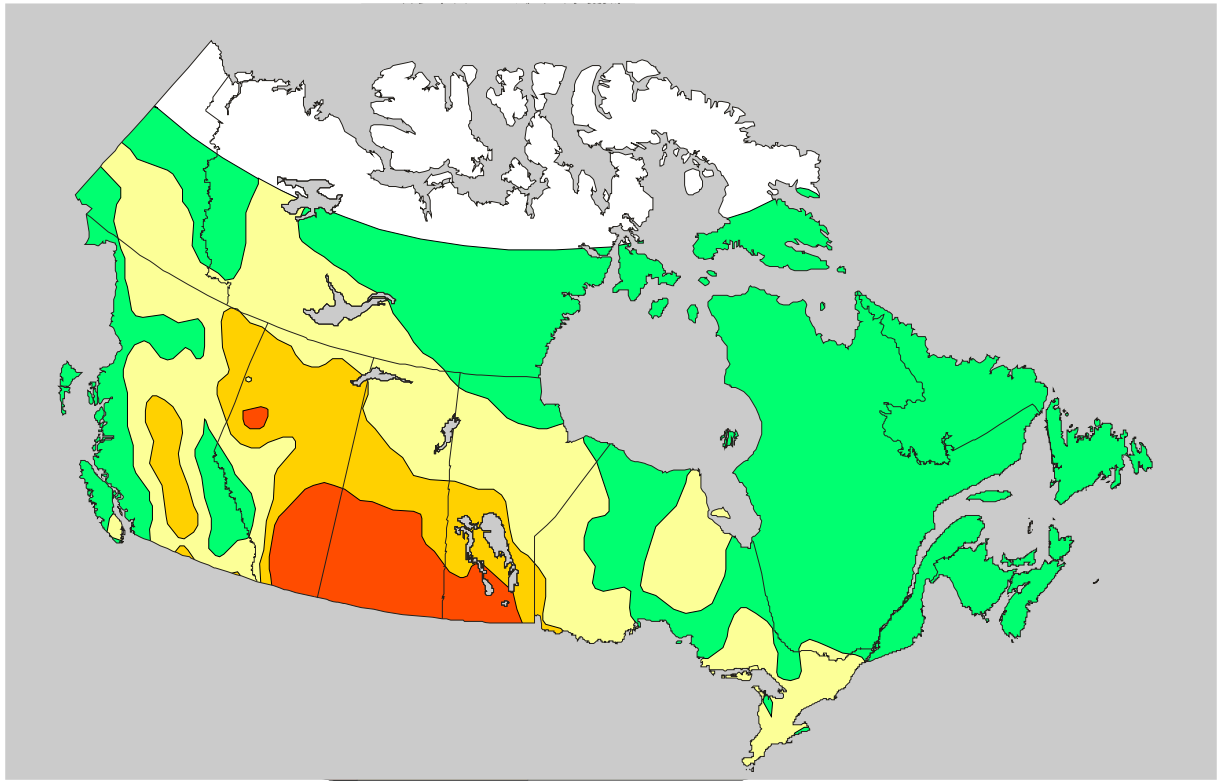


Approach to study the impact of climate change on insects – Bio-climatic Models

- CLIMEX defines potential abundance and distribution of a species based on climate
- CLIMEX models produce indices values related to growth (TI, MI, DI) and stress (CS, HS, DS, WS)
- Indices are combined to produce an ecoclimatic index (EI) that defines species specific climatic suitability of specific locations



Bioclimatic models – Output
Melanoplus sanguinipes

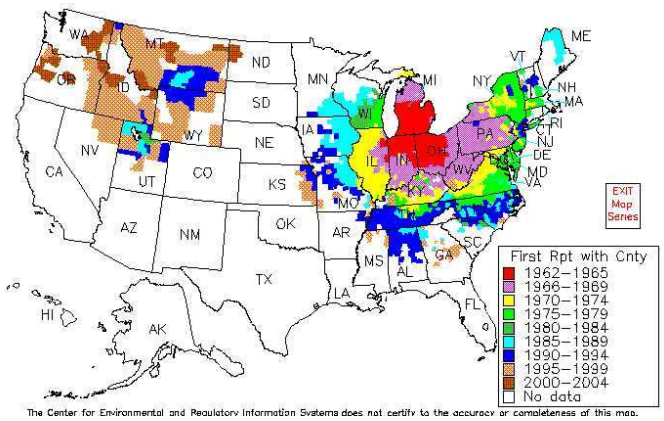


Cereal Leaf Beetle (CLB)

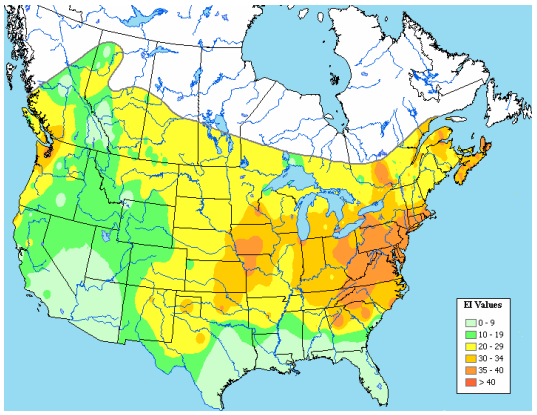
Oulema melanopus

- Introduced from Europe and first reported in the Michigan region in 1962
- First reported in Canadian prairies (Lethbridge) in 2005

Current



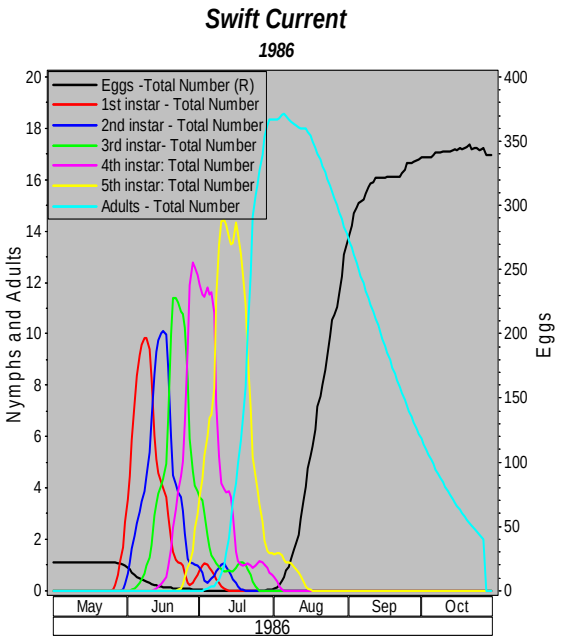
Predicted



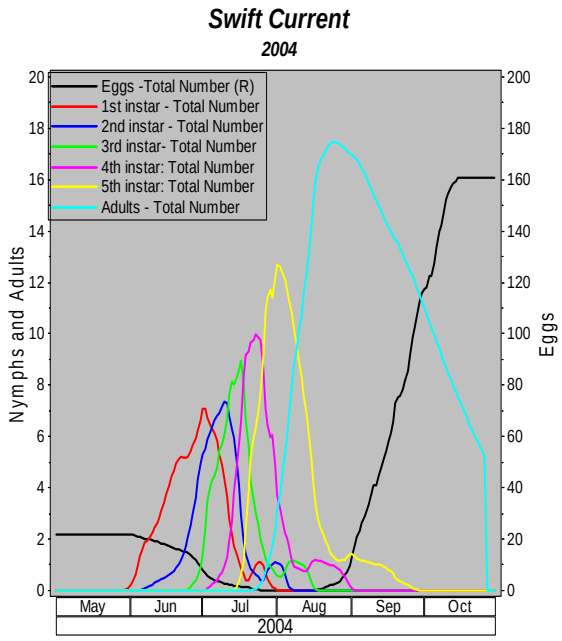
The Effect of Warmer Temperatures – Current Climate

- The 1986 growing season was 0.6 ^{0}C warmer than 2004.
- Warmer temperatures resulted in earlier insect activity in the spring.

Outbreak – hot/dry

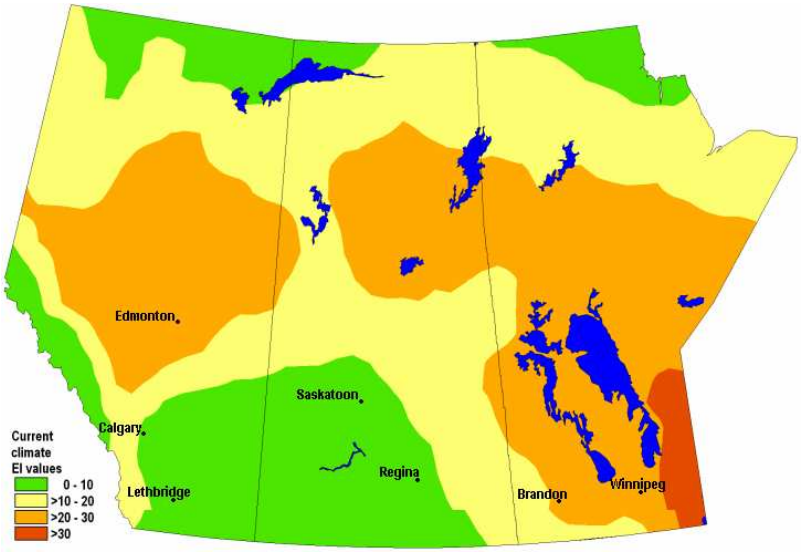


Low densities – cool/wet

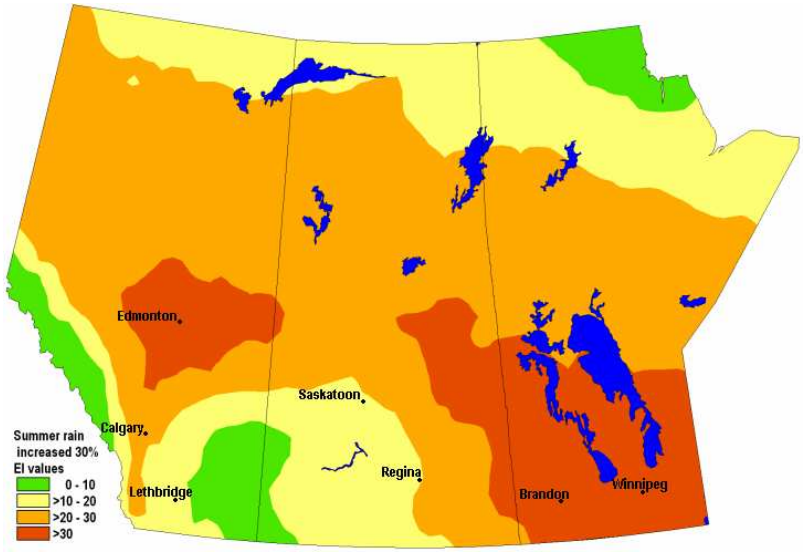


Seasonal Forecasts–
Effect of rainfall on FHB

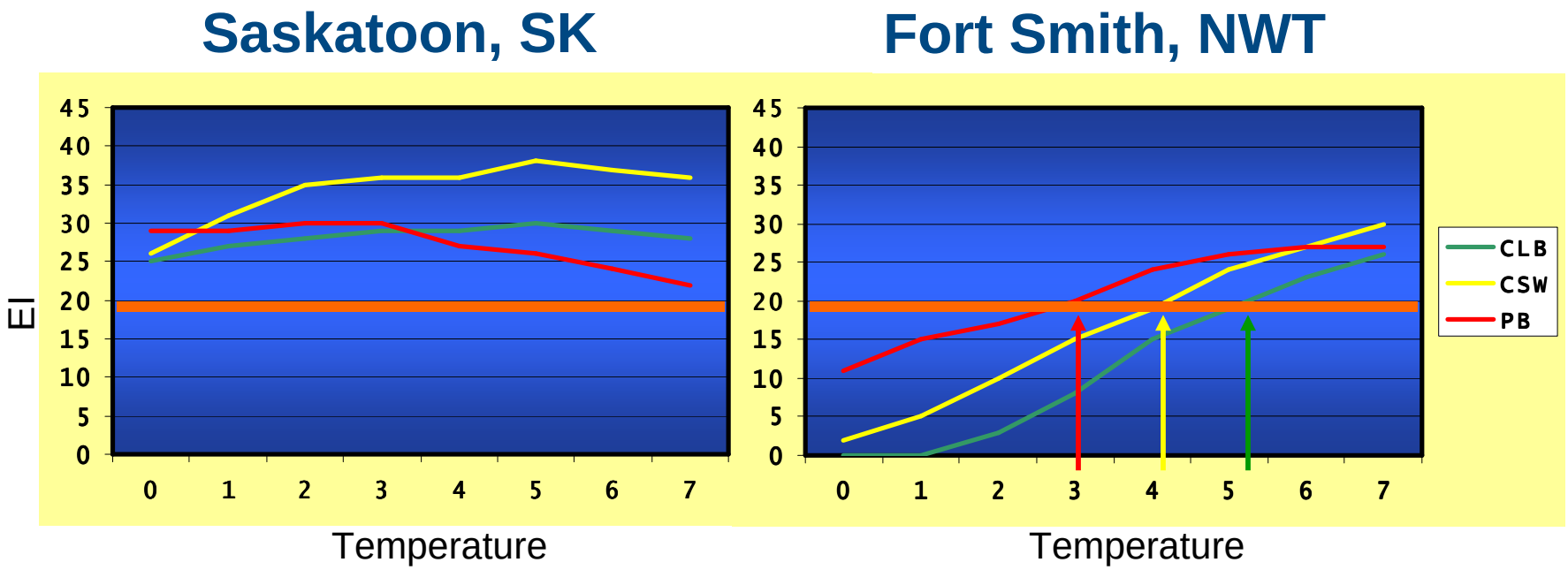
Observed climate



Wetter than normal

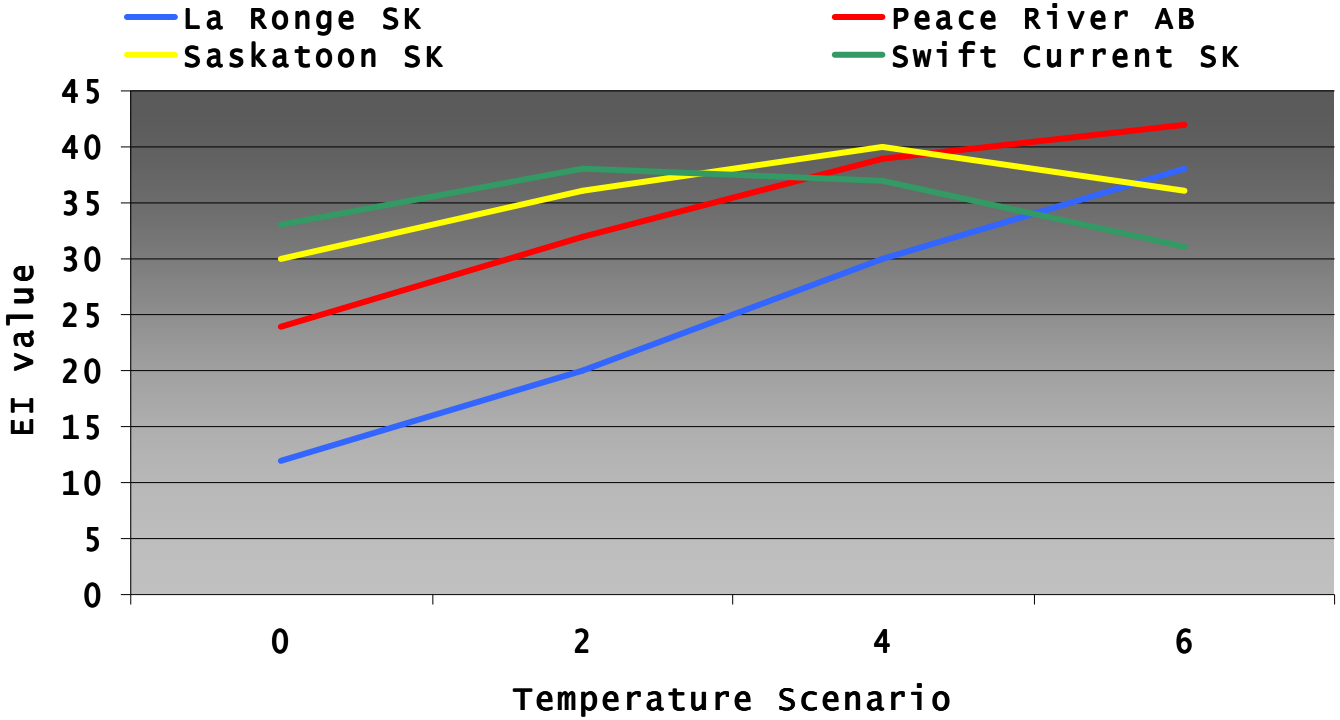


Response to temperature changes was site specific



- At Saskatoon, EI values had a marginal increase as temperatures increased to LTN+3 ^{0}C and then had a marginal decrease at higher temperatures
- Response to increased temperature greater in northern areas than southern areas.

Response to temperature change was site specific – *Melanoplus sanguinipes*

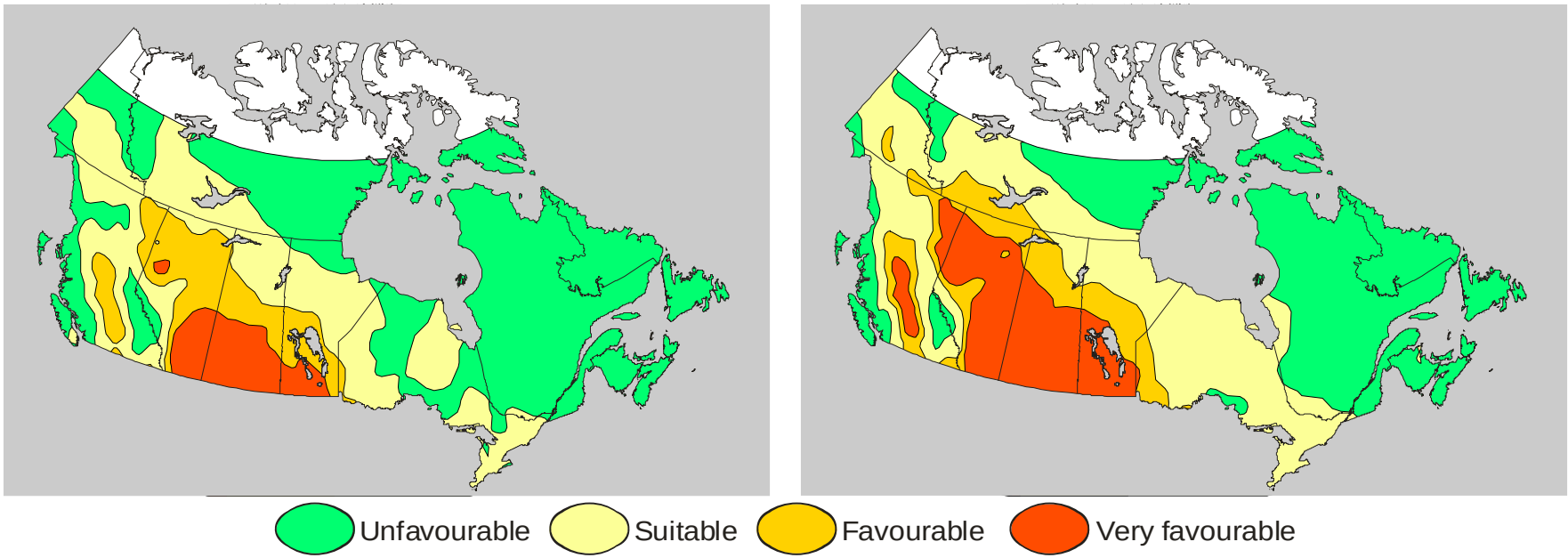


- Response to increased temperature greater in northern areas than southern areas.
- In southern locations EI values decreased for warmer scenarios.

Source: Sutherst (2000)

Potential Distribution at +2^{0}C

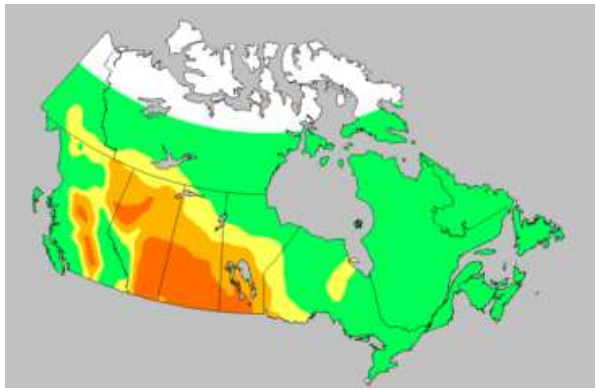
Current **+2^{0}C Scenario**

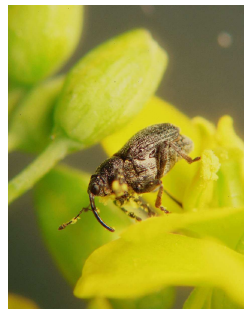


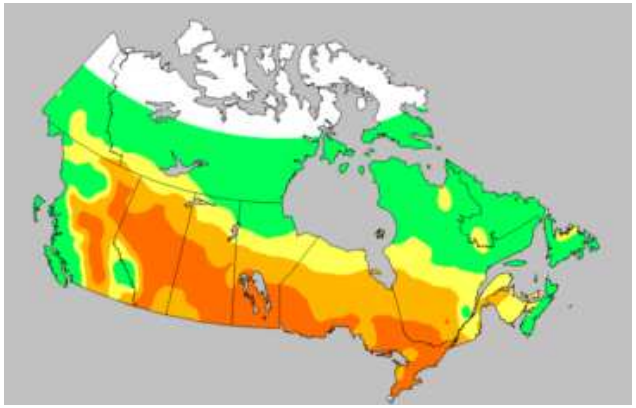
- Currently 7.2% of Canada has climate that is suitable for potential pest populations.
- A 2^{0}C increase in temperature resulted in 17.3% of Canada being exposed to potential outbreaks.

Potential Distribution Cabbage Seedpod Weevil +3 ^{0}C with changes in precipitation

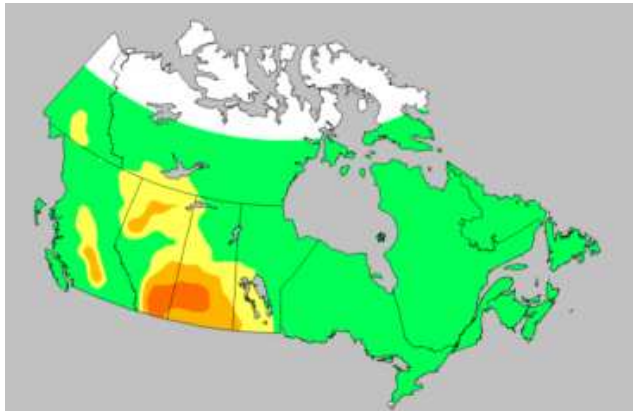
No precipitation change





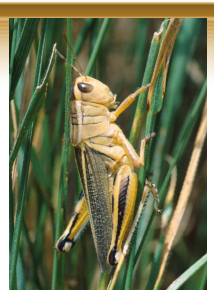


-40 % precipitation

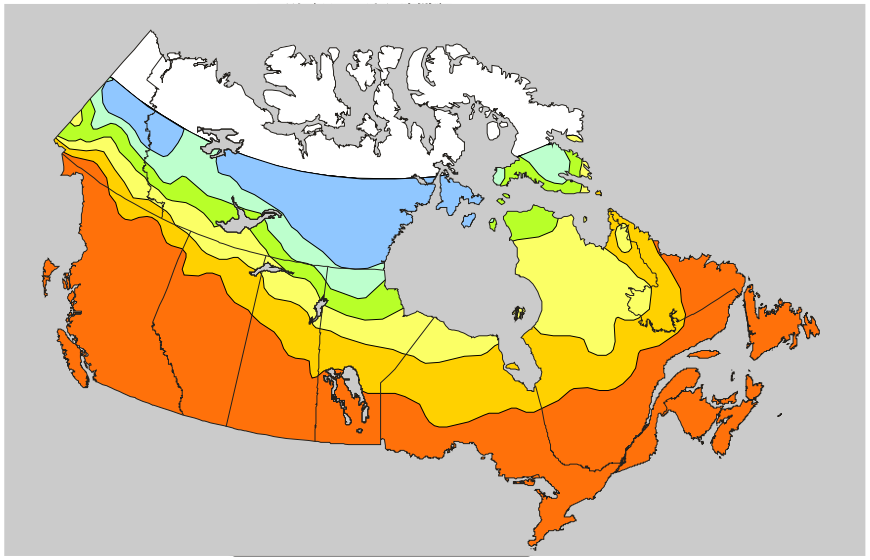


+40% precipitation

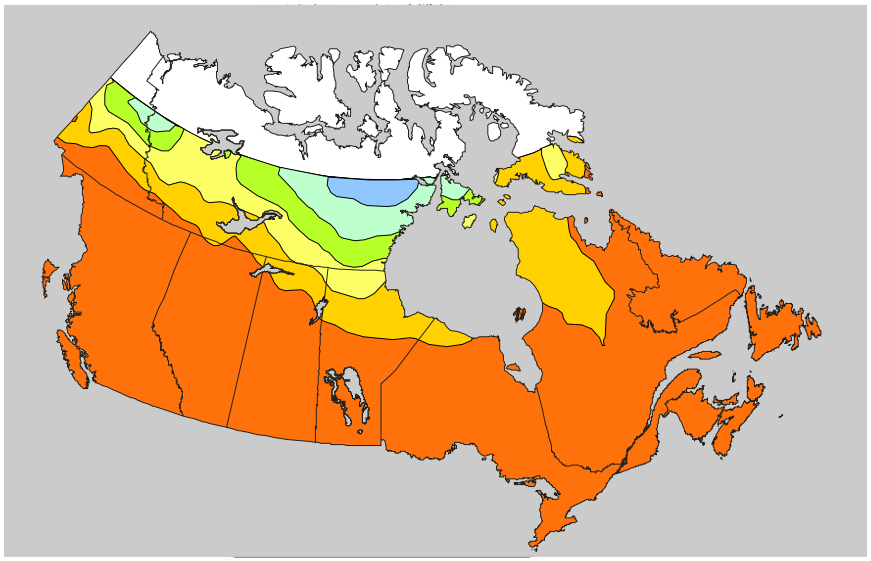
Cold Stress - Grasshoppers

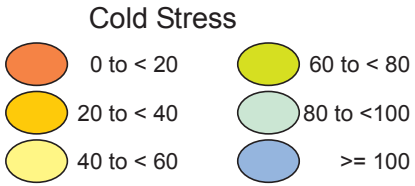


Current



+4^{0}C Scenario





- Cold stress is a reflection of temperature and duration of winter period
- Cold stress accumulation limits northern distribution for current climate
- Warmer climates will reduce the rate of cold stress accumulation

Fort Smith, NWT (60^0N)???

- Mills (1994) conducted a study of arable soils in northwestern NA (north of 55^0N and west of 110^0W)
- The climate change scenario, with a temperature increase of 3.8^0C, resulted in an increase in arable land to an area that is almost equal to the current amount of arable land on the Canadian prairies

Where from here???

- Results suggest that many regions are vulnerable to climate change. Changing climates were predicted to result in range shifts and relative abundance of insect species.

- Risks associated with these species will become more severe, both in terms of their ability to become established in areas where they do not presently occur and overall abundance.

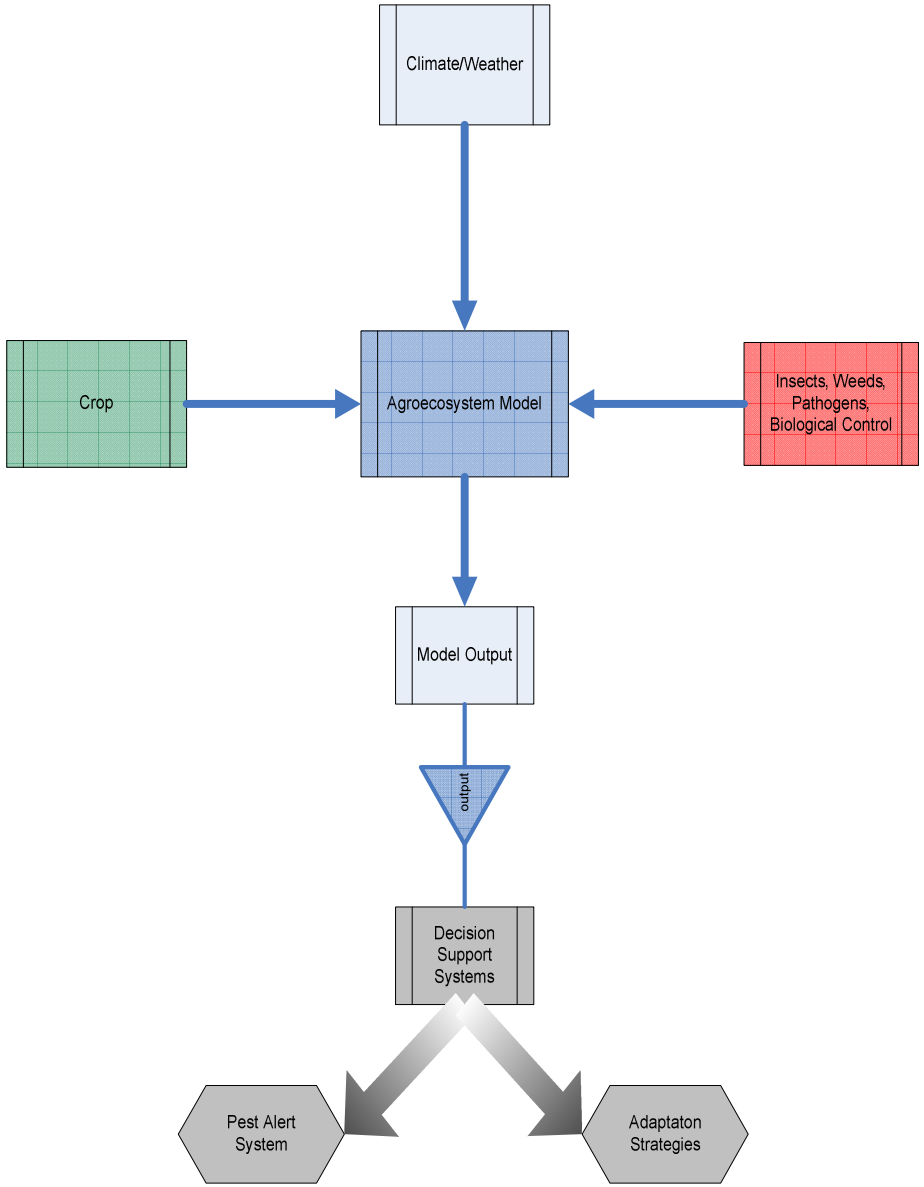
- Results demonstrate the importance of investigating adaptation strategies that will assist the agricultural sector to deal with implications of climate change.

Where from here???

- In an effort to address the consequences of climate change, we must first determine the vulnerability of the system

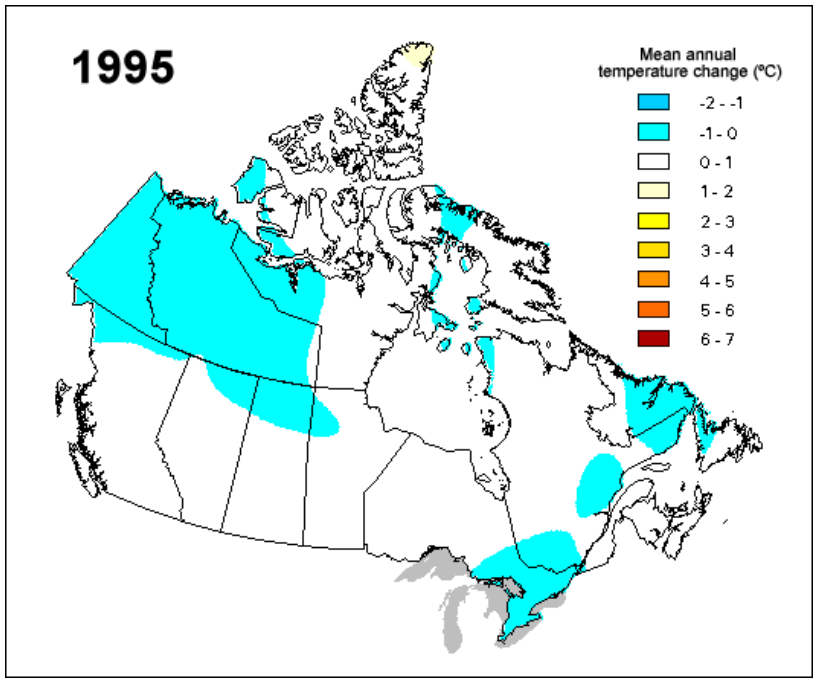
- Identify adaptation strategies that can be employed to mitigate the effects of climate change and reduce vulnerability

Agroecosystem Model (AEM)



Thank You

Annual Temperature



Annual Precipitation