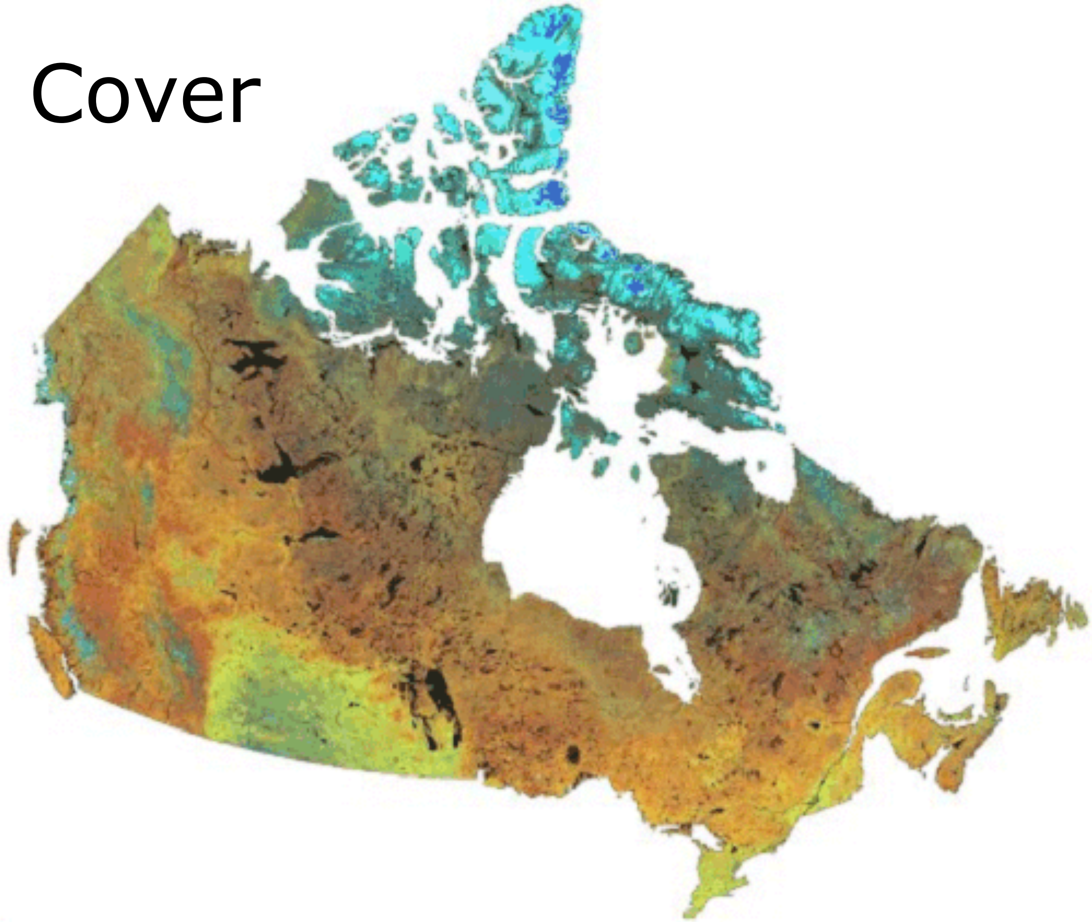
# Aridity, drought and landscape change

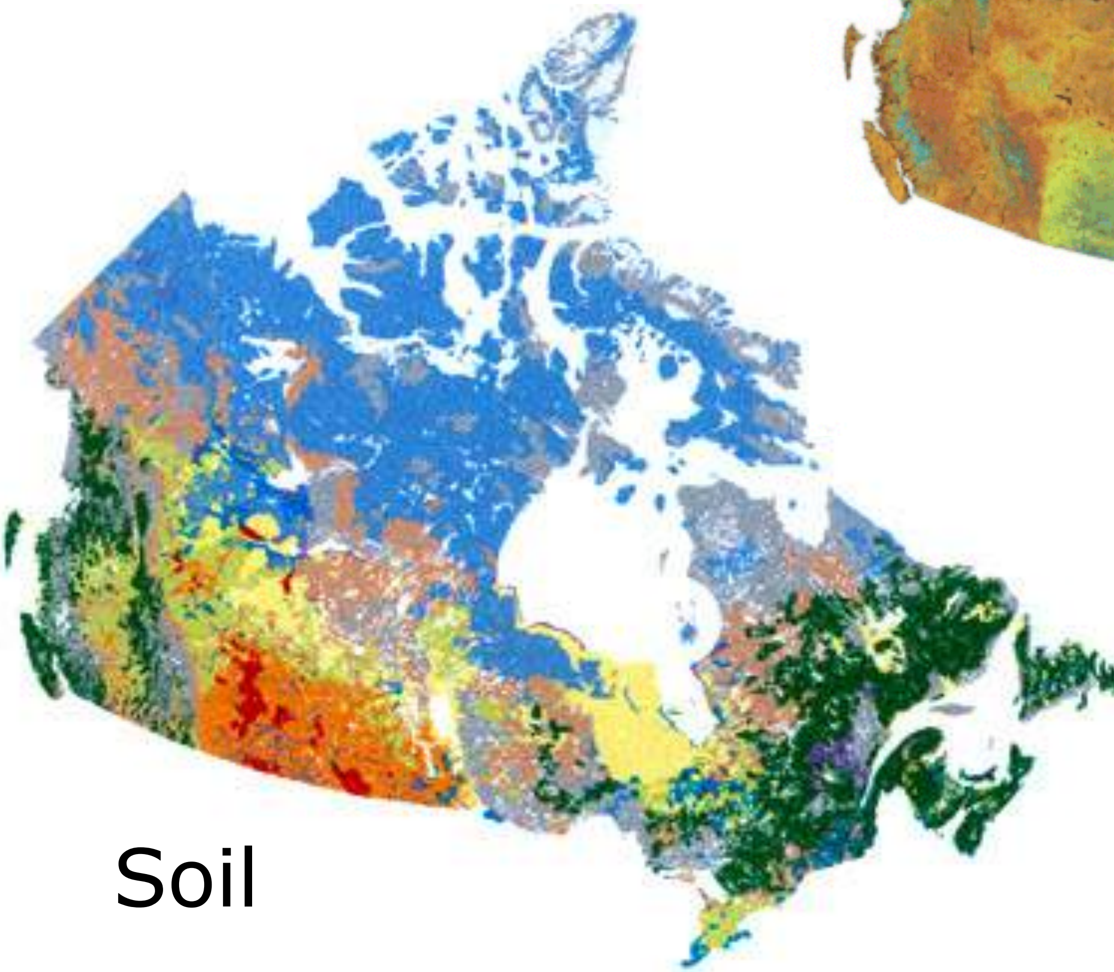
Dave Sauchyn
Prairie Adaptation Research Collaborative, U of R

Elaine Barrow
Canadian Climate Impacts Scenarios Project, Environment Canada

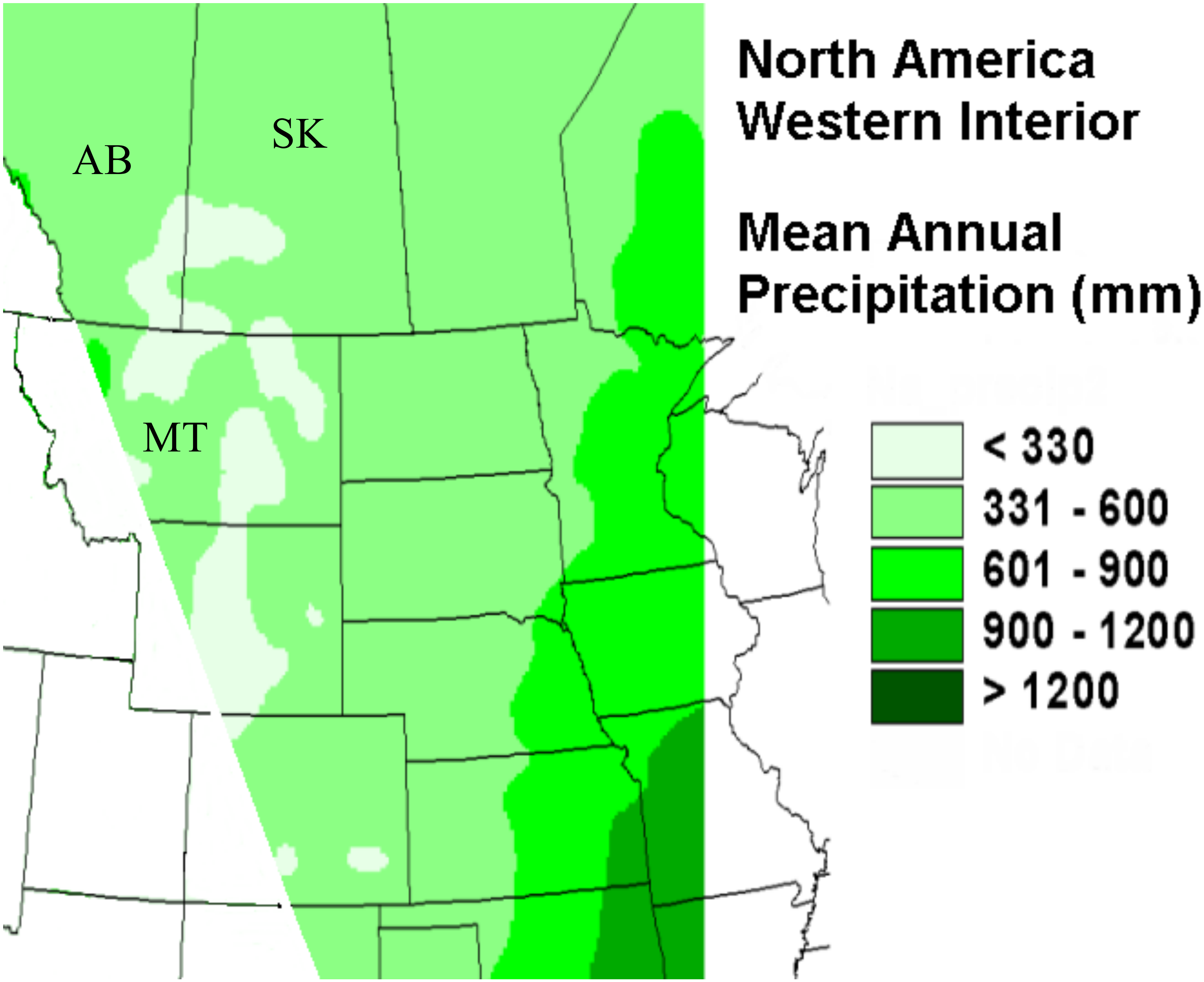
"Plain as The Eye Can See" Conference
Regina, May 15-17, 2003

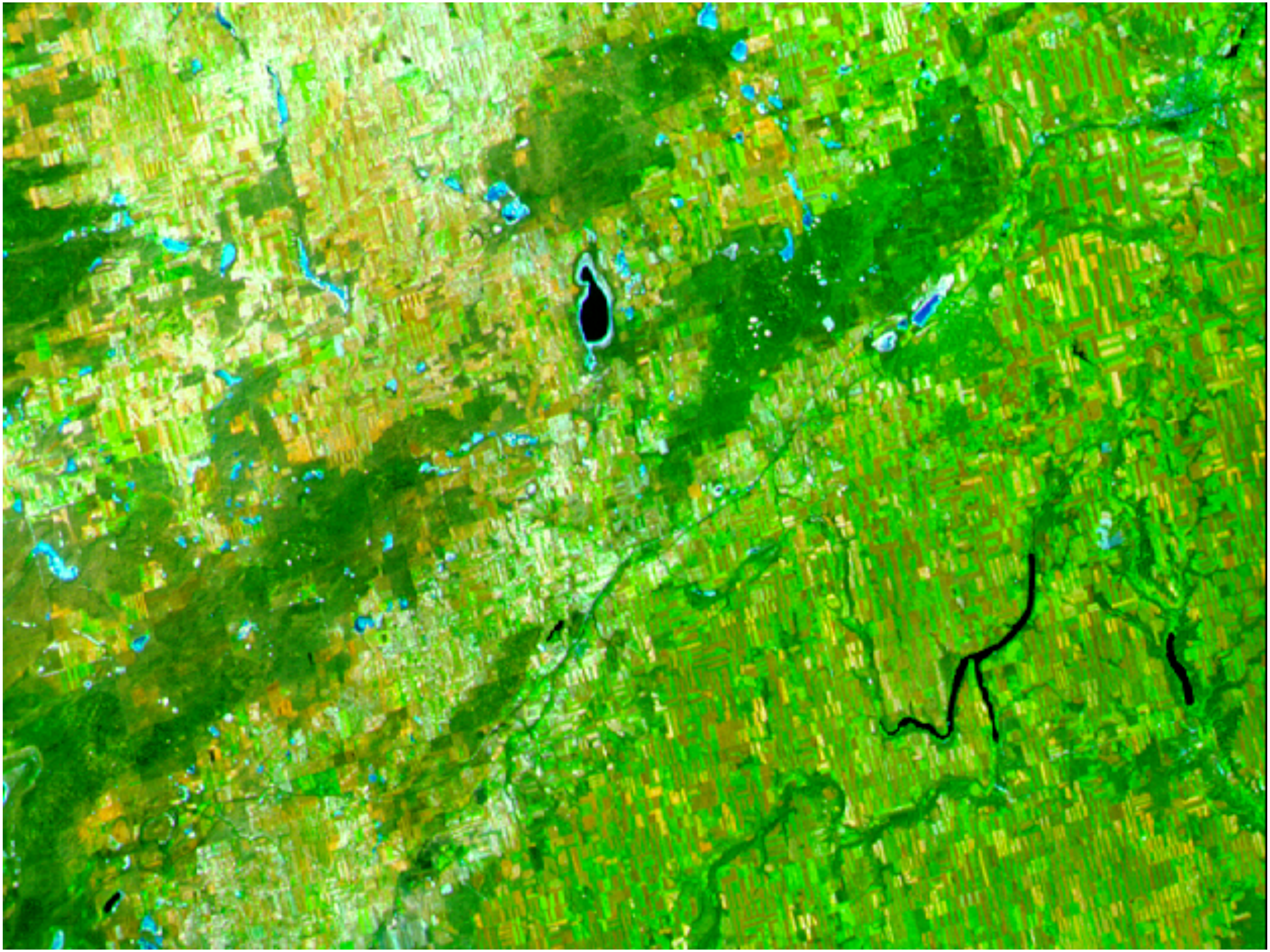
Land Cover



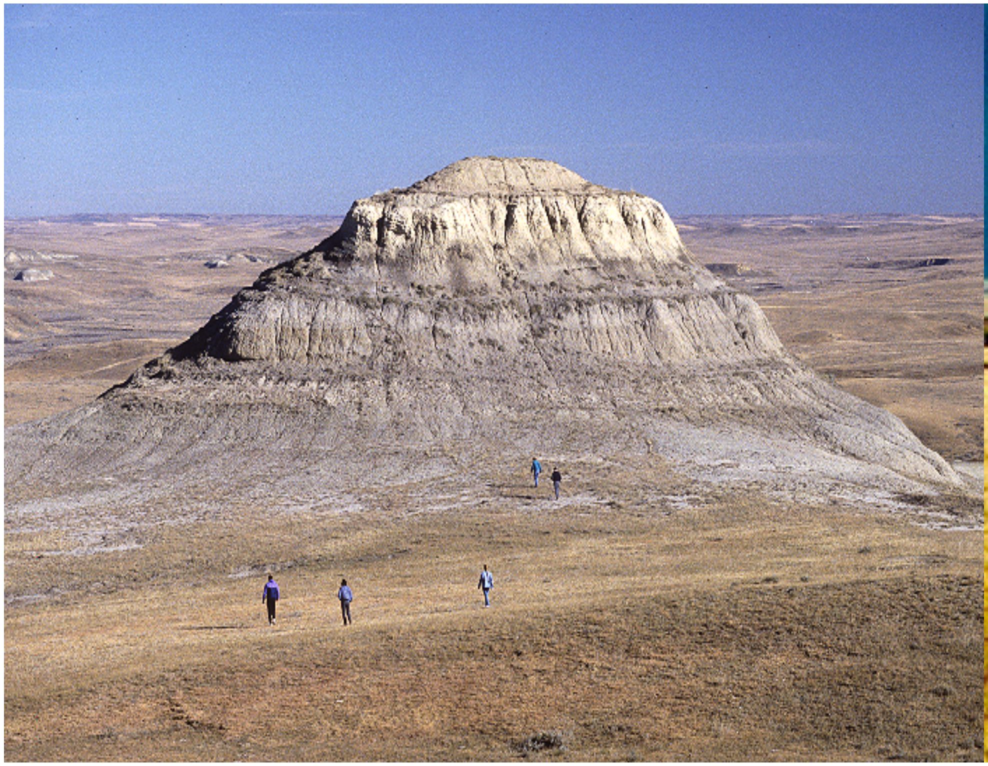


Soil

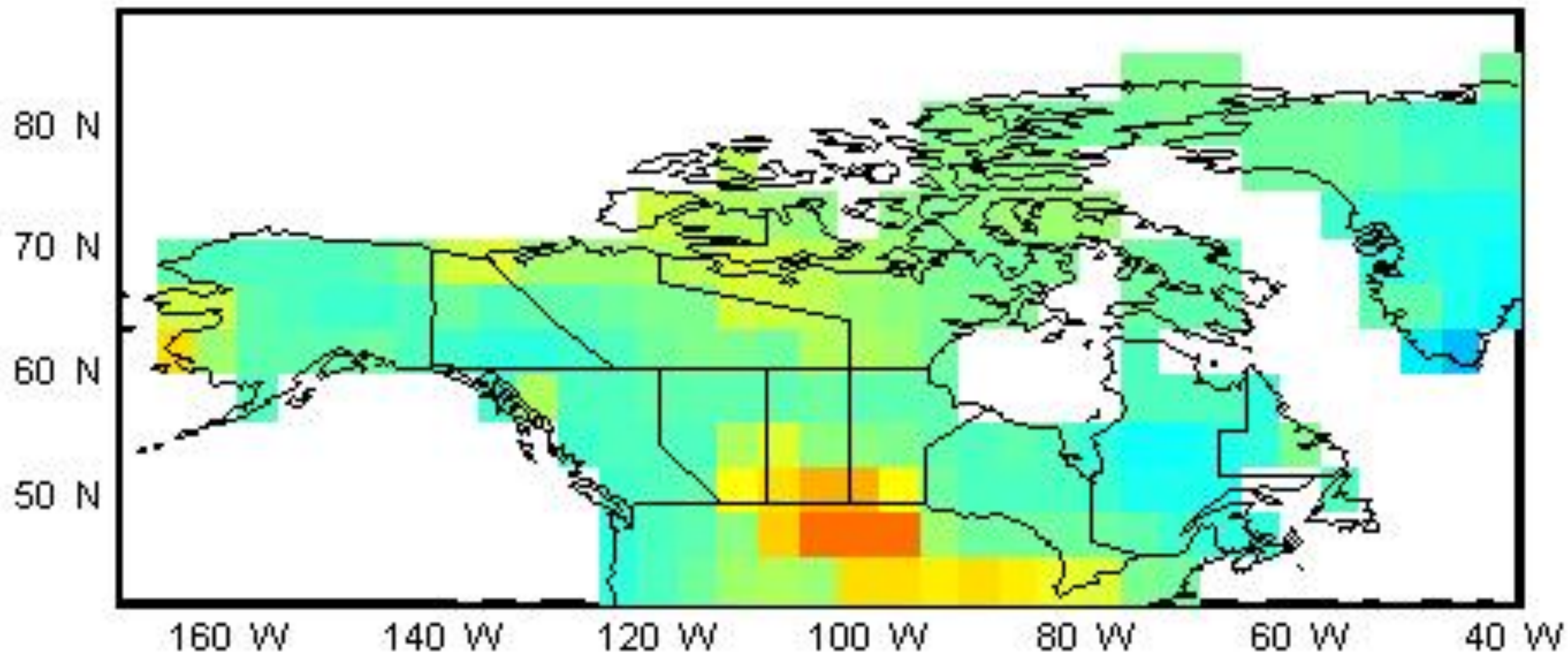

North America
Western Interior
Mean Annual
Precipitation (mm)
AB
SK
MT
< 330
331 - 600
601 - 900
900 - 1200
> 1200



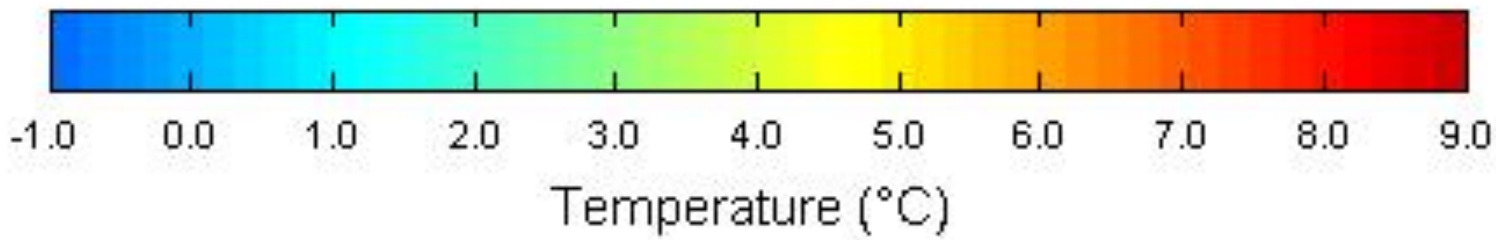
# The Canadian Plains



Natural and socio-economic systems are sensitive to climatic variability, climatic change and extreme hydroclimatic events

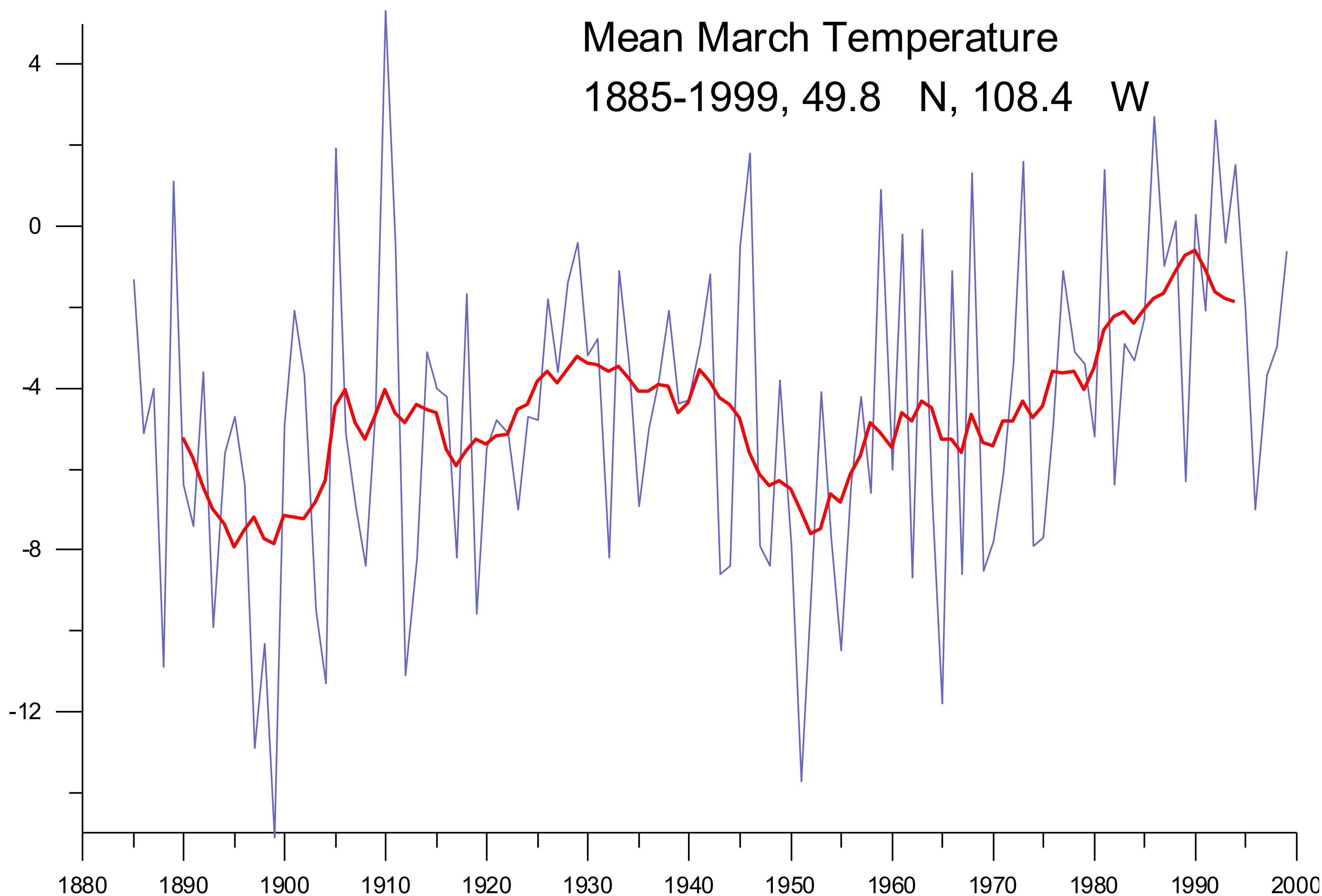



CGCM2 - - B21 (SRES)




Mean Temperature Change Spring - MAM 2050s

http://www.cics.uvic.ca/scenarios/index.cgi

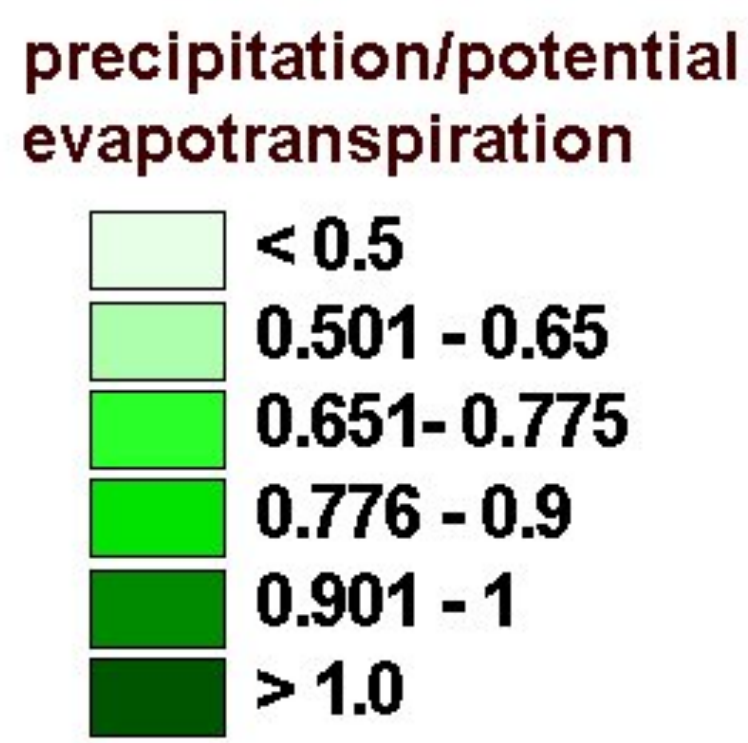


Mean March Temperature
1885-1999, 49.8 N, 108.4 W
4
0
-4
-8
-12
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000

# Projections for the future climate of the Prairie Provinces

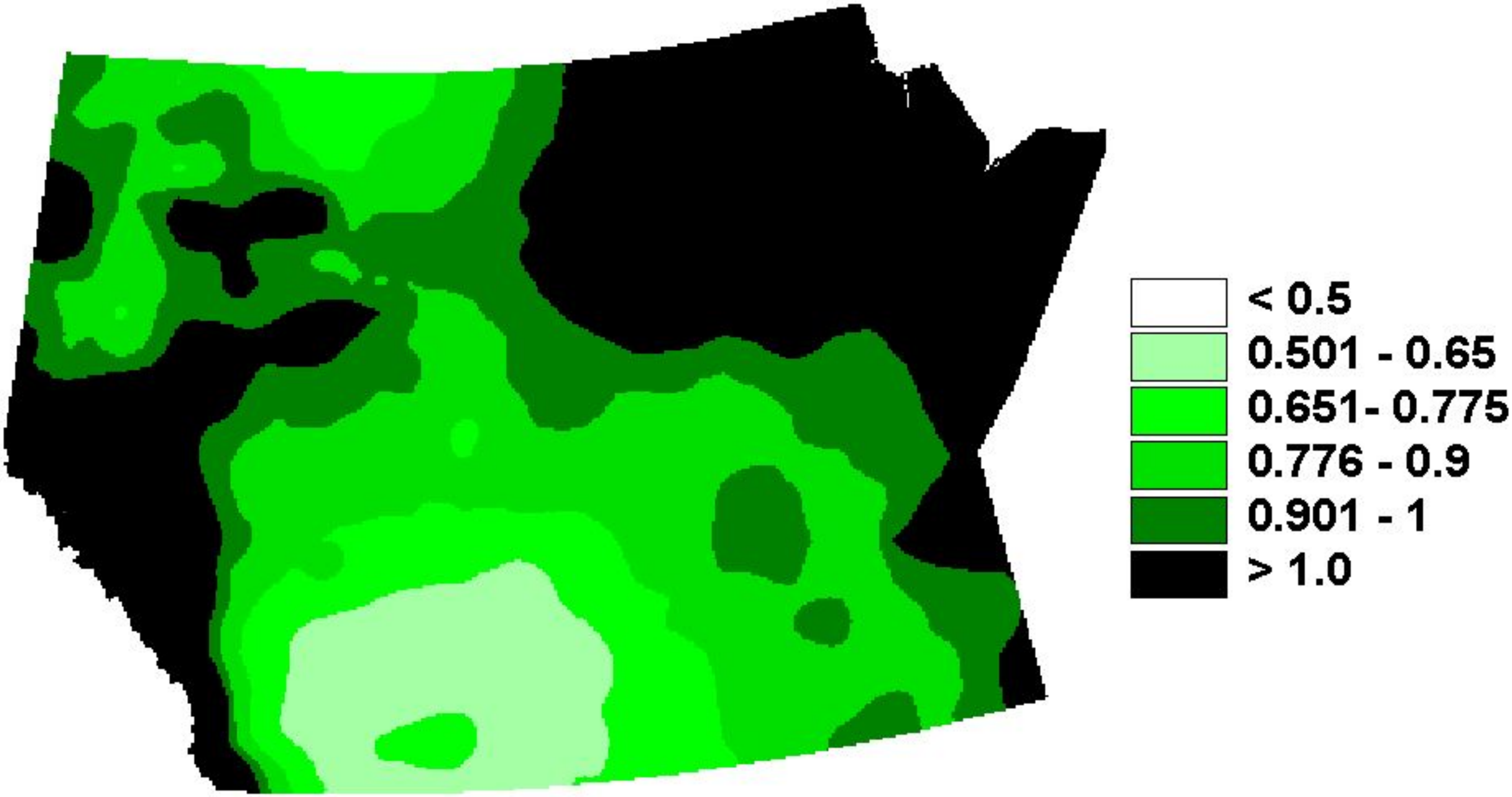
| | |
|---|---|
| **Temperature** | increasing, greater in winter than summer, greater at night than during day |
| **Precipitation** | great uncertainty, annually small decrease to significant increase |
| **Evaporation** | significant increase |
| **Soil moisture** | decrease |
| **Growing season** | increased length |
| **Water Resources** | increased variability, earlier peak flows |
| **Extreme events** | increased frequency and magnitude |

# Aridity Index: P/PET

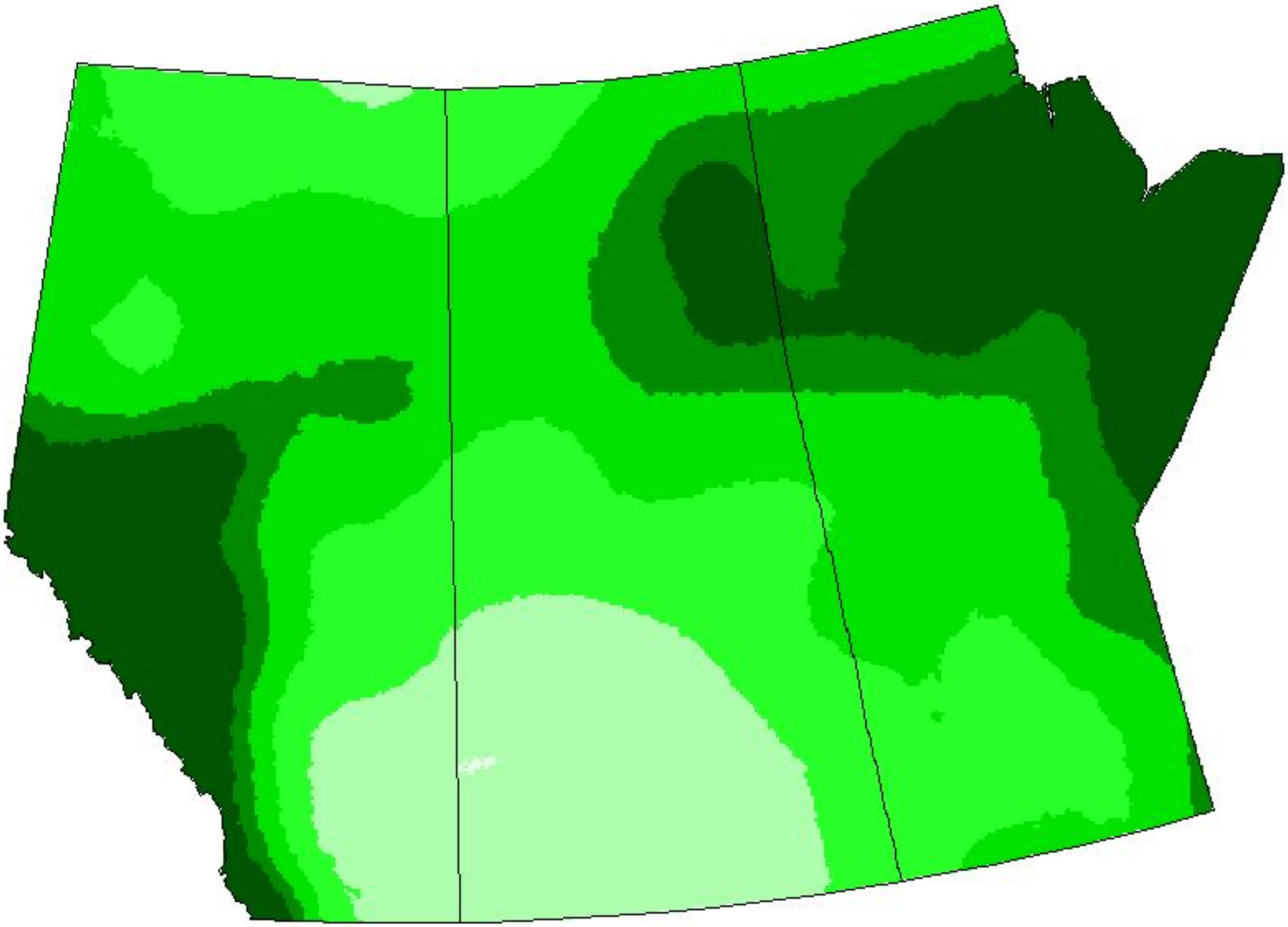



Desertification: "land degradation in arid, semiarid (P/PET < 0.5) and dry subhumid (0.5 ≤ P/PET < 0.65) areas resulting mainly from adverse human impact" (Middleton and Thomas, 1992)

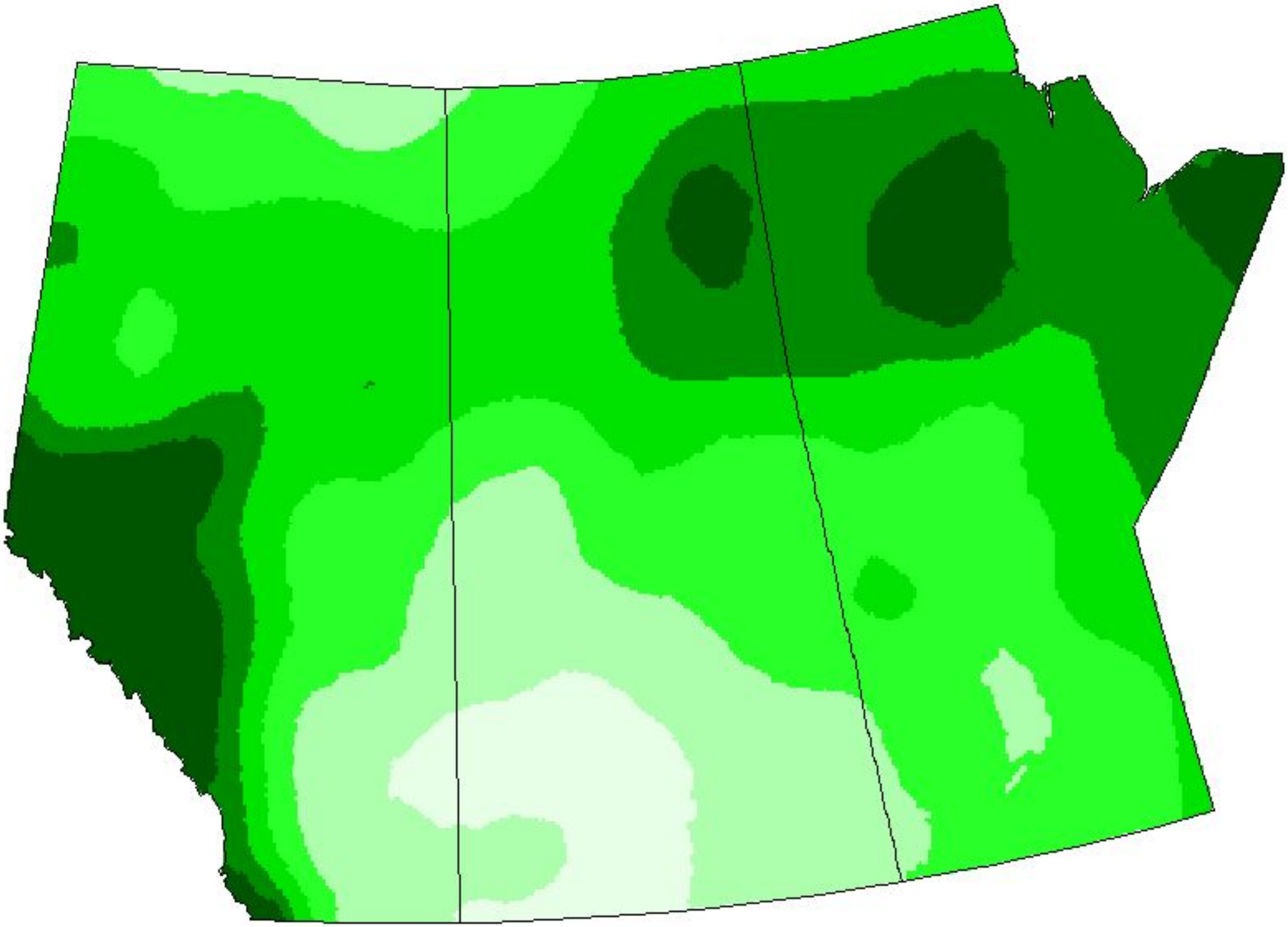
# Aridity Index (P/PET), 1961-90



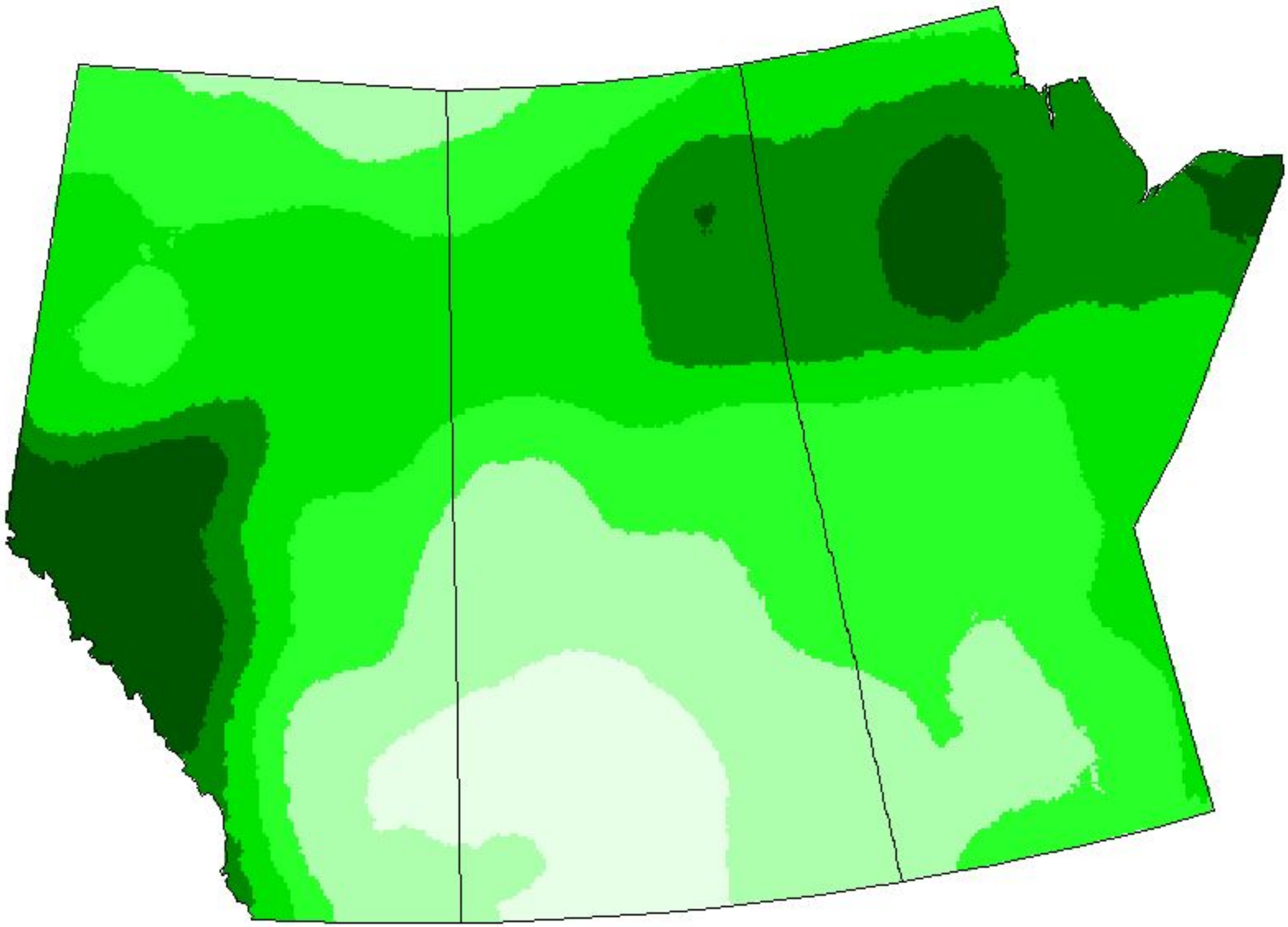
Aridity (P/PET), 2020, CGCM2



# Aridity (P/PET), 2050, CGCM2



Aridity (P/PET), 2080, CGCM2



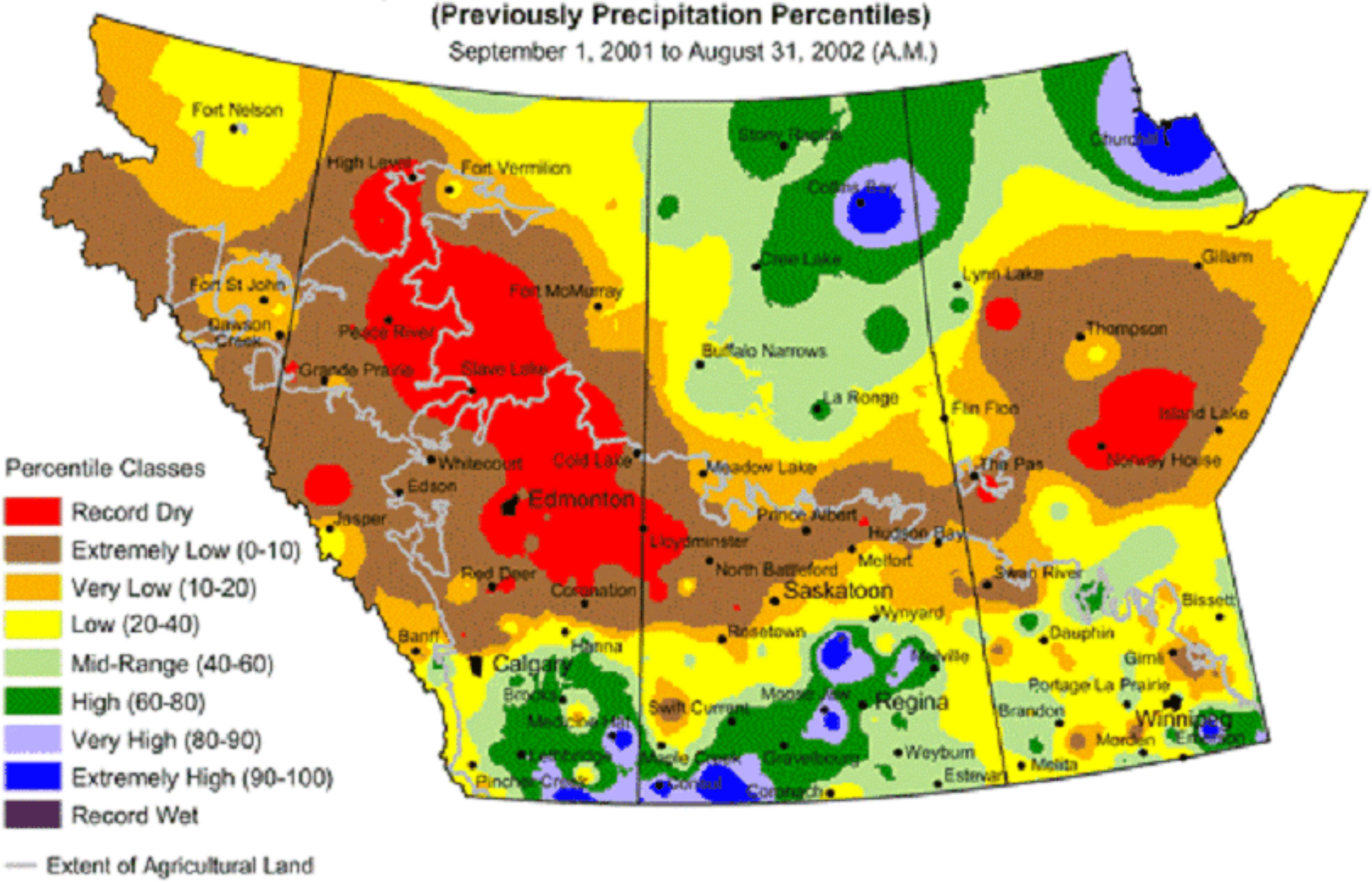
# Climatic Variability

A projected increase in climate variability, including more frequent drought and major hydroclimatic events, is the most ominous climate change scenario. Social and biophysical systems respond to extremes of climate and to short-term departures from average conditions long before they respond to long-term trends in temperature or precipitation. More extreme climate anomalies are more likely to exceed natural and engineering thresholds beyond which the impacts of climate are much more severe.

# Current Precipitation Compared to Historical Distribution

**(Previously Precipitation Percentiles)**

September 1, 2001 to August 31, 2002 (A.M.)




Prepared by PFRA (Prairie Farm Rehabilitation Administration) using data from the Timely Climate Monitoring Network and the many federal and provincial agencies and volunteers that support it.

# Medicine Hat (1884-2001)

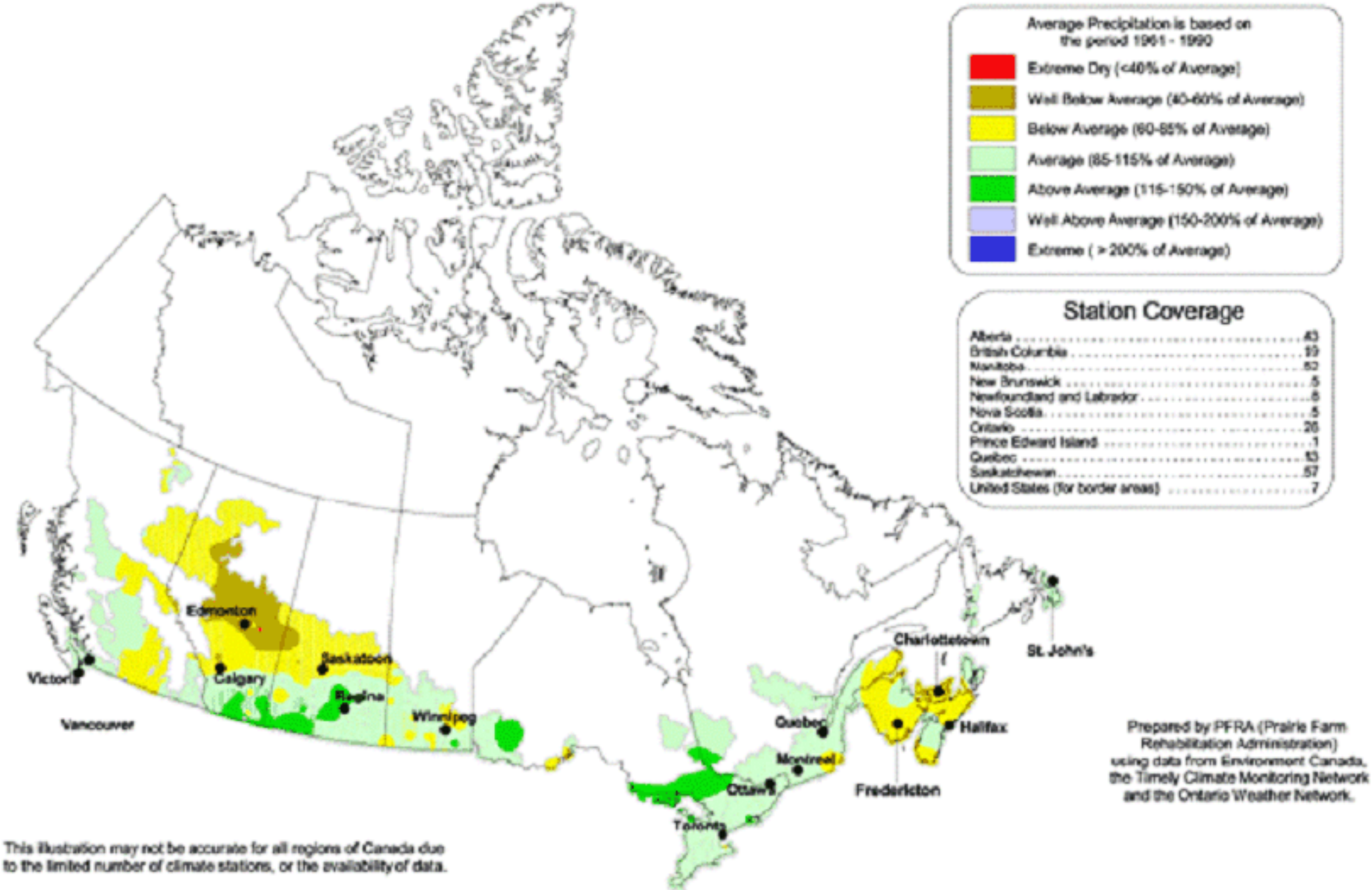
| Single Years | | Three-year droughts | |
|---|---|---|---|
| **2001** | **147.3** | **1999-2001** | **662.6** |
| 1907 | 173.1 | 1907-09 | 681.6 |
| 1943 | 182.2 | 1918-20 | 716.4 |
| 1928 | 194.1 | 1905-07 | 721.5 |
| 1919 | 195.6 | 1928-30 | 724.9 |
| 1997 | 197.3 | | |
| 1929 | 207.0 | | |
| 1924 | 207.6 | | |
| 1961 | 207.7 | | |
| **2000** | **214.3** | | |


Southern Alberta, August 2001


Near Outlook, SK, May 2002

# Percent of Average Precipitation in Agricultural Areas

## September 1, 2001 to August 23, 2002



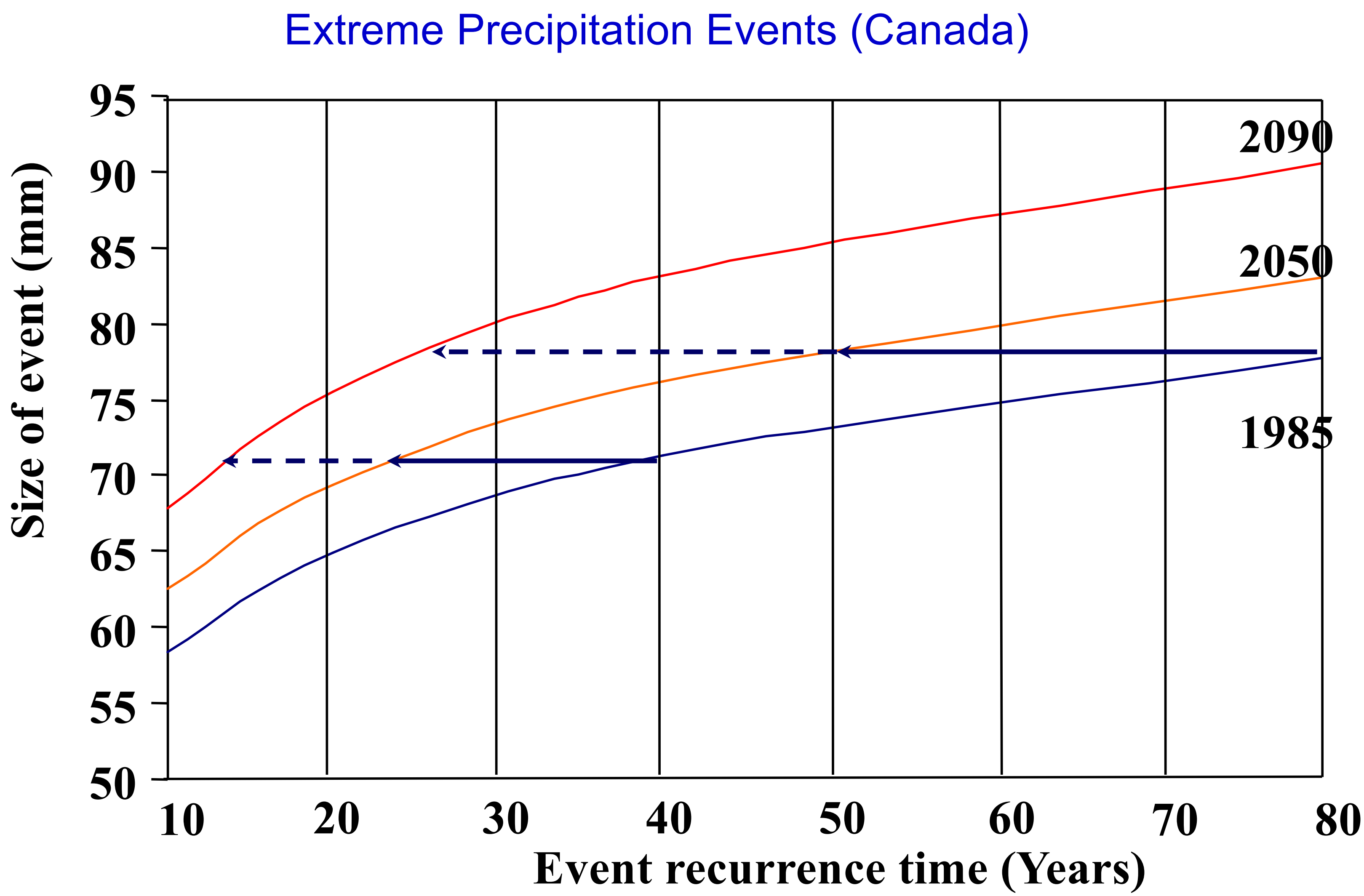

This illustration may not be accurate for all regions of Canada due to the limited number of climate stations, or the availability of data.

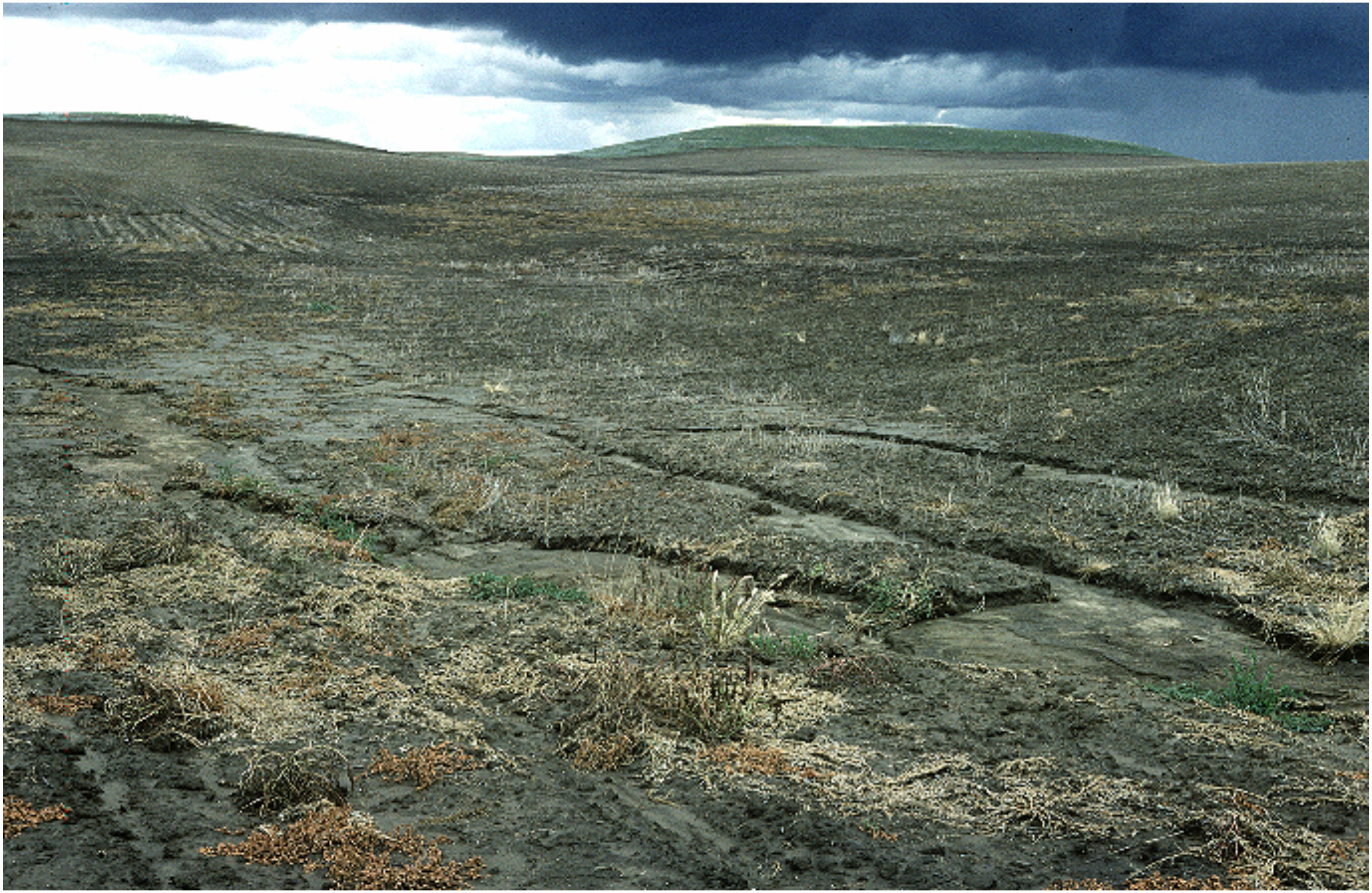
# Soil drifting near Oyen, Alberta, May 5, 2002

# Landscape Change

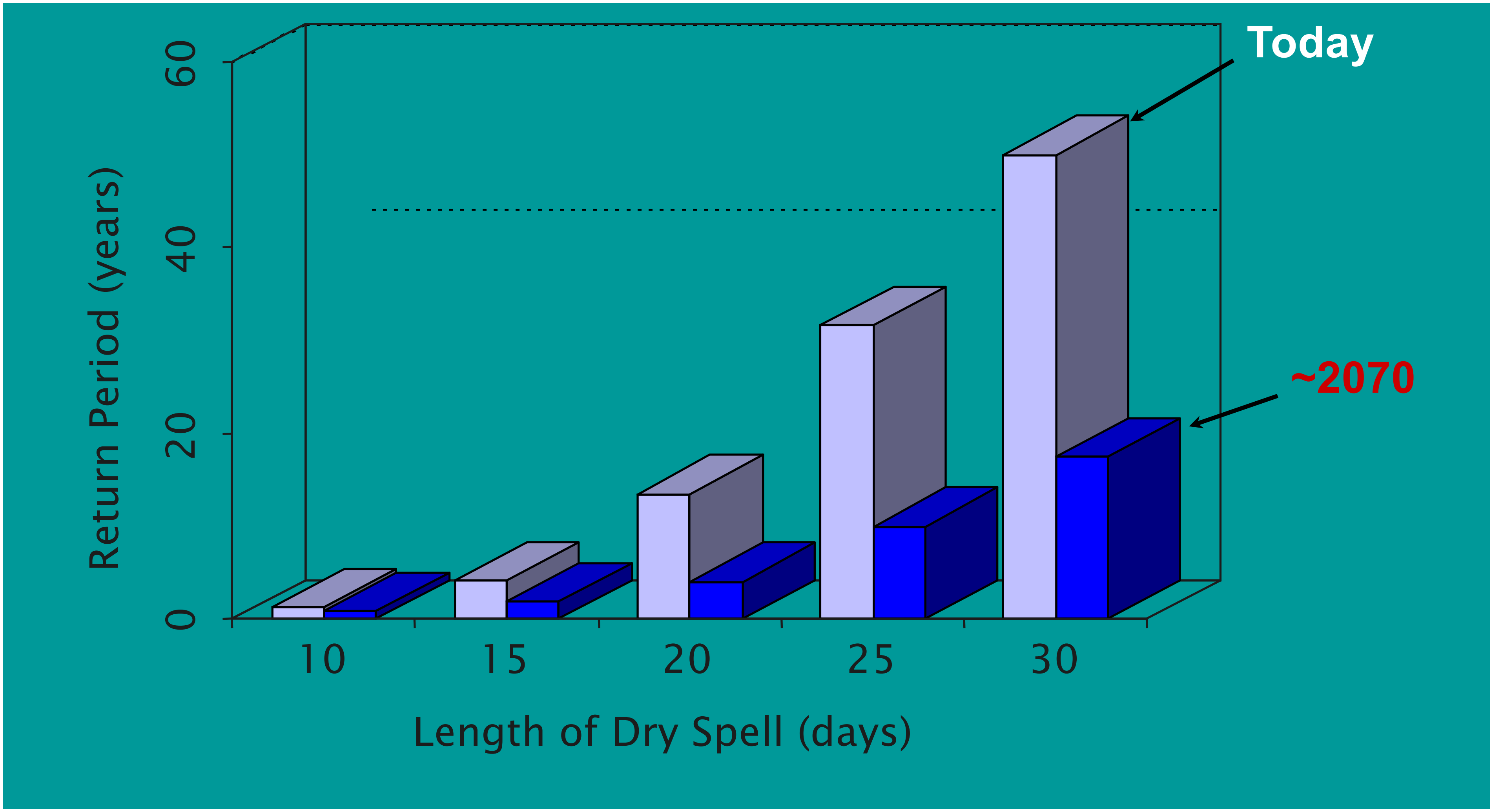
As with most other natural and social systems, the greatest threat to the stability of soil landscapes is posed by extreme climate. Higher magnitude hydroclimatic events are more likely to exceed thresholds of erosion. Long periods of landscape stability are interrupted by short bursts of erosion. Irreversible landscape change can occur in response to single events.

# Extreme precipitation events are likely to become more frequent

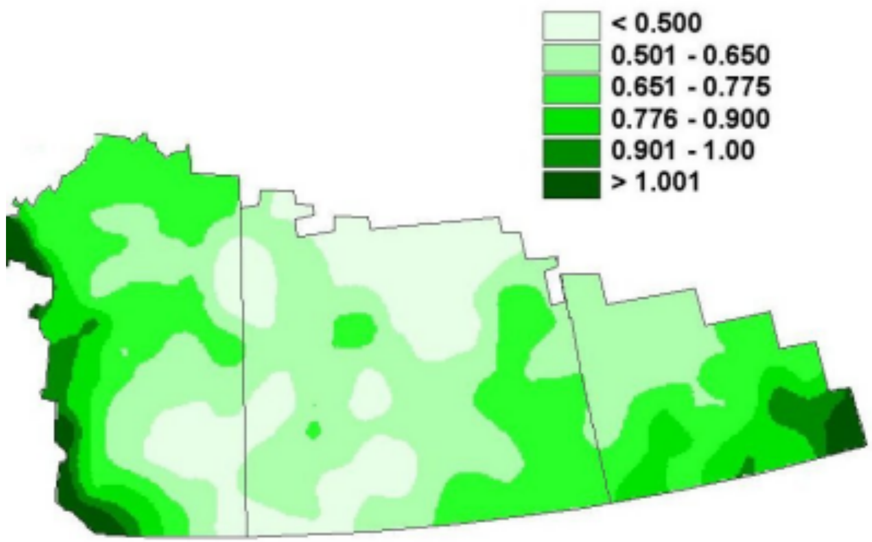




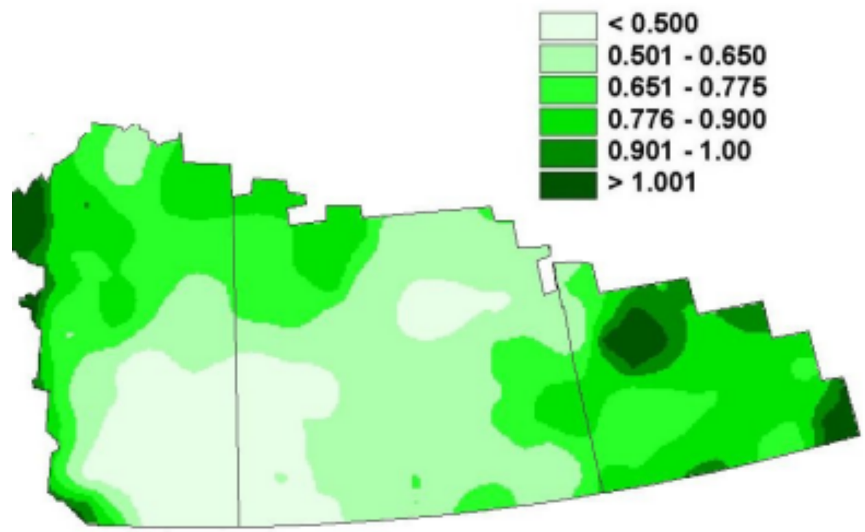
# Increasing Frequency (Decreasing Return Period) of Dry Spells of a Specific Length



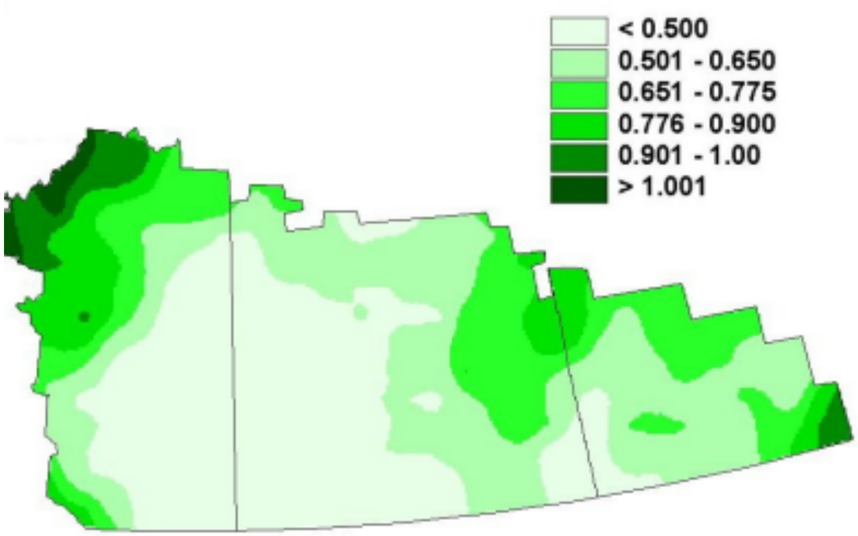
## Aridity Index (P/PE), 1928



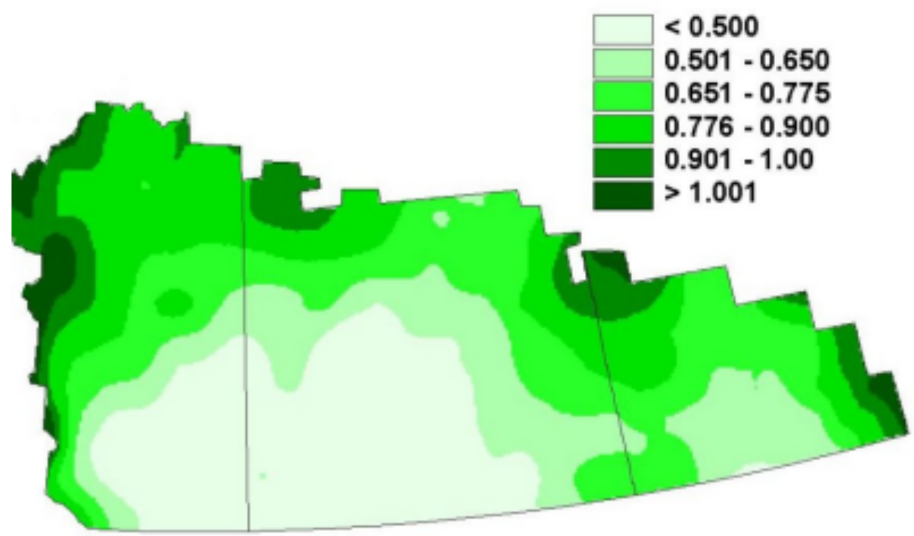

## Aridity Index (P/PE), 1943




## Aridity Index (P/PE), 1936

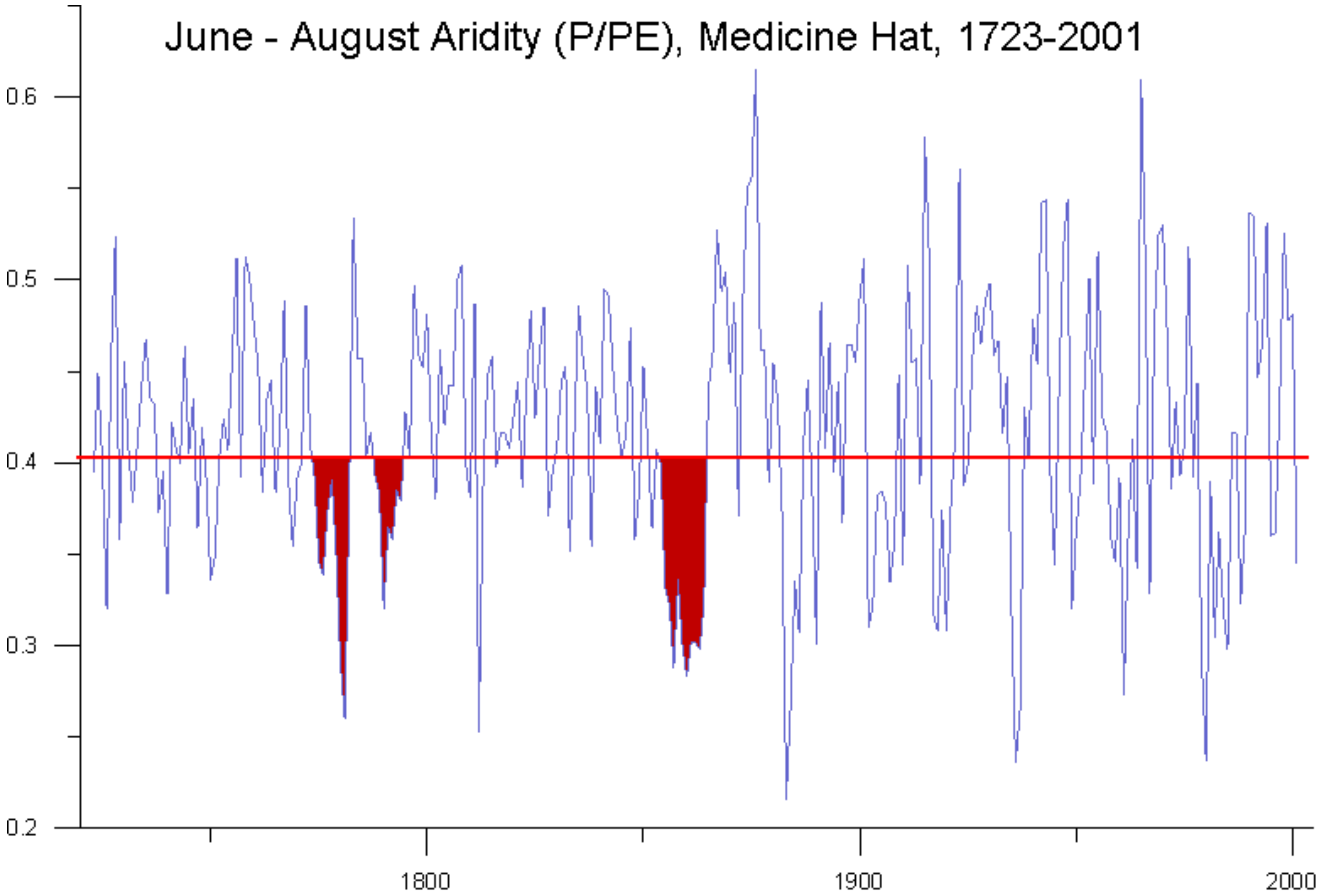



## Aridity Index (P/PE), 1988

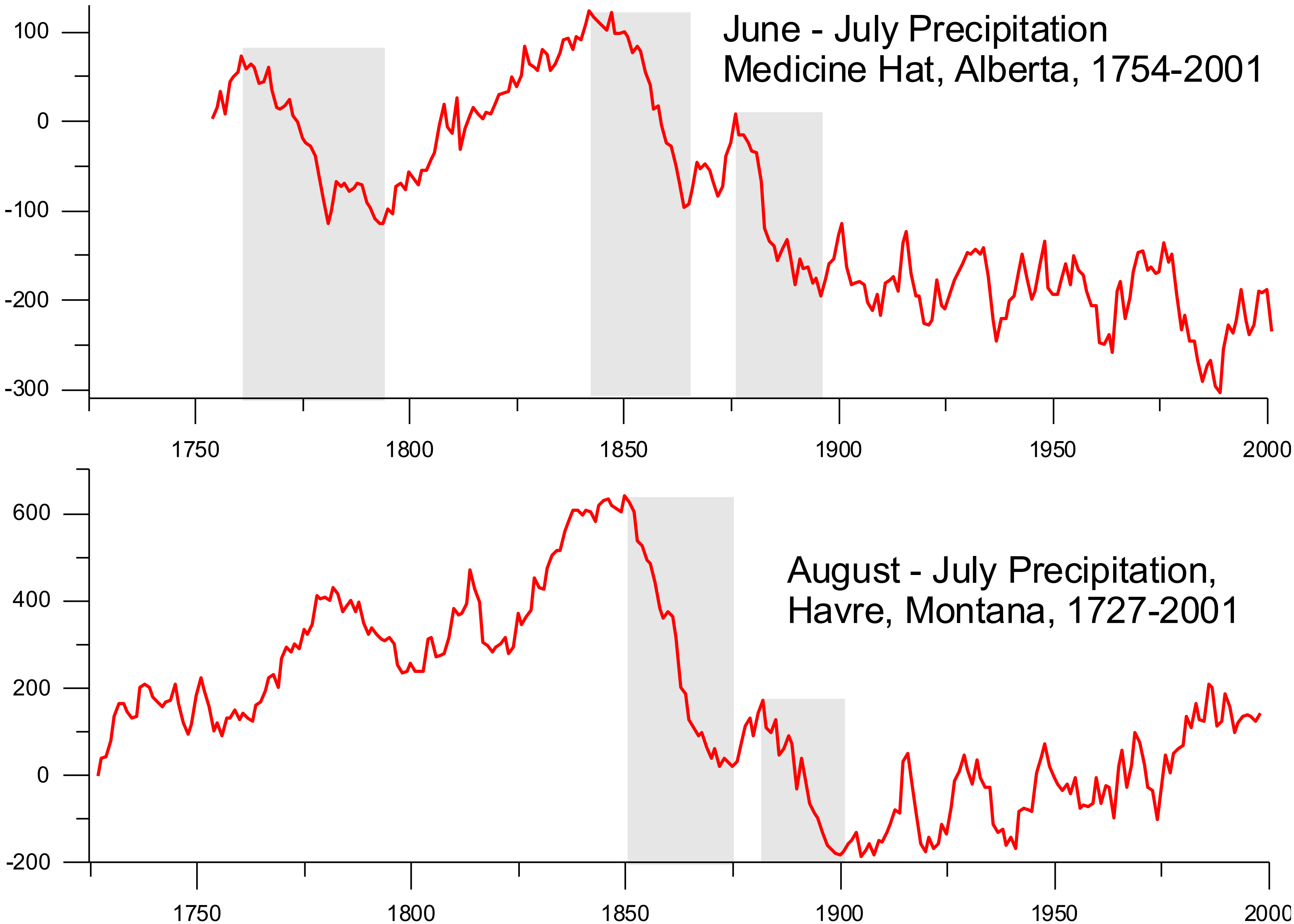



WESTCOTT® Flexible Stainless Steel Ruler
MADE IN U.S.A.

# Battle Creek valley, West Block, Cypress Hills


June - August Aridity (P/PE), Medicine Hat, 1723-2001
0.6
0.5
0.4
0.3
0.2
1800
1900
2000

# Departures From Median Precipitaton




Widespread dune activity induced by late 18th century dryness
Wolfe, *et al*. 2001

# Fort Edmonton – HBC Archives

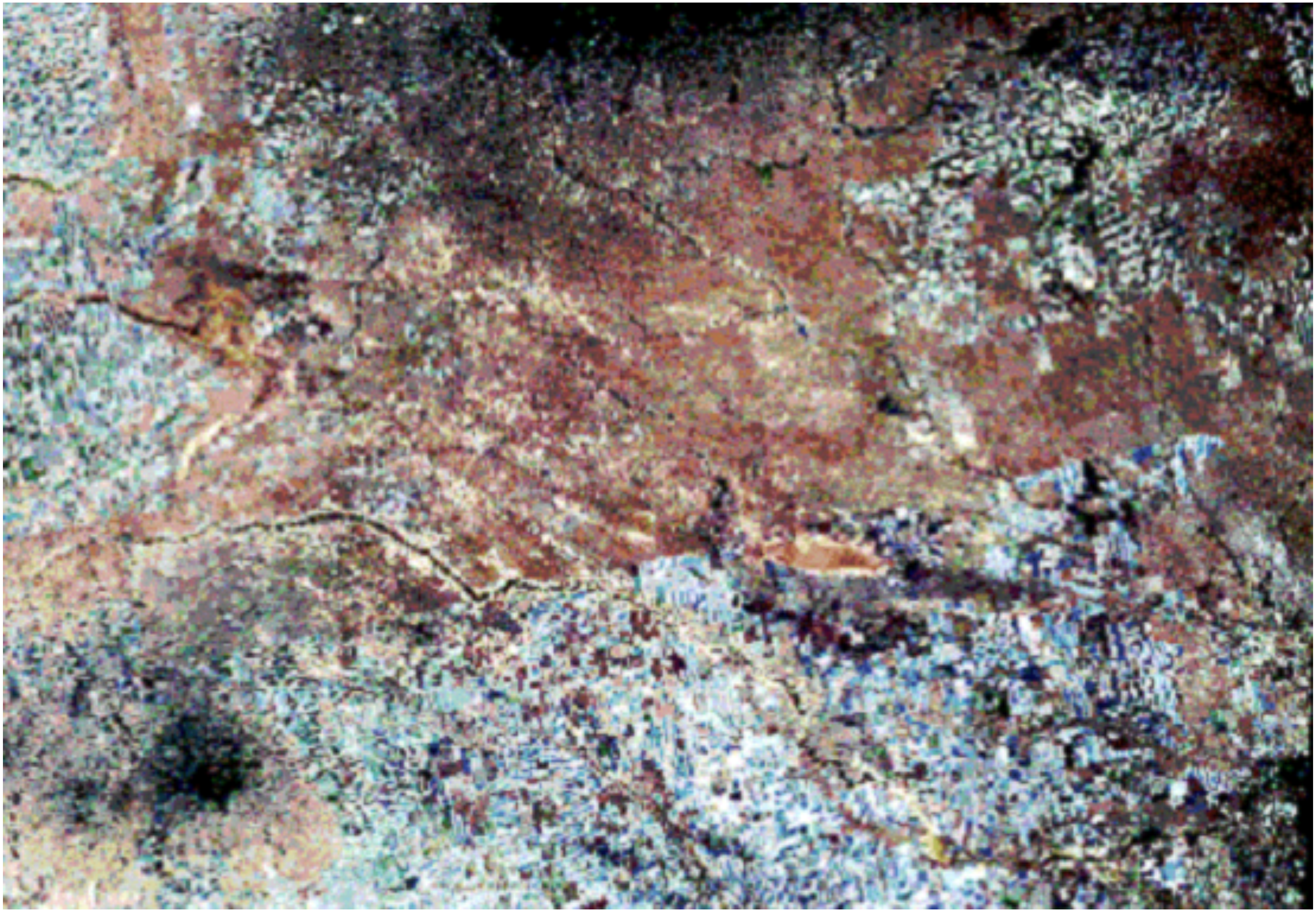
At Edmonton House, a large fire burned "all around us" on April 27th (1796) and burned on both sides of the river. On May 7th, light canoes arrived at from Buckingham House damaged from the shallow water. Timber intended to be used at Edmonton House could not be sent to the post "for want of water" in the North Saskatchewan River. On May 2nd, William Tomison wrote to James Swain that furs could not be moved as, "there being no water in the river." (Johnson 1967: 33-39, 57)

In 1800 "Fine weather" continued into April at Edmonton House. On April 18th, James Bird repeated his observation that the poor trade with both the Slave and Southern Indians was the result of "the amazing warmness of the winter" diminishing both the bison hunt and creating a "want of beaver." Bird reported "clear weather except for the smoke which almost obscures the sun. The country all round is on fire." On June 15th, he noted that the "amazing shallowness of the water" prevented the shipment of considerable goods from York Factory (Johnson 1967: 240-248)

*This large belt of country embraces districts, some of which are valuable for the purposes of the agriculturalist, while others will for ever be comparatively useless. ... The least valuable portion of the prairie country has an extent of about 80,000 square miles, and is that lying along the southern branch of the Saskatchewan, and southward from thence to the boundary line, ...*

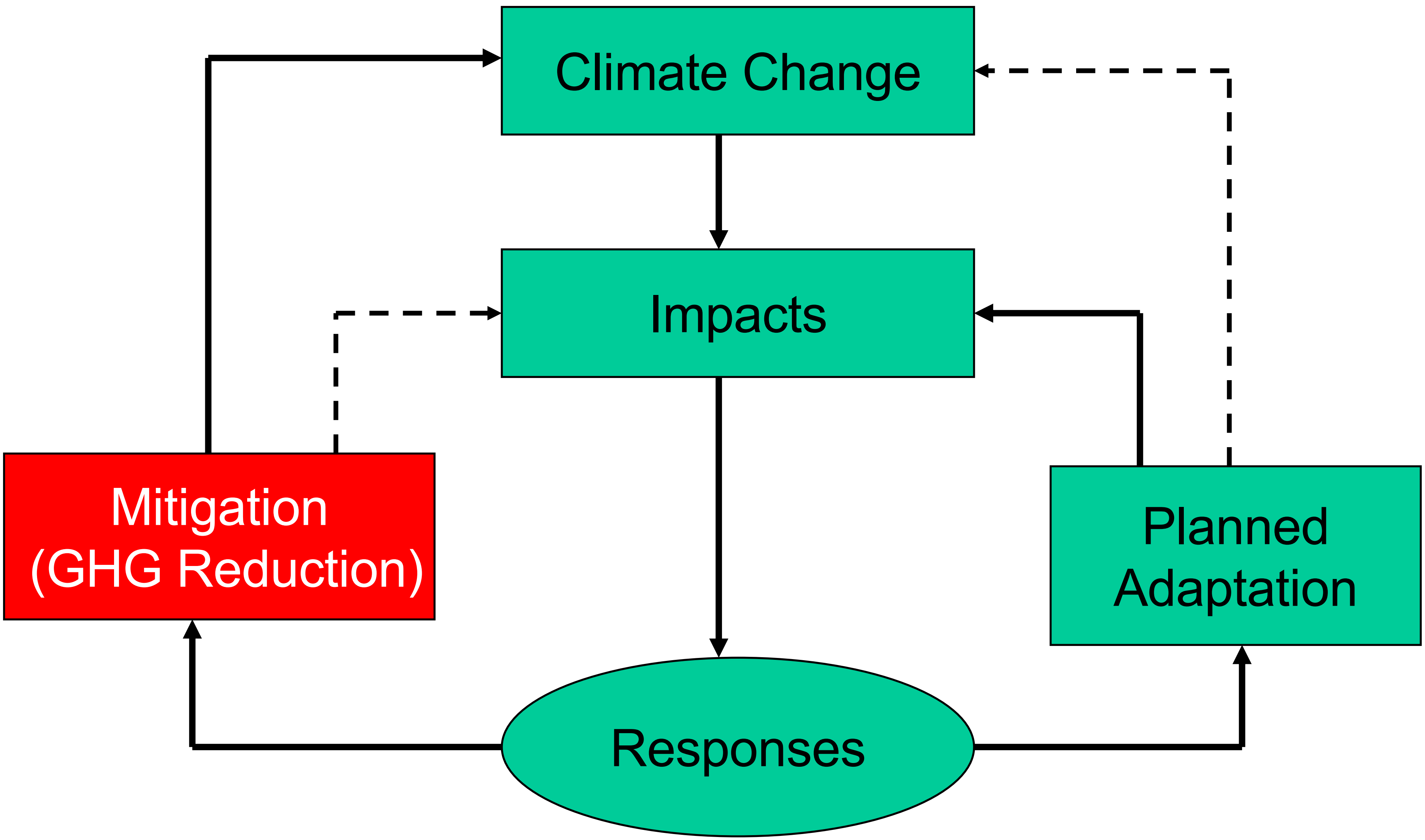
CAPT[N]. JOHN PALLISER,
London, July 8, 1860

SE 6-33-11-W4, May 1914

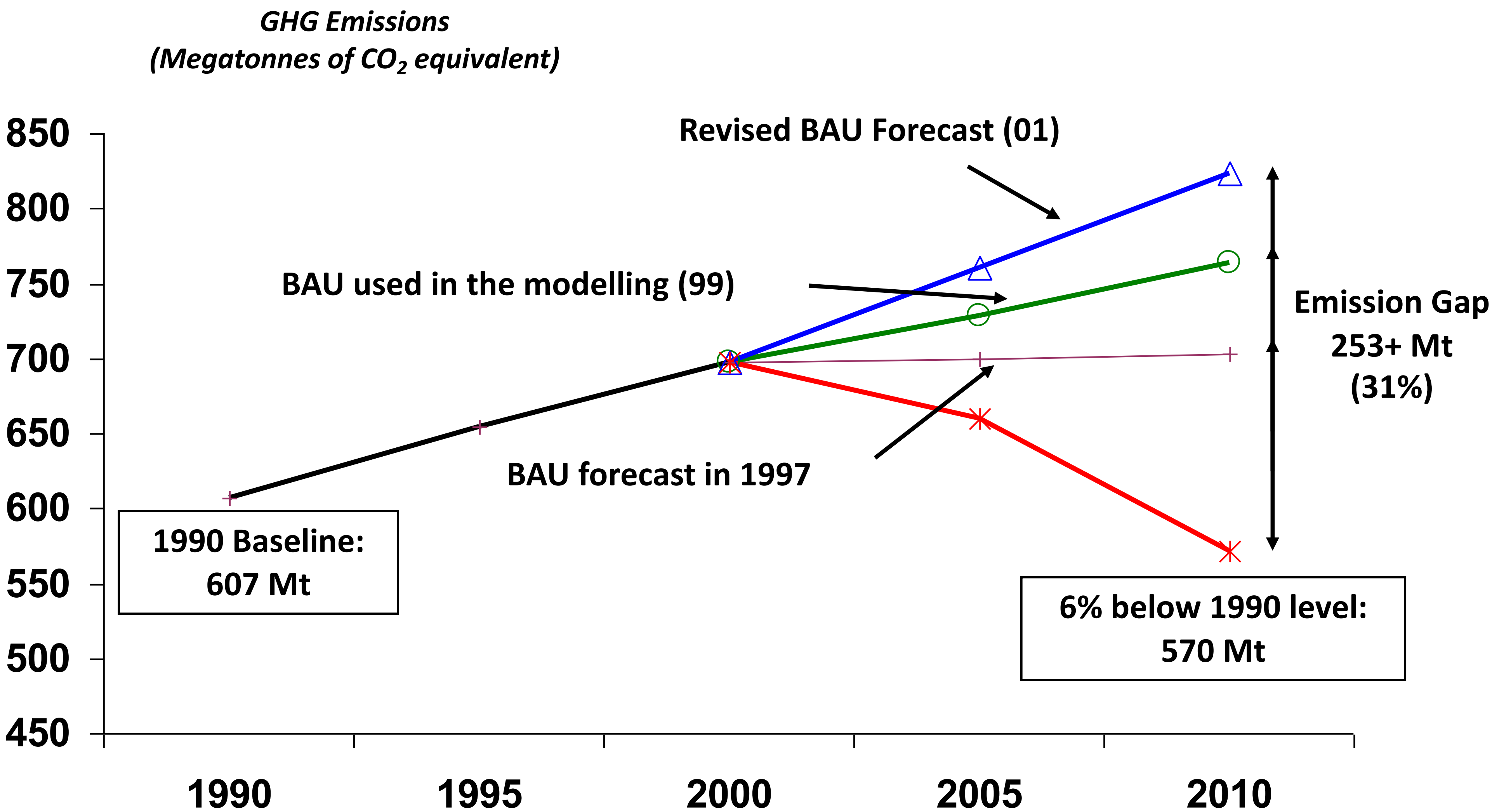


Landsat 7, July, 2000

# Addressing Climate Change: Mitigation and Adaptation



# GHG Emissions: Forecasts and Kyoto Target



# The Carbon Sink Potential In Saskatchewan

Report of an Expert Workshop held at
Prairie Adaptation Research Collaborative
Regina SK, March 25-26, 2002

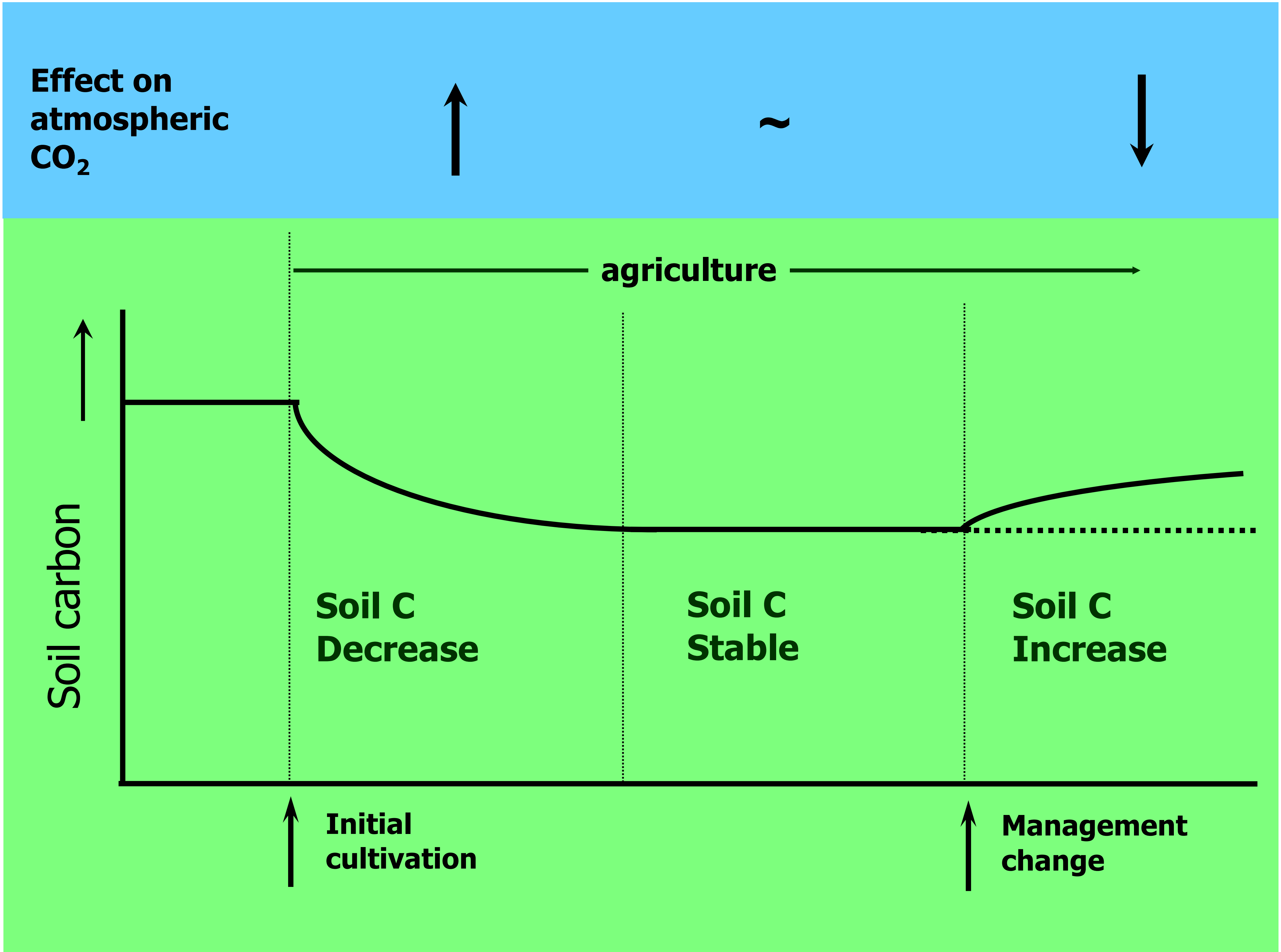
Prepared by Mark Johnston, Ph.D.
Senior Research Scientist
Saskatchewan Research Council

13 May, 2002

Available at www.parc.ca

# Soil carbon sink potential on agricultural land

- Large sink potential on agricultural land
- Most on cropland
  - reduced tillage, reduced summerfallow, forages in rotation and better use of organic amendments (manure, compost)
- C sequestration created by change to more soil aggrading practice
  - Adoption rate of soil aggrading practice largest uncertainty
  - Additional uncertainty largely from duration and persistence of sequestration

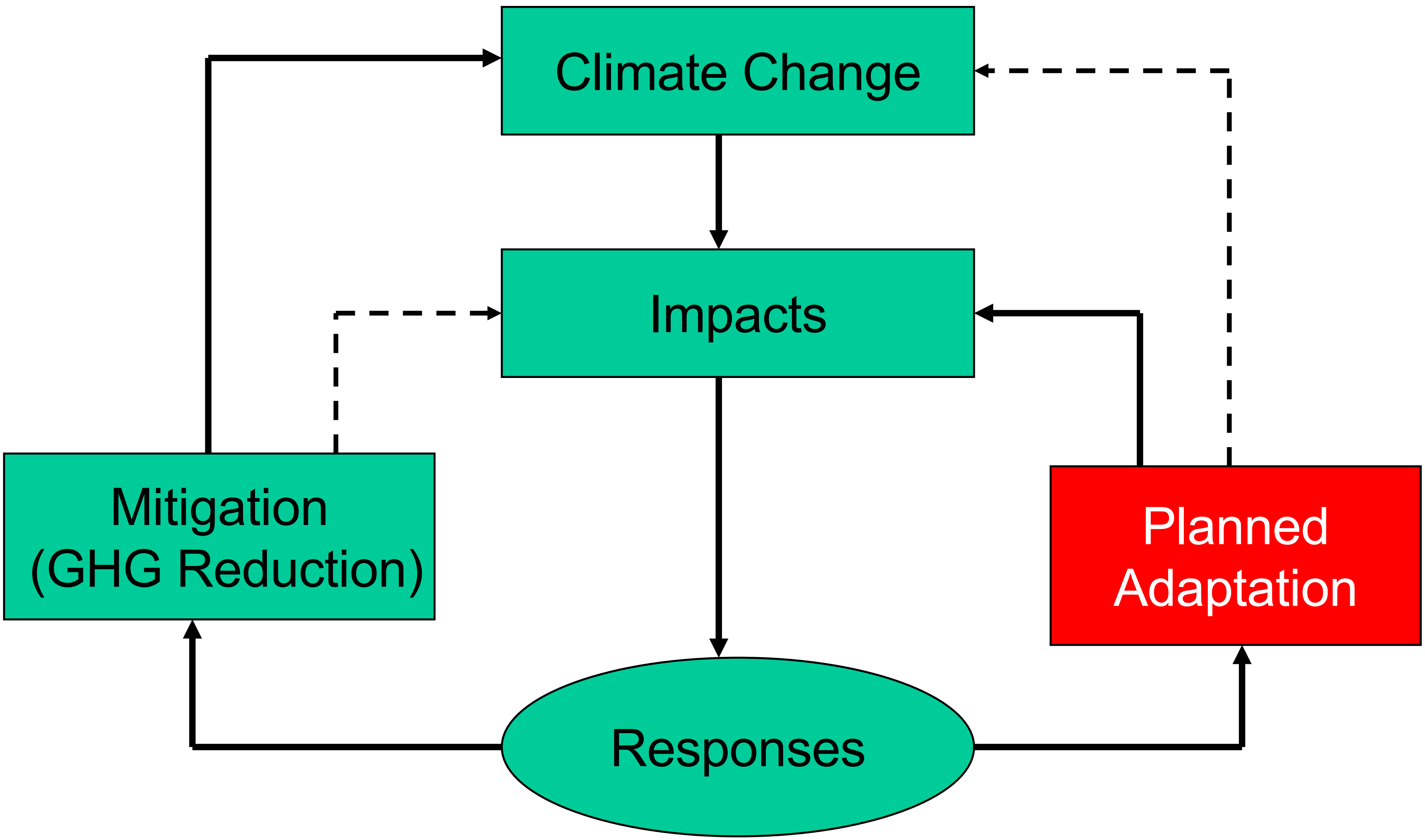

Effect on atmospheric $CO_2$
~
agriculture
Soil carbon
Soil C Decrease
Soil C Stable
Soil C Increase
Initial cultivation
Management change

# Carbon sequestration opportunities on Saskatchewan cropland

| Practice | Rate (Mg C $ha^{-1}$ $yr^{-1}$) | Confi-dence | Feasi-bility |
|---|---|---|---|
| Reduce Tillage | 0.0 to 0.4 | Med | High |
| Forages in rotation | 0.0 to 0.5 | Med | Med |
| Reduce Fallow | 0.0 to 0.5 | High | High |
| Revegetation with perennials | 0.2 to 1.0 | High | Low |
| Increasing residue additions | 0.0 to 0.3 | Med | Med |
| Addition of organic materials (manure, compost) to degraded land | 0.0 to 0.5 | High | Med |

Brian McConkey, AAFC, Swift Current

# Addressing Climate Change: Mitigation and Adaptation



# ADAPTATION

- Degree to which adjustments are possible in practices, processes, or structures of systems to projected or actual changes of climate (IPCC, 2001).
- Soil conservation is a prime example of a ‘no regrets’ adaptation strategy; preventing soil loss is beneficial, whether or not global warming occurs as forecast.
- Soil conservation practices can be defeated, however, by climate change: “Severe and widespread erosion could still occur during extreme climatic events and especially during a period of years with back-to-back droughts” (PFRA, 200).

# ADAPTATION

- Unmanaged (natural) systems are resilient but vulnerable to rapid climate change since adaptation is limited to the spontaneous adjustment to climate.
- Managed systems include management structures to buffer the impacts of climatic change and variability. Land use and management have the potential to significantly mitigate the impacts of climate.
- Despite the vast area and relatively sparse population of the Prairie Provinces, most of the landscape is managed.

# ADAPTATION

- In managed landscapes, erosion is mostly a socio-economic problem since it can be prevented by soil conservation, but capacity and willingness to are governed by a host of social and economic factors.
- Even though rates of erosion can be managed, landscape change is a threshold process, such that the conditions that lead to land degradation can be established well before the soil degrading events.
- An increase in the probability of erosional events, above "once in a lifetime", with climate change will justify increased use of soil conservation.

# C-CIARN Prairies


## Prairie Adaptation Research Collaborative

### Menu

- Home
- Overview
- Partners
- Research Program
- Publications
- Bibliography
- Internet Map Server
- Contact Us
- Events
- Links

PARC

PRAIRIE ADAPTATION RESEARCH COLLABORATIVE

www.parc.ca