Climate Change and Canadian Native Prairie

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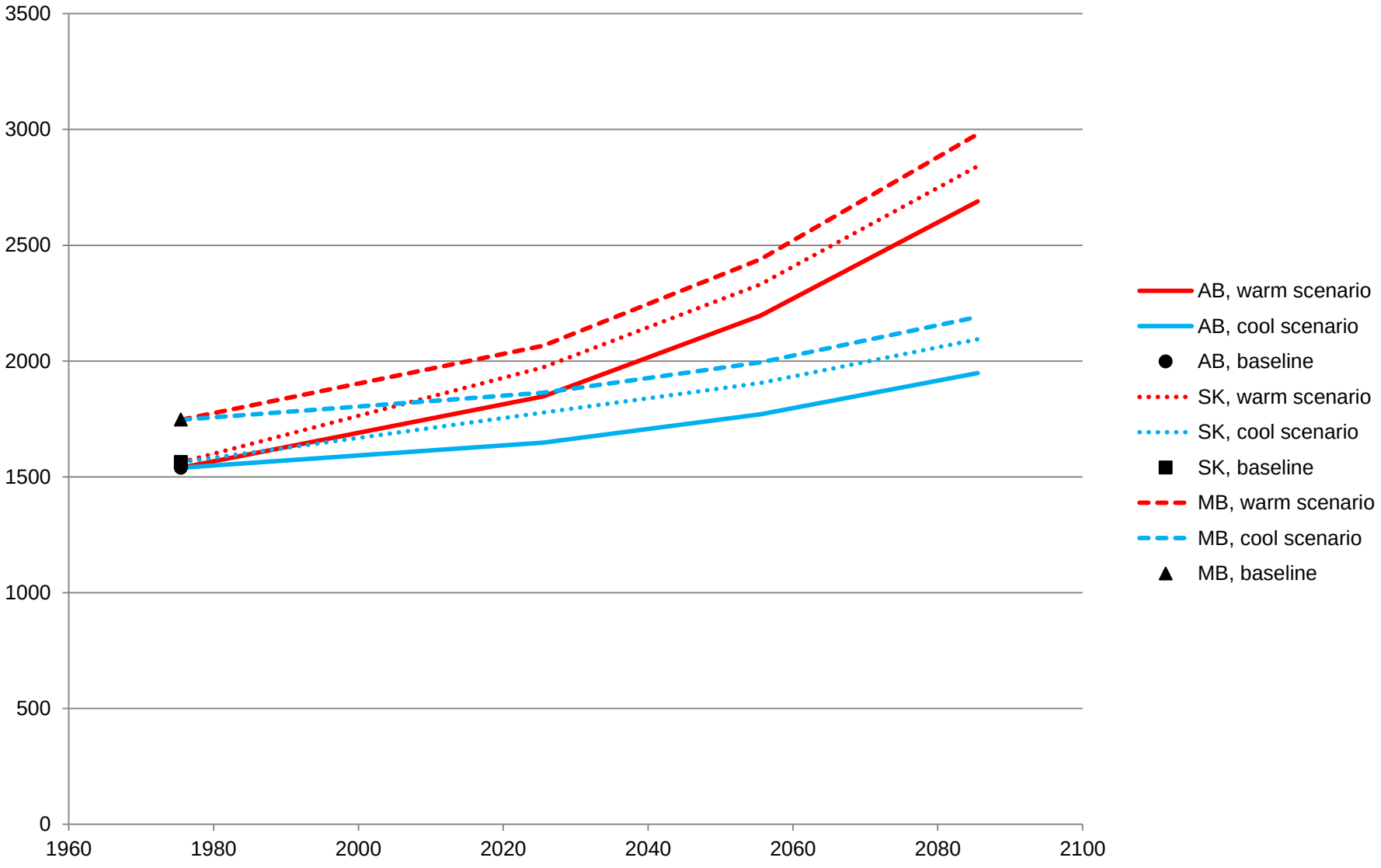
Native prairie

- Created the rich soils that now support prairie agriculture.
- Still makes up 20 - 25% of the Prairie Ecozone.
- Provides a grazing resource for livestock producers.
- Protects sensitive soils.
- Supports biodiversity

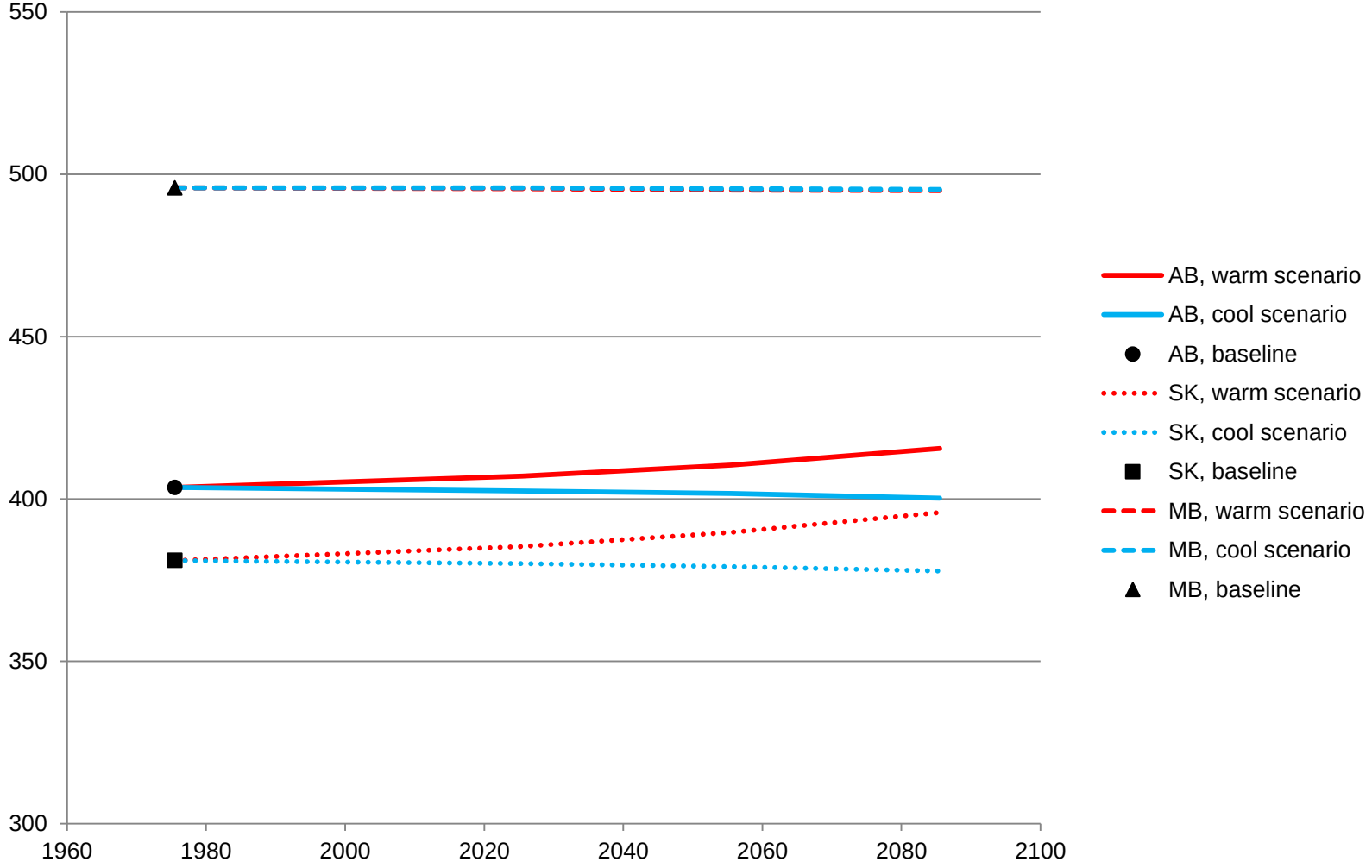
Assessing the impacts of climate change:

- Use Global Climate Models (GCMs) – large computer models of the circulation of the atmosphere.
- Standard recommendation is to use several GCMs and emission scenarios to show the range of variation in predictions.

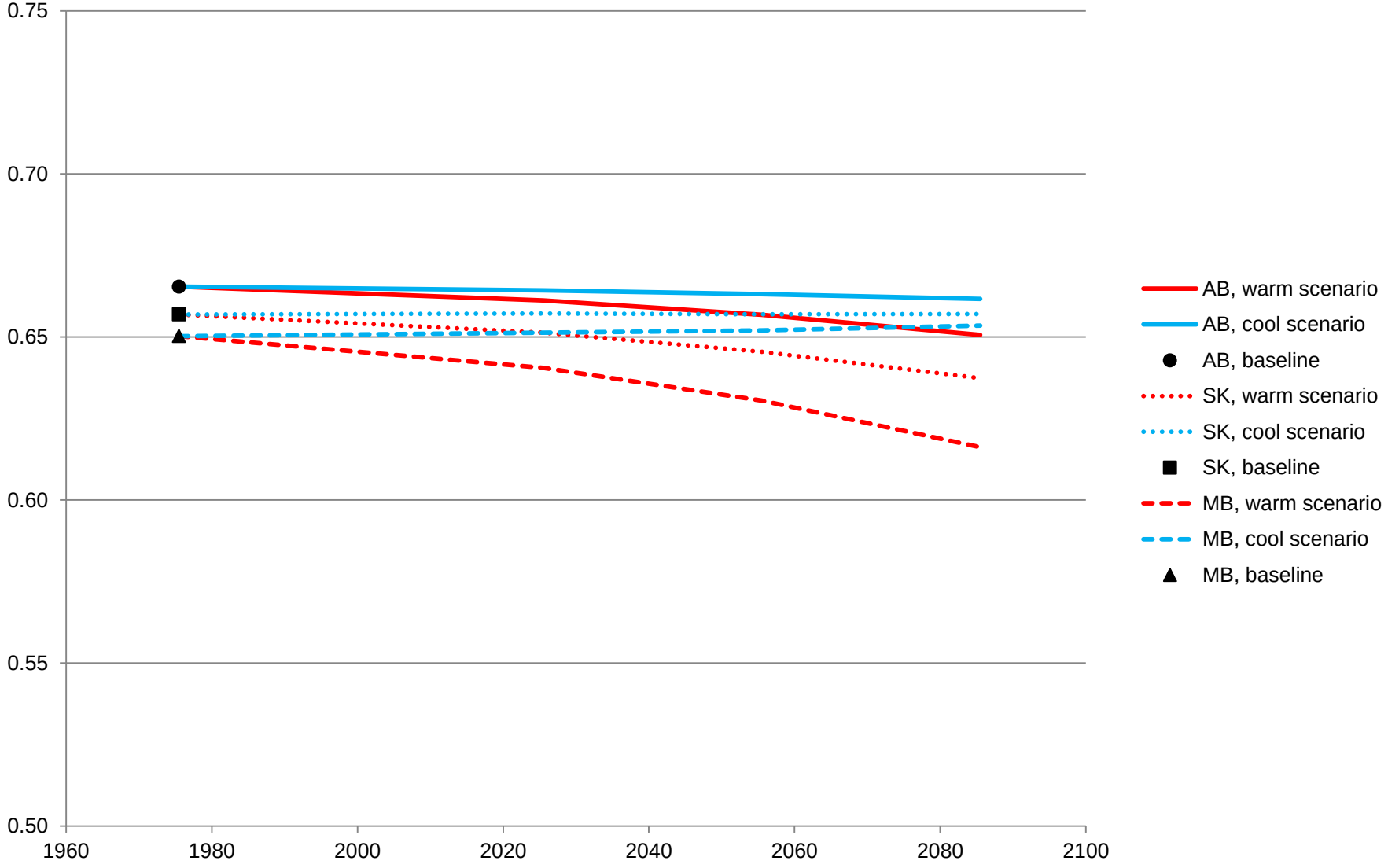
Growing Degree-Days (average over Prairie Ecozone)



Annual Precipitation (mm)
(average over Prairie Ecozone)



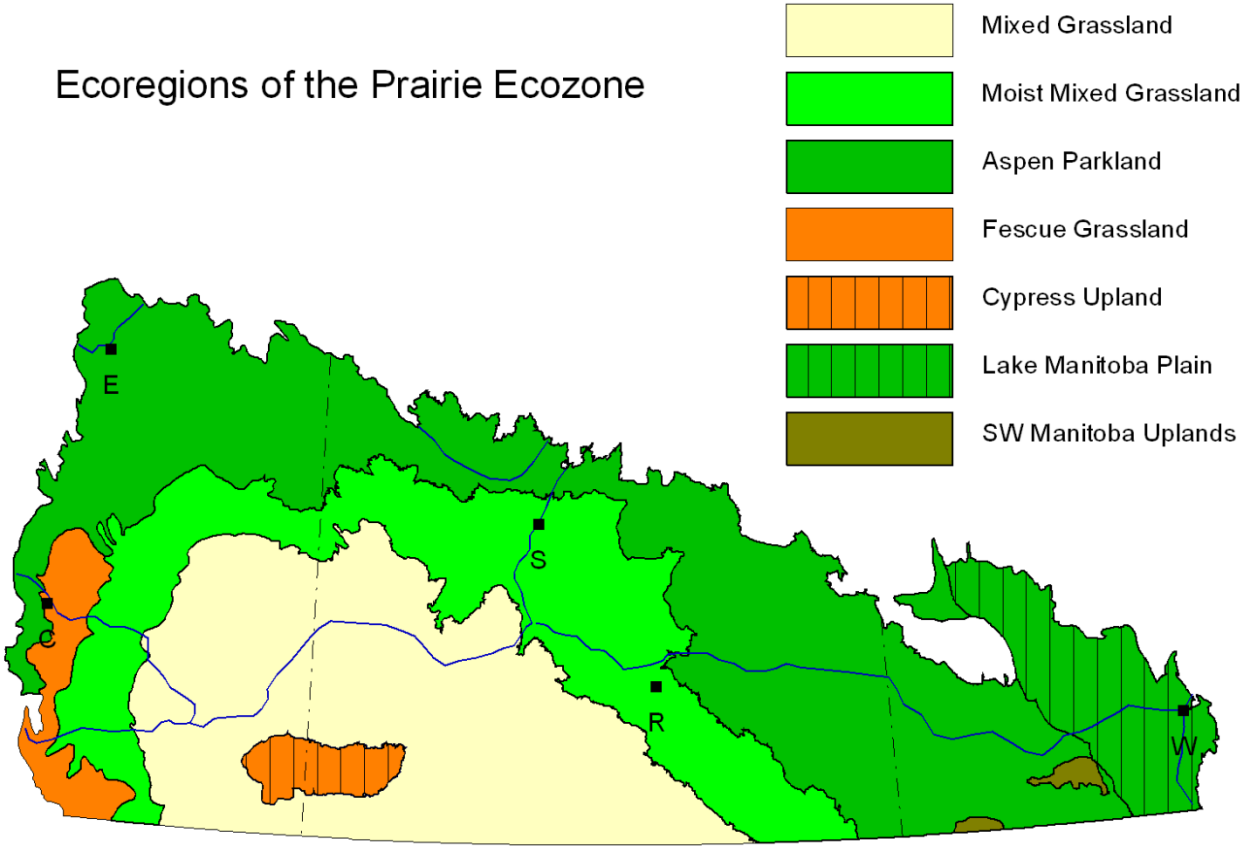
Proportion of Precipitation in Summer (average over Prairie Ecozone)



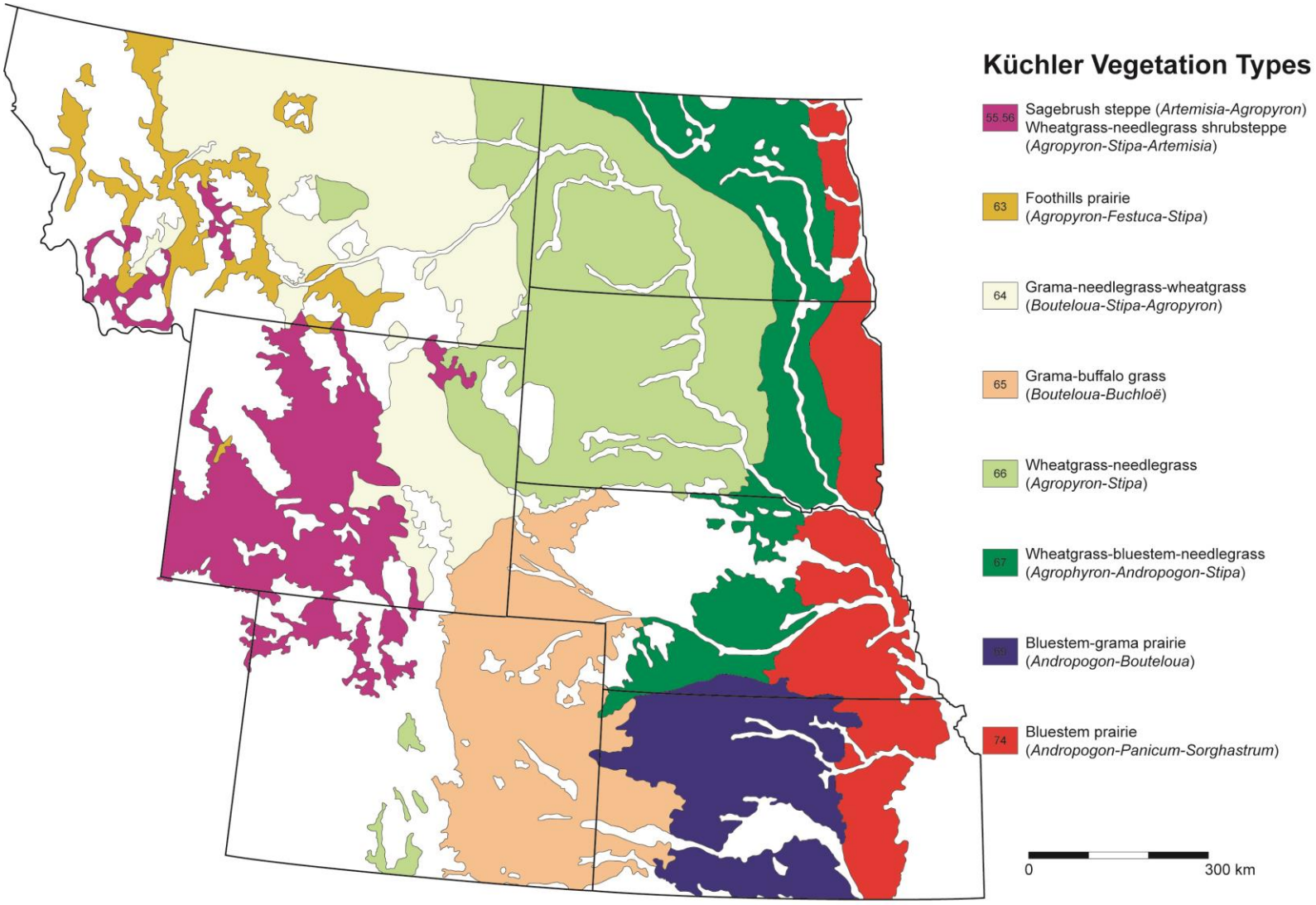
Modeling of vegetation responses to climate change

- Different types of grassland occur in different climatic regions.
- A model was developed to predict the shift in grassland zonation with climate change
- The model was calibrated using data from both Canada and the U.S. - using the U.S. Great Plains as an analogue for the future Canadian Prairies.

Ecoregions of the Prairie Ecozone

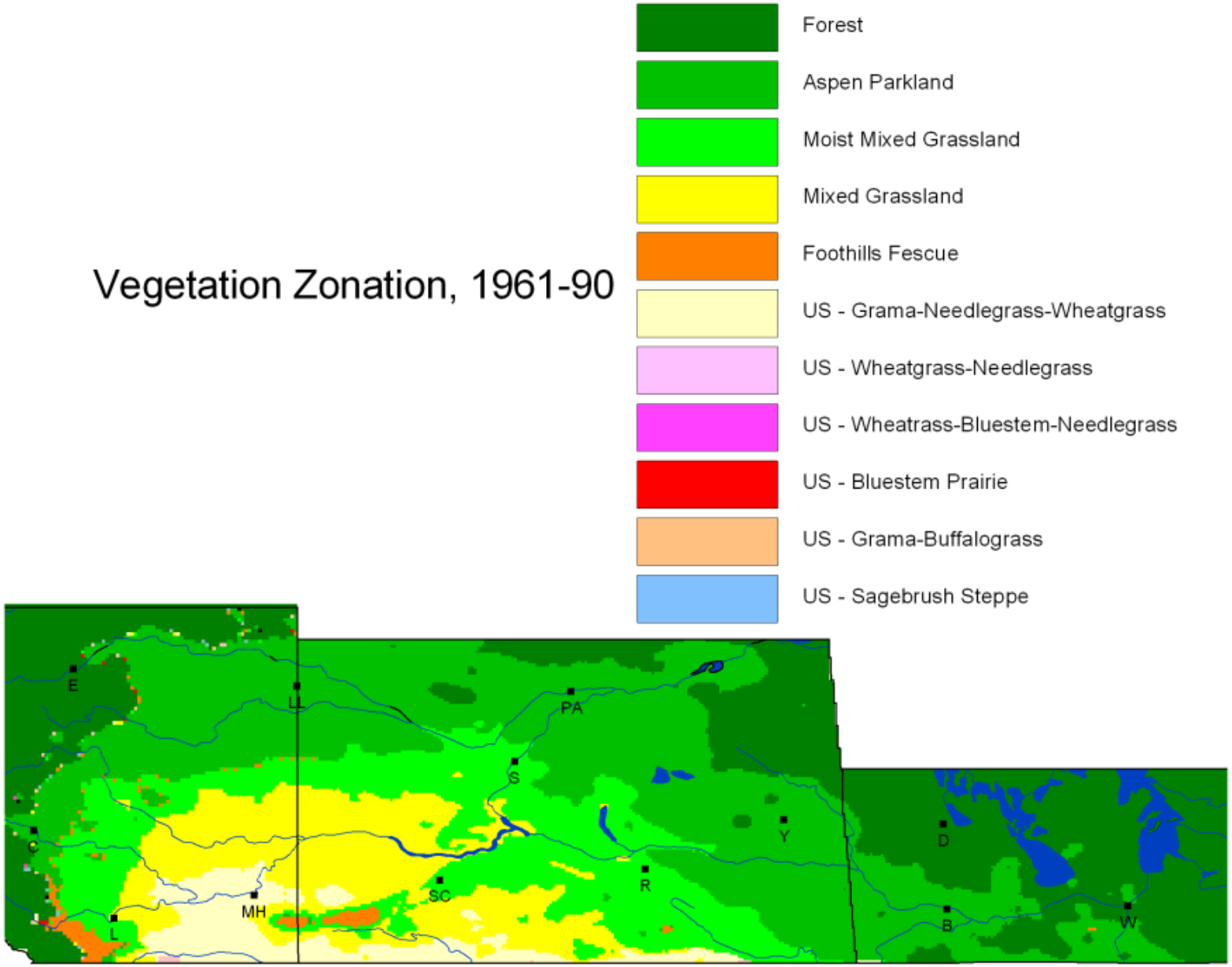


Kuchler vegetation types used for U.S. zonation



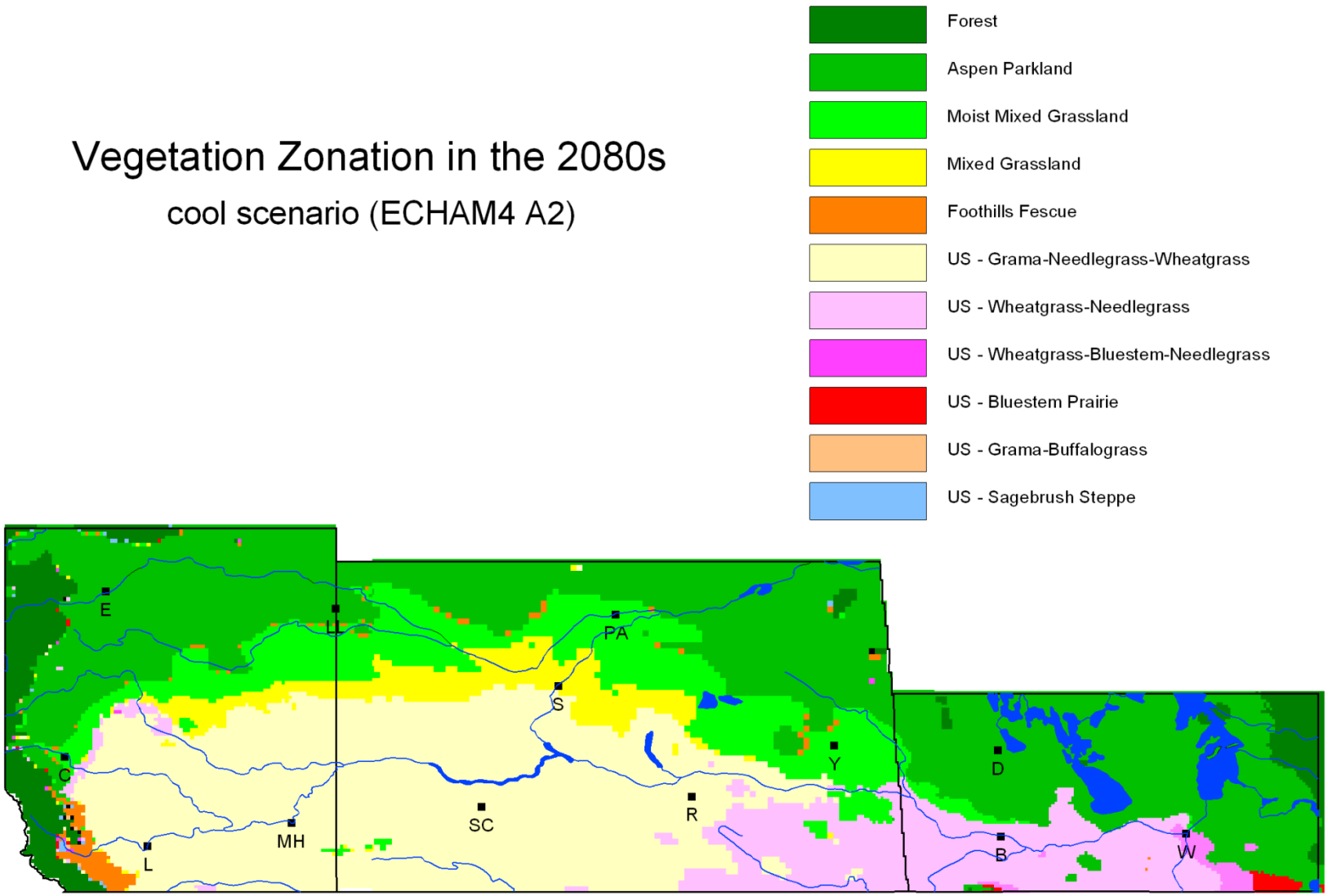
Source: Küchler, A. W. *Potential Natural Vegetation of the Conterminous United States*, American Geographical Society

Vegetation Zonation, 1961-90



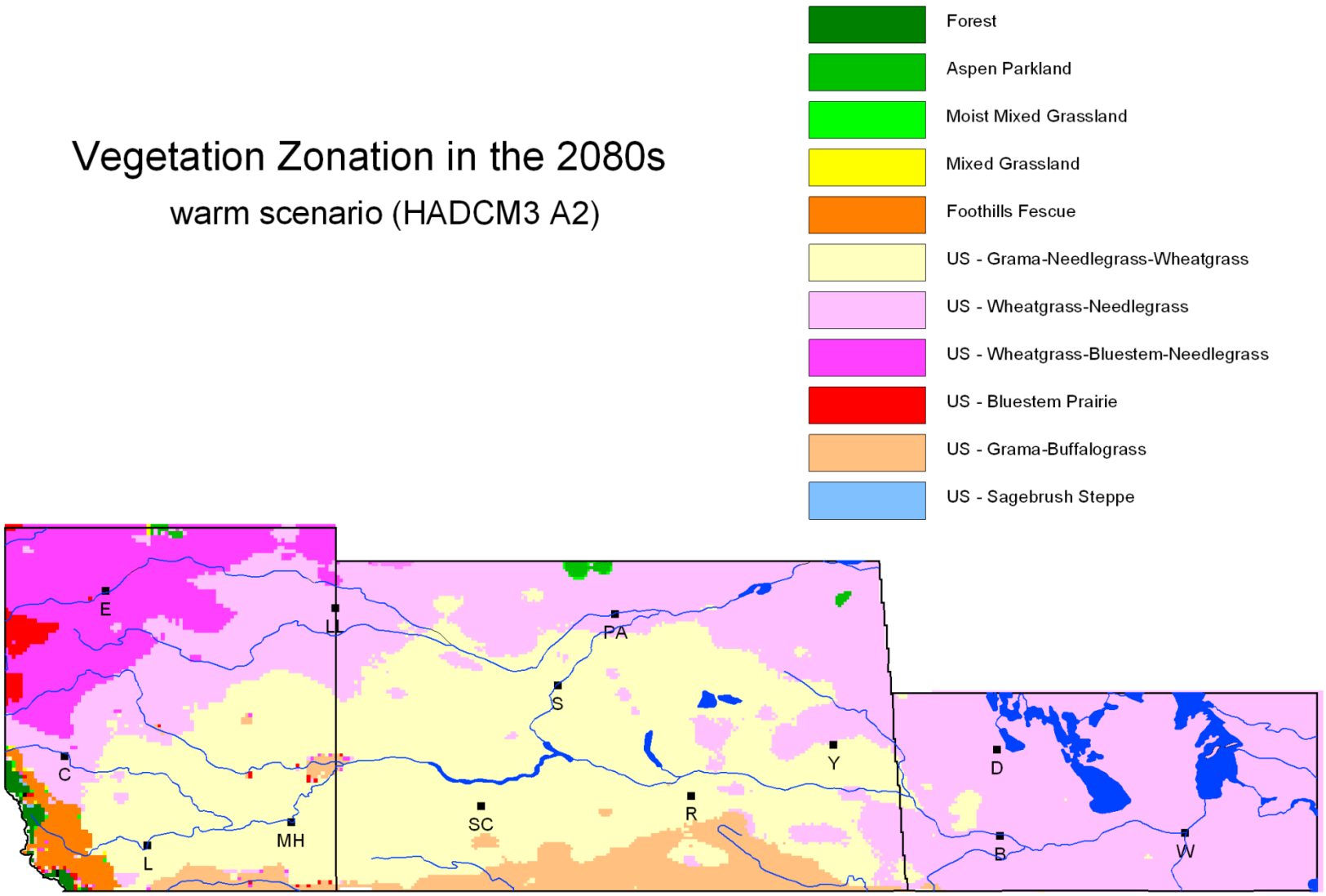
Vegetation Zonation in the 2080s

cool scenario (ECHAM4 A2)



Vegetation Zonation in the 2080s

warm scenario (HADCM3 A2)



The zonation model is not an exact prediction, but it shows probable future trends:

- gradual reduction in tree and tall shrub cover.
- shifts in structure of grasslands from taller to shorter species.
- decrease in cool-season grasses, increase in warm-season grasses.
- gradual introduction of plant and animal species currently found only in the U.S.

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Shifts in species ranges

- One way species can adjust to climate change is by moving their ranges.
- Over many species, average range shift 6.1 km northward per decade over 20th Century (Parmesan and Yohe 2003).
- Species vary in migration rate, so there will be sorting of species along the migrational front, led by the most invasive and trailed by the least invasive.
- Impacts of fragmentation - habitat specialists with poor dispersal ability will be the least able to keep pace with climate change.

Advantages of invasive species

- Efficient dispersal allowing faster range shifts.
- High habitat connectivity because of use of disturbed habitats.
- So the first new species to arrive could be invasives.
- Climate change may be a stress that makes native ecosystems more susceptible to invasion.

Phenological shifts:

- Another way in which species can adjust to climate change is by phenological change.
- Globally, average shift toward earlier spring timing of 2.3 days per decade through the 20th Century.
- At Edmonton, first-flowering date of trembling aspen advanced by two weeks from 1936-2006.
- At Delta Marsh, 25 out of 27 bird species showed earlier arrival dates over a 63 year period.

Climate change and wetlands

- Weather controls wetlands:

  moisture balance
  ↓
  number of ponds
  ↓
  number of ducks

- Models predict decreasing pond numbers and duck populations with climate change.
- Interaction with land use: drainage of wetlands exacerbates impact of climate change.

Changes in grassland production

- If the climate is drier, the production of forage is lower.
- Annual production determines sustainable stocking rates.
- Model the predicted changes in production with climate change.

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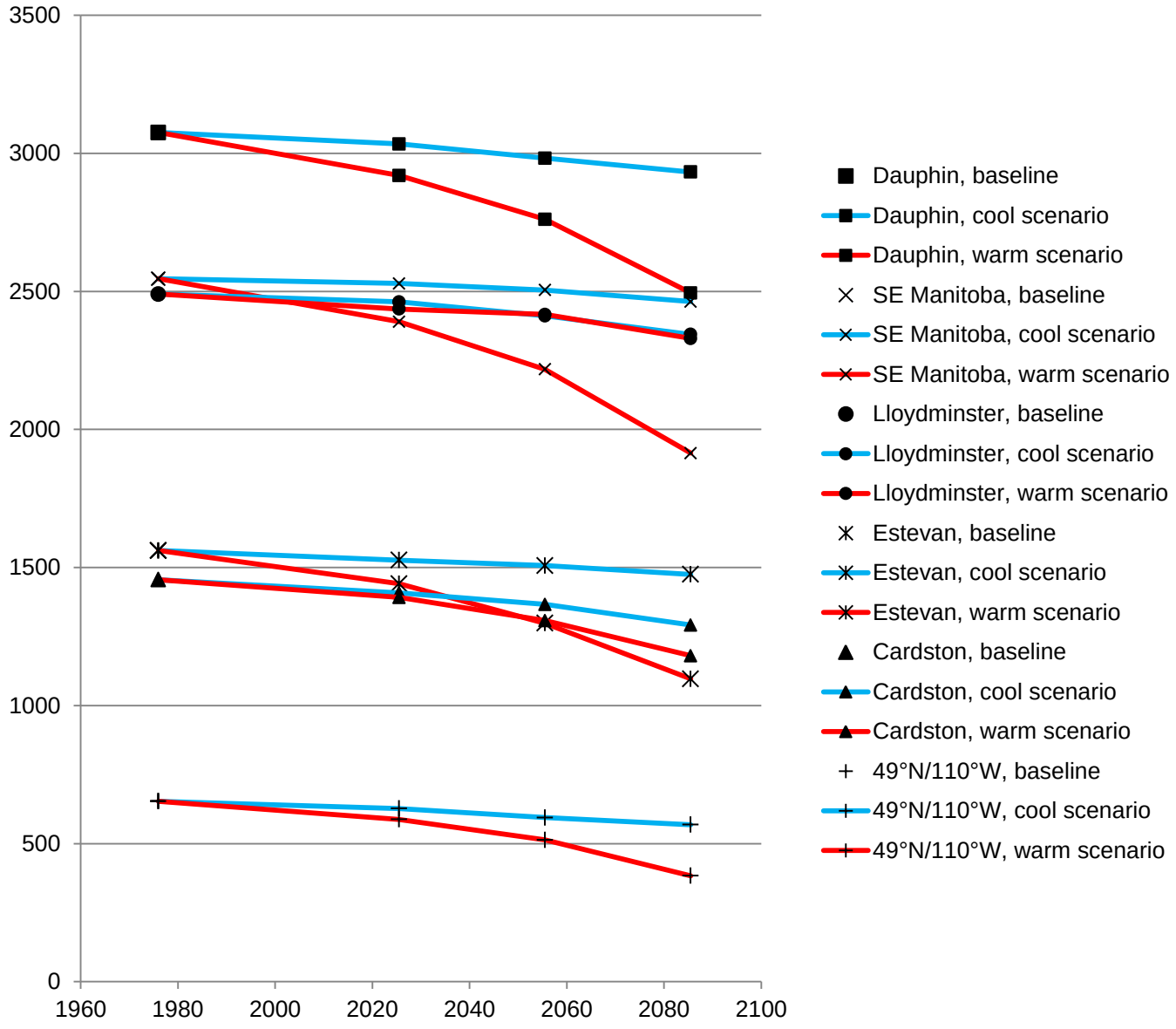
Grassland Production on Loam (kg/ha)



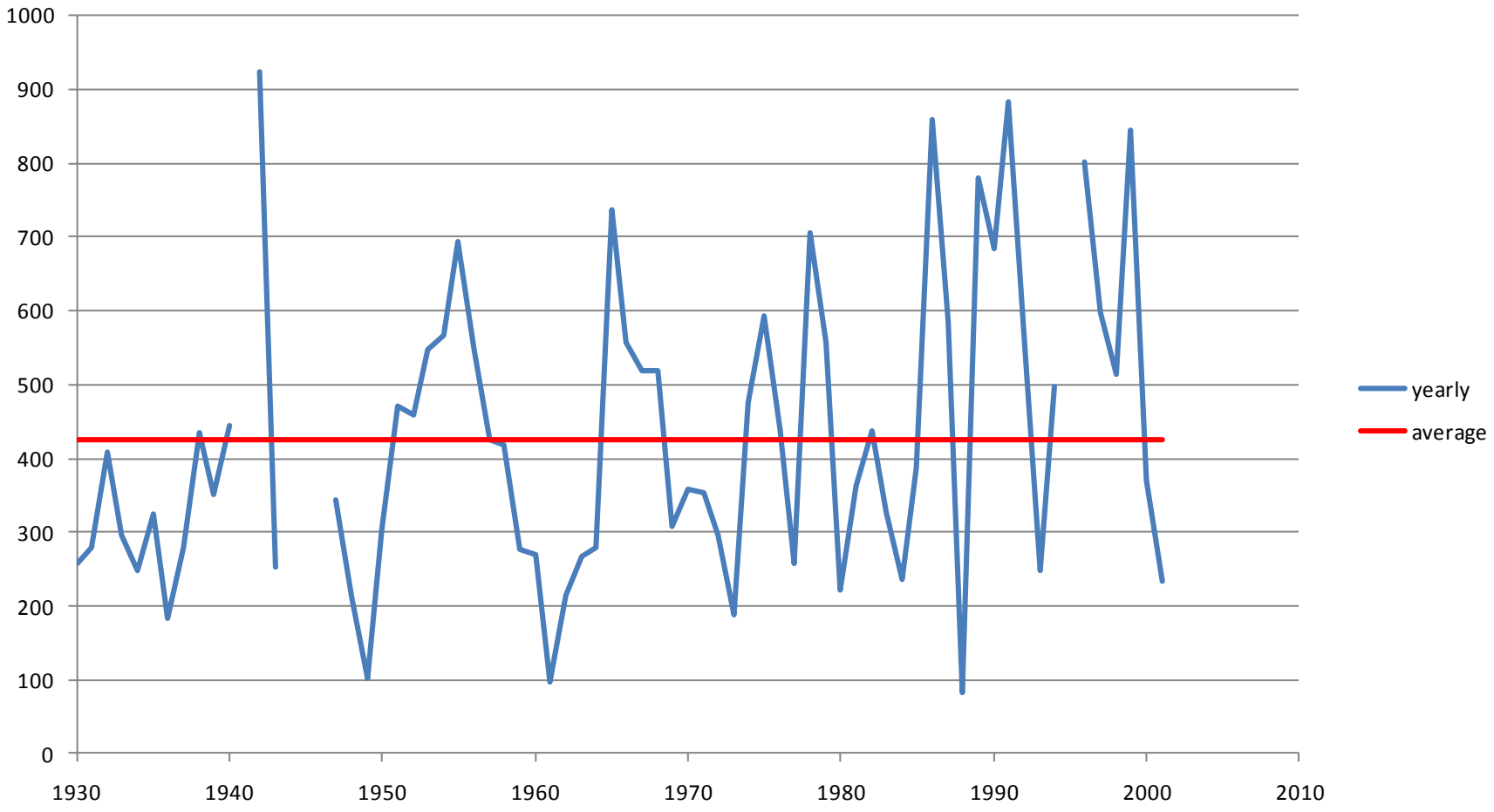
Carbon fertilization effect

- Model does not account for the fertilizing effect of increasing carbon dioxide concentrations.
- Field experiments with CO_2 enrichment chambers show increased grassland production.
- Other factors such as heavy grazing or nutrient deficiency could reduce the ability of plants to take advantage of carbon fertilization.
- Overall effect is uncertain, but carbon fertilization may help to offset the effect of a drier climate.

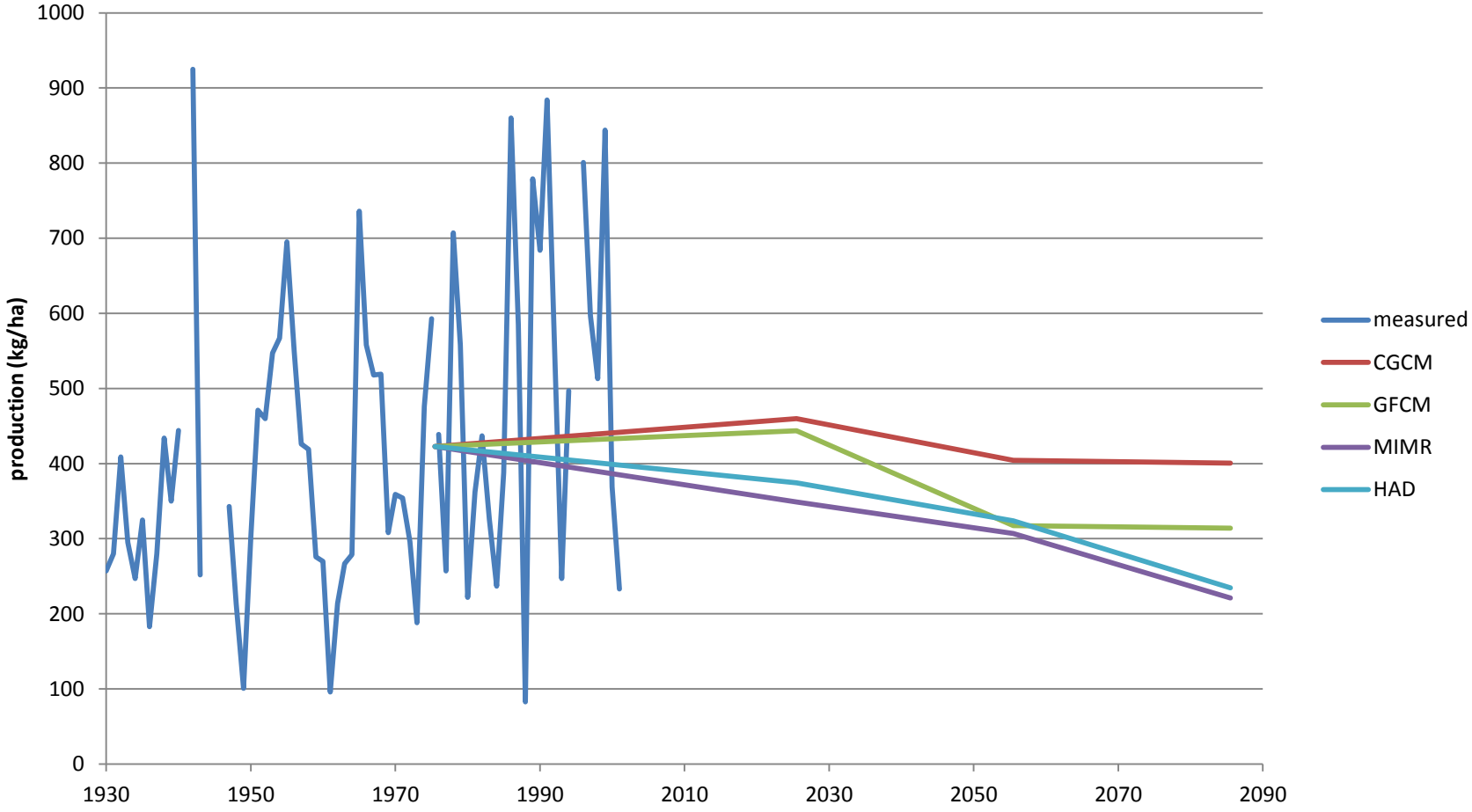
Effects of Extreme Events

- These models represent the average climate – what about year-to-year variation?
- Some studies indicate that climate change will increase variability in precipitation, resulting in more frequent and more intense droughts.
- Droughts are a characteristic feature of grassland climates.
  - immediate response – reduced grassland productivity
  - multi-year response – shift in species composition from taller to shorter species
  - drought of 1930s: increase of early-growing species
- Extreme wet years can also be bad for livestock operations.

Year-to-year variation in measured production at Manyberries, Alberta



Yearly Production at Manyberries, AB, and Effect of Climate Change on Average Production



Adaptation options – the three Rs:

- Short term – **resist** the effects of climate change
- Medium term – increase **resilience**, allowing system to return to previous state following disturbance
- Long term – help the system to adaptively **respond** to change rather than resisting it

Short term adaptations – actions of producers to resist the effects of extreme events

- Reducing numbers of livestock
- Moving livestock to alternative grazing
- Purchasing feed
- Hauling water

Medium term adaptations – actions by producers and government to increase the resilience of the system

- Changing herd structure – higher proportion of yearlings
- Sustainable grazing management to improve rangeland health
- Converting marginal cropland to perennial forages
- Increasing feed reserves
- Improving water storage and distribution systems
- Detection and control of invasive species
- Crop insurance and assistance programs
- Drought monitoring and prediction tools

Long term adaptations

- Predictions of future change are too variable for development of long-term prescriptive plans.
- Have monitoring systems in place so you can detect them and adjust policies accordingly.
- In the meantime:
  - keep grassland systems healthy
  - don’t reduce your future options (e.g. by eliminating grasslands)
  - help grasslands to respond to change.

Helping grasslands to respond

- Prairie grasslands have a high capacity to respond to climatic variability by shifts in proportions of species.
- But eventually new species will have to move northward.
- Habitat fragmentation will impede this response.
- Conserving as much grassland as possible, and maintaining connections between patches, will facilitate migration.

Grassland fragmentation (SW Manitoba)