Impacts of Climate Change on Rocky Mountain River Flows

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Waterton Lakes National Park

November 2019

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Water Management in the South Saskatchewan River Basin (SSRB)

Irrigation development in southern Alberta was inevitable

- Fertile soils, abundant sunshine
- Limited rainfall, reliable river flows
- Flat, sloping landscape

Climatic variation

John Palliser – 1859 – an inhospitable desert
- drought, fires

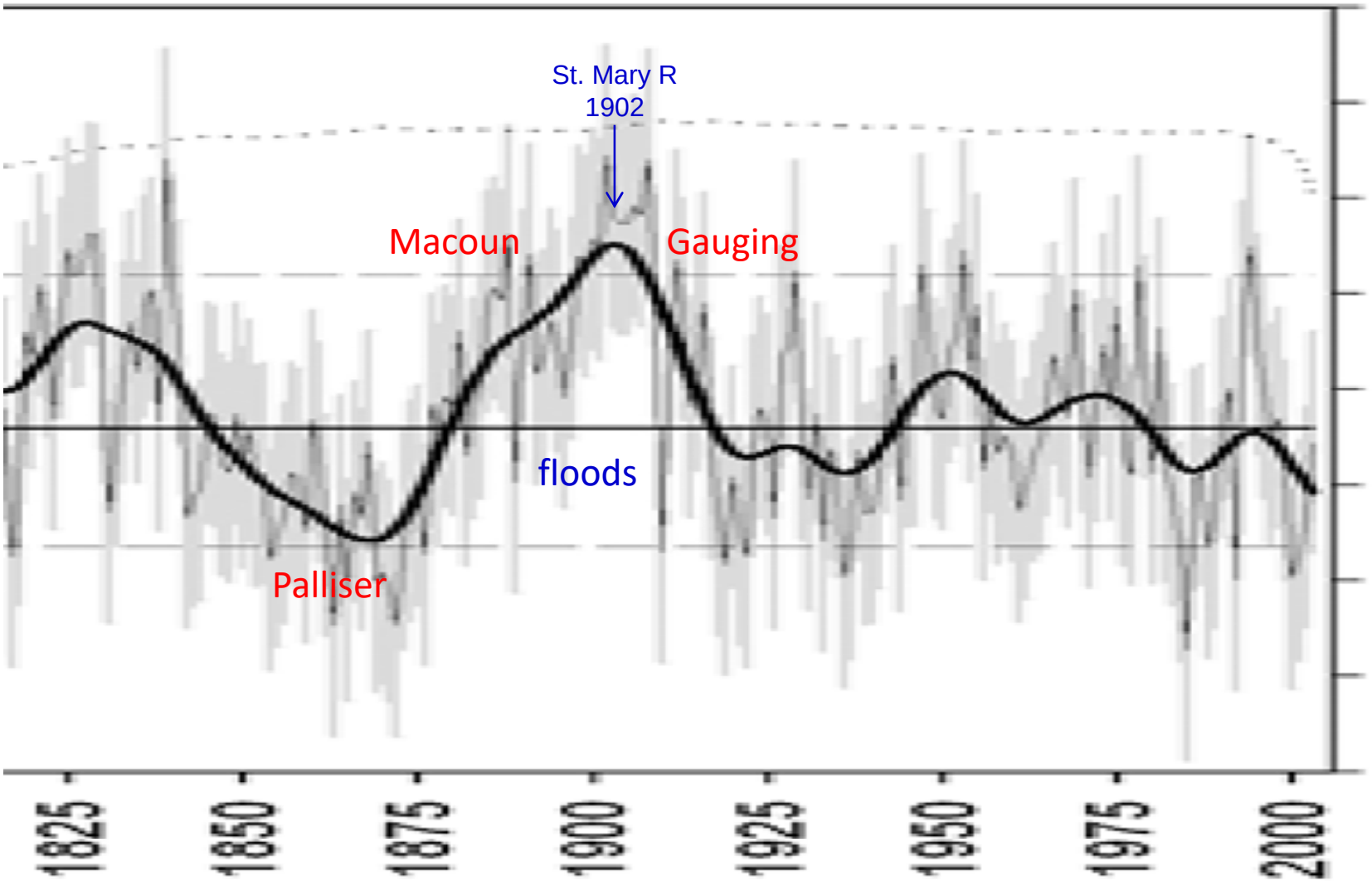
John Macoun – 1880s – an oasis

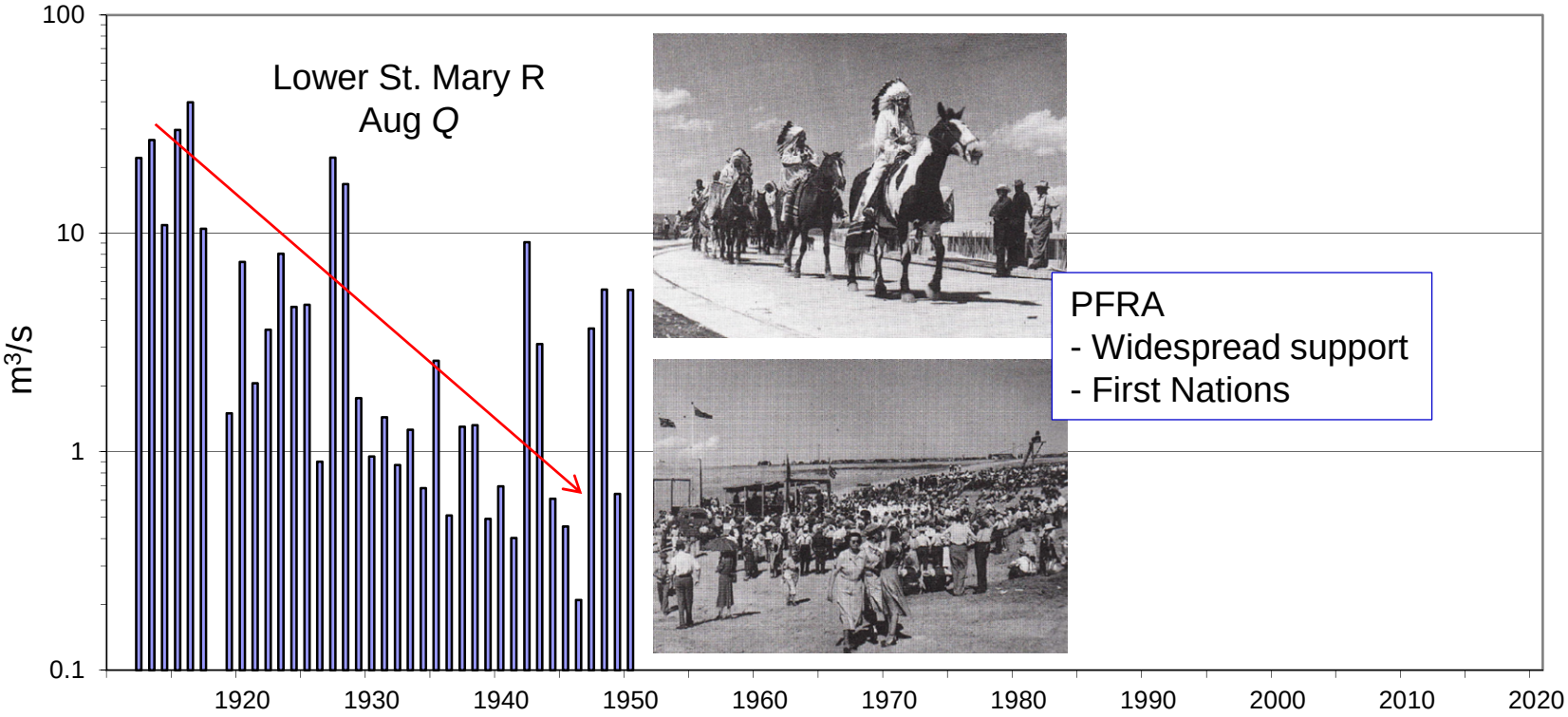
1900 1950 2000

1867 – Confederation
1882 – Navigable Waters Protection Act
1887 – Treaty 7
1899 – St. Mary Project
1905 – Province of Alberta
1909 – Boundary Waters Treaty

Axelson et al (2009) *WRR*

Oldman River flow reconstruction from conifer rings





Master Agreement on Apportionment (MAA) 1969

1900 1950 2000

St. Mary Dam 1951

Waterton Dam 1964

‘Any water flowing to Saskatchewan is wasted’

‘Rivers provide valuable but vulnerable resources’

MAA

1900

1950

2000

LNID Weir 1922

St. Mary Dam 1951

Oldman Dam 1991

An impending water crisis in Canada's western prairie provinces

PNAS 2006

D. W. Schindler*† and W. F. Donahue‡

River flows integrate hydrology over watersheds.

The Rocky Mountains and foothills provide the source for the SSRB.

While river flows have declined, how much has climate change contributed?

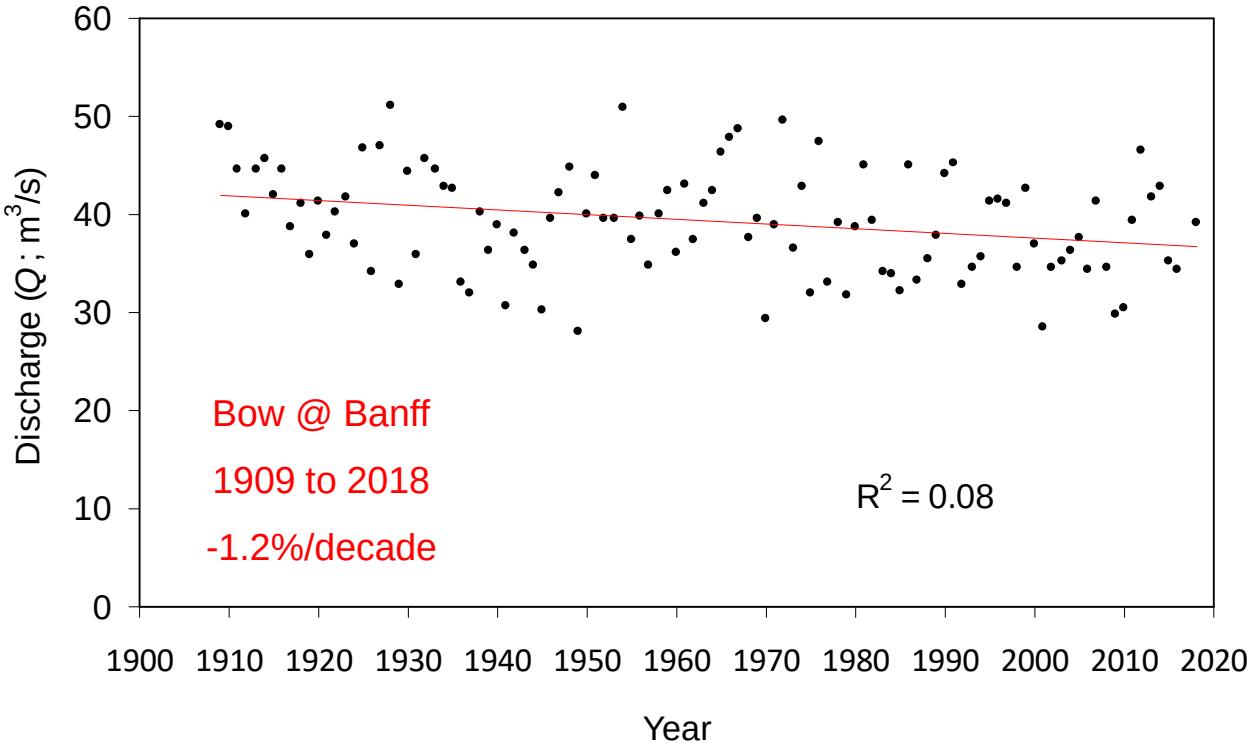
- Analyze flows upstream of withdrawals.
- Unaltered watersheds – e.g. Waterton & Banff.

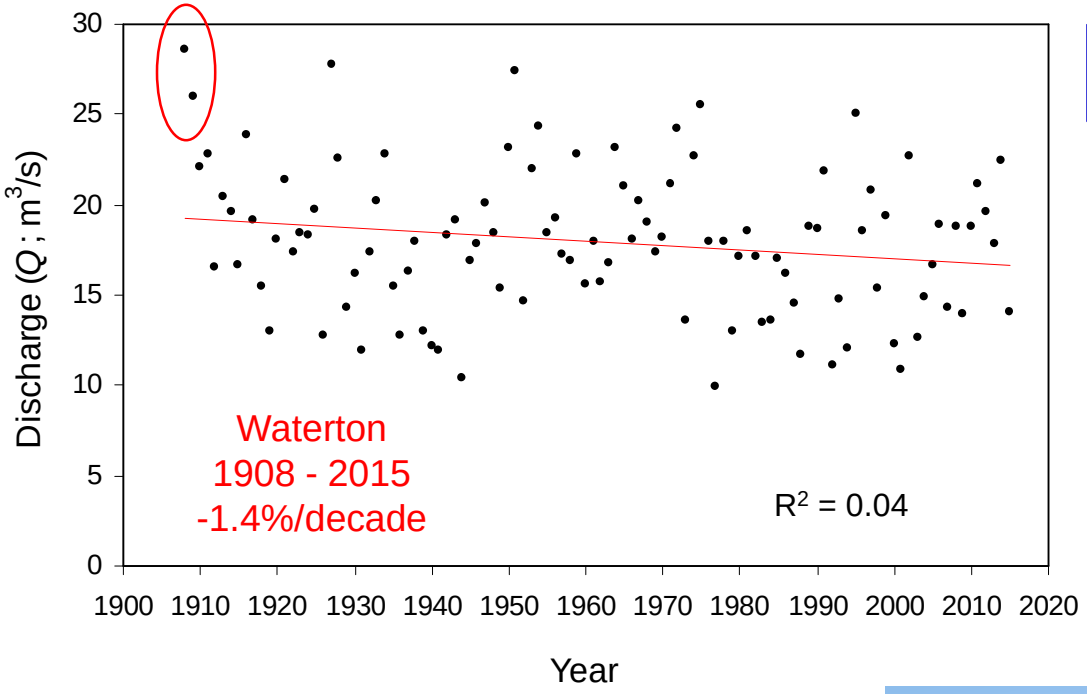
Oldman River
Lethbridge, July 1988

Extend time series:

Annual *Q* from summer *Q*

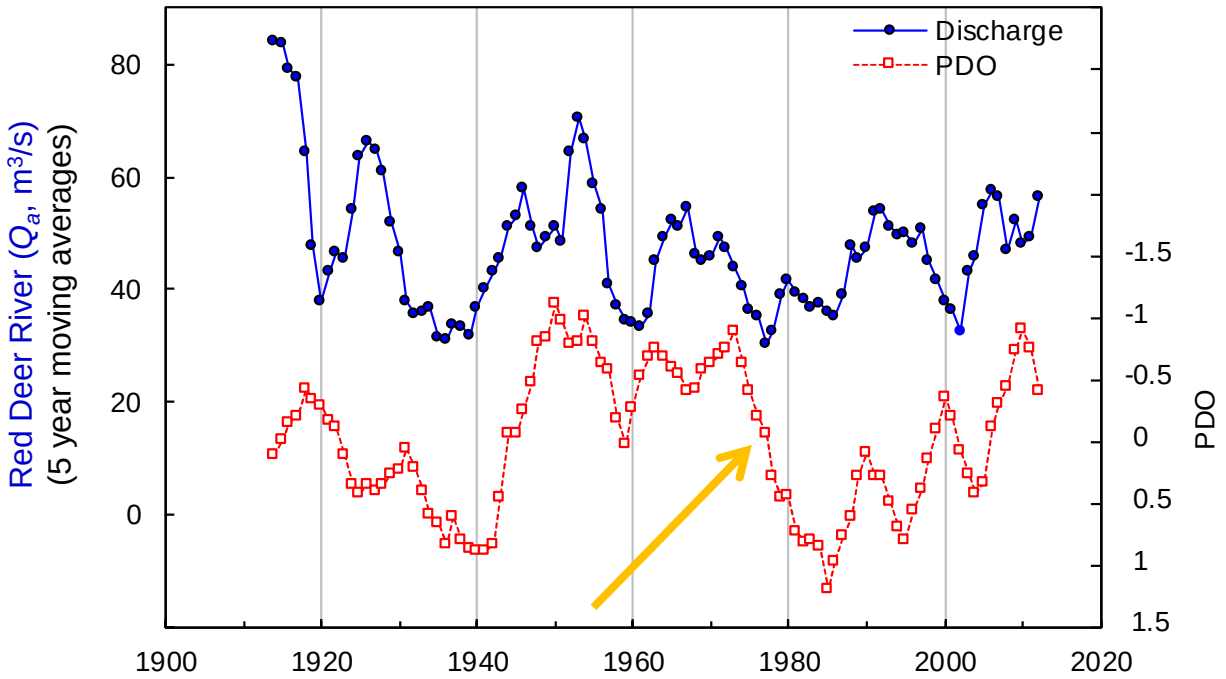
Coordination across gauges



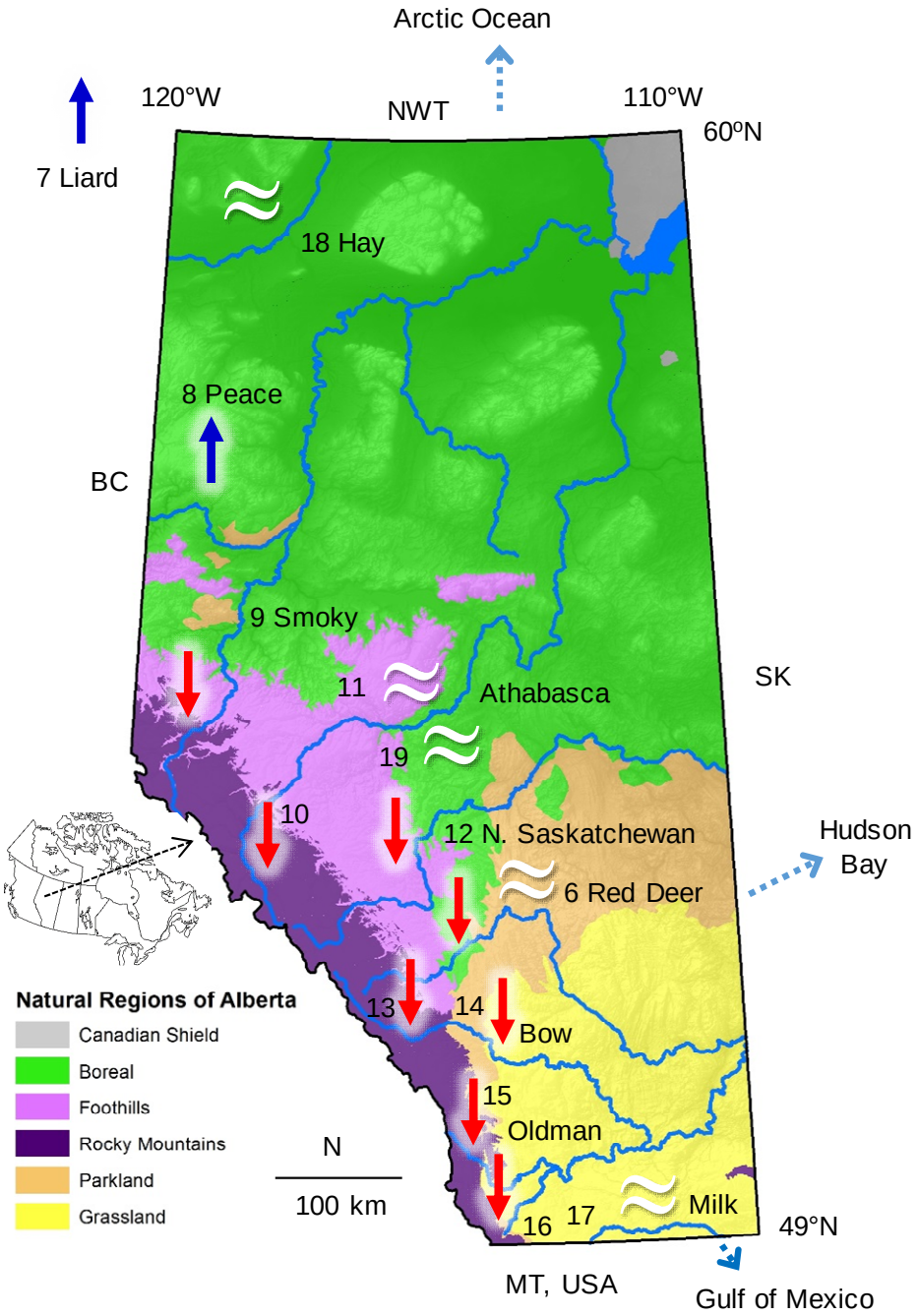


Also: Non-parametric rank-order tests.

Pacific Decadal Oscillation (PDO)

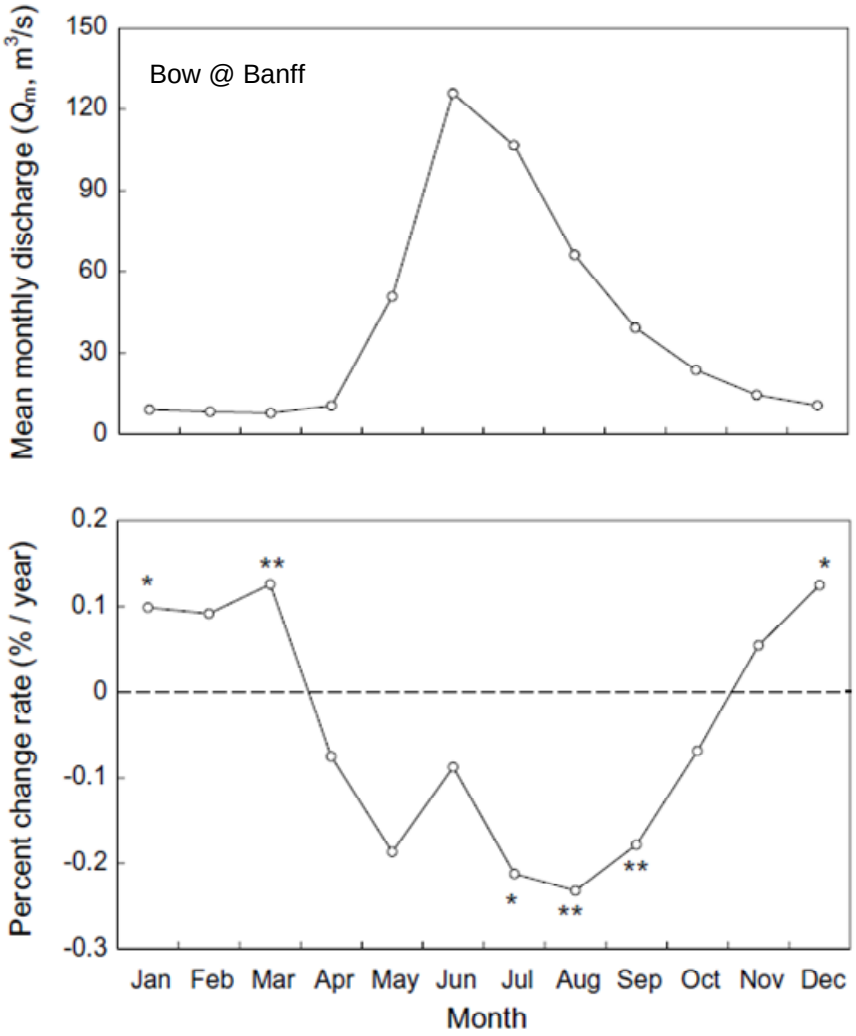


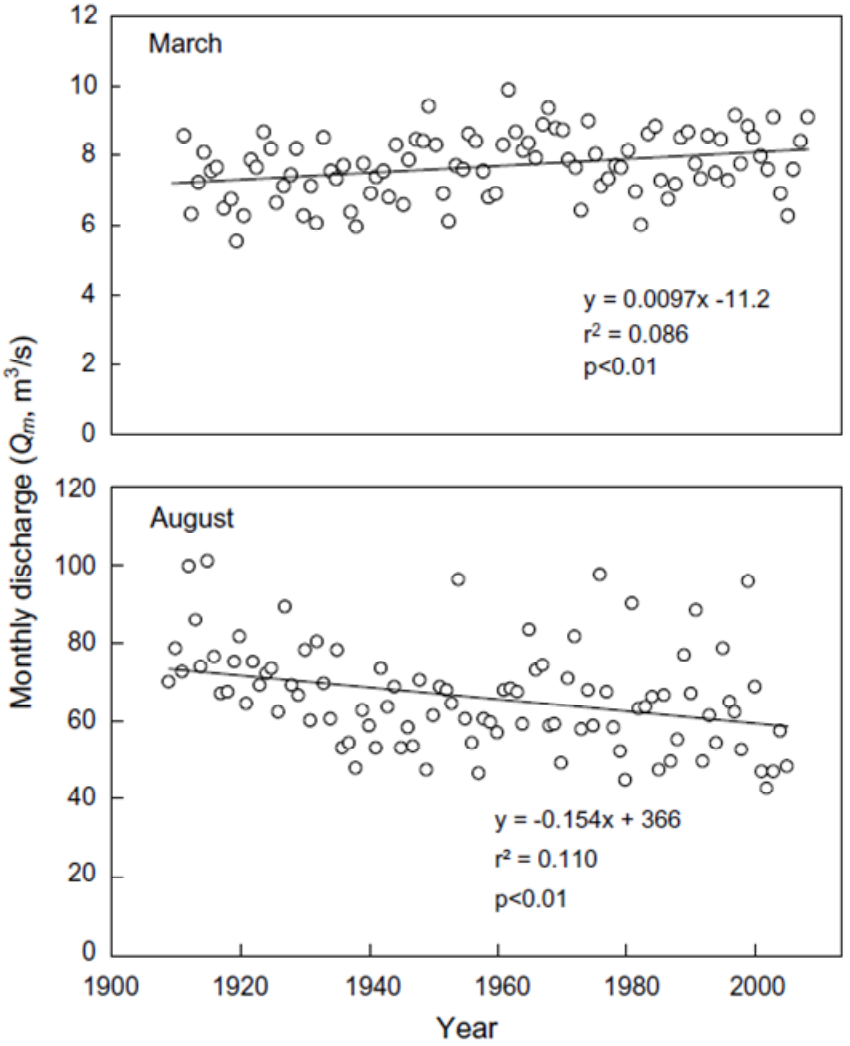
Philipsen et al 2018
Hydrological Processes



Philipsen et al 2018
Hydrological Processes

Greater changes in flow seasonality

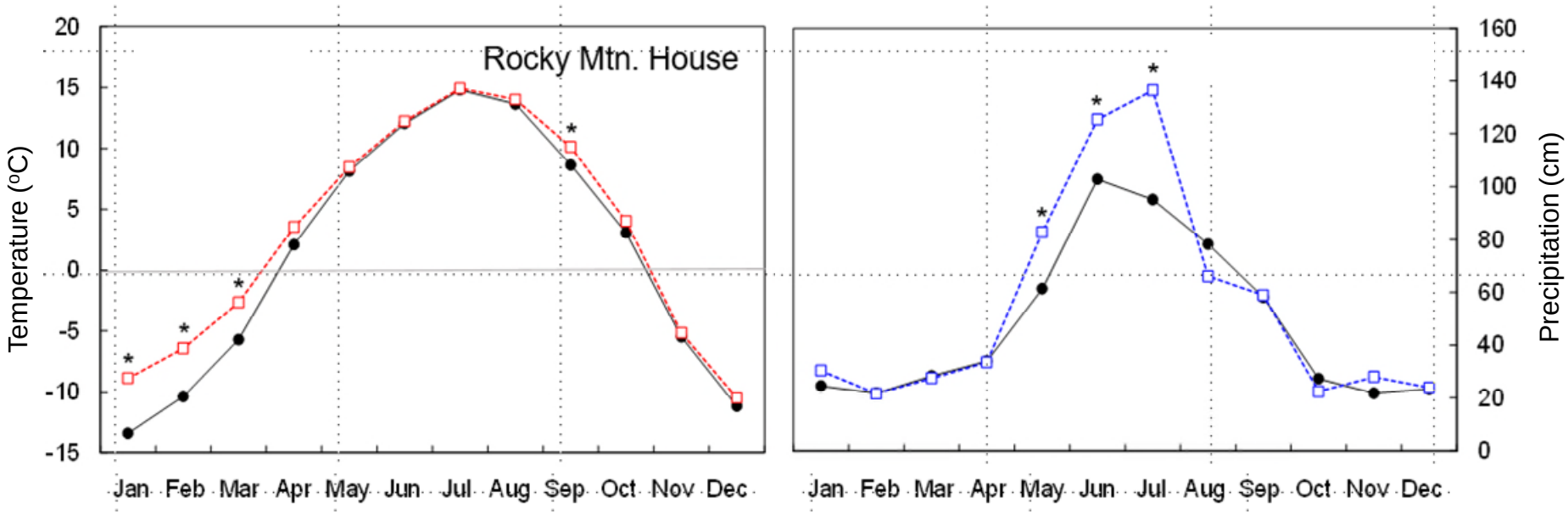




Rood et al 2008
J Hydrology

Underlying Mechanism

Winter and Spring Warming Δ/century Increasing Precipitation



Philipsen et al 2018
Hydrological Processes

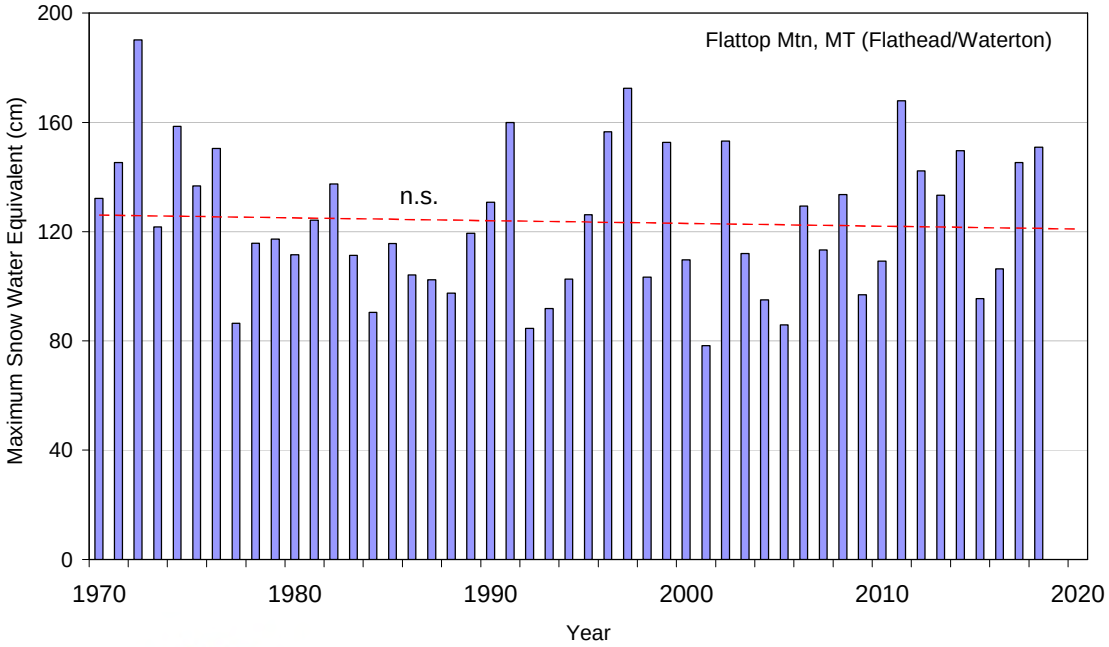
Snow packs

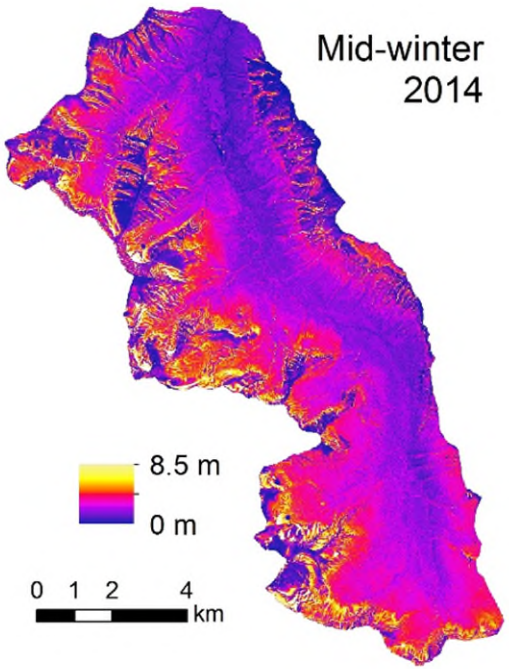
Projected to decline

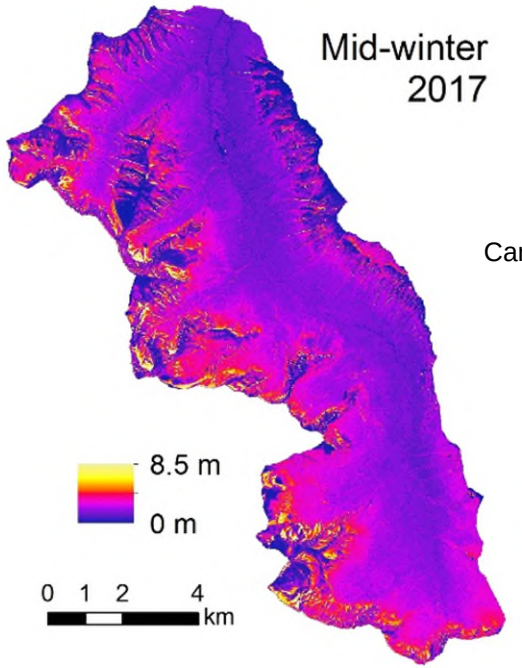
MacDonald et al (2011) *J HydroMet*

Little change →

Castle - Snow Depth LiDAR ↘



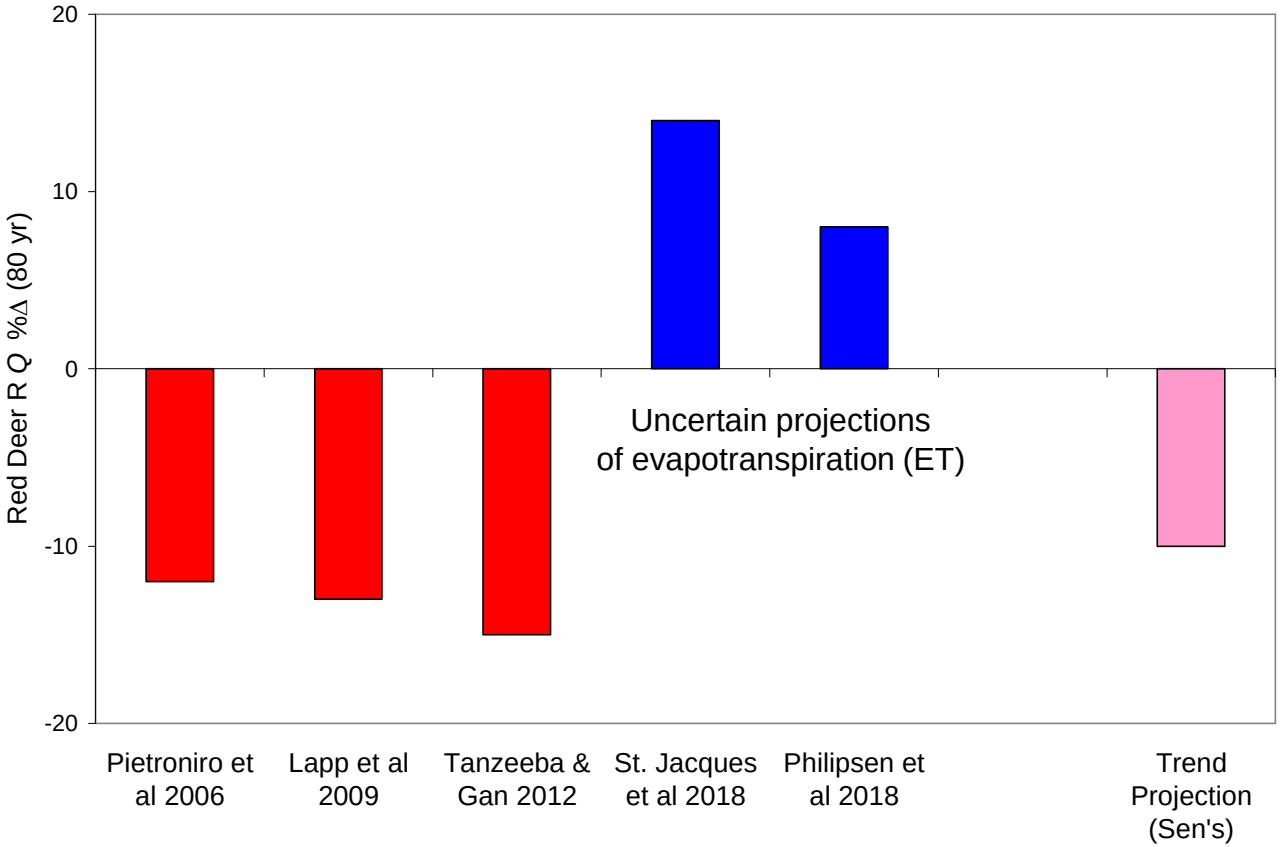




Cartwright, Hopkinson et al
in preparation

Hydroclimatic modeling:

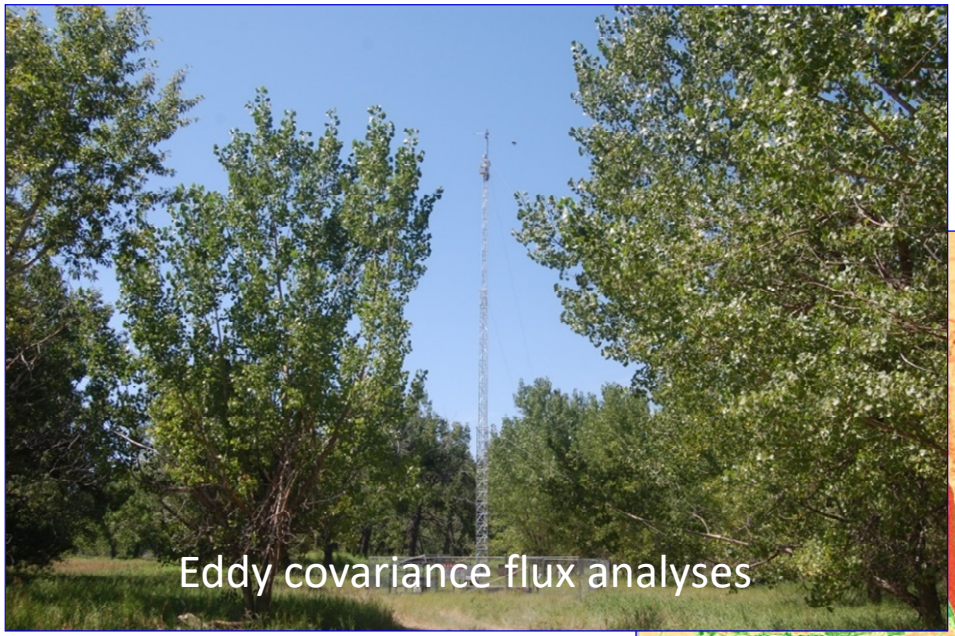
- GCMs & Simulations
- Regional down-scaling
- Watershed routing

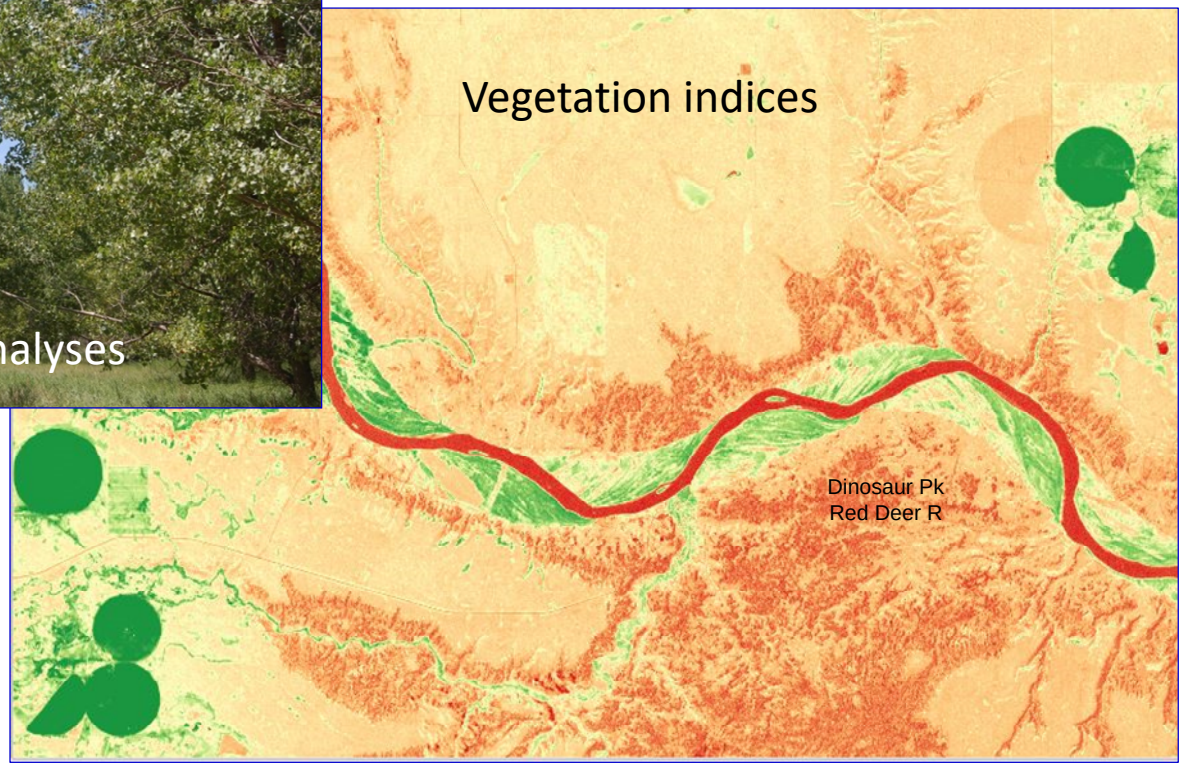


Philipsen et al 2018
Hydrological Processes

Evapotranspiration (ET)

- Seasonal water use by different vegetation communities
- Influences of ΔT & ΔP





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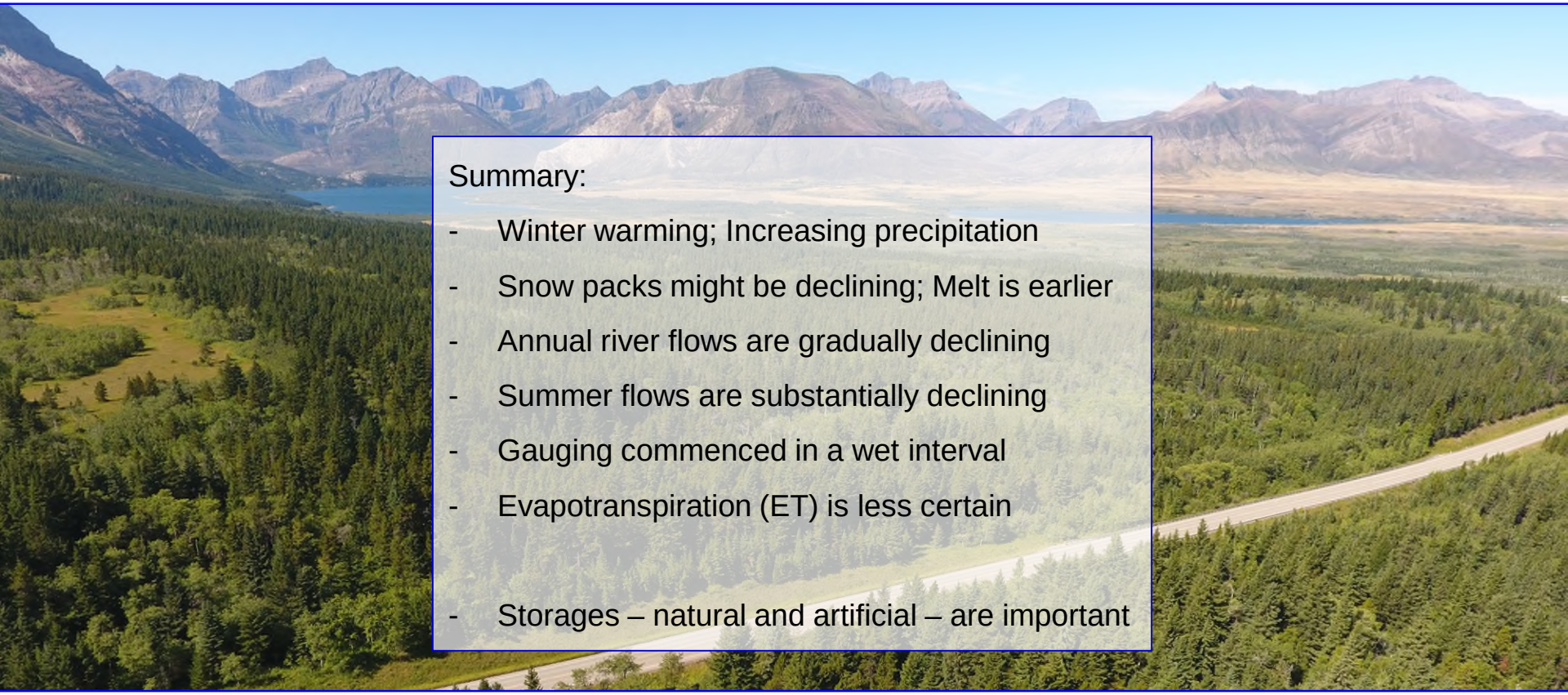

Summary:

- Winter warming; Increasing precipitation
- Snow packs might be declining; Melt is earlier
- Annual river flows are gradually declining
- Summer flows are substantially declining
- Gauging commenced in a wet interval
- Evapotranspiration (ET) is less certain
- Storages – natural and artificial – are important

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