

2000 Year History of Drought in the Prairies

Dave Sauchyn and Samantha Kerr

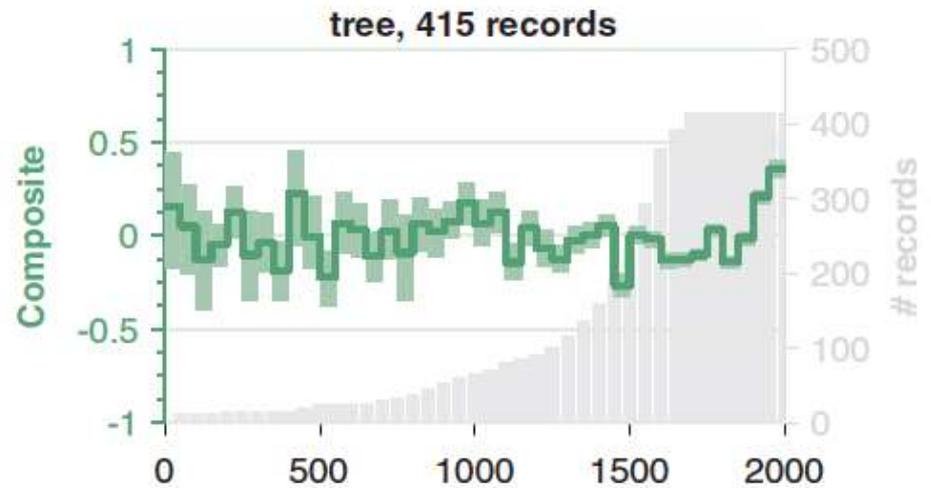
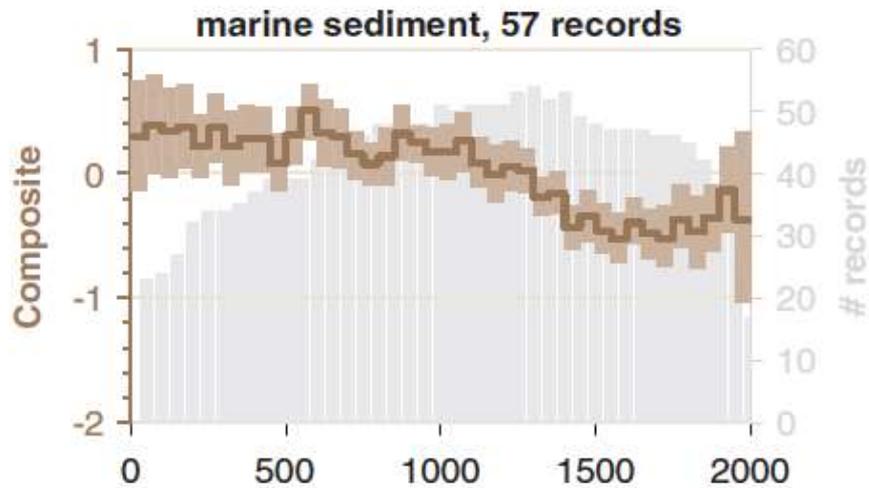
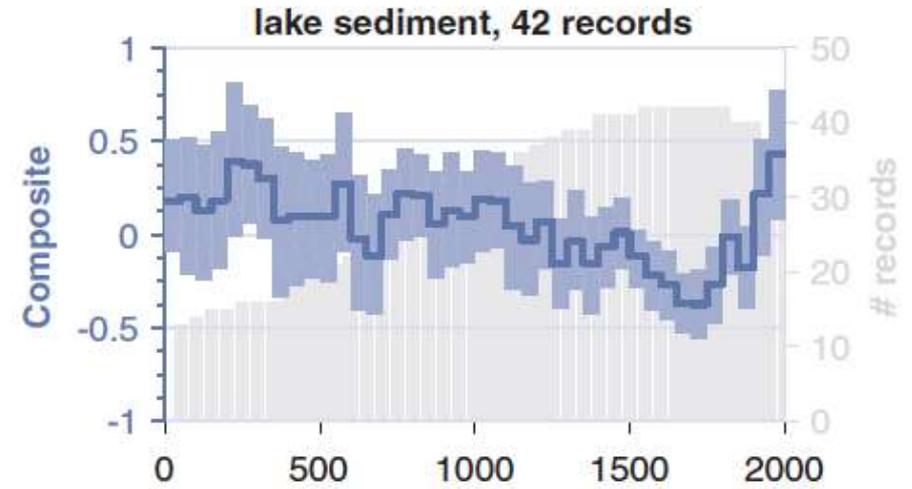
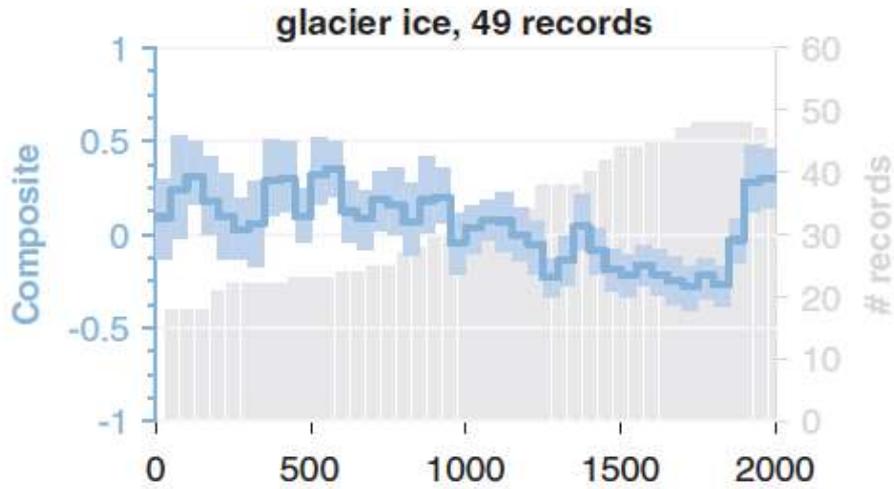
Prairie Adaptation Research Collaborative, University of Regina



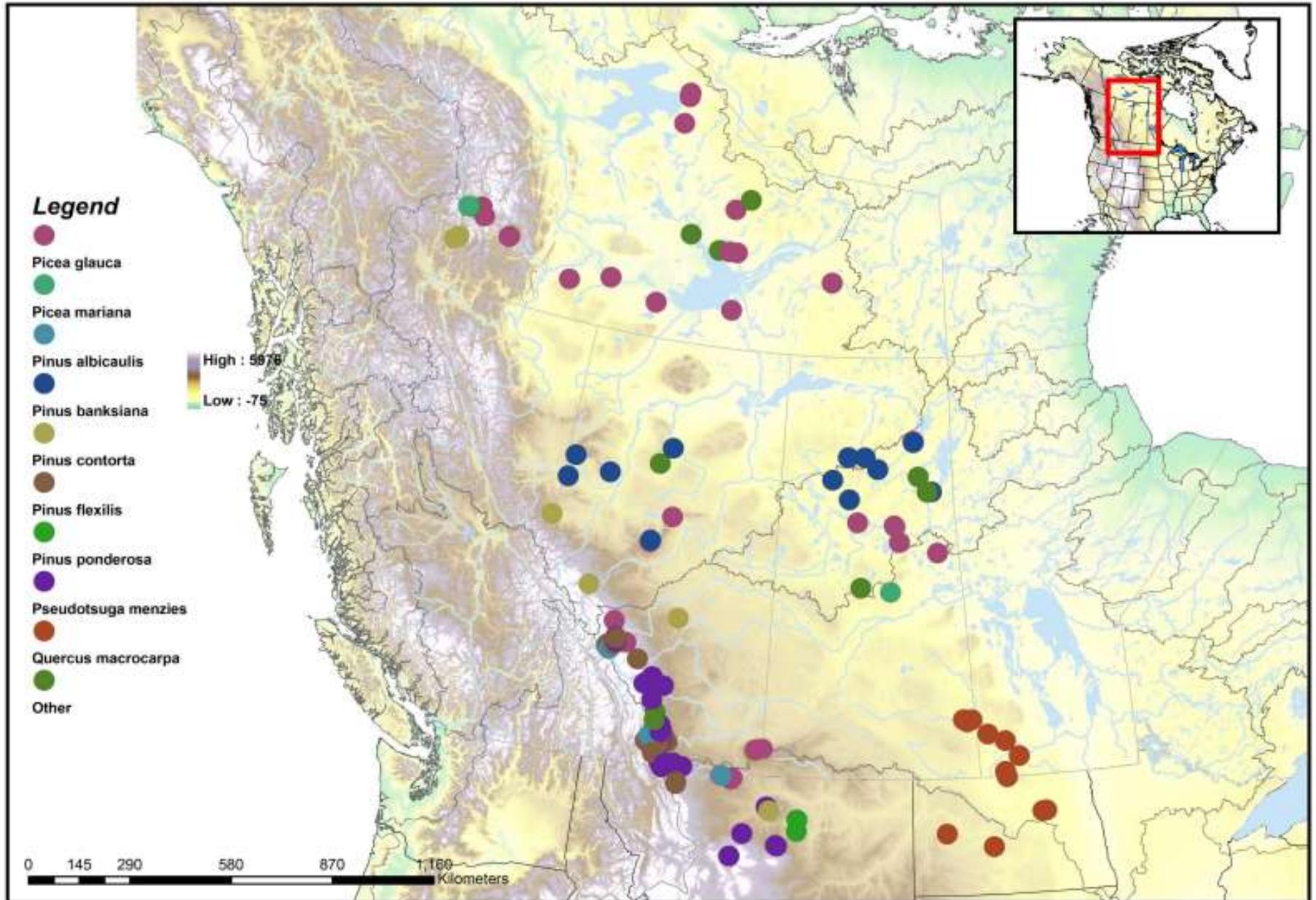
NADM Forum, Calgary, 01 May 2018



PAGES2k Consortium. 2017. A global multi-proxy database for temperature reconstructions of the Common Era, *Nature Scientific Data*

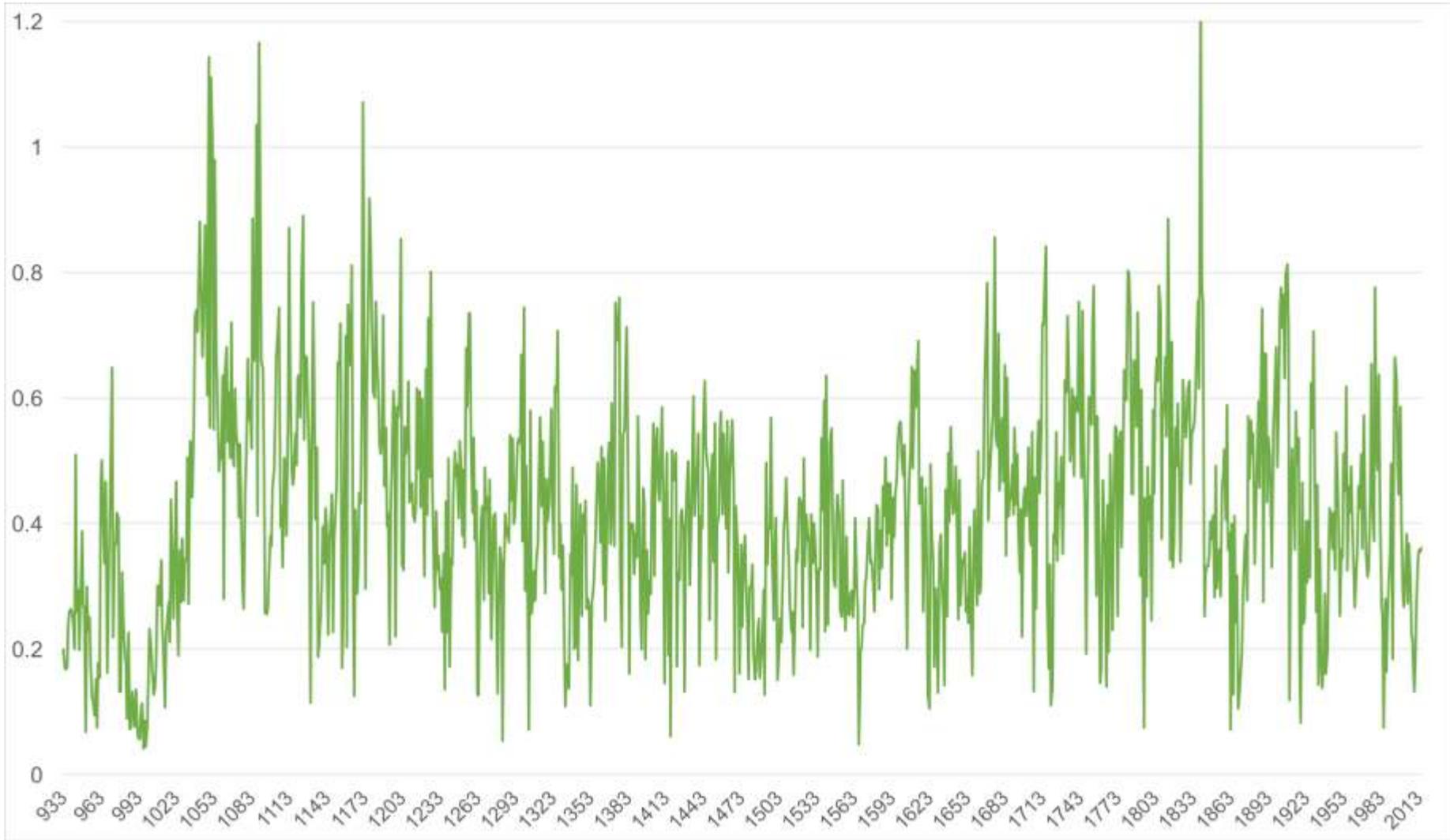


University of Regina, Tree-Ring Network

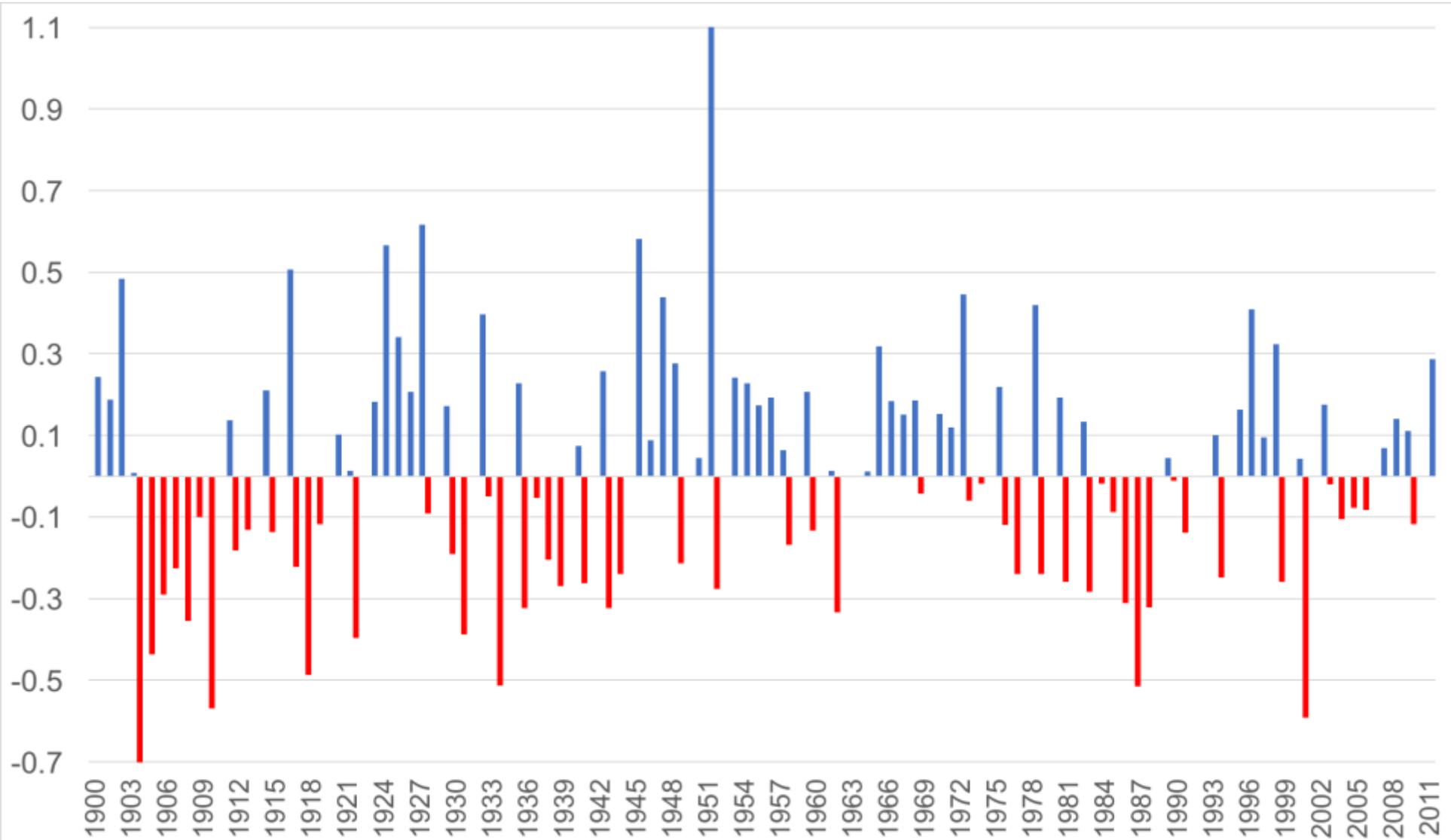




Oldman River, Limber Pine, Standardized Ring-Width Chronology, 933-2015



SPEI Calgary, 1900-2011



Address Information Gaps:

2011

City of Calgary: Drought Management Plan

“In order to expand The City’s understanding of historical drought conditions it is important to **reevaluate historical drought using tree ring analysis** historically conducted by the David Sauchyn (University of Saskatchewan [*sic*])”



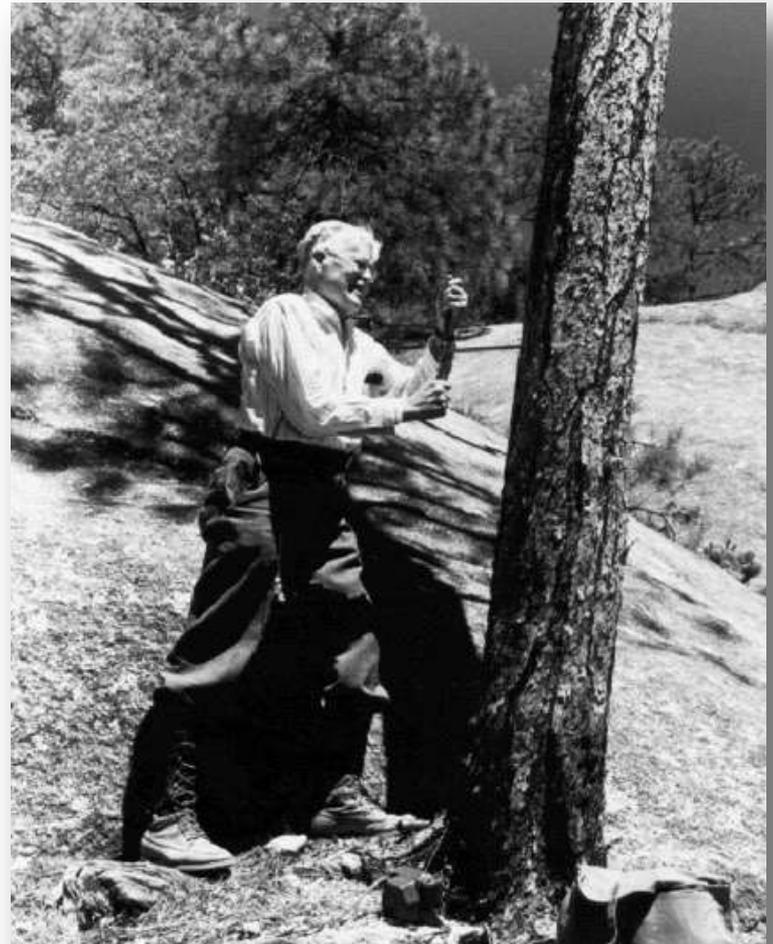


Theophrastus of Eru; a pupil of Aristotle (Greece 322 BC):
Recognized the annual nature of tree rings in two fir species

Leonardo da Vinci: “Rings in the branches of sawed trees show the number of years and, according to their thickness, the years which were more or less dry.”

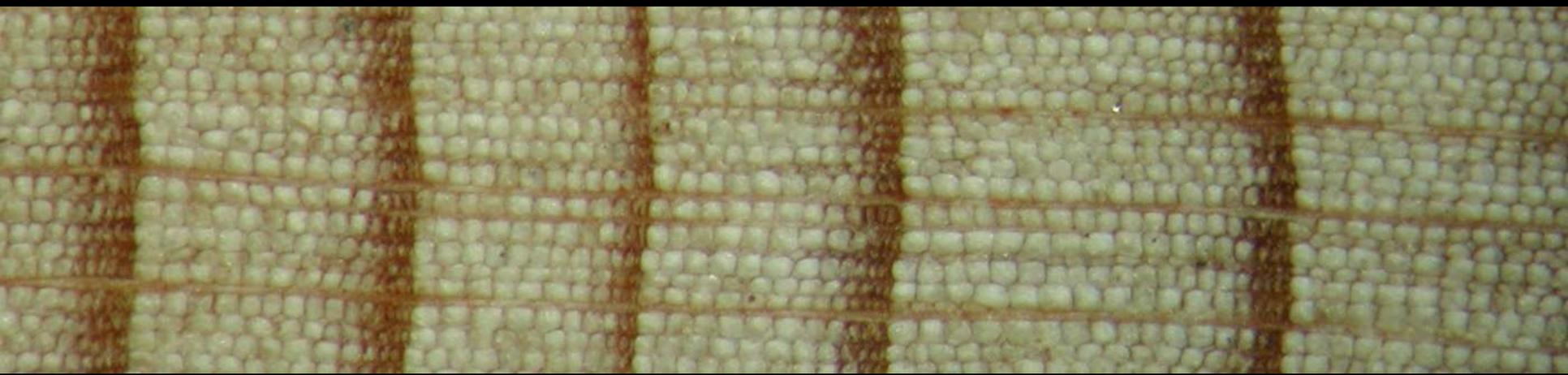
Jacob Kuechler: studied post oaks Texas in the 1850s, “ A tree contains the record of its life history, and this history is most closely interwoven with the annual rainfall.”

In 1894, **Andrew E. Douglass** (1867-1962) was sent to Arizona to build an observatory. He noticed similar ring-width patterns in the stumps of the trees cut for construction. He founded the **Laboratory of Tree-Ring Research.**



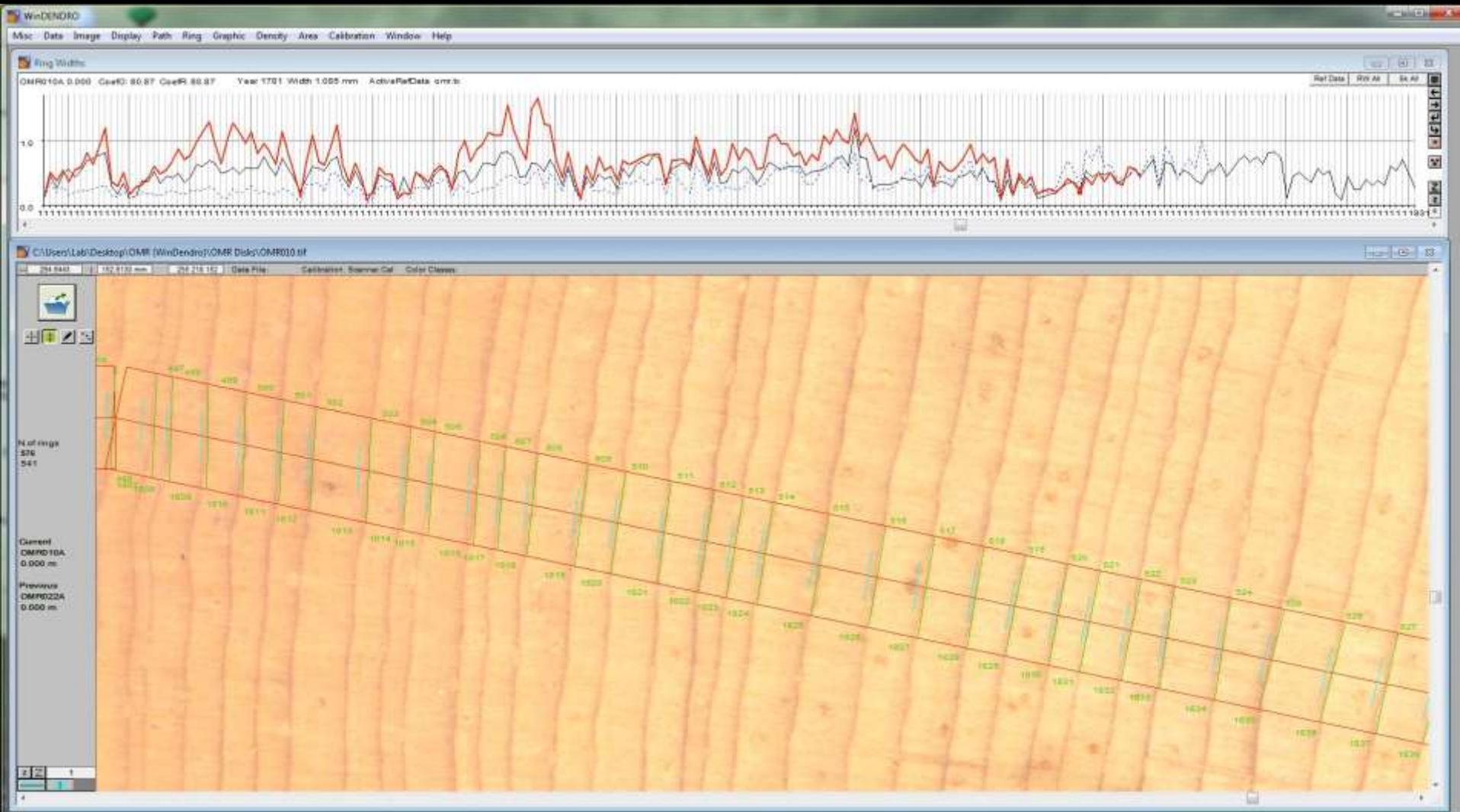
Cross-Dating

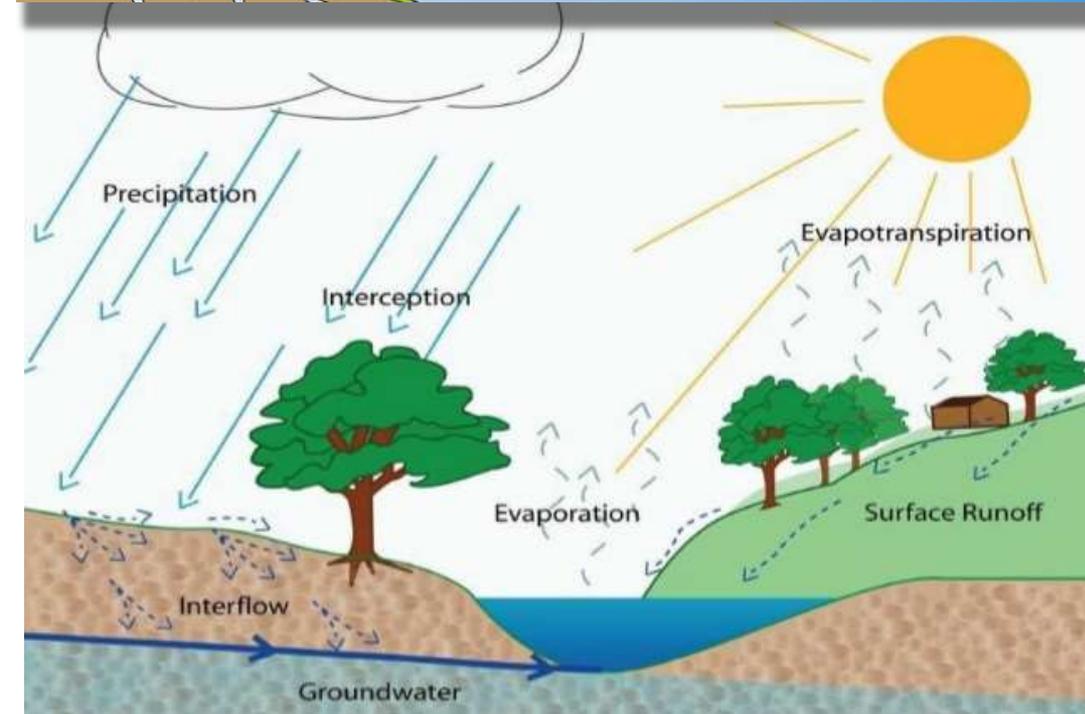
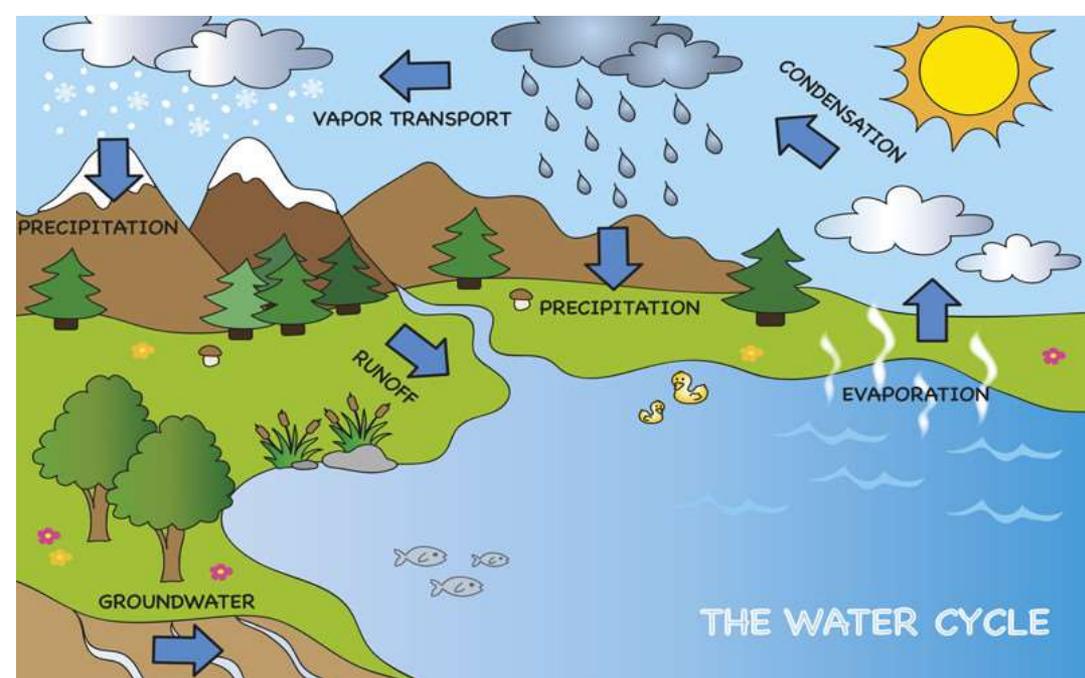




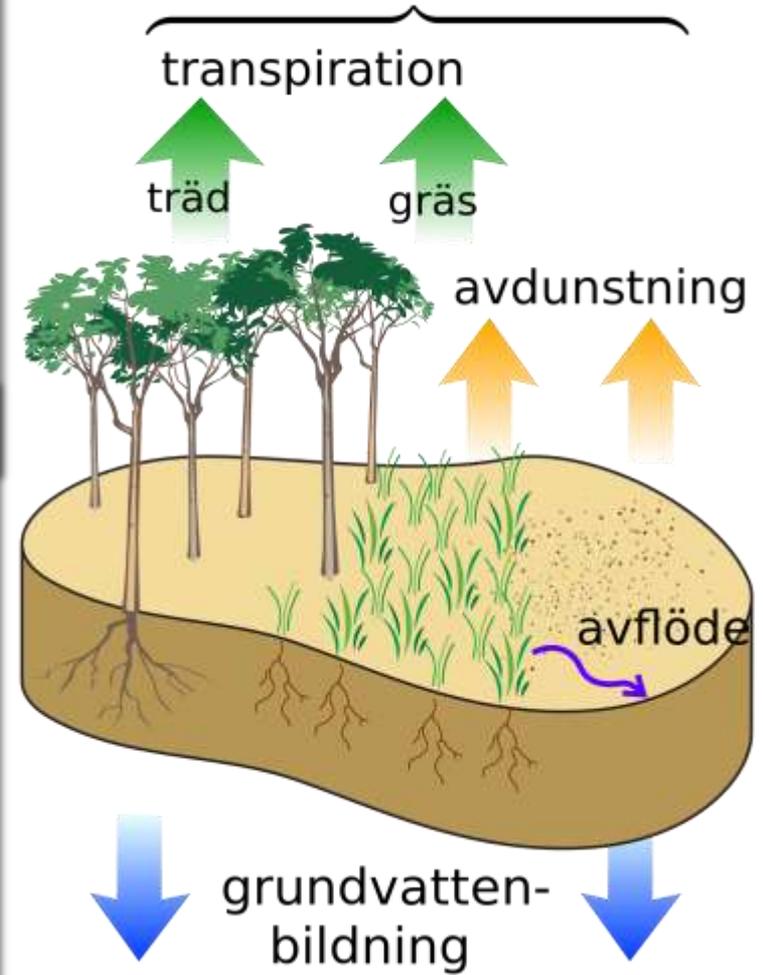


WinDendro: Semi-automated image analysis and measurement of tree rings





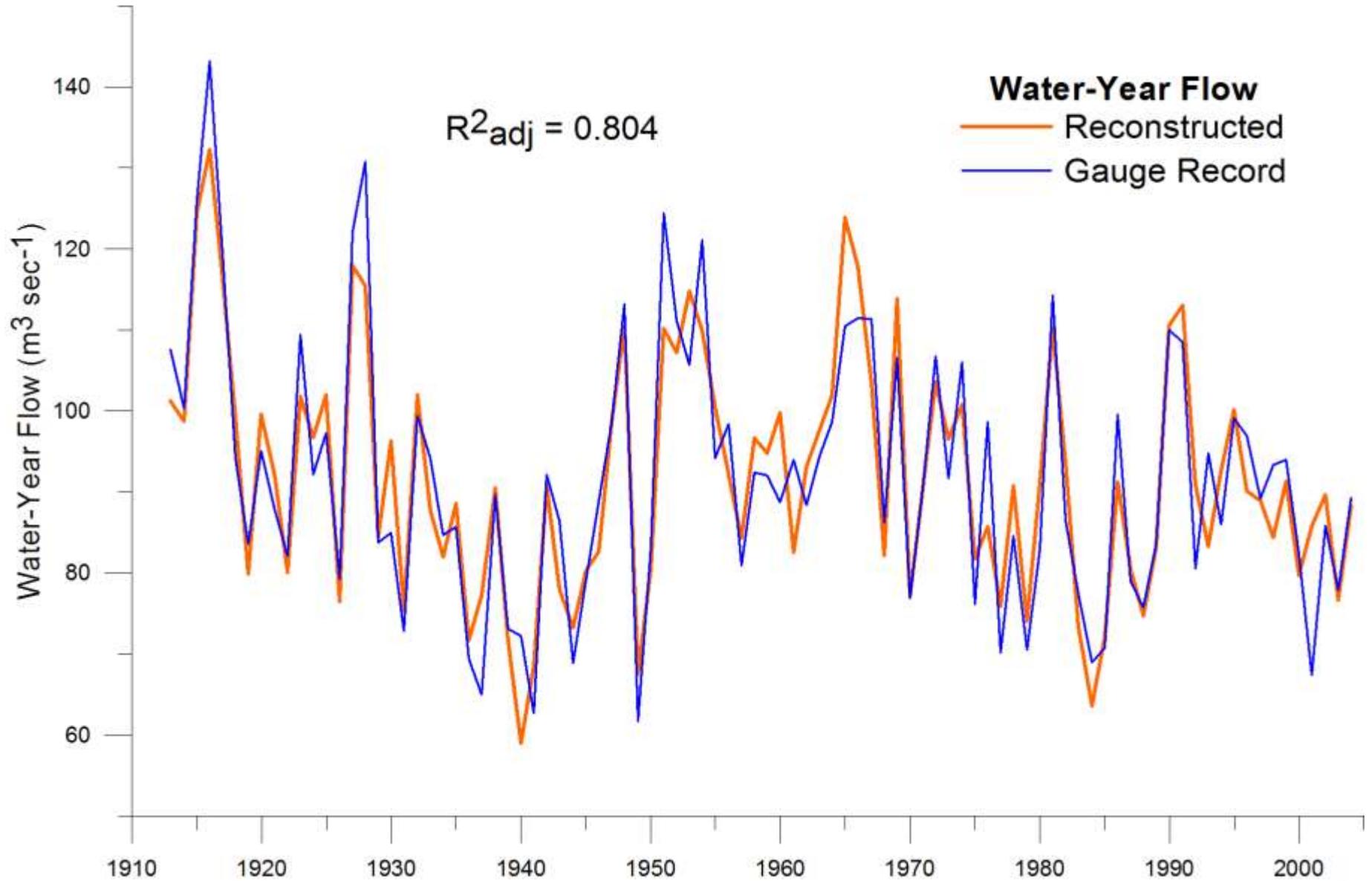
evapotranspiration =
transpiration + avdunstning



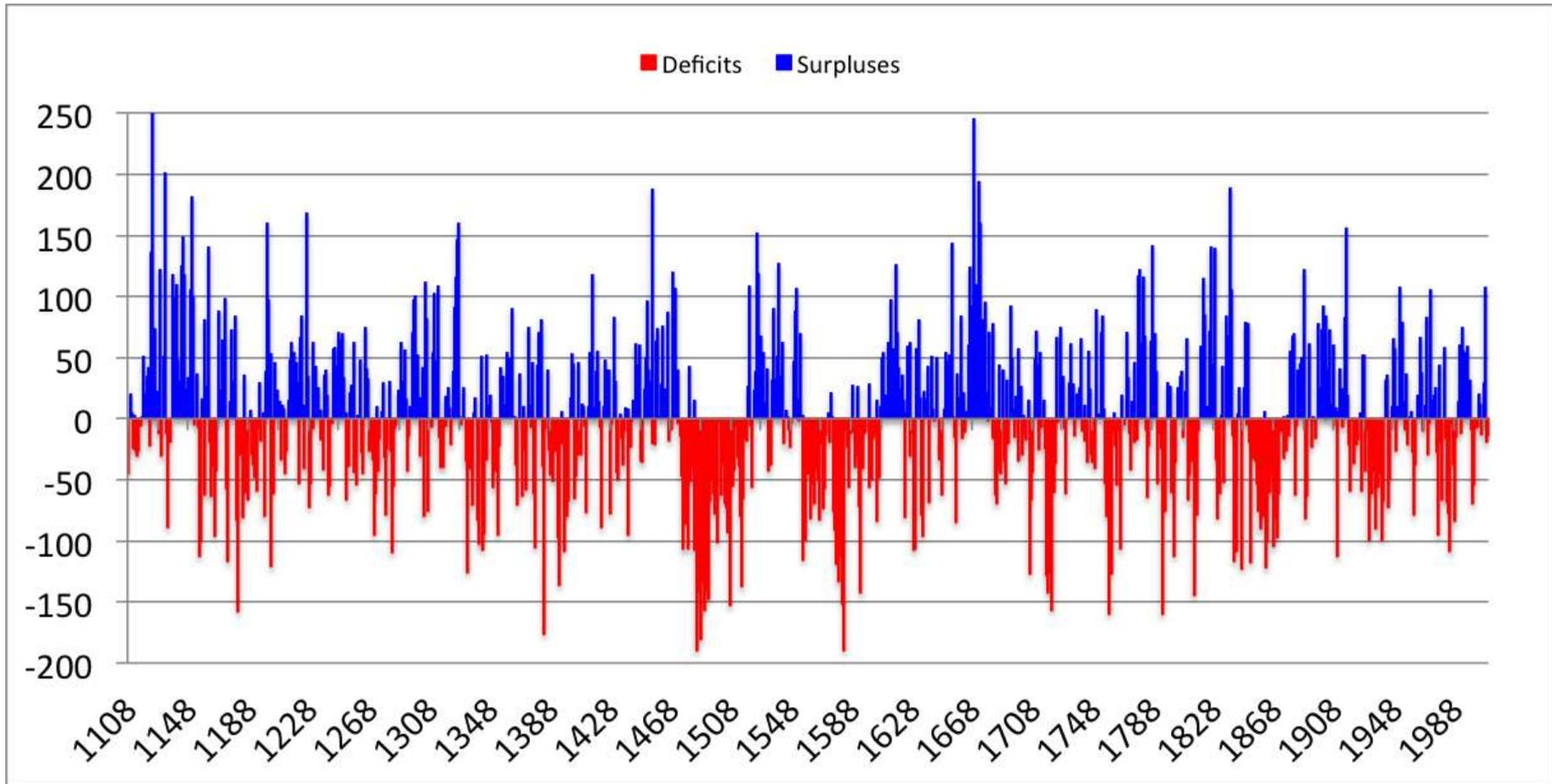
Bow River at Stoney Trail, Calgary



Reconstructed and Recorded Flow, Bow River



Mean Water Year Flow (m³/s) South Saskatchewan River at Medicine Hat, 1108-2010





Kettle Lake, northwestern North Dakota (Clark et al., 2002)

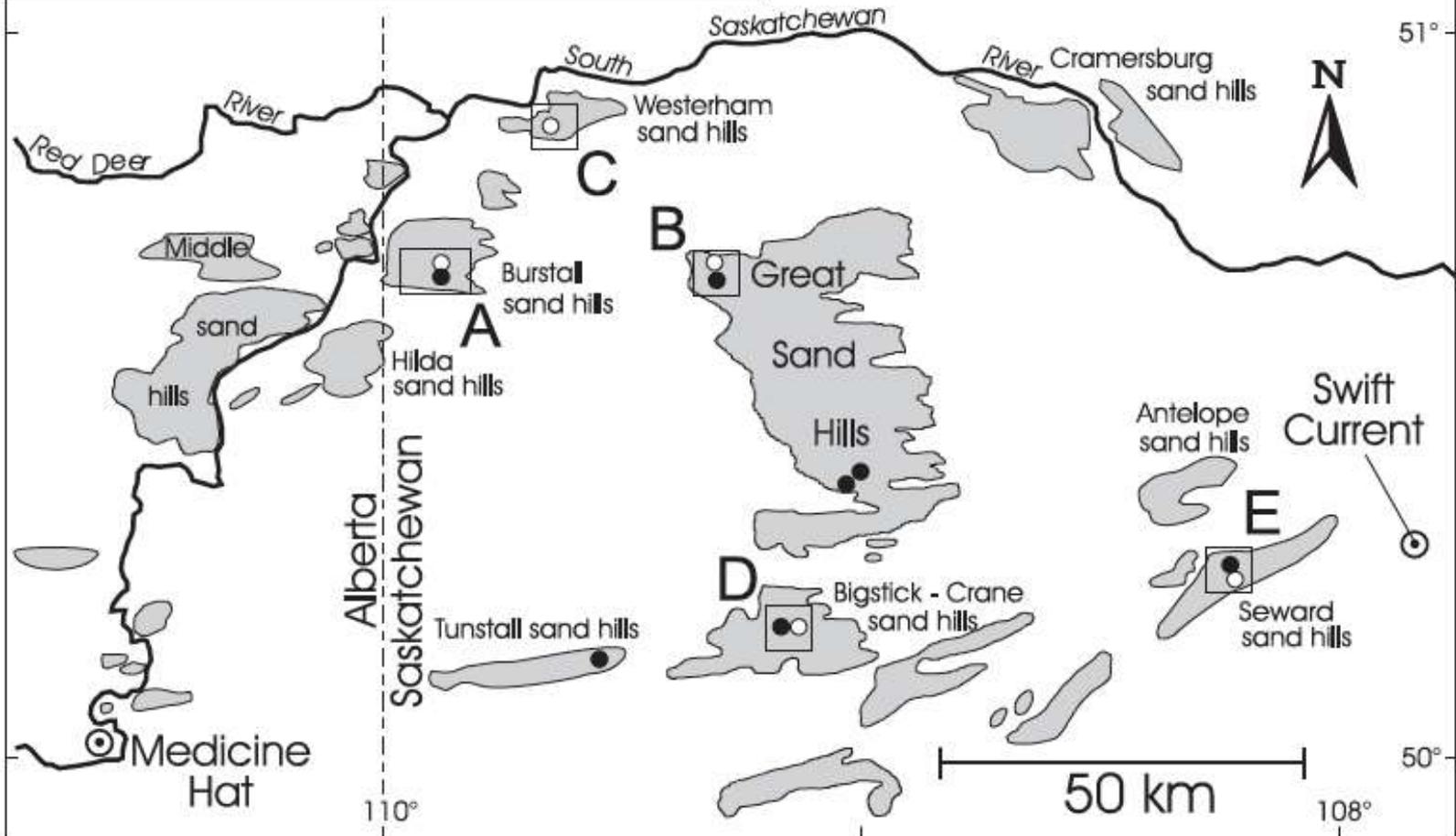
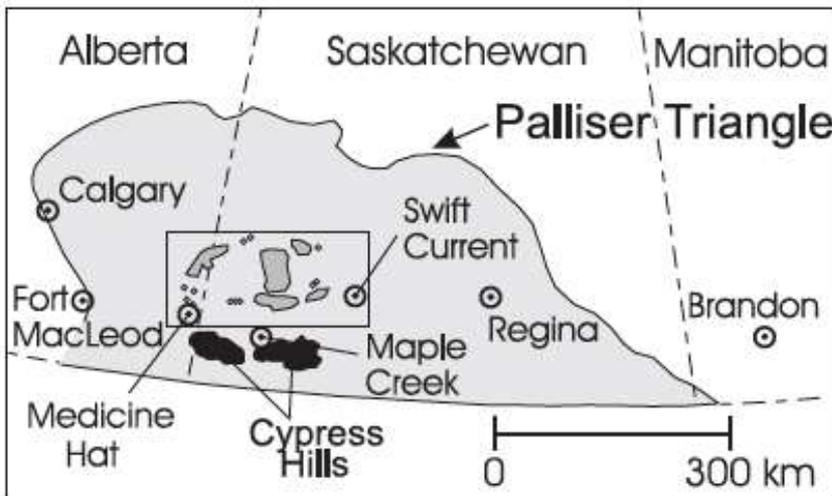
Drought:

- grass pollen inputs dropped to between less than 5% to about 8%
- quartz levels spiked, indicating erosion; and charcoal amounts dropped to near zero suggesting the vegetation was too dry to support prairie fires
- repeated drought cycles shifted the vegetation composition permanently to more C₃ grasses; drought tolerance of C₄ grasses was exceeded in summer

“drought severity during past, and possibly future, arid phases cannot be anticipated from the attenuated [historical] climate variability ... **the Dust Bowl was unremarkable in the context of the last two millennia**”

Sand Dune Activity

Wolfe et al., 2001



Sand Dune Record

Great Sand Hills, southwestern Saskatchewan (Wolfe et al., 2001) - extensive activity starting in the late 18th century resulting from **recurring drought in the 1700s**

Multiple dune fields (Hugenholtz et al., 2010) - **widespread activity up to the mid 19th century**, and **declining activity since then** in the absence of sustained severe drought, and with the demise of bison and human (aboriginal) populations

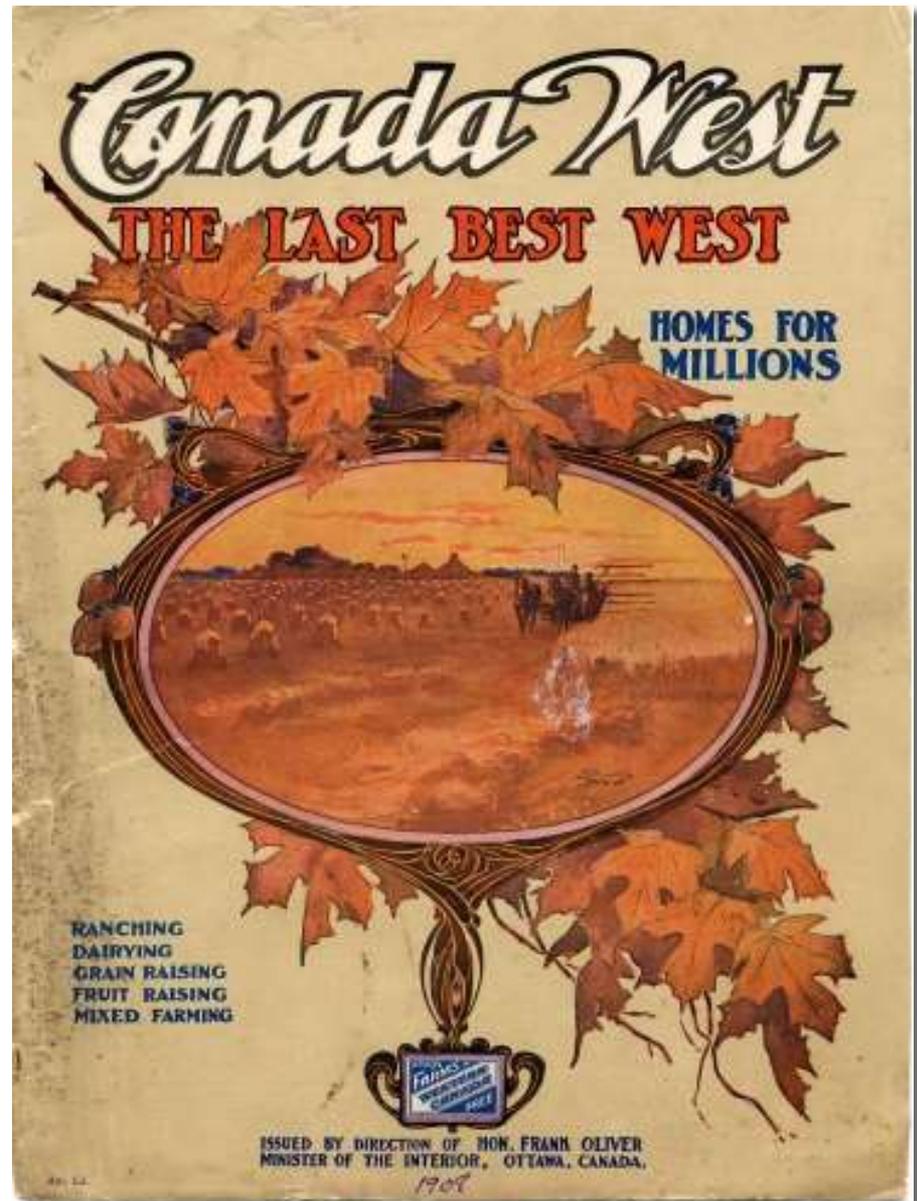
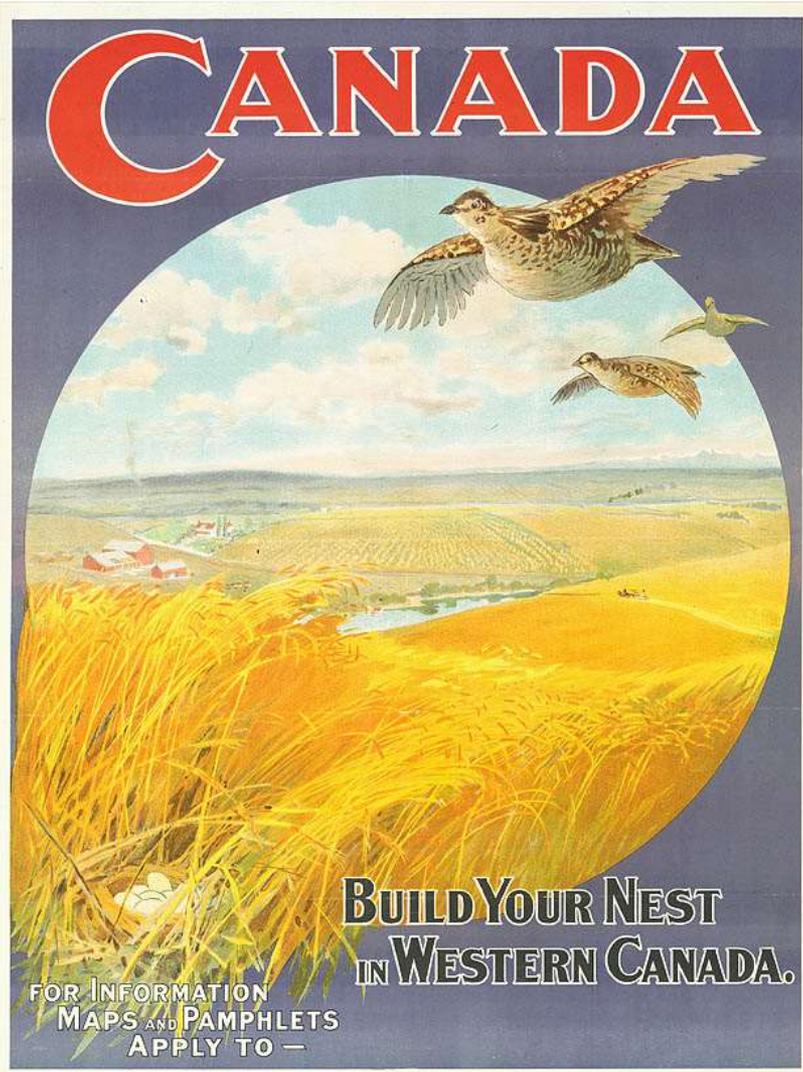
Middle Sand Hills, eastern Alberta (Wolfe et al. , 2013) - Now buried sand was previously exposed to light in the **1850s** when John Palliser passed through this dune field and observed “**miles of burning sand**”

This large belt of country embraces districts, some of which are valuable for the purposes of the agriculturalist, while others **will forever be comparatively useless.**
John Palliser, London, July 8, 1860



It would be almost criminal to bring settlers here to try to make a living out of straight farming.

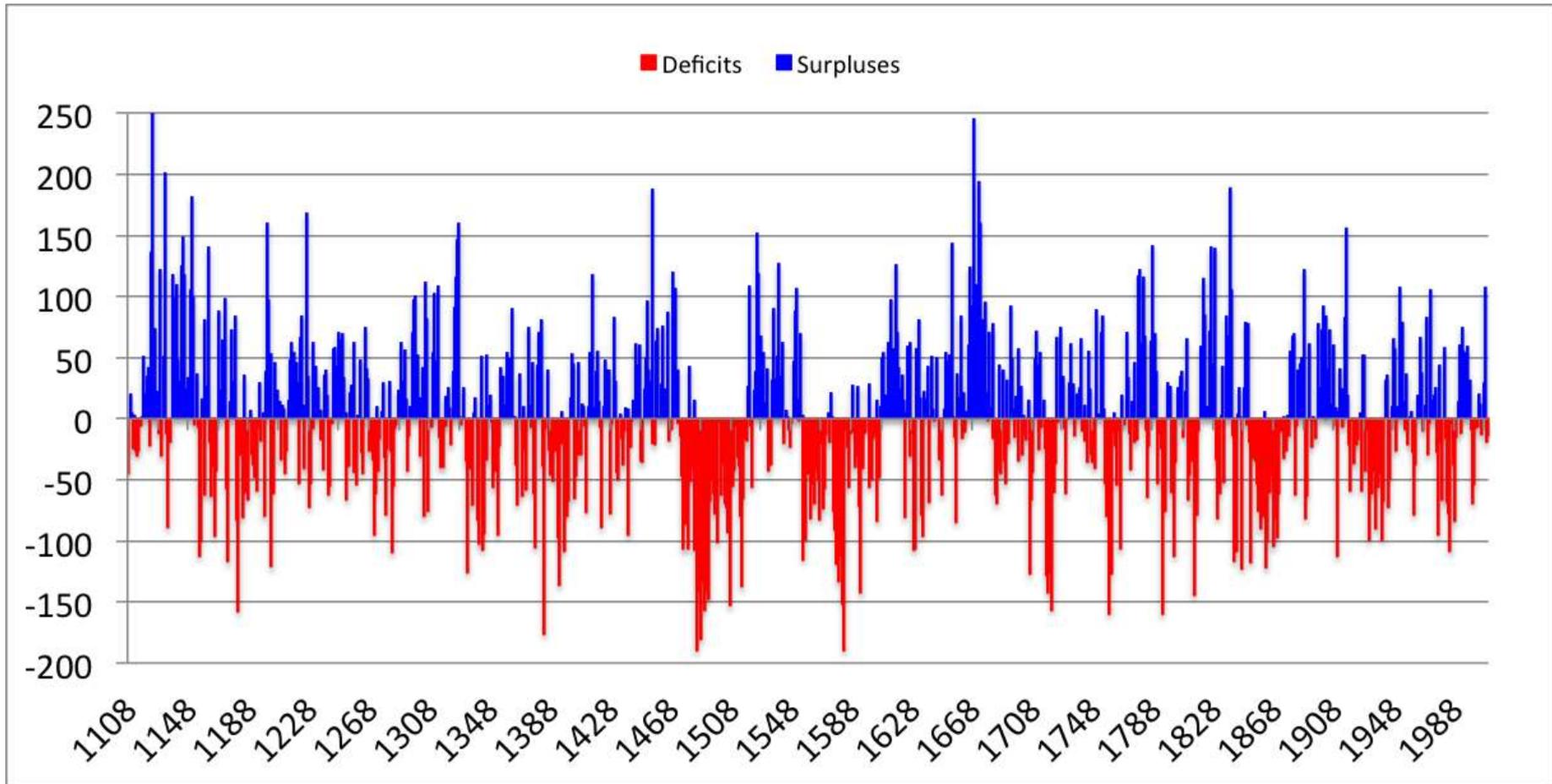
Our True Immigration Policy,
Medicine Hat Times, Feb 5, 1891



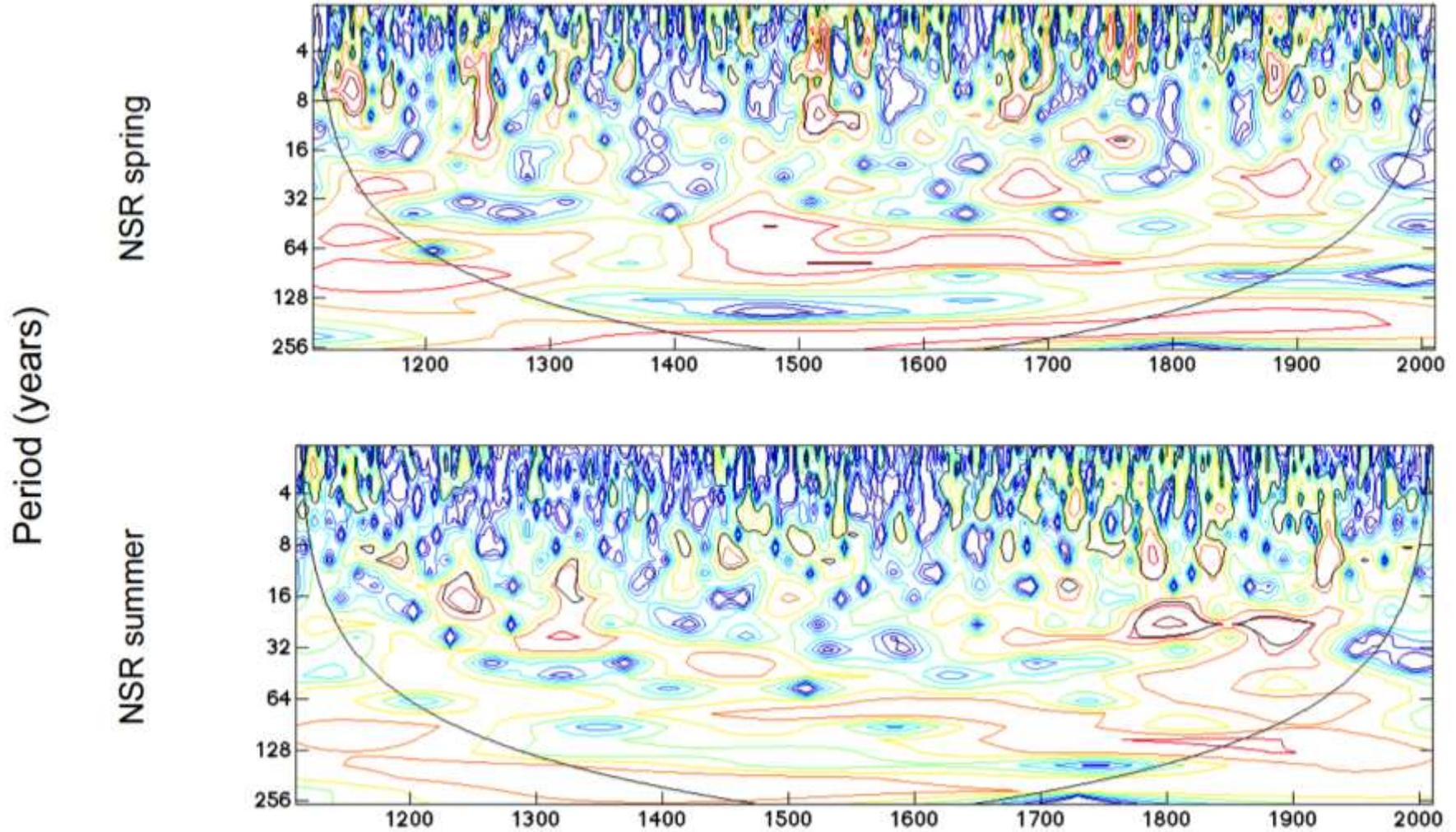
	1901	1911	1921	1931
SK	91,279	492,432	757,510	921,785
AB	73,022	374,295	588,454	731,605



Mean Water Year Flow (m³/s) South Saskatchewan River at Medicine Hat, 1108-2010



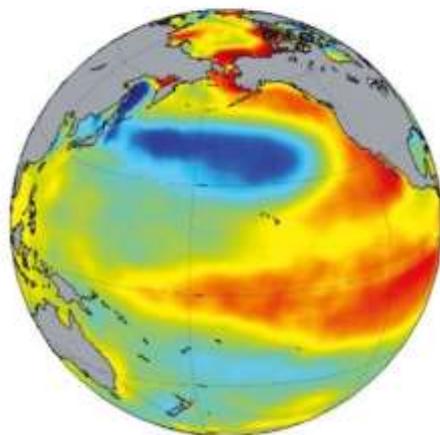
Wavelet plots of periodic variability in mean seasonal flow, North Saskatchewan River



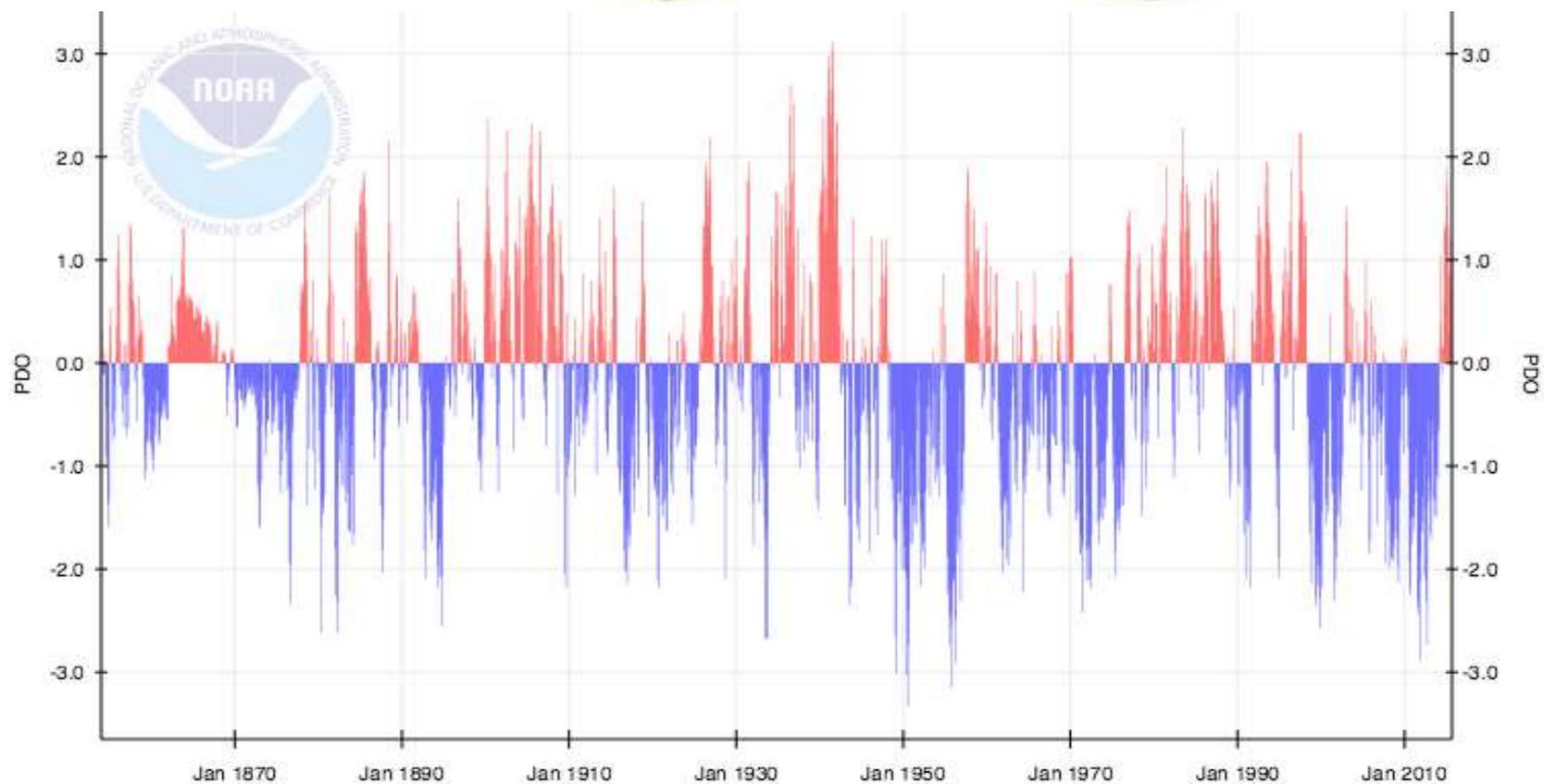
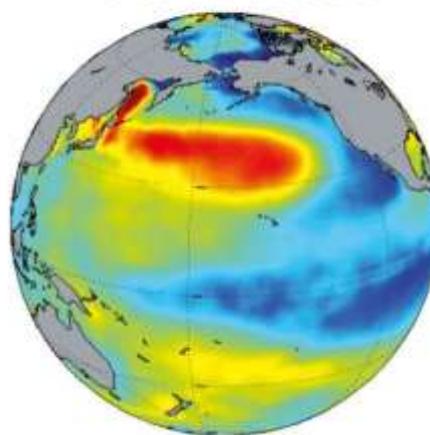


Pacific Decadal Oscillation

Warm Phase

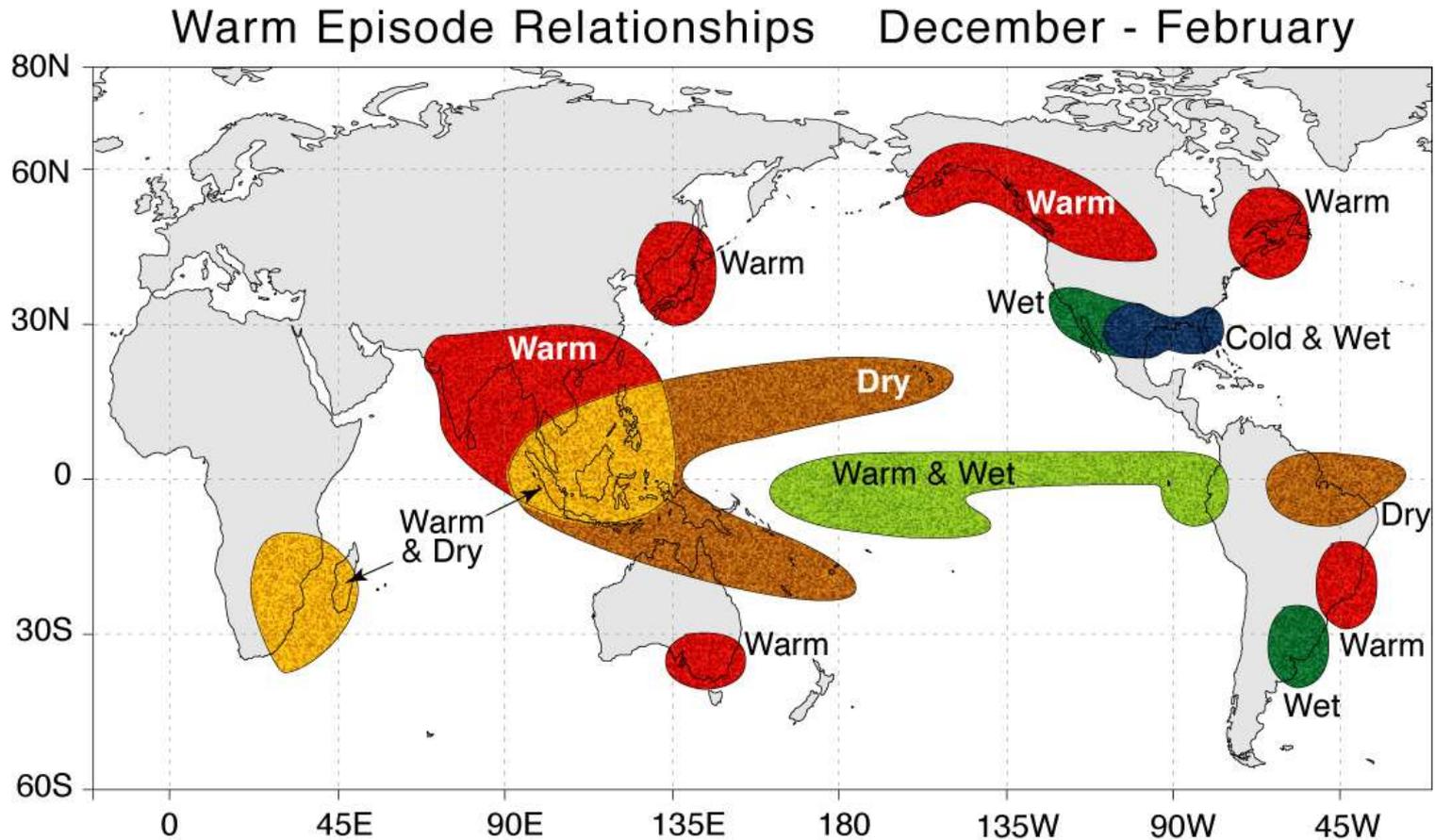


Cold Phase



El Niño remote impacts: Teleconnections

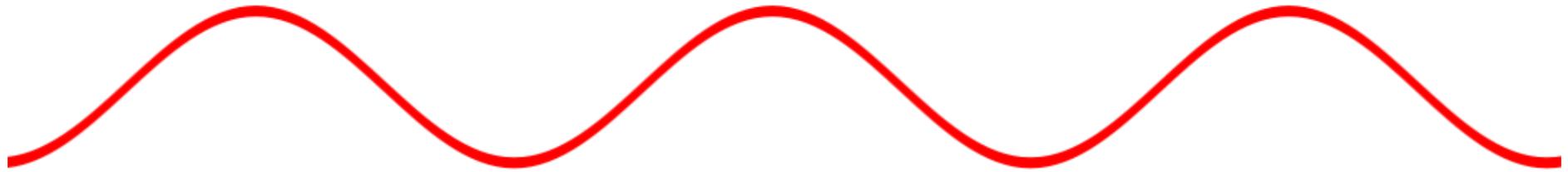
La Niña teleconnections have the opposite effect



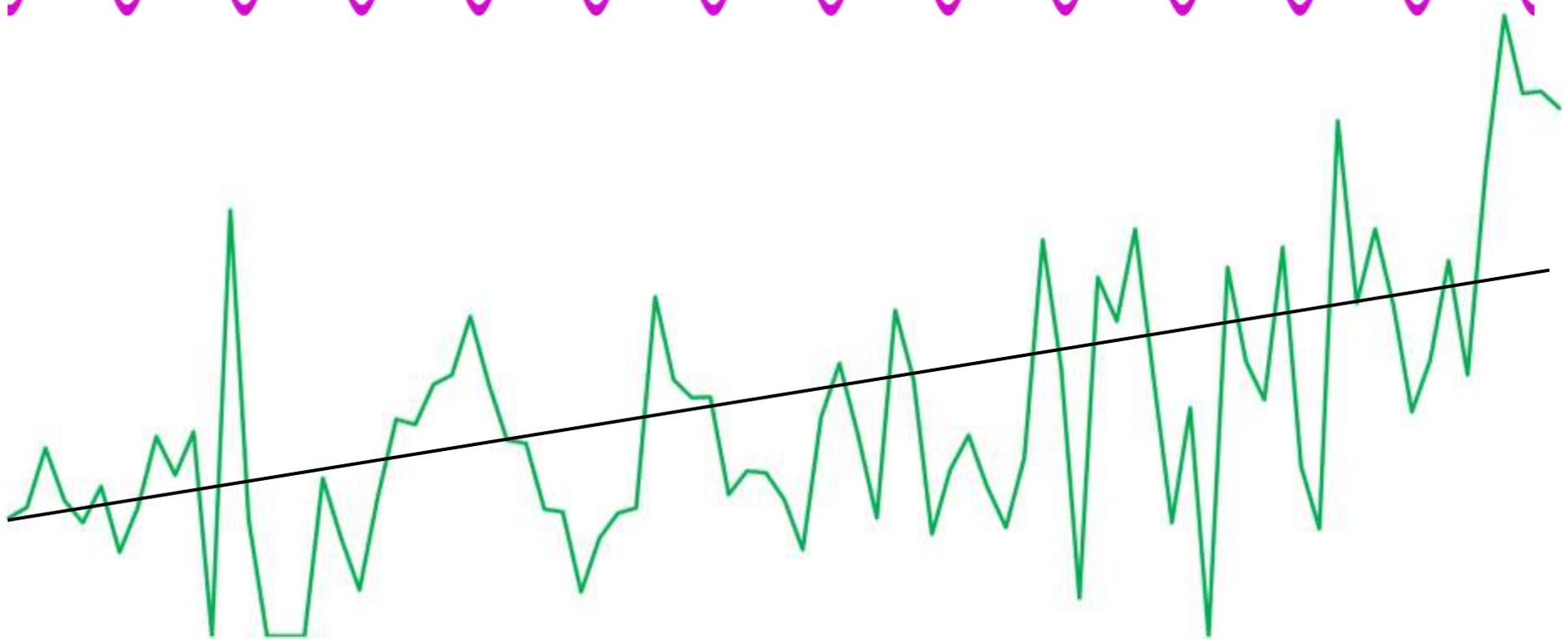
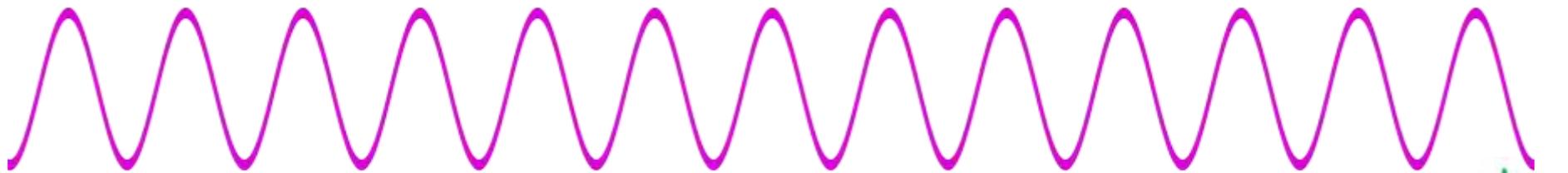
Forage Yield (kg/ha), OneFour, AB, 1930-2014



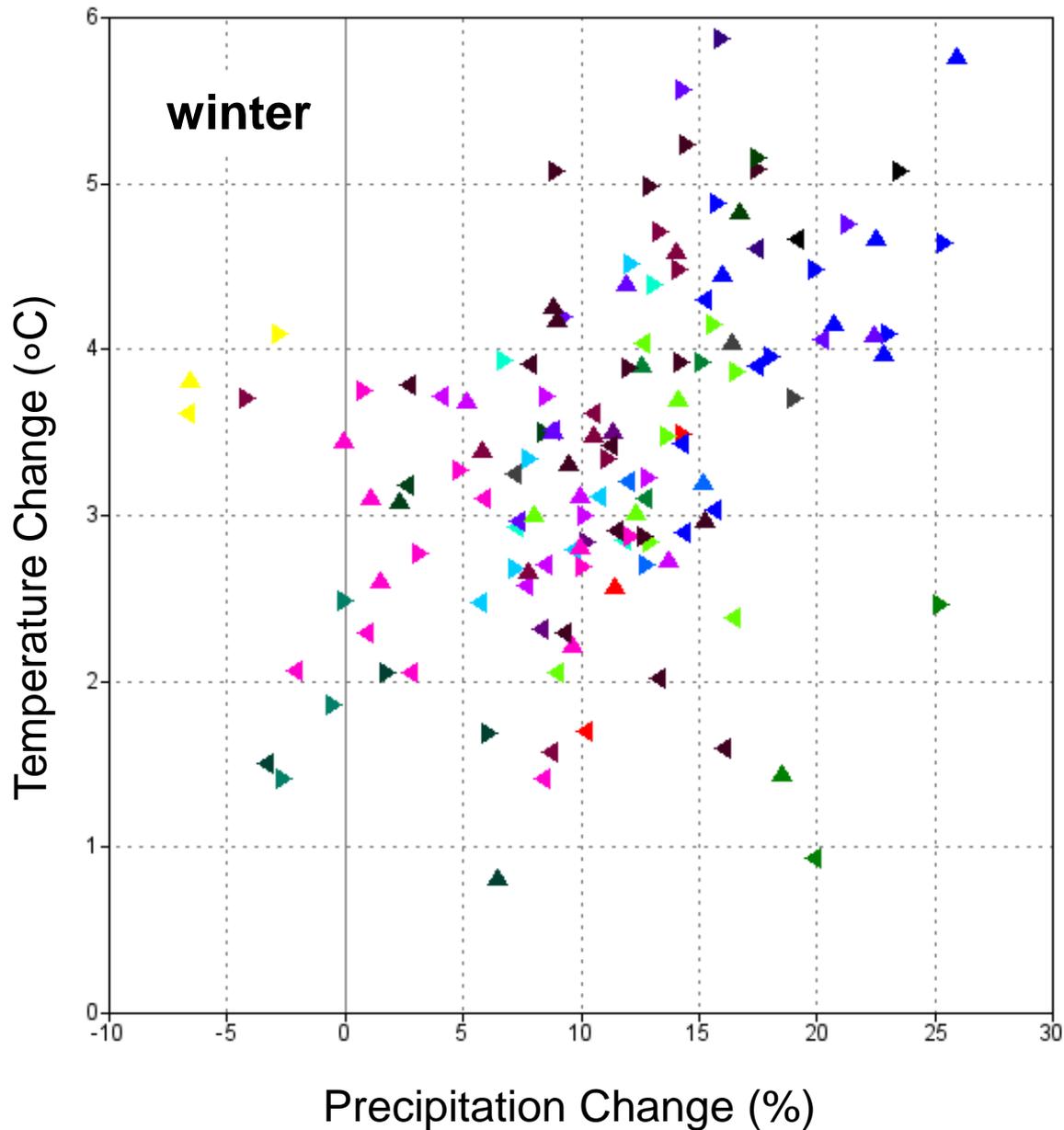
decadal cycle



annual cycle



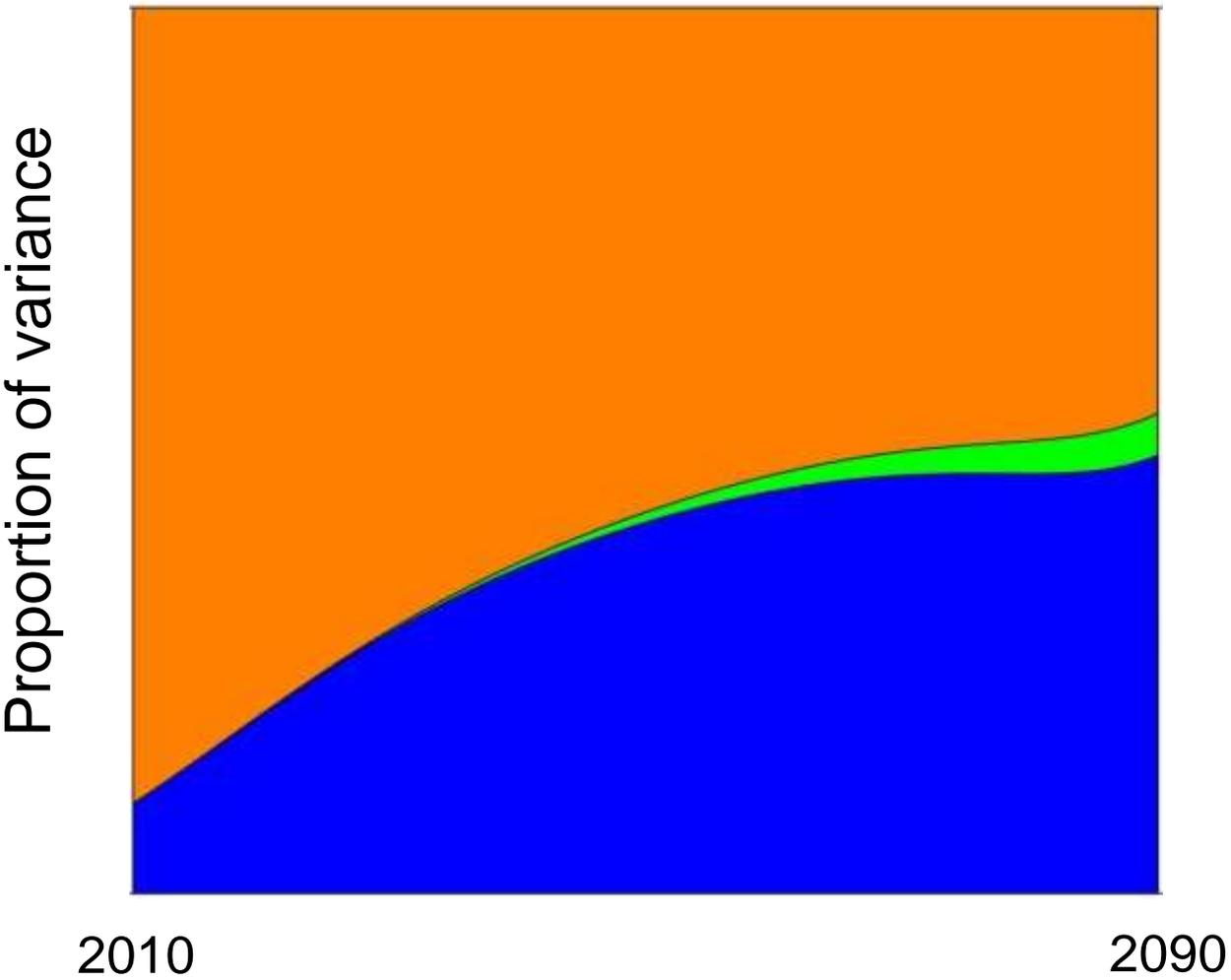
Projected Climate Changes, 2040-69 versus 1971-2000



Source: PCIC

Future Precipitation – Sources of Uncertainty

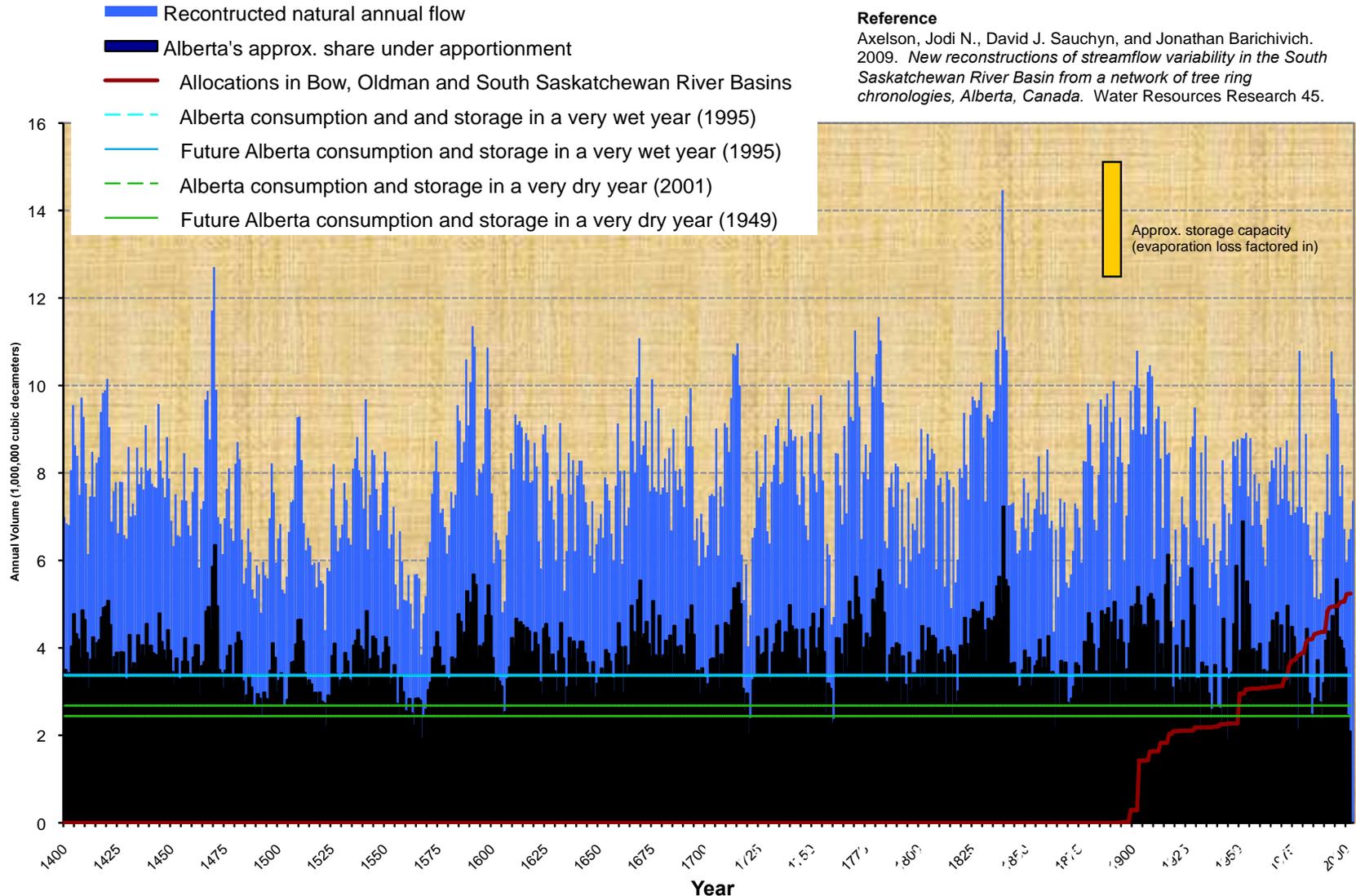
■ natural variability ■ climate models ■ GHG scenarios



Barrow
and
Sauchyn,
In review



Since August 2006, the Alberta government no longer accepts applications for new allocations of water in the Oldman, Bow, and South Saskatchewan sub-basins.





Agriculture and
Agri-Food Canada

Agriculture et
Agroalimentaire Canada



**EXTREME CLIMATE EVENTS
PREPAREDNESS AND ADAPTATION
(EXTRA) PROJECT**

Invitational Drought Tournament

Prepared by: Shanda Buchanan, Monica Hadarits, Harvey Hill, Nancy Lee and Rick Rieger



The Master Agreement on Apportionment (MAA)



The MAA is enforced by the **Prairie Provinces Water Board**

Resiliency of the MAA under multi-year hydrological drought

- assess the capacity and robustness of the provincial water management agencies to handle significant drought events
- determine their ability to meet water demands within their jurisdictions as well as their obligations under the MAA
- develop strategies and mechanisms to best handle drought situations under the MAA

EPCOR Utilities Ltd provides water supply and wastewater treatment to 85 communities in western Canada

March 2007:

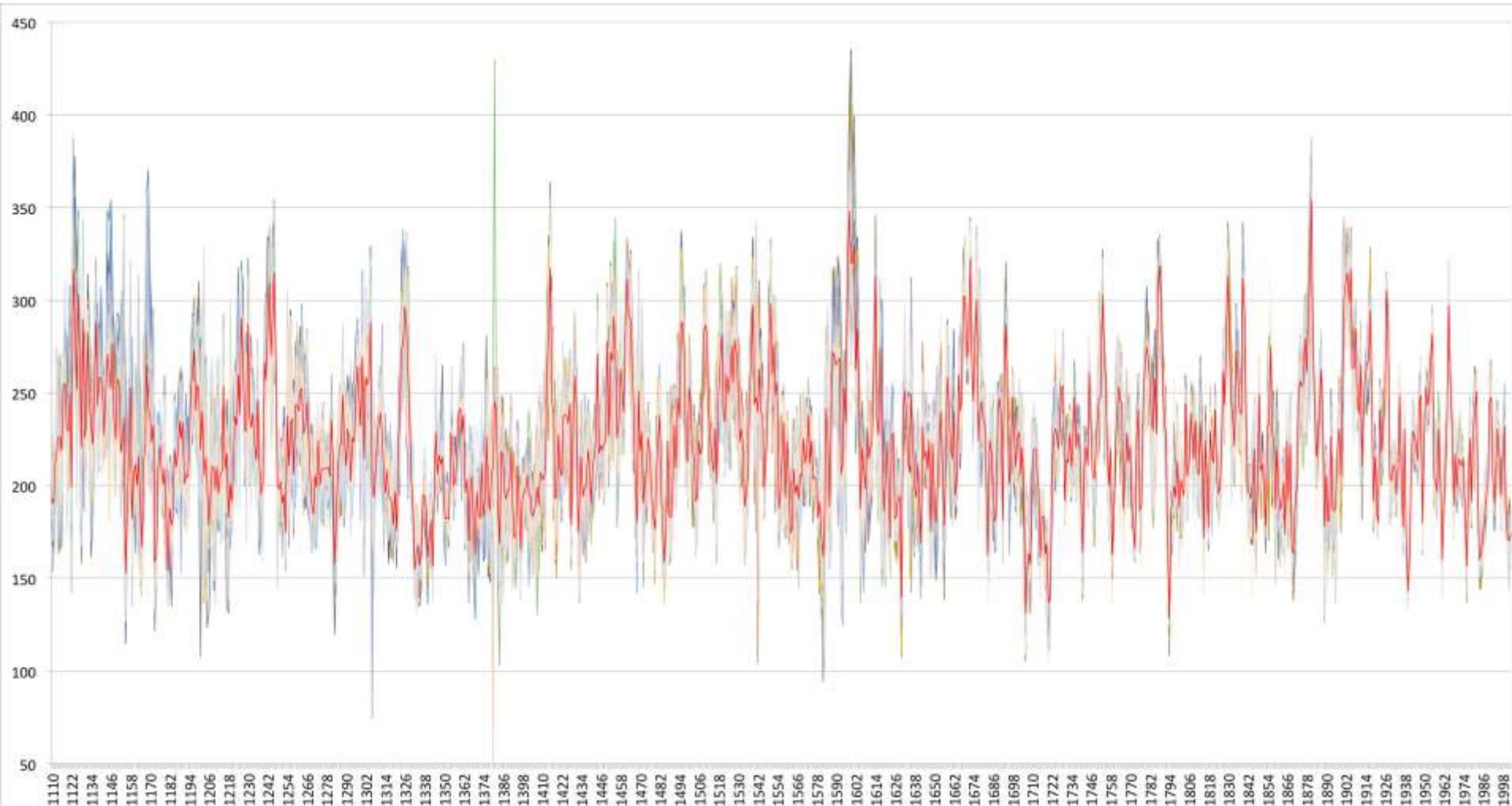
Traditional planning would **consider flow characteristics of the raw water streams as “knowns”** in the system. [*... that is, a stationary climate and water regime*]



On May 2nd [1796] William Tomison wrote to James Swain that furs could not be moved as, **“there being no water in the river.”**



Ensemble of 100 reconstructions of water-year flow (m³/s) North Saskatchewan River, 1110-2010



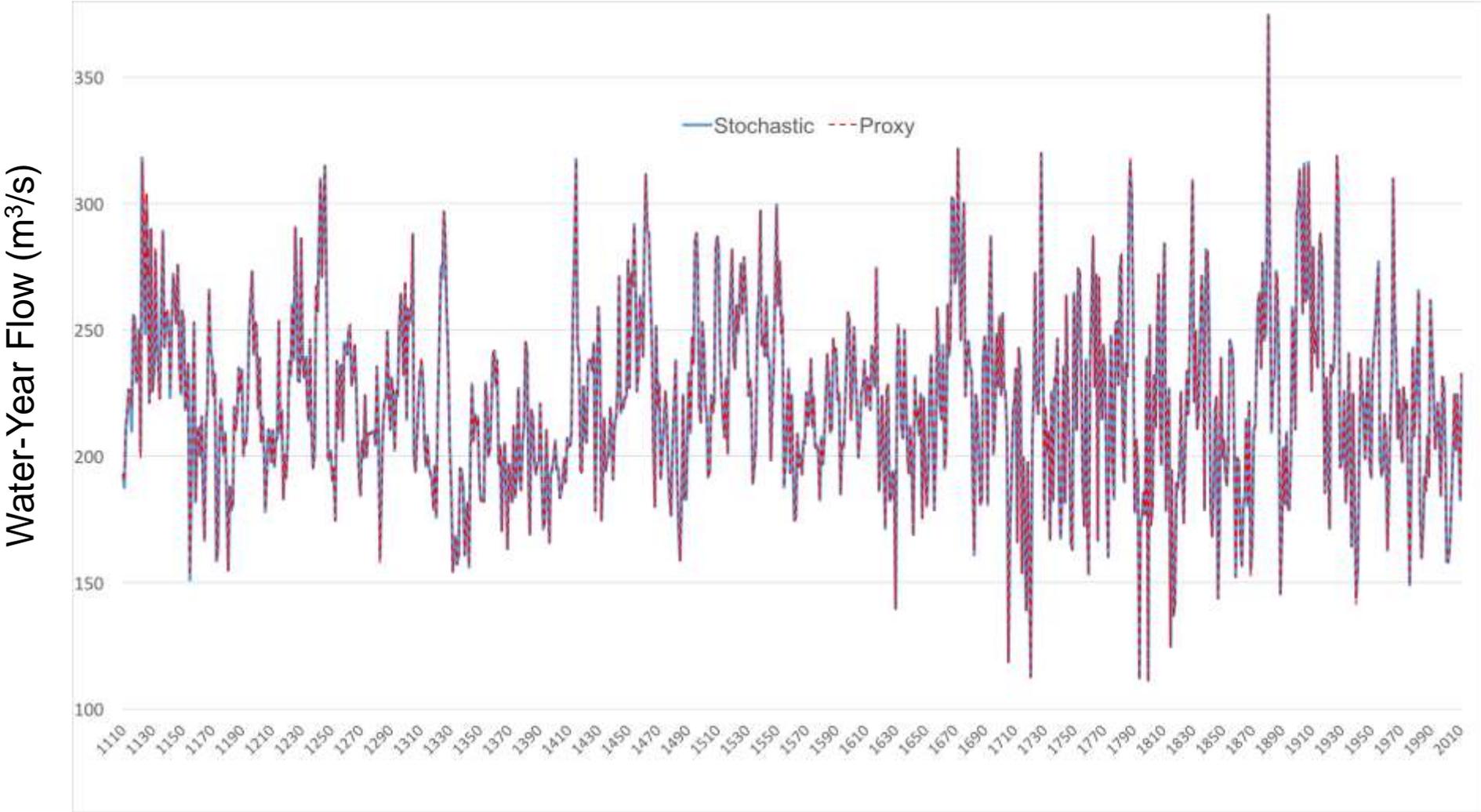
— ensemble mean



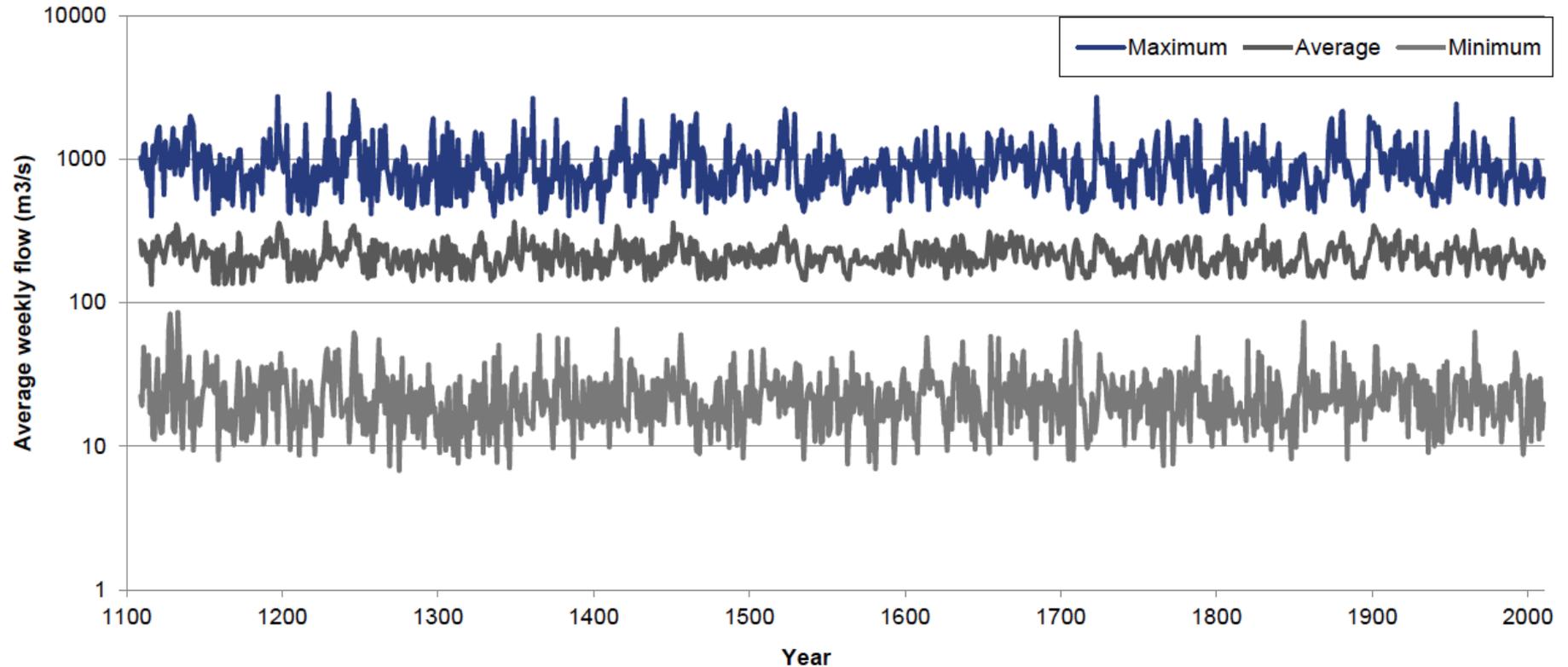
Sauchyn and Ilich,
2017, WRR

900 years of weekly flows, North Saskatchewan River

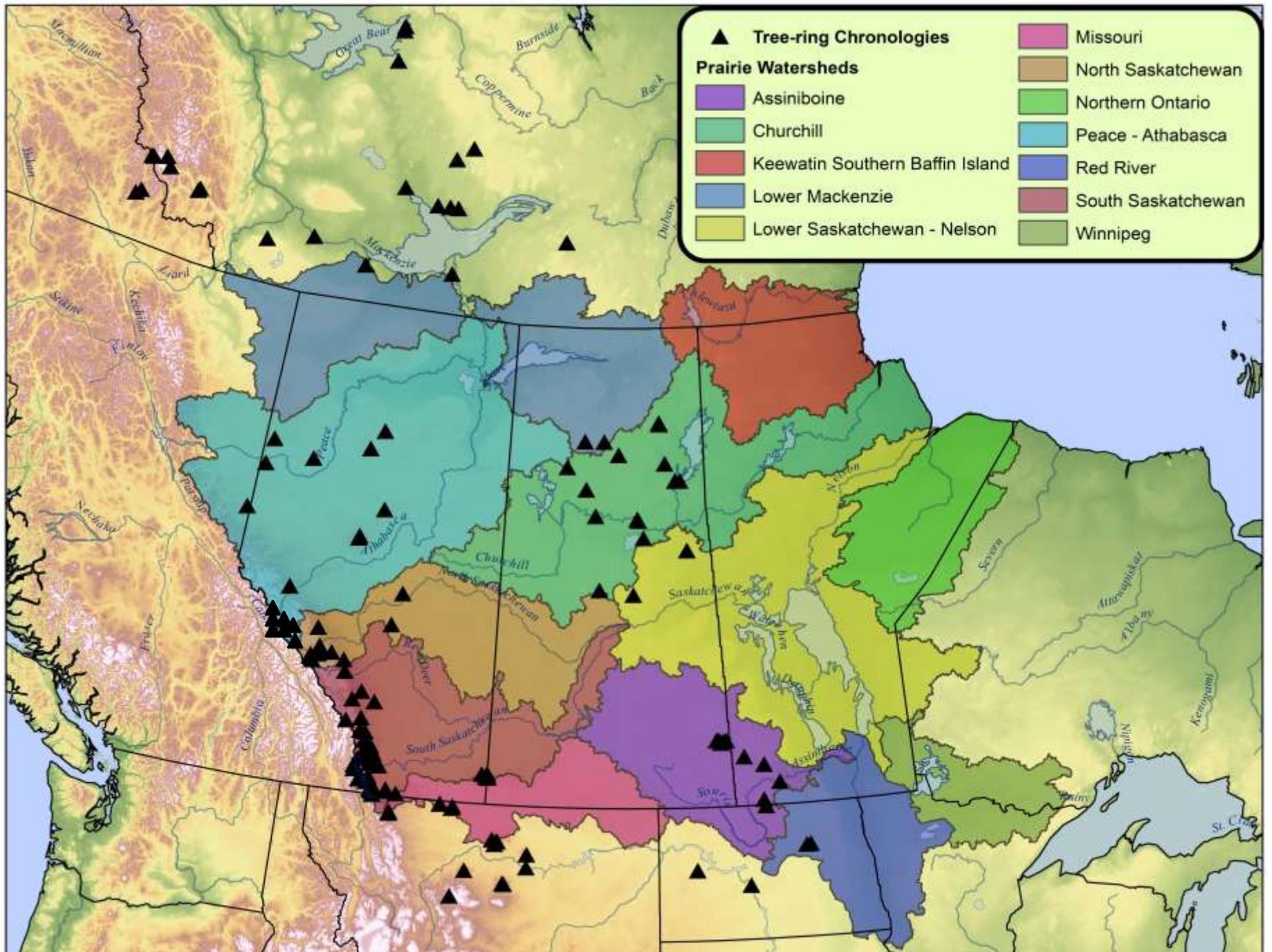
Sauchyn and Ilich, 2017, WRR



How low can it go?

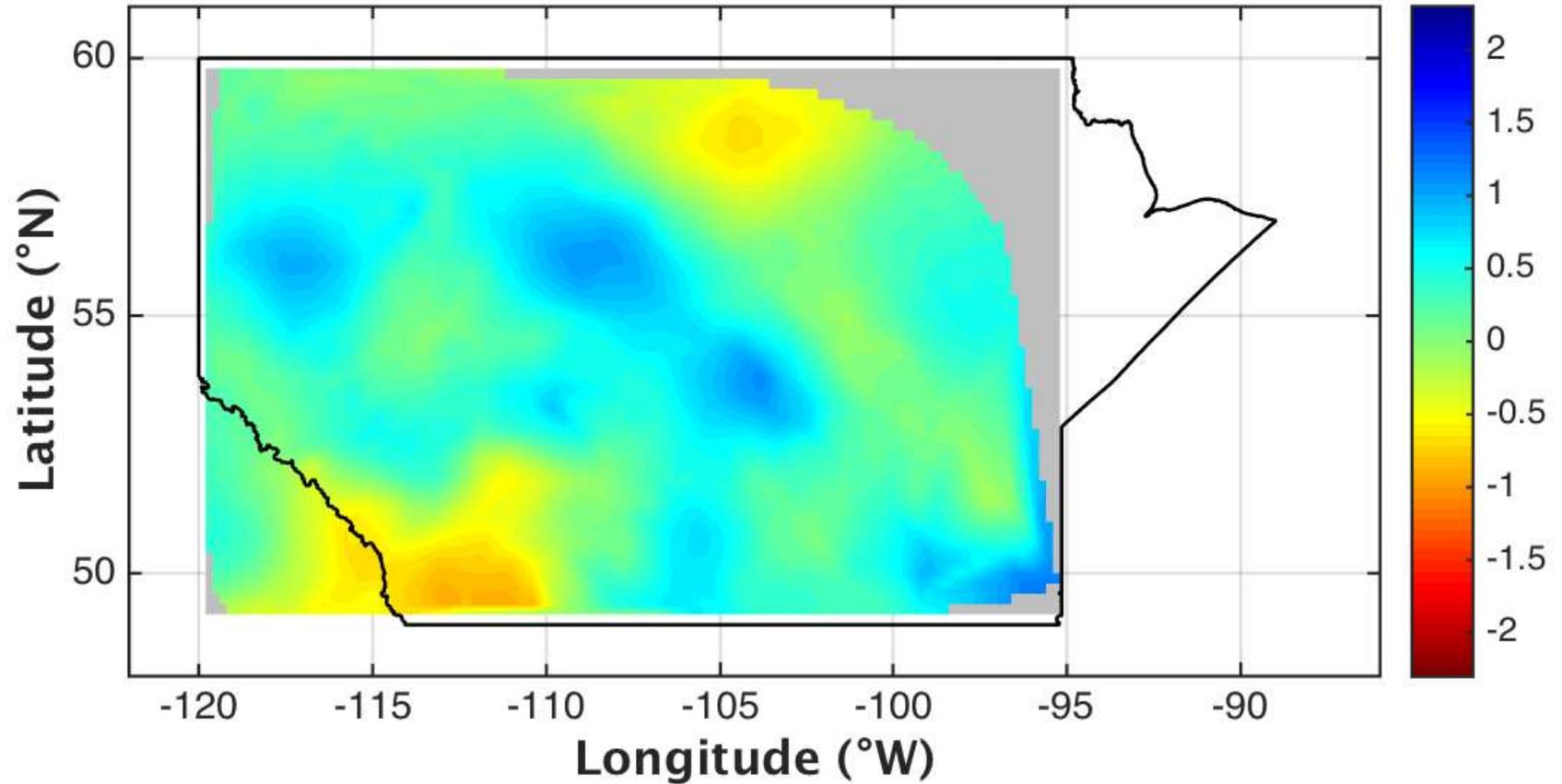


Very low- 10 m³/s where the river is likely series of disconnected pools



Prairie Paleo-Drought Atlas

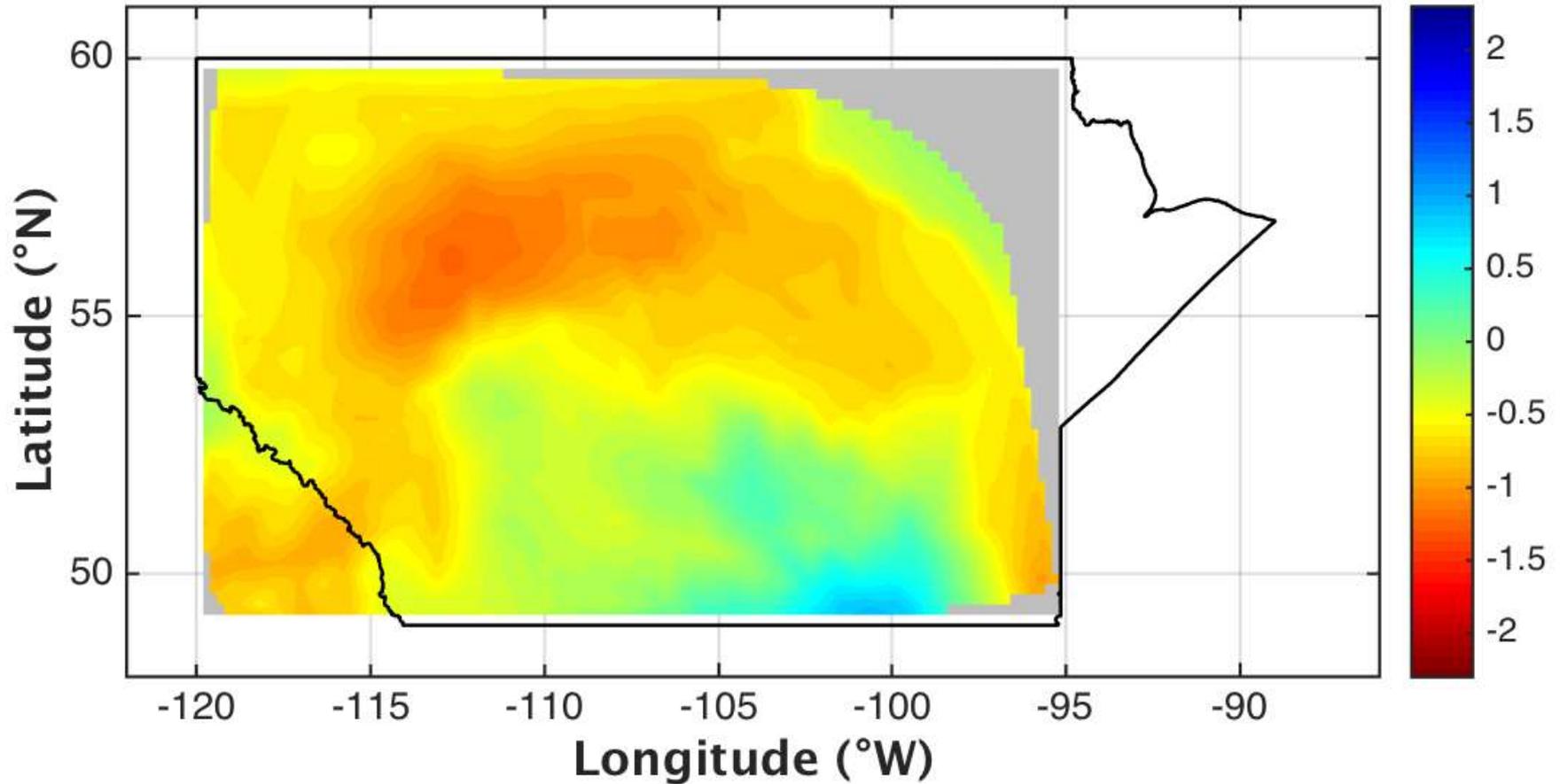
SPEI 1857



Kerr, In Progress

Prairie Paleo-Drought Atlas

SPEI 1870



Kerr, In Progress