Forest growth dynamics in northwestern North America

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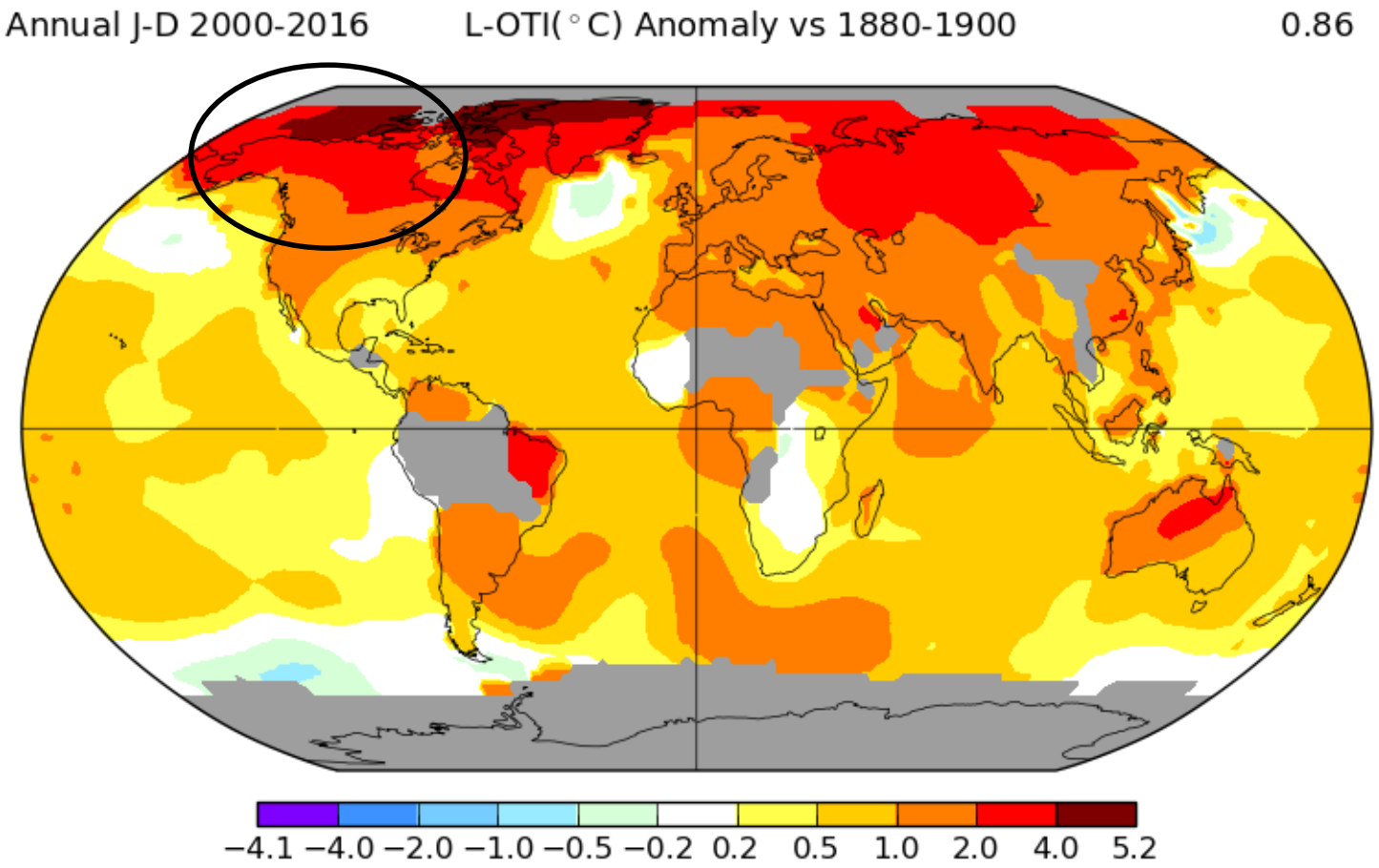
2 UNIVERSITY OF SASKATCHEWAN

Warming and the boreal

Change over the past century



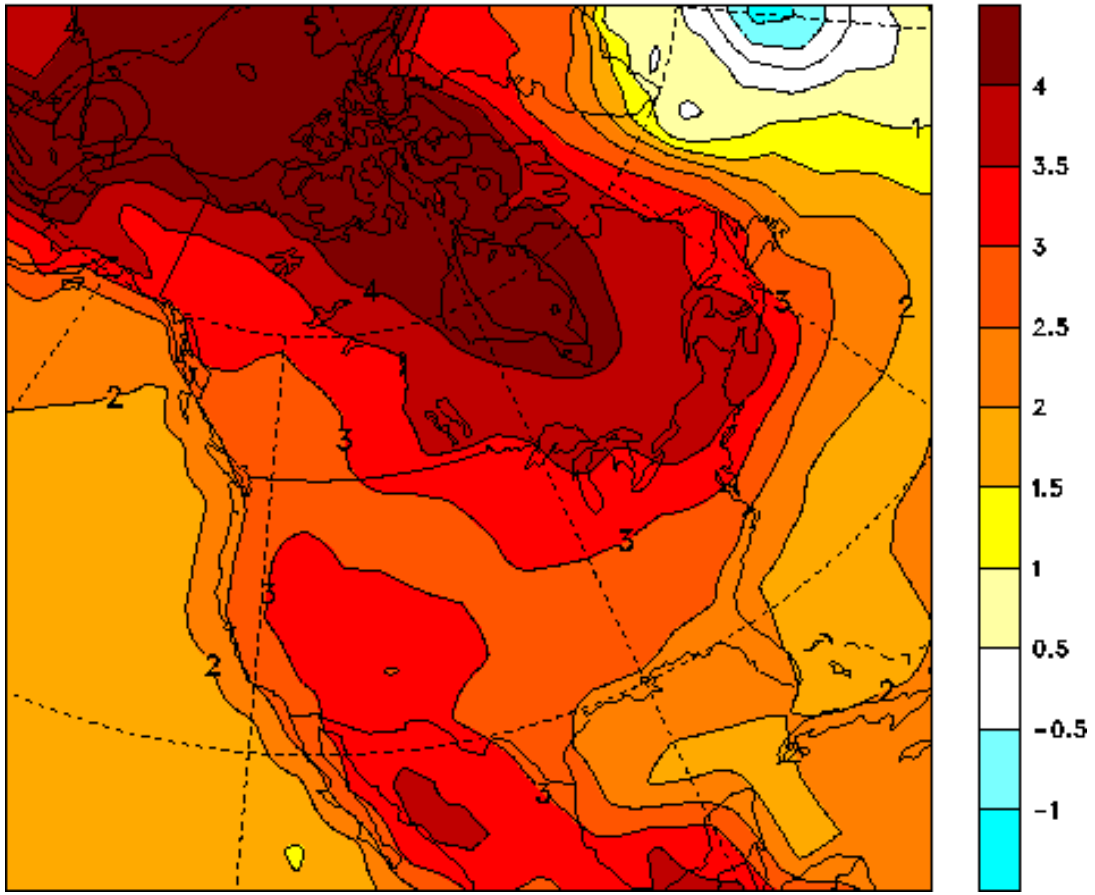
Generated with NASA GISS Surface Temperature Analysis

Warming and the boreal

Black Spruce
Picea mariana

Surface Air Temp, C, change, SRESA1B/T47 ANN 2081-2100 vs 1981-2000

Projected change, next 100 years

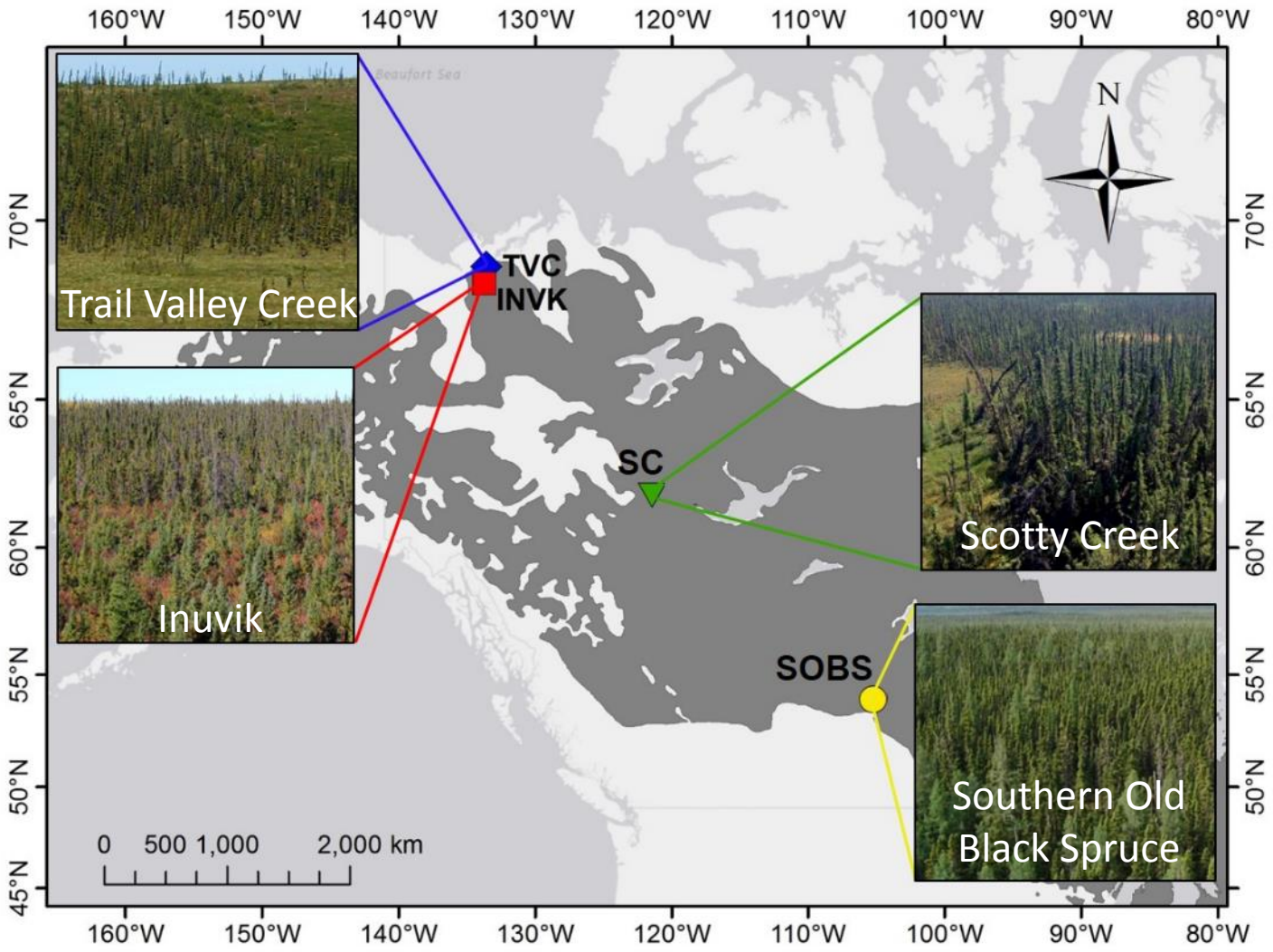


Generated by Canadian Centre for Climate Modeling Analysis, Canadian Global Circulation Model 3

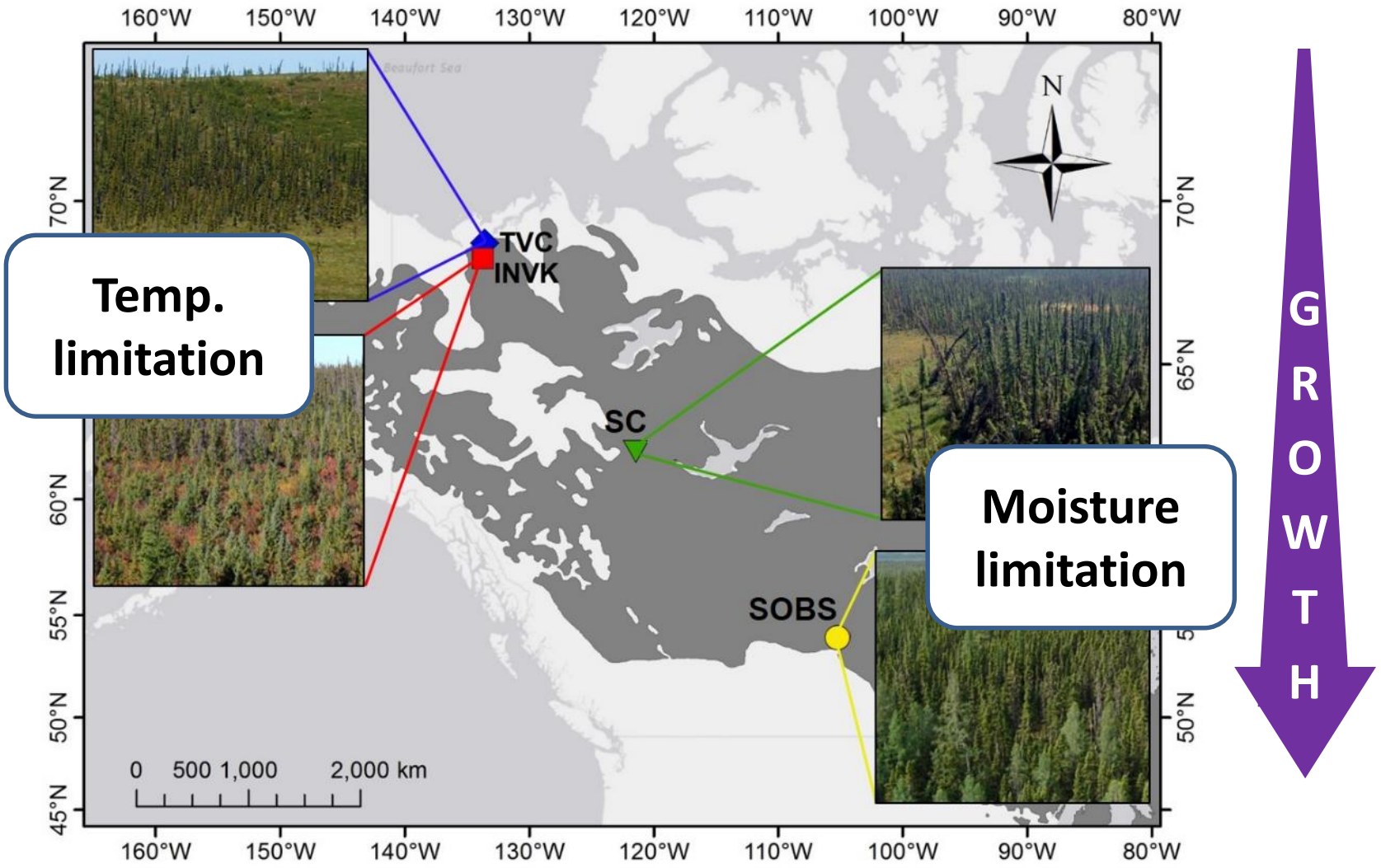
Objective

- Capture variability in growth dynamics of black spruce in northwestern Canada, both spatially and temporally
  - Using traditional tree-ring growth analysis and stable carbon isotope analysis

Study Sites


160°W
150°W
140°W
130°W
120°W
110°W
100°W
90°W
80°W
70°N
65°N
60°N
55°N
50°N
45°N
N
TVC
INVK
SC
SOBS
Trail Valley Creek
Inuvik
Scotty Creek
Southern Old Black Spruce
0 500 1,000 2,000 km

Predictions



Research Question #1

- What are the differences in growth patterns across the latitudinal extent of black spruce in western Canada?

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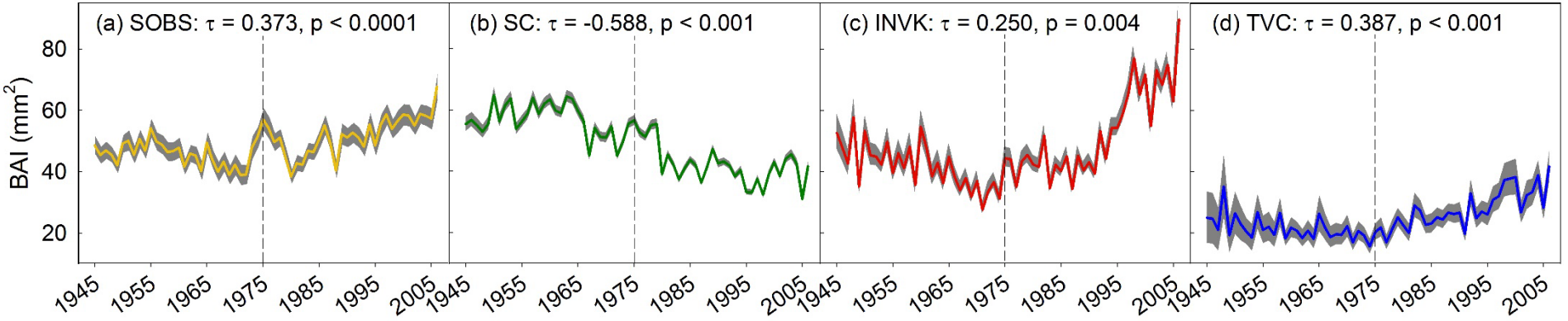
Mann-Kendall trend test; all trends over time significant



South → **North**

Research Question #2

- What are the main climatic drivers of these differences, and do they change over time?

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South

North

Site	Early response(s) 1945-1975	Late response(s) 1976-2006
SOBS	[+] Spring Prec	Climate n.s.
SC	Climate n.s.	[+] Summer Prec [-] Summer Temp
INVK	[+] Winter Temp [+] Spring Prec	[+] Winter/Spring Temp [-] Winter Prec
TVC	[+] Winter/Summer Temp [-] Winter Prec	[+] Summer Temp [-] Winter Prec

Research Question #3

- Do trends in stable C isotope signals of water use efficiency (WUE) differ among sites?
  - calculated $\Delta^{13}C$, discrimination against ^{13}C isotope
  - Lower $\Delta^{13}C$ = more stomatal closure, higher WUE

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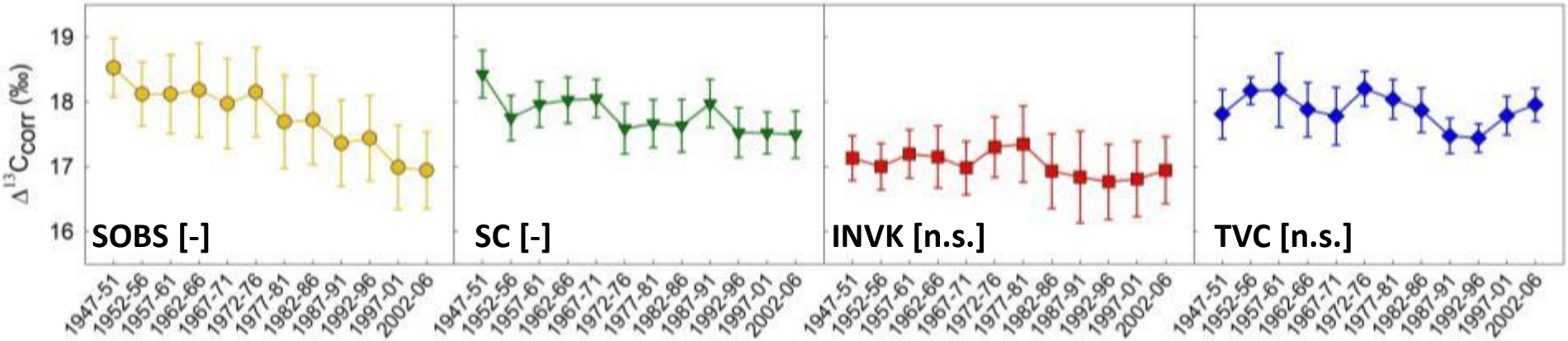

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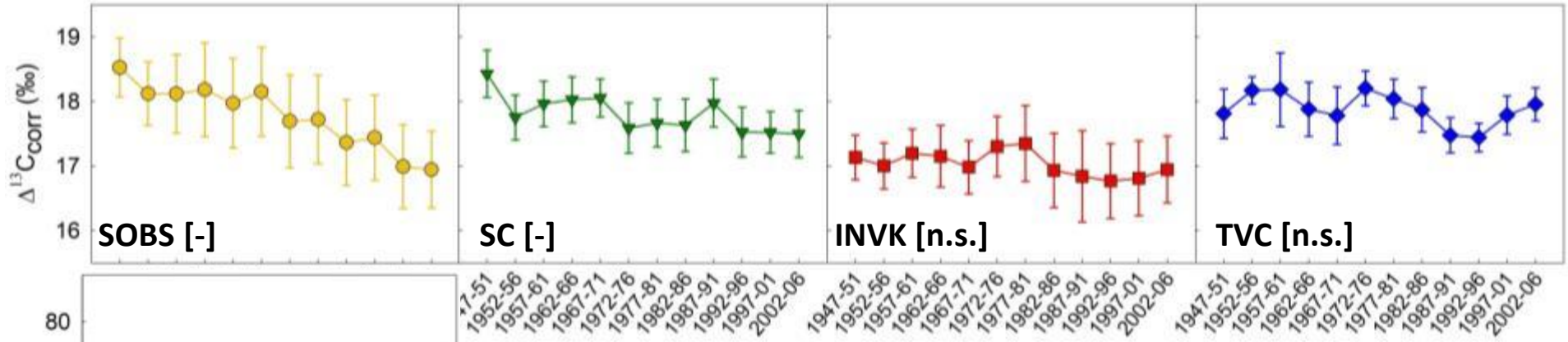

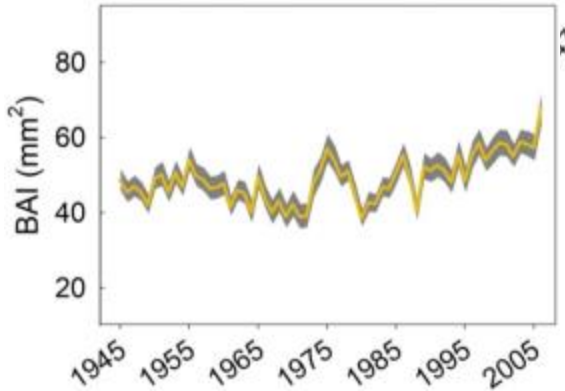

Increased WUE + Increased BAI
= evidence of possible CO_2 fertilization?

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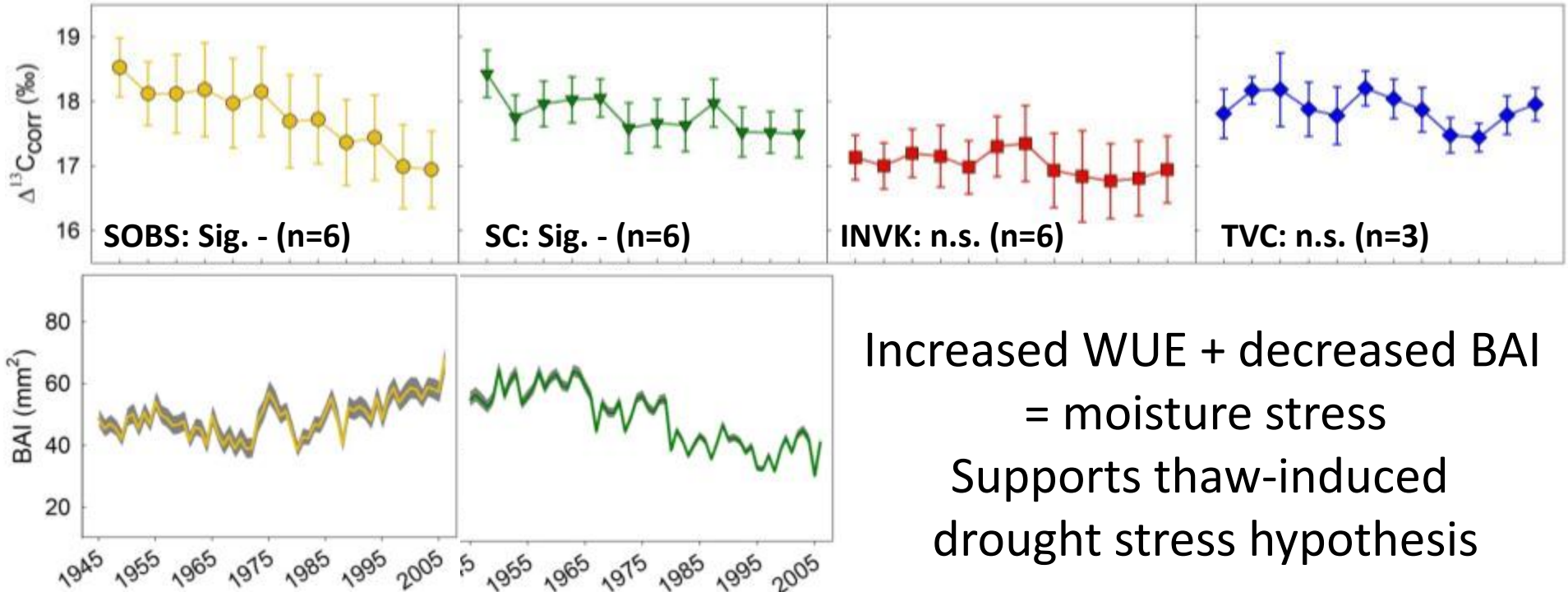
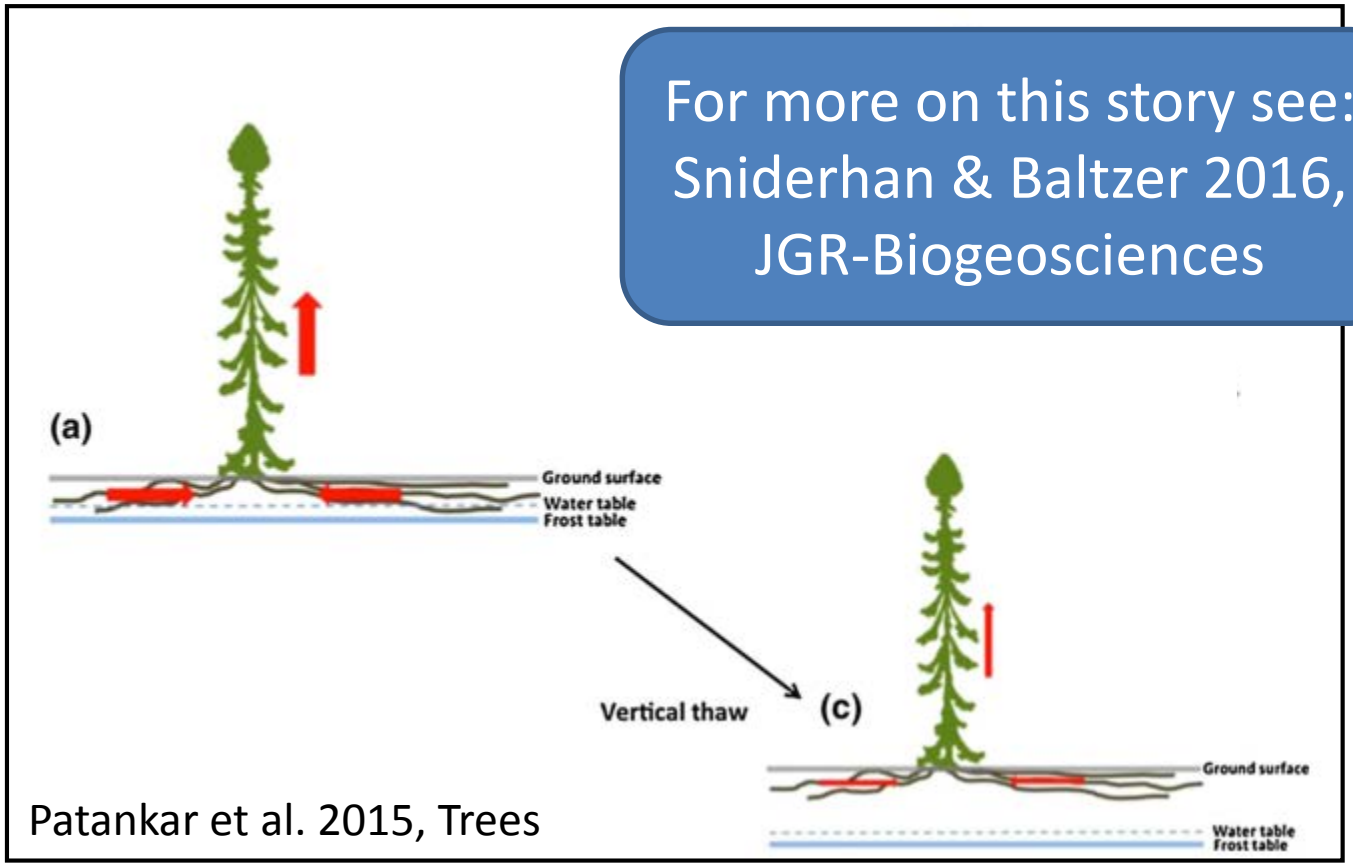
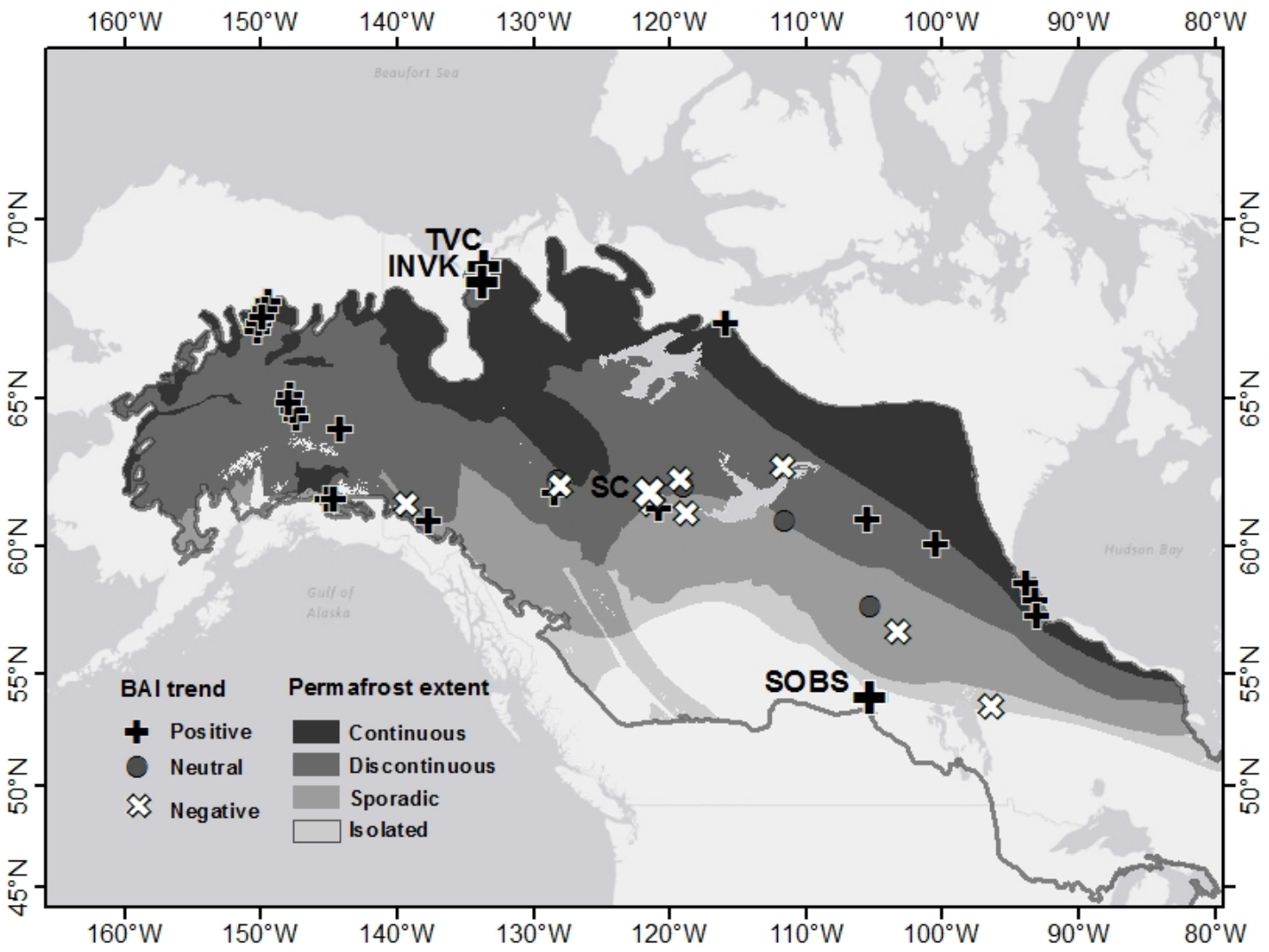


Increased WUE + decreased BAI = moisture stress
Supports thaw-induced drought stress hypothesis

Thaw-induced drought



Broad Scale Trends - ITRDB



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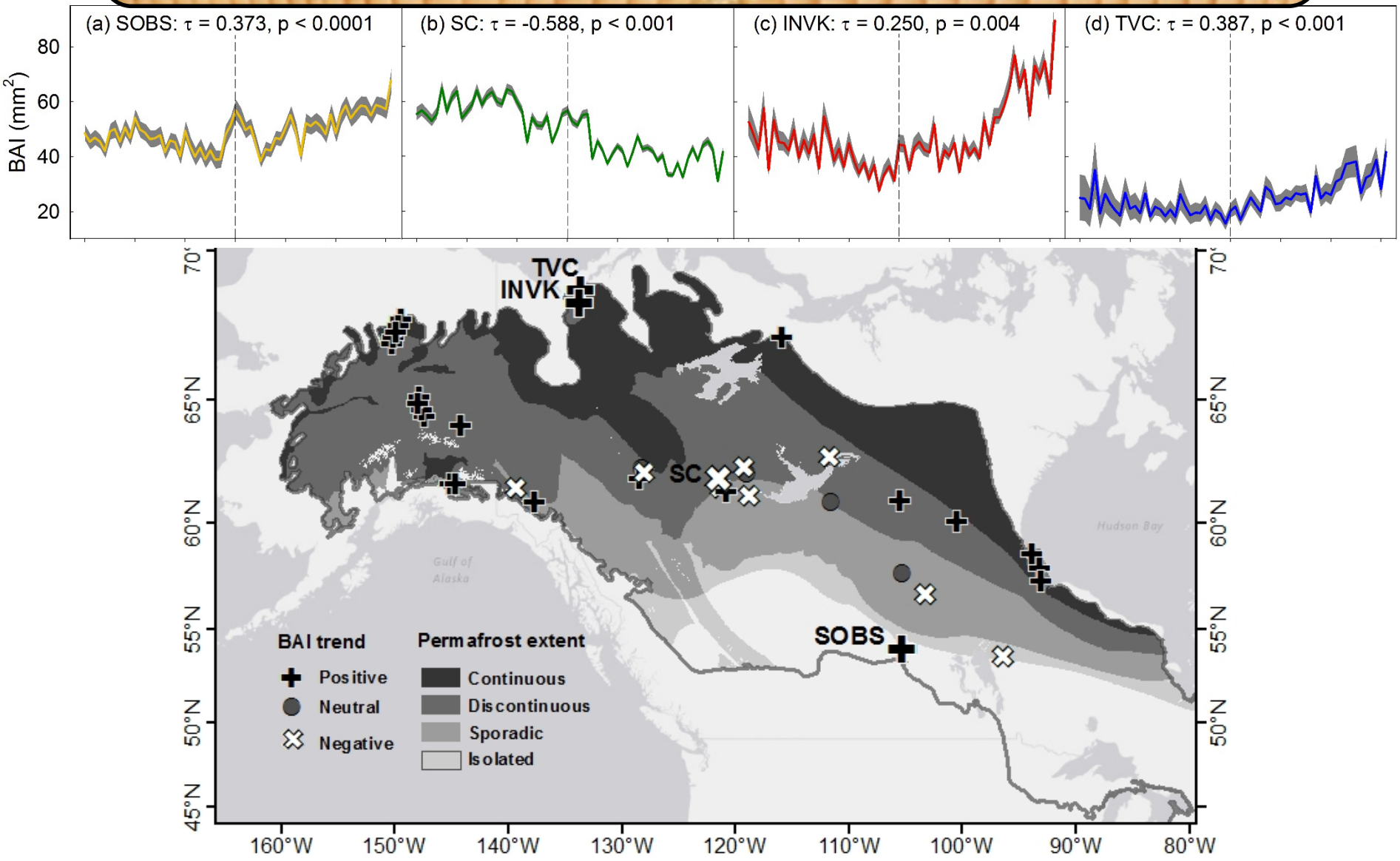

Next steps

- Canadian Forest Service National Forest Inventory
- 134 PSPs across Taiga Plains ecoregion in NWT
- Detailed info on soils & vegetation at each PSP

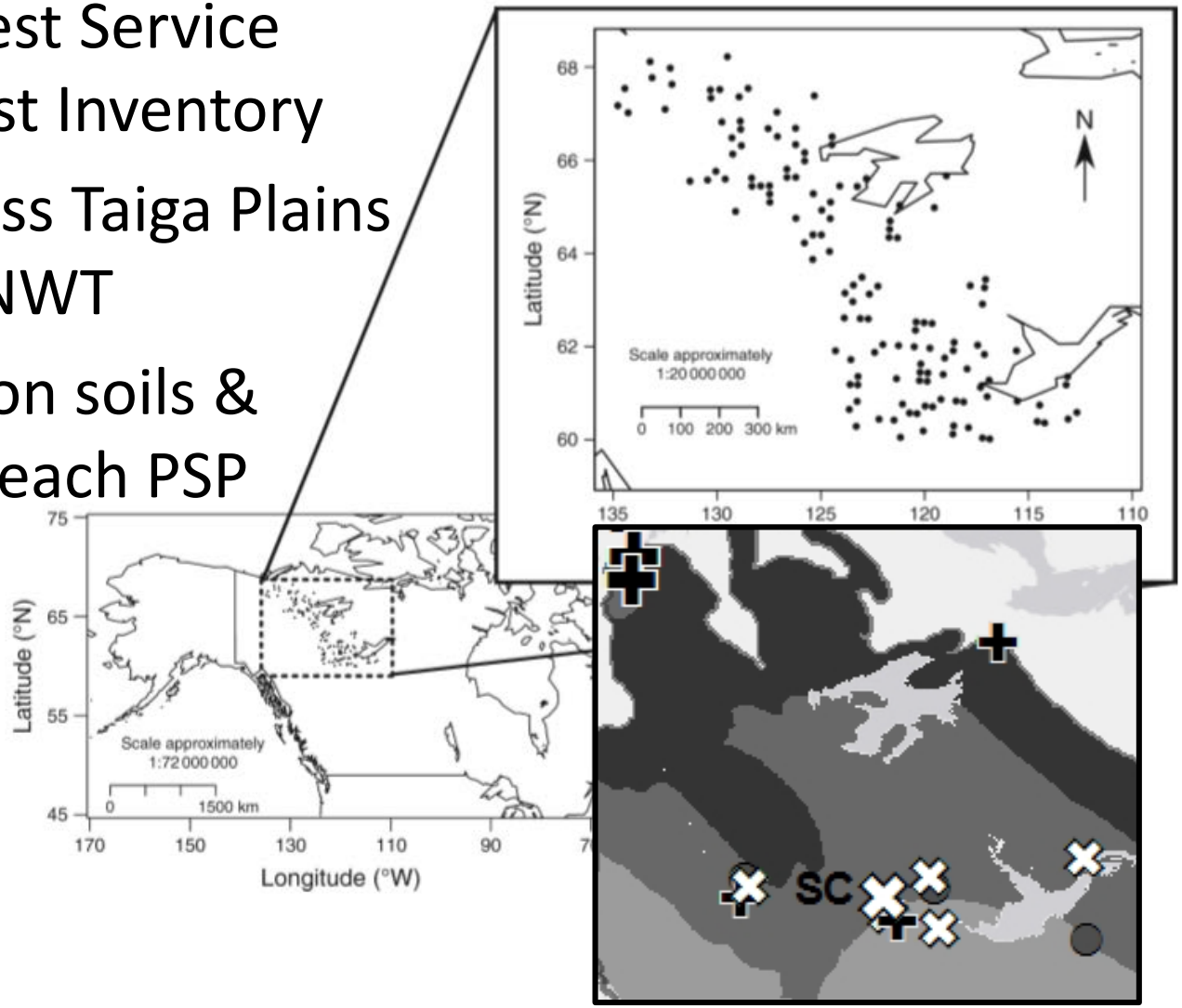

Figure adapted from Marshall & Baltzer 2015, Ecology

Northern Water Futures

LAURIER Inspiring Lives.

University of Saskatchewan

Field Assistants:
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-Melissa Fafard
-Megan Horachek
-Greg Lynch
-Gordon McNickle
-Kirsten Reid
-Cory Wallace

NSTP PFSN
Northern Scientific Training Program
Programme de formation scientifique dans le Nord

Ontario
MINISTRY OF RESEARCH AND INNOVATION
MINISTÈRE DE LA RECHERCHE ET DE L'INNOVATION

Northwest Territories

NSERC CRSNG

CCRN
Changing Cold Regions Network

Research Question #2

- What are the main climatic drivers of these differences, and do they change over time?

- Compared early (1945-1975) and late (1976-2006) climate-growth (RWI) responses

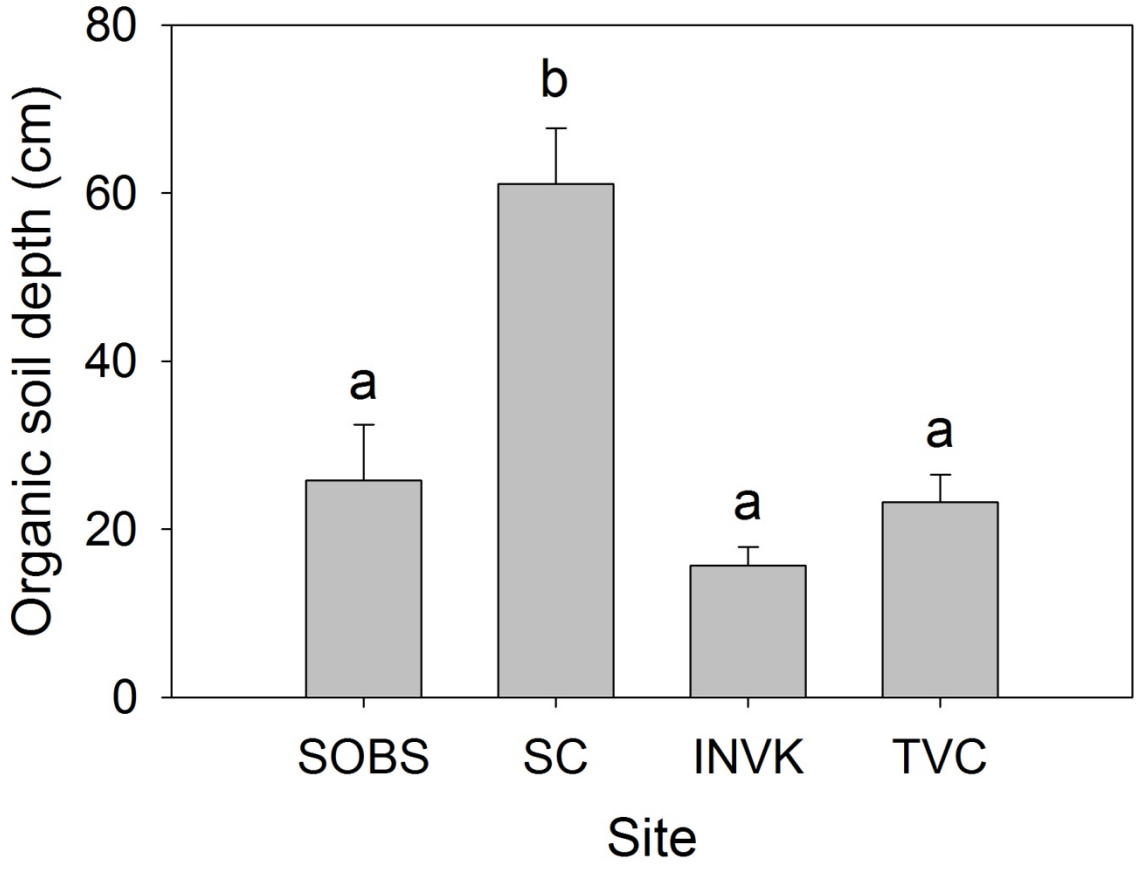
- Individual Climate-Growth correlations

→Hierarchical Cluster Analysis (HCA)

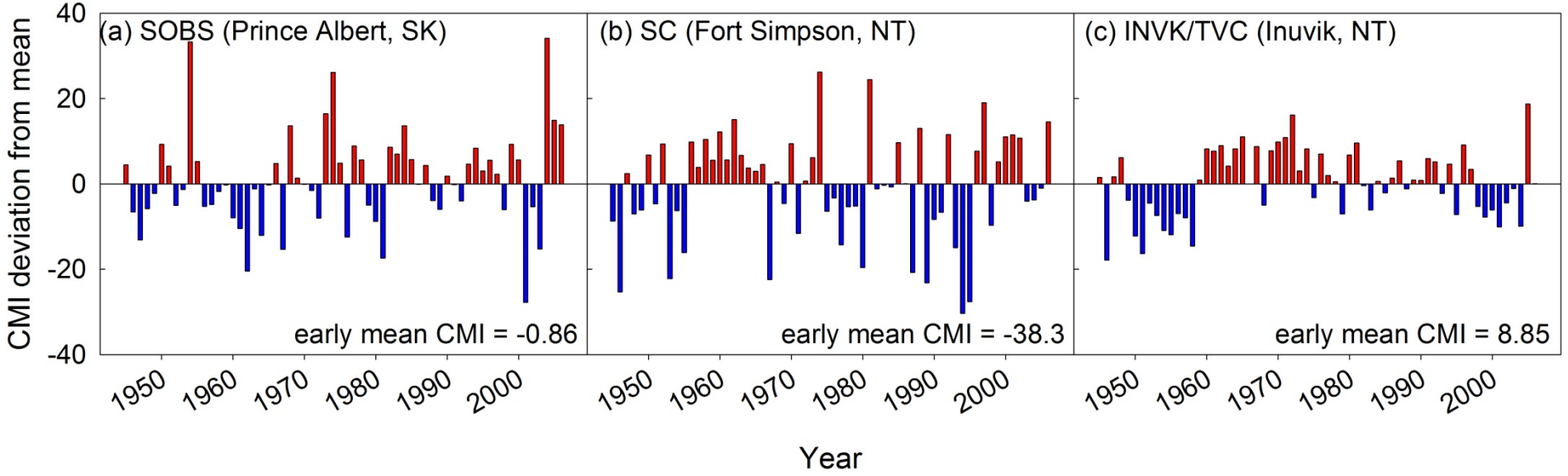
→ Redundancy Analysis (RDA)

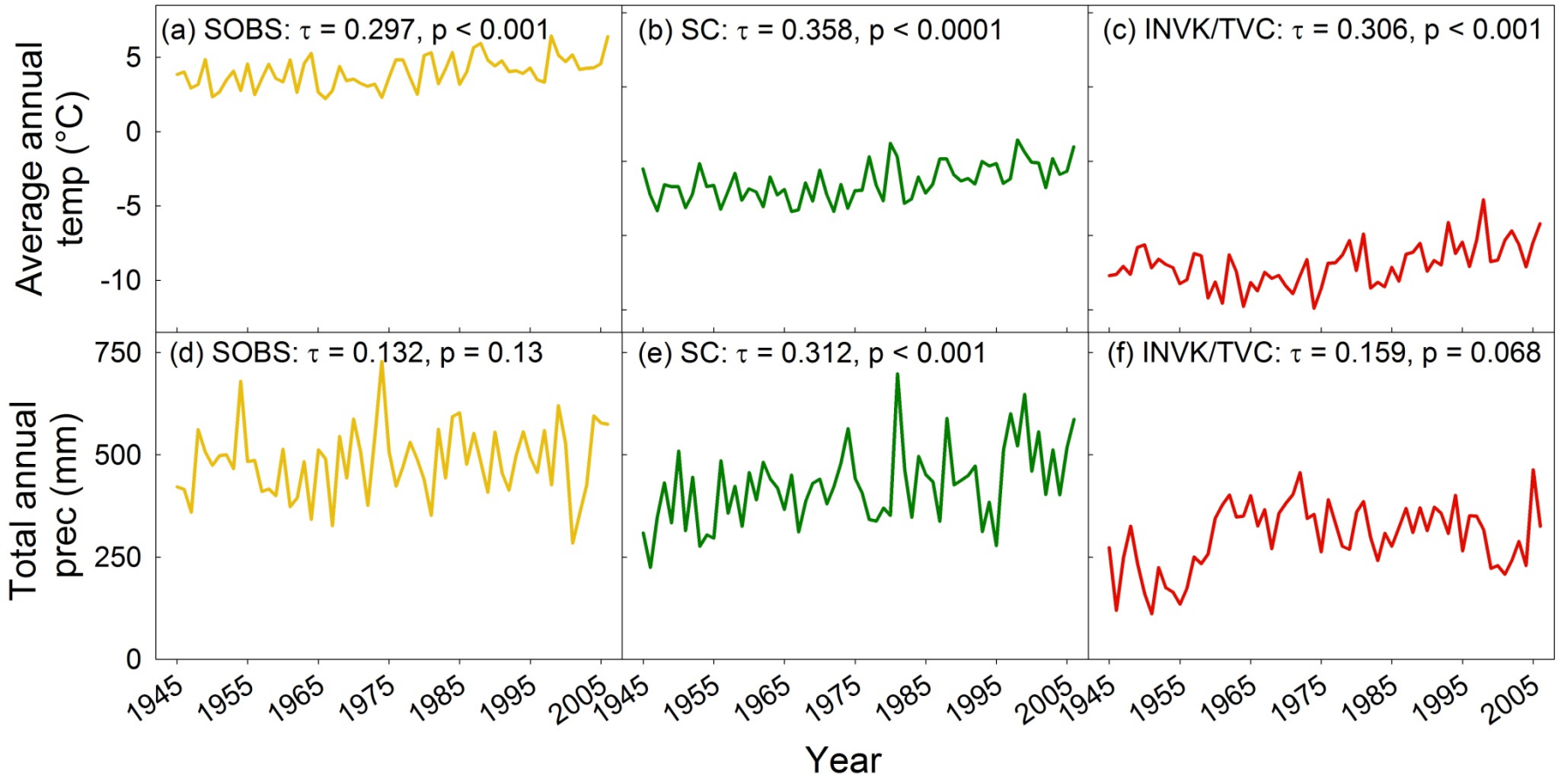
→ Cluster Climate-Growth Correlations

END RESULT: Multiple chronologies per site, significant climatic drivers of growth identified within chronologies



Average depth of organic soil at each of the sites. Depth of organic soil was measured at least once within each stand sampled. SOBS: n = 10, SC: n = 16, INVK: n = 12, TVC: n = 15. Error bars shown represent standard error. Treatments showing significant differences (ANOVA, Tukey HSD, $p<0.05$) are indicated by different letter codes.


(a) SOBS (Prince Albert, SK)
(b) SC (Fort Simpson, NT)
(c) INVK/TVC (Inuvik, NT)
early mean CMI = -0.86
early mean CMI = -38.3
early mean CMI = 8.85
CMI deviation from mean
40
20
0
-20
-40
1950
1960
1970
1980
1990
2000
Year


(a) SOBS: τ = 0.297, p < 0.001
(b) SC: τ = 0.358, p < 0.0001
(c) INVK/TVC: τ = 0.306, p < 0.001
(d) SOBS: τ = 0.132, p = 0.13
(e) SC: τ = 0.312, p < 0.001
(f) INVK/TVC: τ = 0.159, p = 0.068
Average annual temp (°C)
Total annual prec (mm)
5
0
-5
-10
750
500
250
0
1945
1955
1965
1975
1985
1995
2005
Year

	EARLY					LATE				
Site	**Clust.**	**n**	**Clim. Var.**	**+/-**	**p-value**	**Clust.**	**n**	**Clim. Var.**	**+/-**	**p-value**
SOBS	G1	100	Climate n.s.			G1	159	Climate n.s.		
	G2	57	Spring_P	+	<0.001					
SC	G1	400	Climate n.s.			G1	188	Climate n.s.		
						G2	59	$Summer\_P_{n-1}$	+	0.023
								Summer_P	+	0.017
						G3	133	$Summer\_T_{n-1}$	-	<0.01
INVK	G1	49	Winter_T	+	<0.01	G1	71	Climate n.s.		
	G2	21	Spring_P	+	<0.01	G2	34	Winter_T	+	0.033
			$Summer\_T_{n-1}$	-	<0.01					
						G3	5	Spring_T	+	0.031
								Winter_P	-	0.058
TVC	G1	8	Climate n.s.			G1	11	Summer_T	+	<0.01
	G2	1	Winter_T	+	<0.01	G2	8	Winter_P	-	0.037
			Winter_P	-	0.014					
	G3	2	$Summer\_T_{n-1}$	+	0.044					