An aerial photograph of a mountain valley. A river flows through the center of the valley, surrounded by dense green forests. In the background, there are large, rugged mountains under a clear blue sky with a few clouds. The text is overlaid on the upper half of the image.

# Climate change, drought and wildfire in Northeast BC

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British Columbia Ministry of Forests

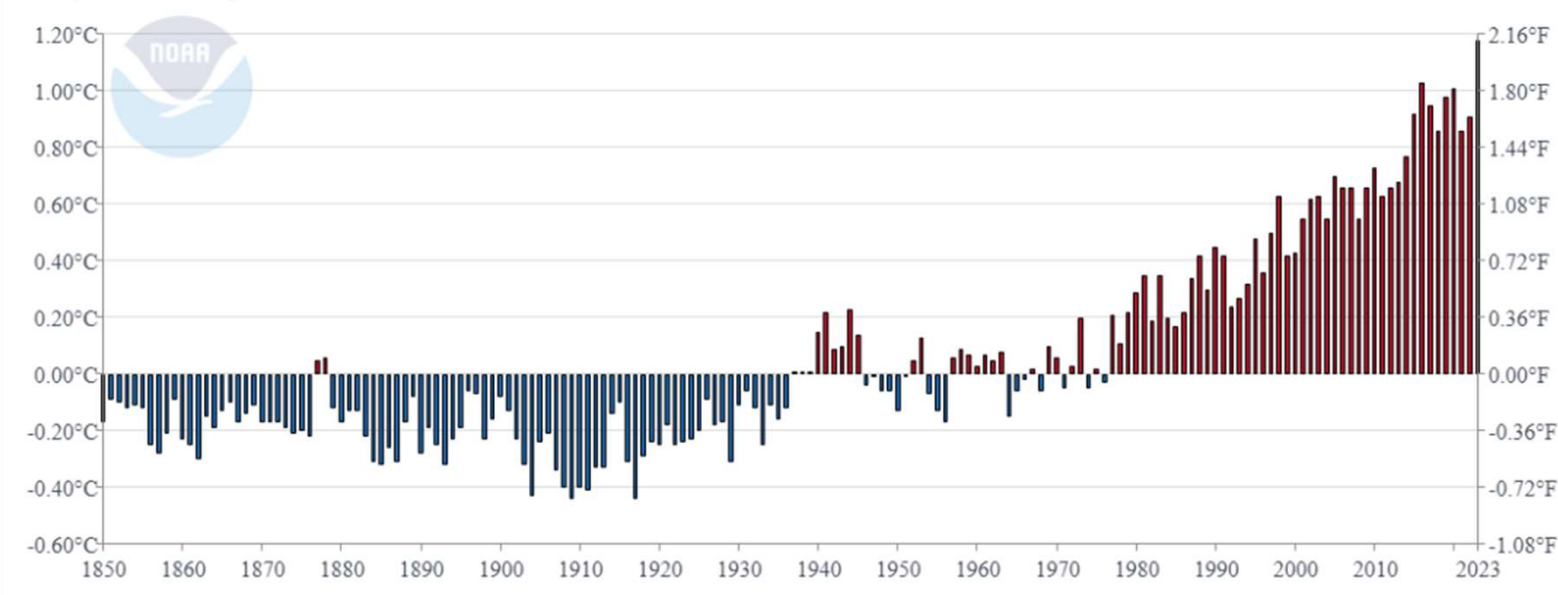
[Vanessa.Foord@gov.bc.ca](mailto:Vanessa.Foord@gov.bc.ca)

NE Region Roundtable Meeting

Jun 5, 2024

# Global Overview:

Global Land and Ocean  
January-December Temperature Anomalies

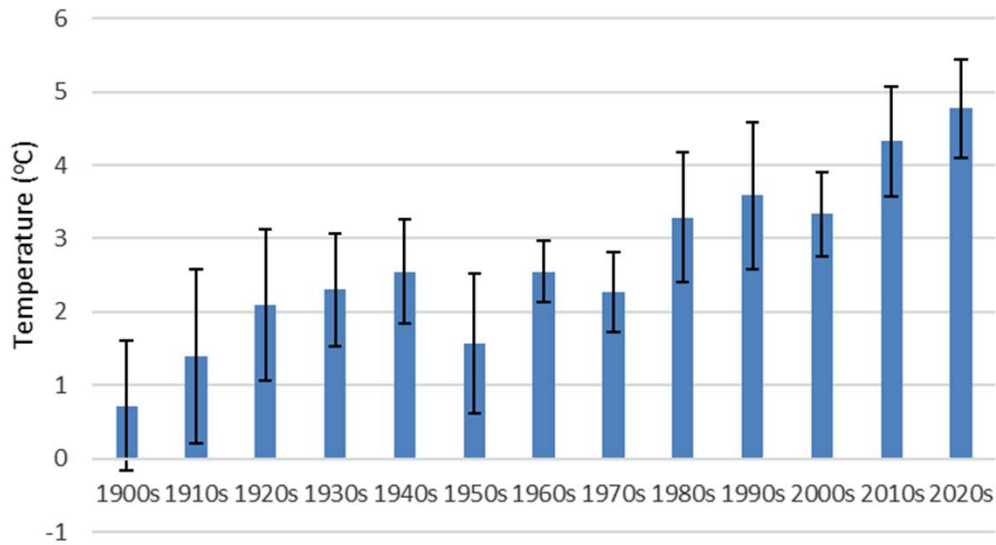


## Warmest Year's:

1. 2023
2. 2016
3. 2020
4. 2019
5. 2017
6. 2015
7. 2022
8. 2021
9. 2018
10. 2014

- The hottest 10 years on record have all occurred within the last 10 years
- April 2024 = 542<sup>nd</sup> consecutive month with global temperatures above the 20<sup>th</sup> century average
  - Hottest April on record, 11<sup>th</sup> consecutive record-breaking monthly temperature

Fort St James Decadal Temperatures

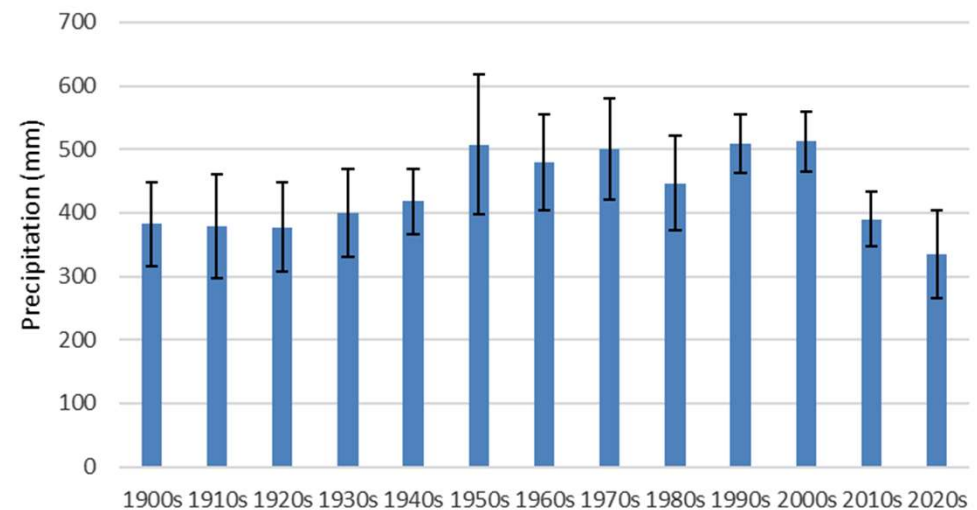


Northern British Columbia has seen an over 3°C increase in mean annual temperatures

Northern British Columbia does not have consistent trends in mean annual precipitation

- Winters drier, spring-fall wetter
- Recent dry conditions

Fort St James Decadal Precipitation





# 2023 Northern BC Climate Review: Monthly/Seasonal Rankings

## 1. Prince George:

- 2023 3<sup>rd</sup> warmest (1.3°C), 2<sup>nd</sup> driest (64%)
- Dec 5<sup>th</sup> warmest (6.0°C)
- Fall 5<sup>th</sup> driest (48%)
- Sep 5<sup>th</sup> driest (27%)
- Summer 2<sup>nd</sup> driest (47%)
- May 2<sup>nd</sup> warmest (3.4°C)

## 2. Chetwynd:

- **2023 warmest (2.5°C), driest (50%)**
- Dec 2<sup>nd</sup> warmest (6.3°C), 2<sup>nd</sup> driest (4%)
- Fall 4<sup>th</sup> warmest (2.4°C), 2<sup>nd</sup> driest (36%)
- Sep 3<sup>rd</sup> driest (17%)
- Summer **warmest** (2.5°C), 2<sup>nd</sup> driest (31%)
- Aug 3<sup>rd</sup> warmest (3.4°C)
- Jul 3<sup>rd</sup> warmest (2.2°C)
- Jun 3<sup>rd</sup> warmest (2.4°C), 4<sup>th</sup> driest (17%)
- May **warmest** (5.0°C)

## 3. Fort St John:

- **2023 warmest (2.6°C), 5<sup>th</sup> driest (71%)**
- Dec 4<sup>th</sup> warmest (8.1°C)
- May **warmest** (5.1°C)

## 4. Fort Nelson:

- **2023 warmest (3.0°C), driest (50%)**
- Dec 4<sup>th</sup> warmest (6.2°C), 3<sup>rd</sup> driest (24%)
- Fall 3<sup>rd</sup> driest (43%)
- Oct 2<sup>nd</sup> driest (5%)
- Summer **warmest** (2.7°C), 2<sup>nd</sup> driest (45%)
- Aug **warmest** (3.6°C)
- Jul **warmest** (3.6°C), 2<sup>nd</sup> driest (28%)
- Jun 3<sup>rd</sup> warmest (2.4°C)
- May **warmest** (4.8°C)
- Jan 5<sup>th</sup> warmest (7.0°C)

## 5. Dease Lake:

- **2023 warmest (2.1°C)**
- Summer **warmest** (2.2°C)
- Aug 2<sup>nd</sup> warmest (2.5°C)
- Jul **warmest** (2.6°C)
- May 4<sup>th</sup> warmest (2.9°C)
- Mar 4<sup>th</sup> driest (30%)
- Jan 5<sup>th</sup> warmest (6.7°C)

## 6. Smithers:

- **2023 warmest (1.7°C), driest (61%)**
- Fall 3<sup>rd</sup> driest (52%)
- Summer **warmest** (2.1°C)
- Aug 2<sup>nd</sup> warmest (2.5°C)
- Jul 4<sup>th</sup> warmest (2.0°C)
- Jun 5<sup>th</sup> driest (25%)
- May **warmest** (3.8°C)

## 7. Terrace:

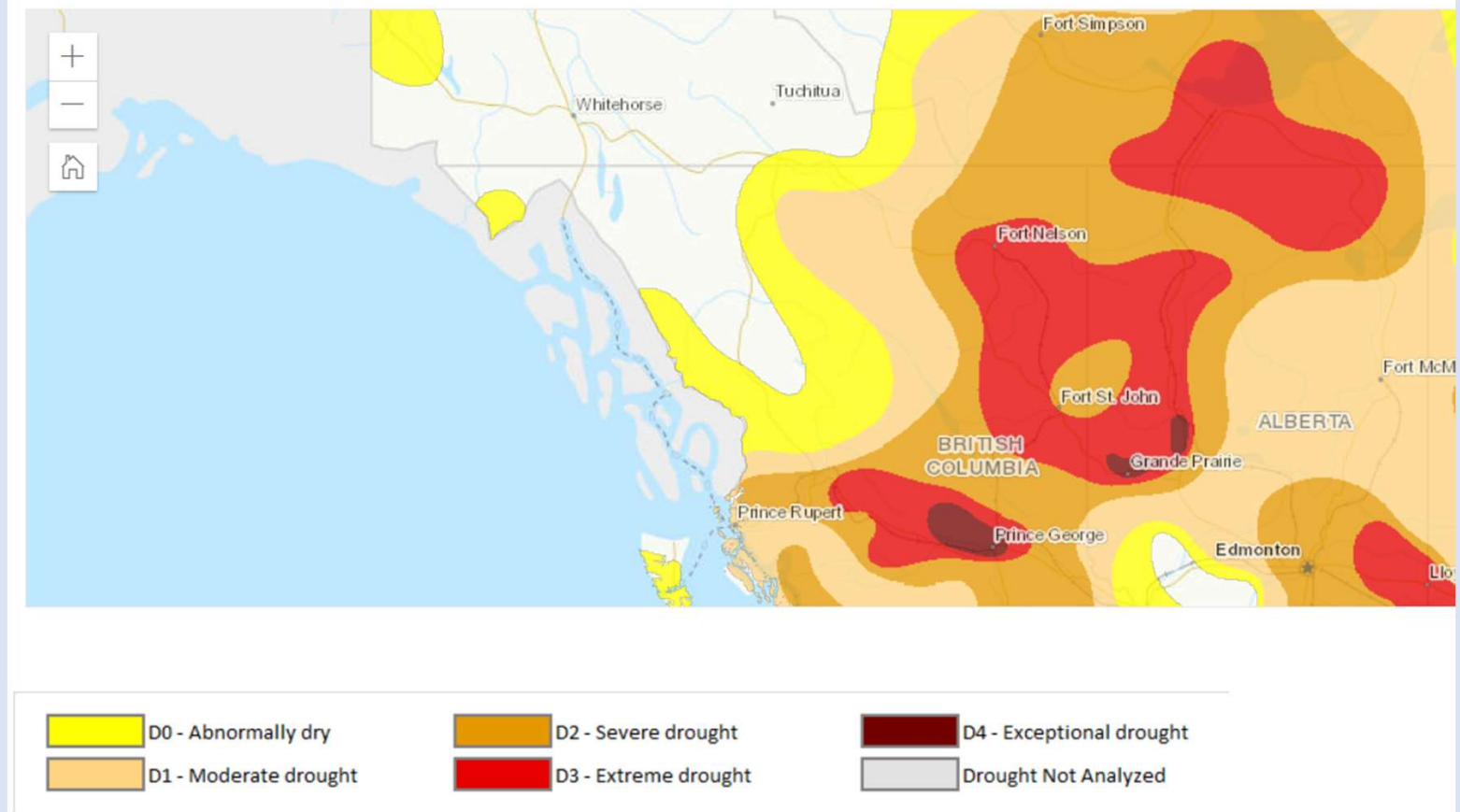
- 2023 4<sup>th</sup> warmest (1.3°C)
- May 4<sup>th</sup> warmest (3.2°C)
- Mar 5<sup>th</sup> driest (31%)
- Feb 5<sup>th</sup> wettest (211%)

## 8. Prince Rupert:

- Summer 4<sup>th</sup> driest (48%)
- May 5<sup>th</sup> warmest (2.1°C)
- Mar 3<sup>rd</sup> driest (26%)
- Feb 4<sup>th</sup> wettest (199%)

# Canadian Drought Monitor

Drought conditions as of April 30, 2024



# What is drought?

Water deficit as related to average conditions

**METEOROLOGICAL** >> Dry weather pattern dominates an area

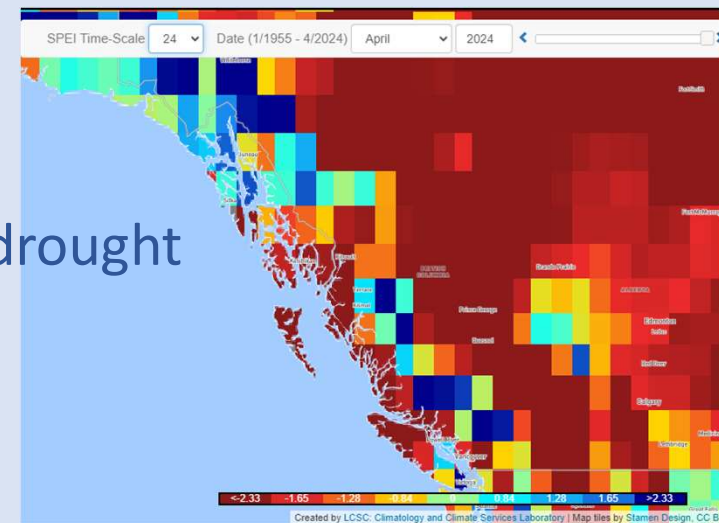
**HYDROLOGICAL** >> Low water supply following drought

**ECOLOGICAL** >> Vegetation impacted by drought

**ECONOMIC** >> Supply/Demand of commodities to drought

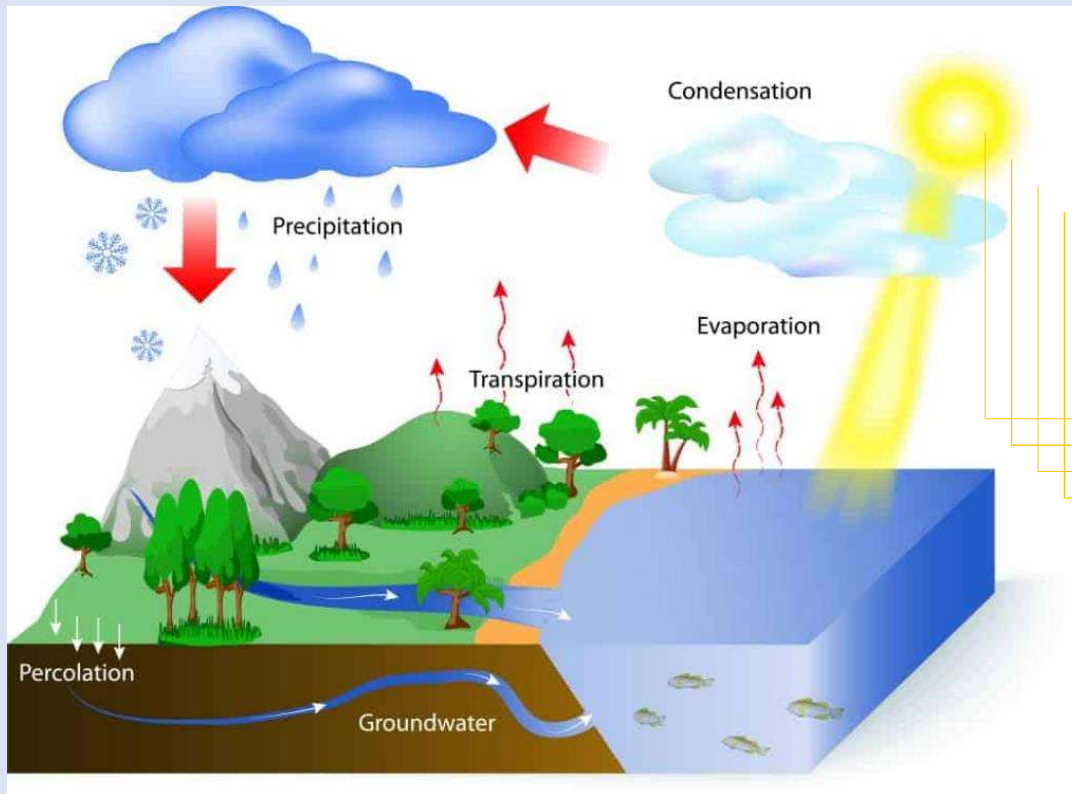
## Quantifying Drought?

- hundreds of indices, methods
- relative in time and space



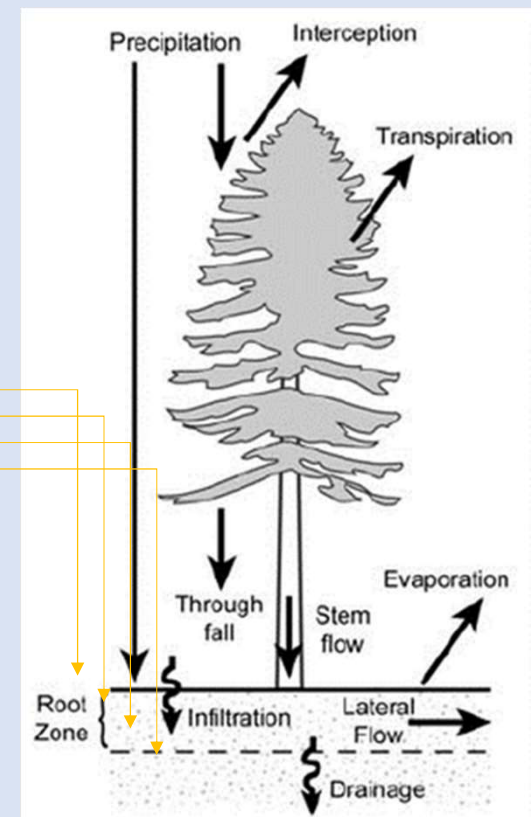
Apr 2022-Apr 2024 Extreme Drought (red)

# Evaporation, Transpiration, Evapotranspiration



<https://fruitgrowers.com/why-understanding-evapotranspiration-is-crucial-to-growers/>

Evapotranspiration =  
Evaporation + Transpiration

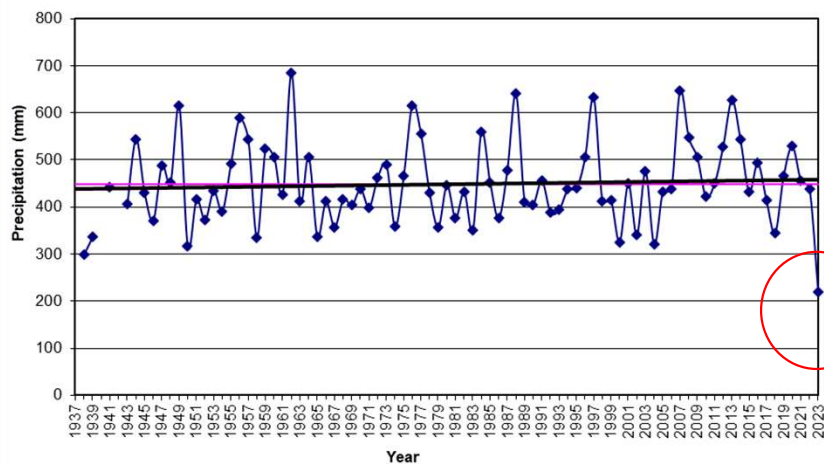


# Standardized Precipitation Evapotranspiration Index\* (SPEI)

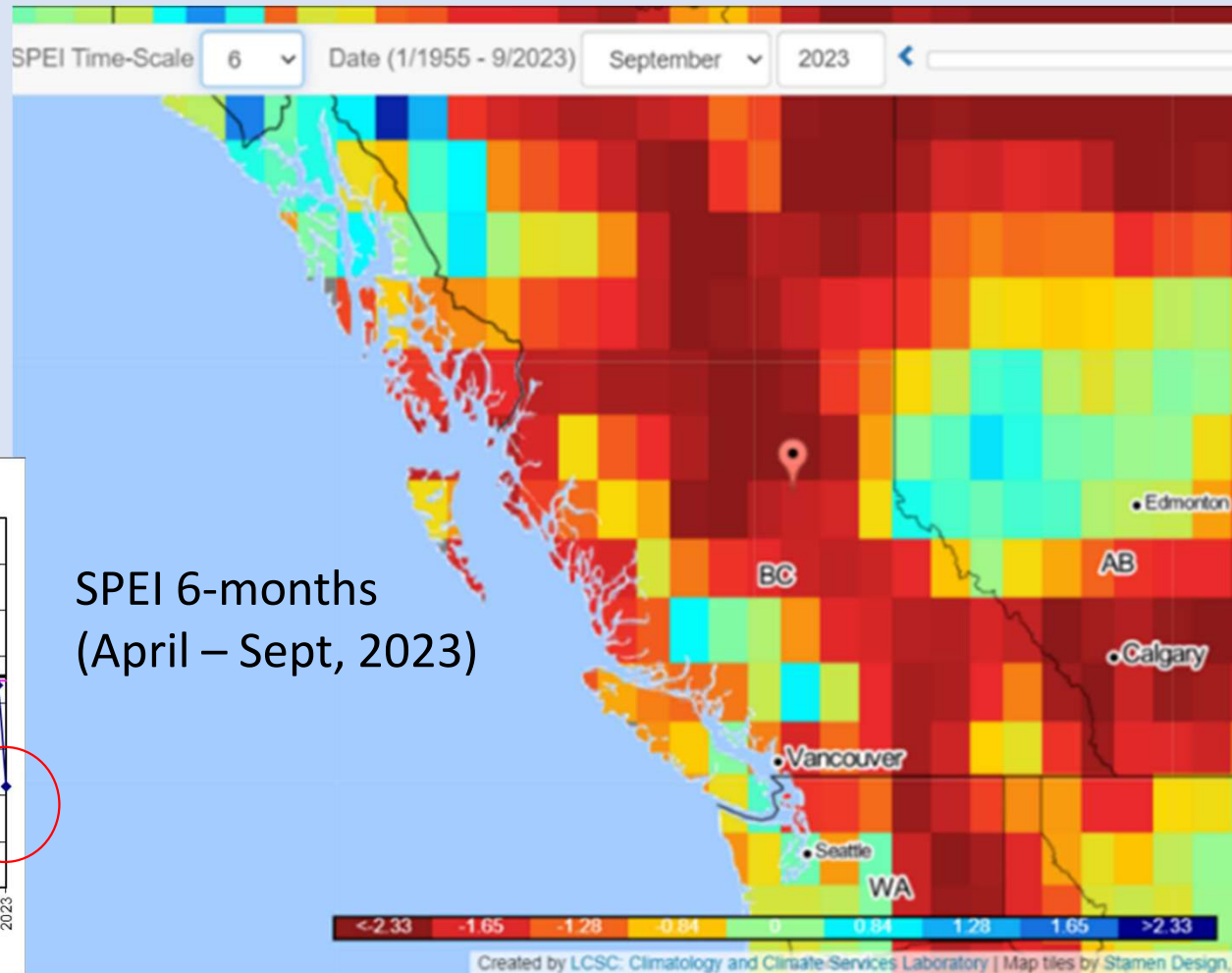
Drought Categories:

- < -1.0 Moderate Drought
- < -1.5 Severe Drought
- < -2.0 Extreme Drought

Fort Nelson A Yearly Precipitation 1937-2023



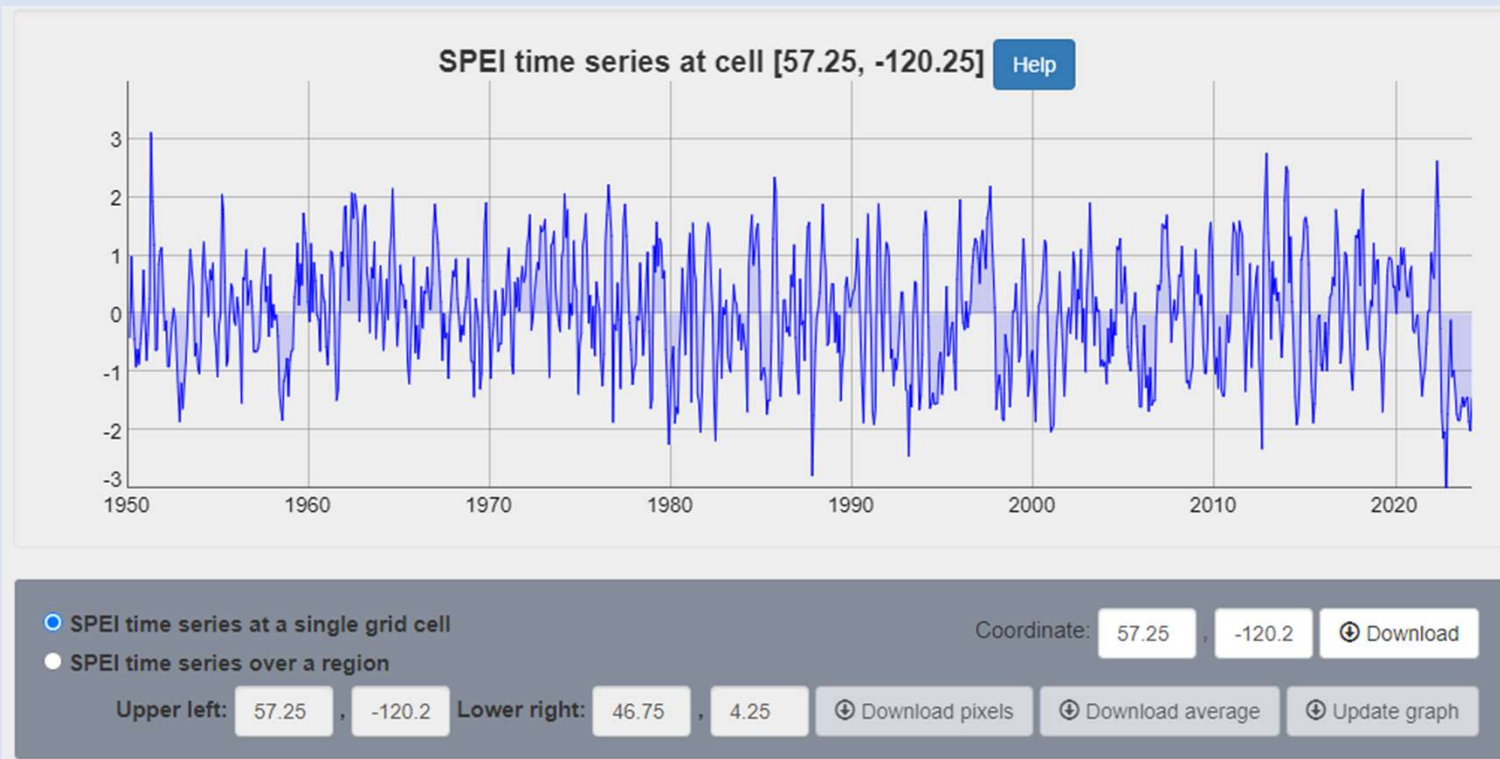
SPEI 6-months  
(April – Sept, 2023)





# 3-month SPEI – Peace Area

“Seasonal Meteorological Drought”



- Extreme Drought is uncommon
- Most of the  $<-2$  SPEI values are during the winter months
- Summer Extreme Drought:
  - Sep 2012 (Jul, Aug, Sep)
- Fall Extreme Drought:
  - 2022
- Severe to extreme drought persists for the region

<https://spei.csic.es/map/maps.html#months=1#month=3#year=2024>



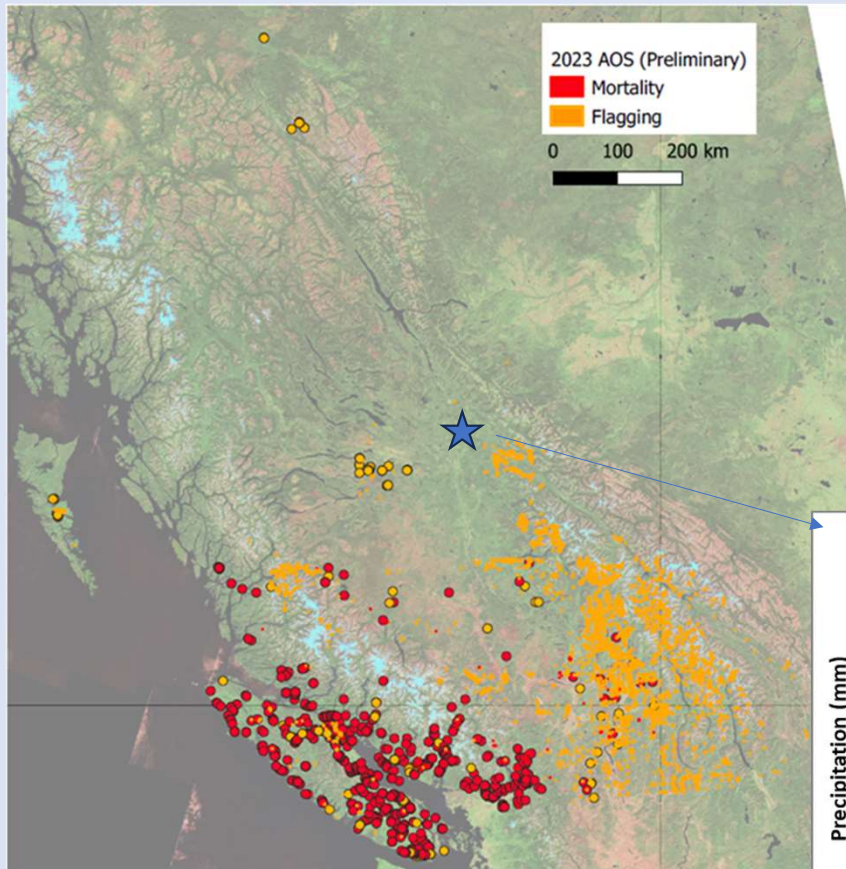
# Forest Drought Impacts

- Tree mortality, dead branches, needles
- Plantation failures (seedling damage or mortality)
- Mast years – conifer cones
- Dry soils
- Build-up of dry fuels
- Reduced photosynthesis
- Drought stressed trees: secondary disturbances
  - Wildfire
  - Insects
  - Windthrow



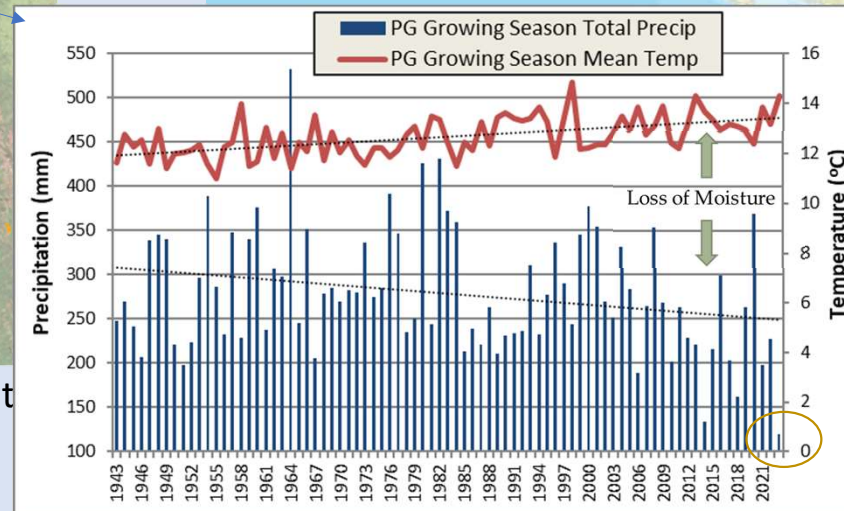
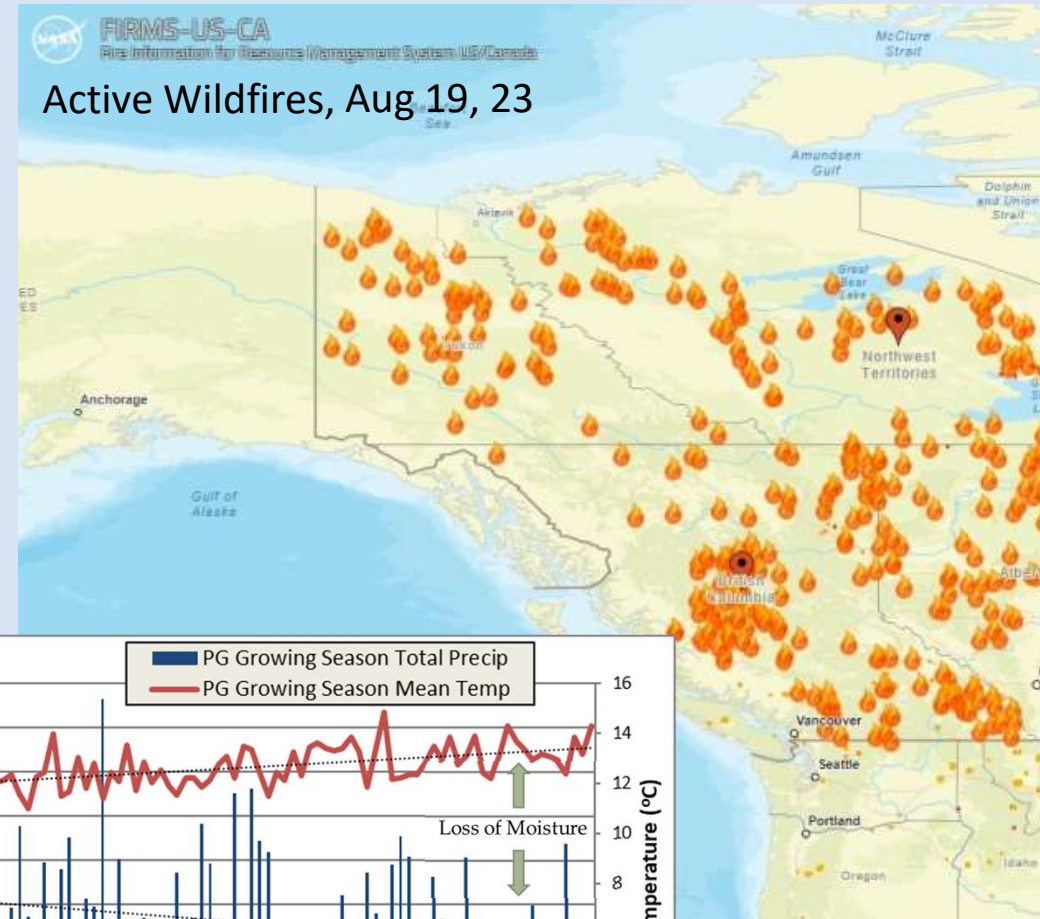


# 2023 Ecological Drought



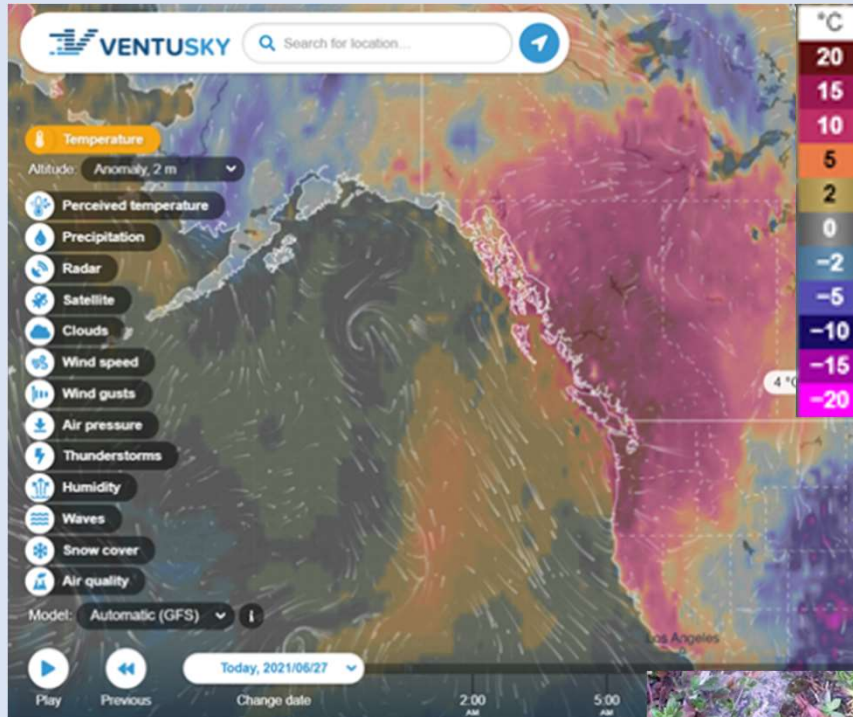
2023 Aerial Overview Survey preliminary drought data (more in north but smoke?)

11 Map created by: Alex Bevington



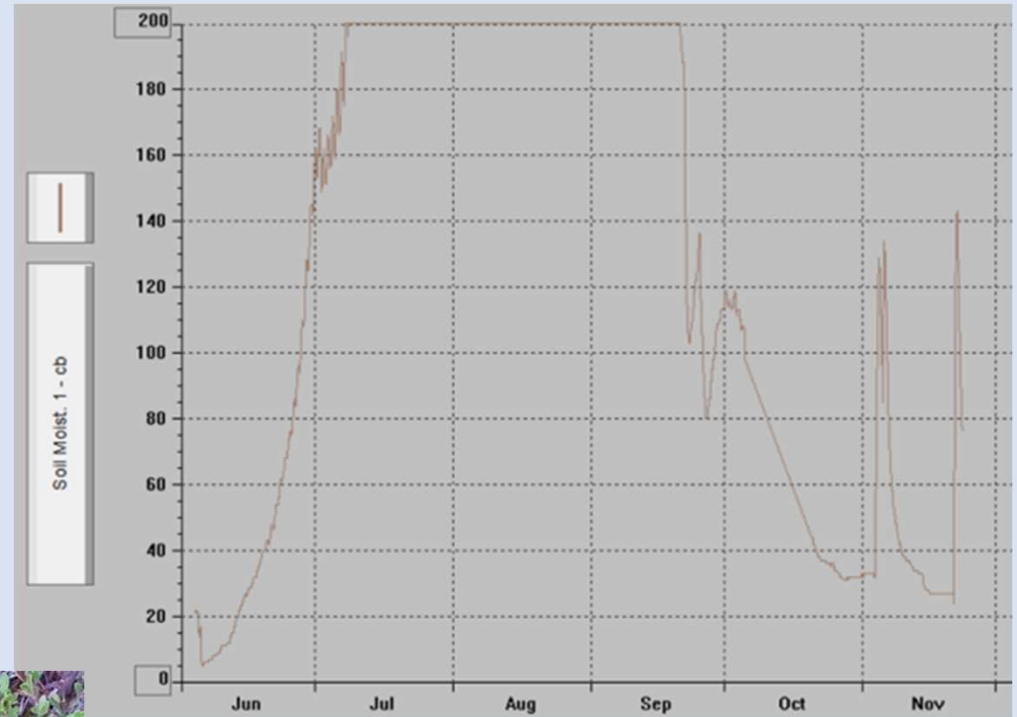
2023 driest May to Sep on record in Prince George

# 2021 **HEAT DOME** - June 25<sup>th</sup> to July 3<sup>rd</sup>



<https://www.ventusky.com/>

Tree scorching



## Flash Drought

Soil moisture @ 20 cm depth

Hydrophobic soils remainder of growing season?



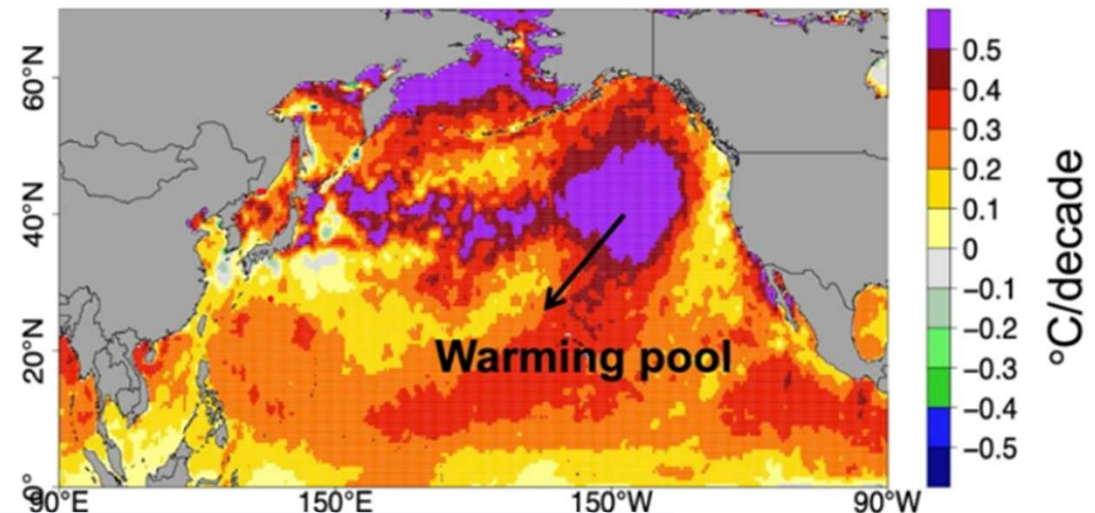
# Why drought in recent years?

Sea Surface Trends: Jun-Nov

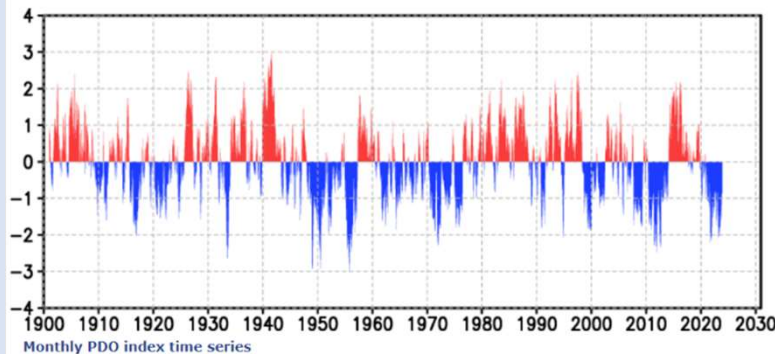
- Climate Change?
- Jet stream changes?
- Marine Heat Waves?
- Land-use change?
- Positive feedbacks from snow and ice melt?
- Climate variability?
  - E.g. El Nino, La Nina, Pacific Decadal Oscillation, Arctic Oscillation

[https://ds.data.jma.go.jp/tcc/tcc/products/el\\_nino/decadal/pdo\\_month.html](https://ds.data.jma.go.jp/tcc/tcc/products/el_nino/decadal/pdo_month.html)

Observed SST trends in JJASON (OISST; 1996-2021)



Monthly Pacific Decadal Oscillation (PDO) index

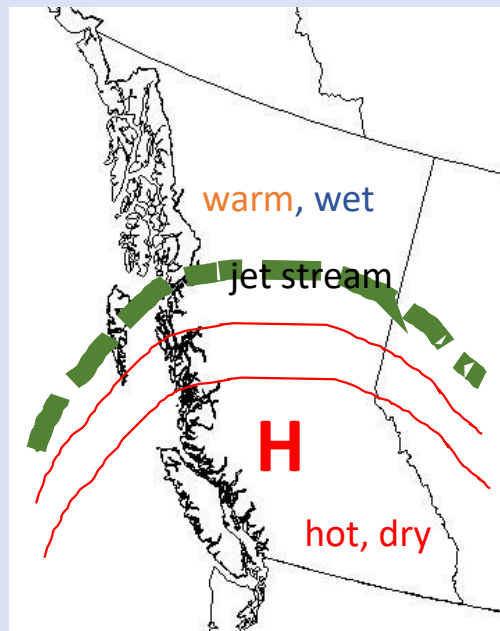


The red (blue) shading represents positive (negative) monthly PDO index values. The solid black line represents three-month running mean values.

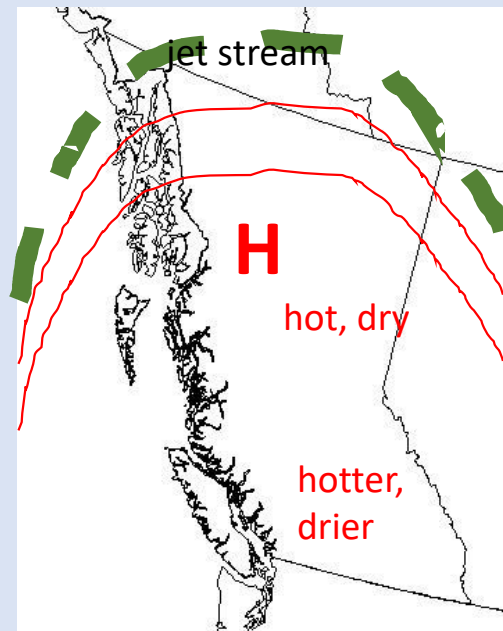
Barkhordarian et al.  
2022.

<https://www.nature.com/articles/s43247-022-00461-2>

# Effect on BC weather: Summer extreme events



“Typical” summer weather

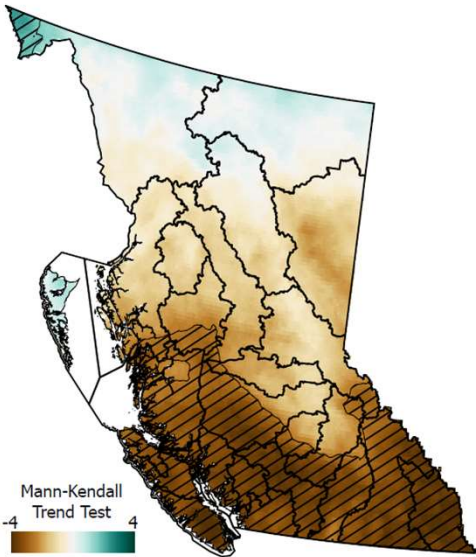


“Future” summer weather  
- hotter, larger, longer

- Amplification of summer “Pacific Highs” leads to more extreme fire conditions and drought
- Increased heat increases risk of extreme thunderstorms (hail, flooding)

# SPEI-3 month Seasonal Drought Trends (1950-2023)

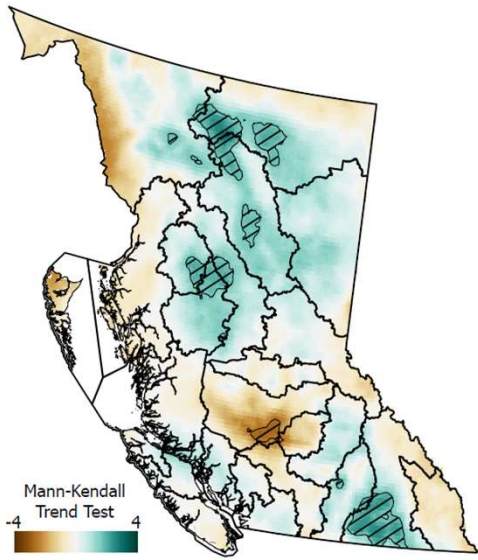
B. SPEI-3 Gridded Trends



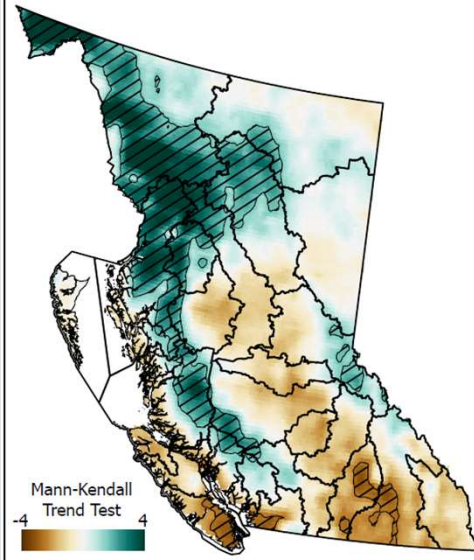
Winter (Dec, Jan, Feb)

Spring (Mar, Apr, May)

B. SPEI-3 Gridded Trends



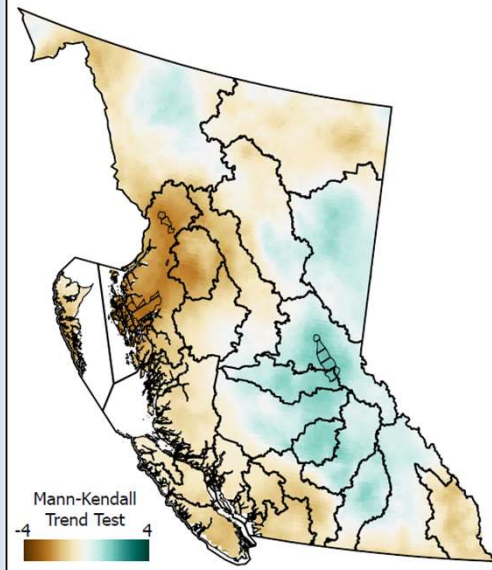
B. SPEI-3 Gridded Trends



Summer (Jun, Jul, Aug)

Fall (Sep, Oct, Nov):

B. SPEI-3 Gridded Trends



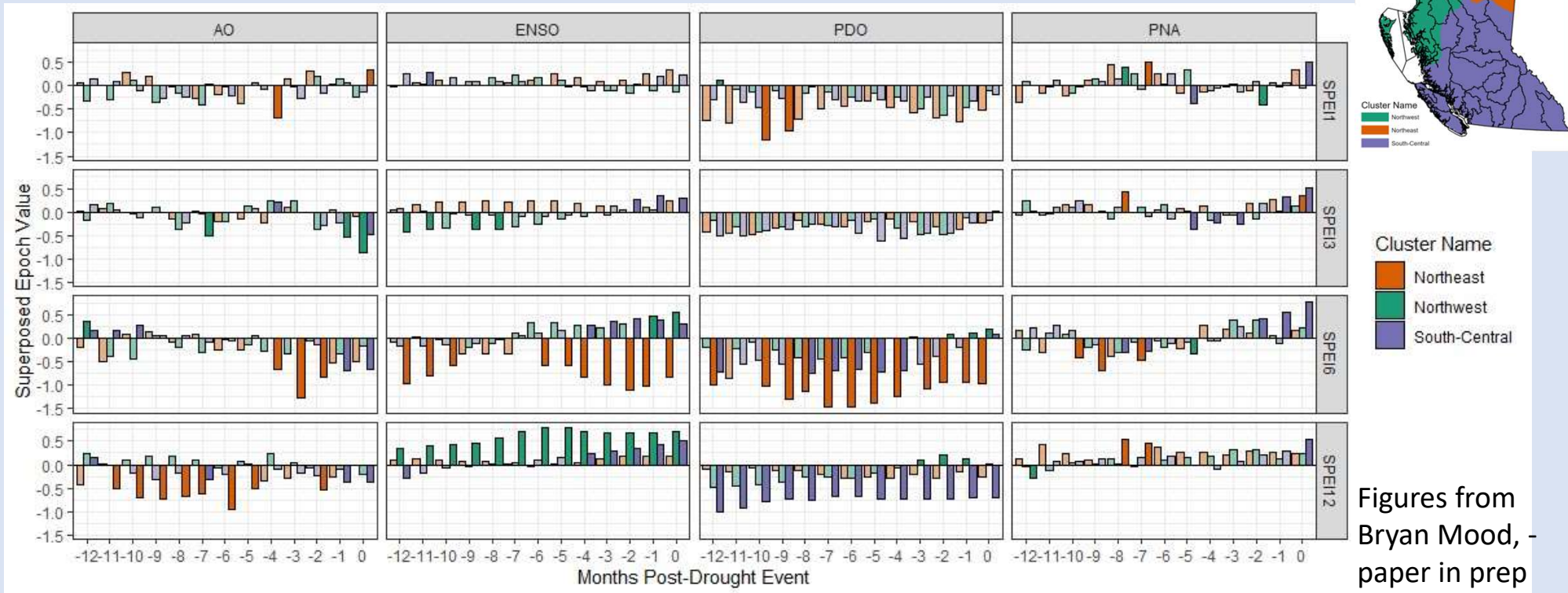
Significant Trend  
( $p < 0.05$ )



Figures from Bryan Mood,  
U of Saskatchewan,  
Stantec – paper in prep



# Teleconnections and Extreme Drought?



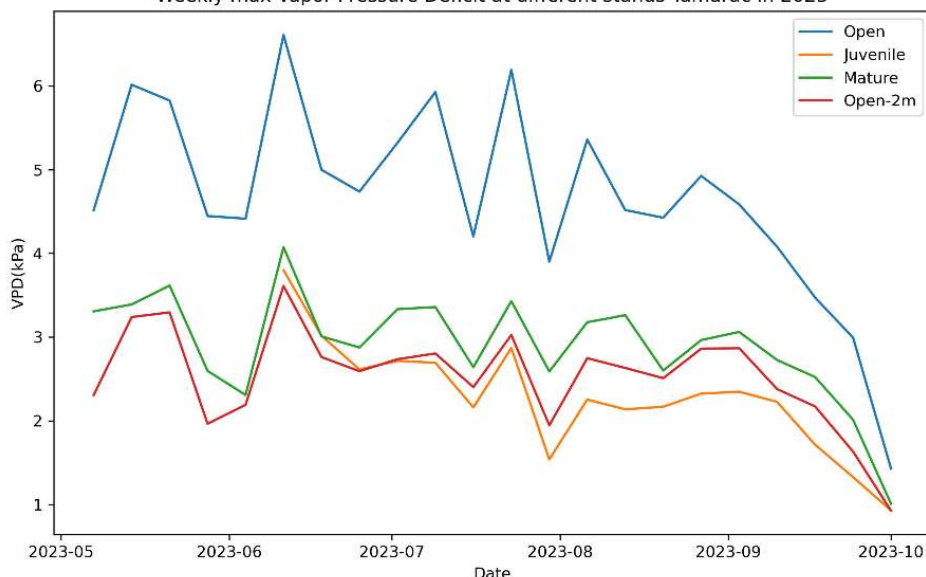
SPEI  $\leq -2$  as related to Arctic Oscillation (AO), Pacific Decadal Oscillation (PDO), Pacific North American pattern (PNA), Multivariate El Nino Southern Oscillation index (ENSO)

Darker colours statistically significant. E.g.s Negative phase of the Arctic Oscillation relates to Extreme Drought in NE BC 4 months prior. SPEI-6 extreme drought related to El Nino in the NW, south central at various months prior. Lots of relationships with drought and negative PDO, e.g. SPEI-6 related to cold PDO phase in NE and south-central.



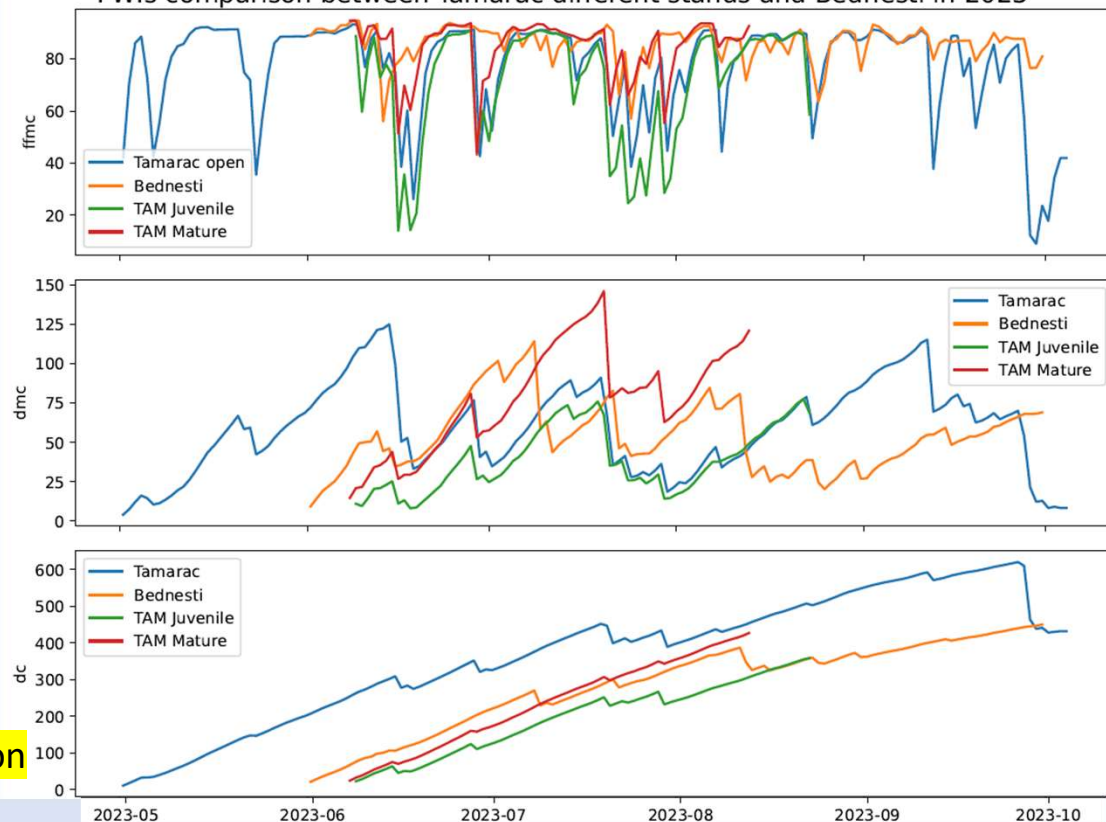
# Vapour Pressure Deficit (VPD) and Fire Weather drought codes ([Canadian Forest Fire Weather System](#)) – different stand types

Weekly max Vapor Pressure Deficit at different stands Tamarac in 2023



- High VPD values can limit tree growth
- Open stands, where seedlings are planted have highest VPD
- Max drought codes are dependent on end of snow season
  - generally higher in open, but not always
  - Seasonality: start of fire season juvenile > mature, mid-season mature > juvenile

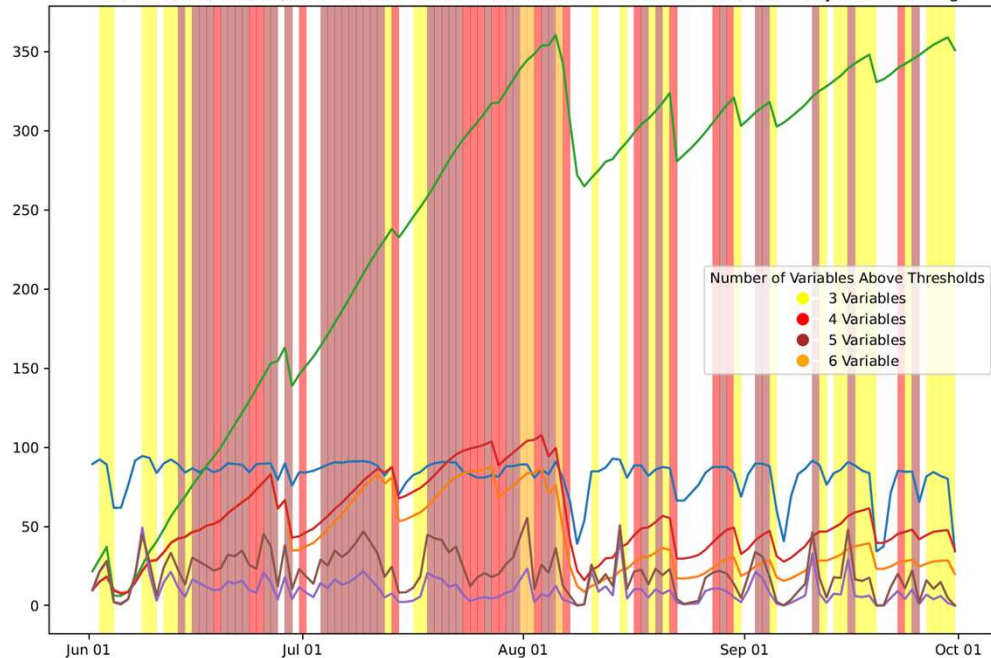
FWIs comparison between Tamarac different stands and Bednesti in 2023



FFMC = fine fuel moisture code, DMC = duff moisture code, DC = drought code,

# 2023 Fire Weather Indices Thresholds

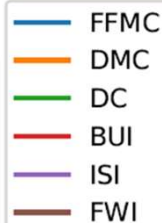
FFMC, DMC, DC, BUI, ISI, and FWI Over Time at Bear Lake fire weather station, with likely fire Time range



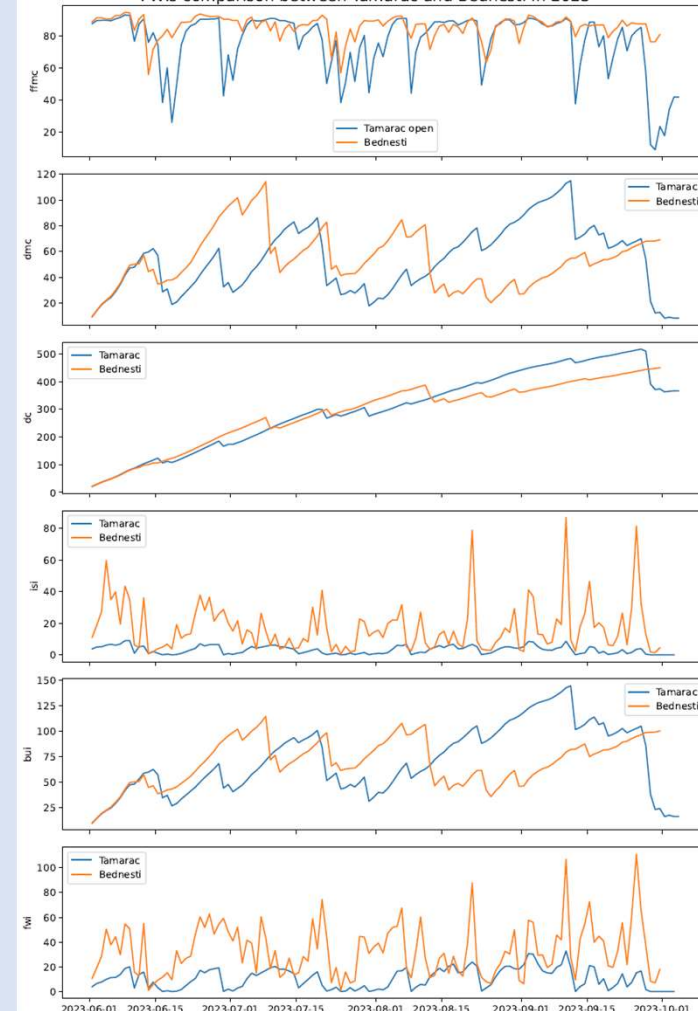
FFMC = Fine Fuel Moisture Code  
DMC = Drought Moisture Code  
DC = Drought Code

BUI = Build Up Index  
ISI = Initial Spread Index  
FWI = Fire Weather Index

Preliminary comparisons with nearby BC Wildfire Service weather station data and our in-stand open weather stations



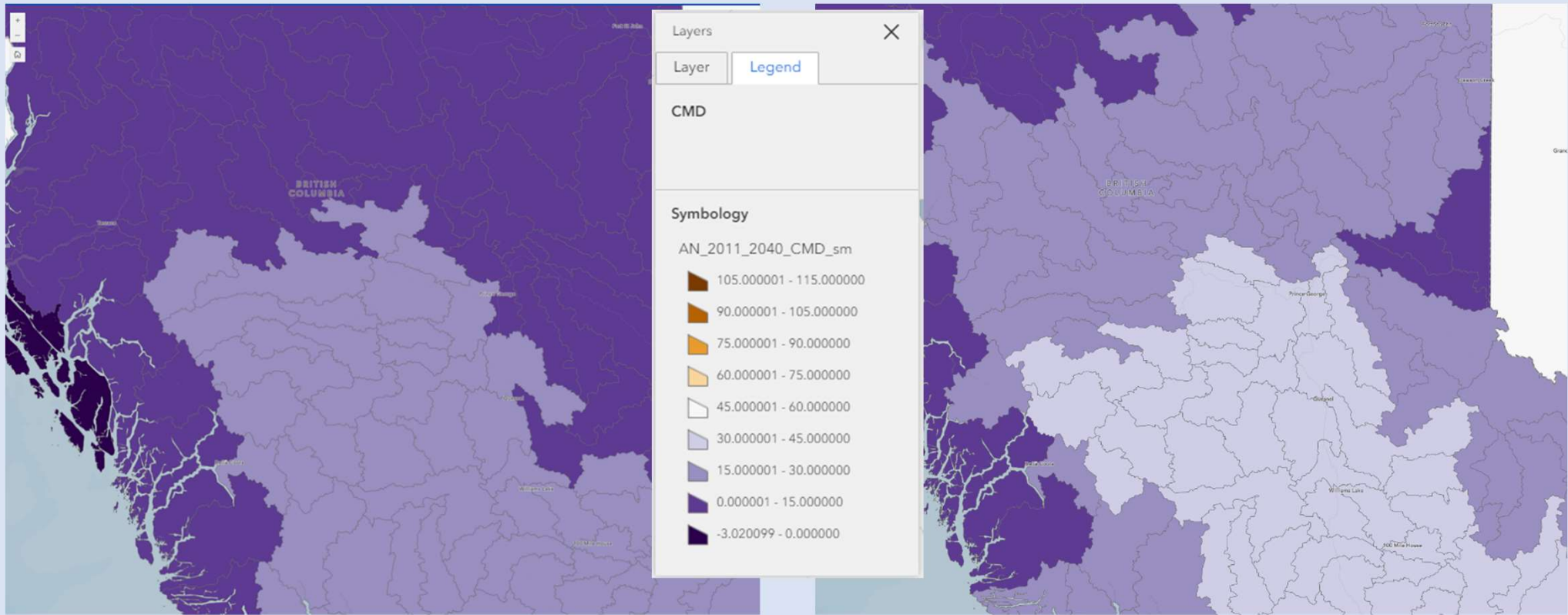
FWIs comparison between Tamarac and Bednesti in 2023



<https://cfs.nrcan.gc.ca/pubwarehouse/pdfs/29152.pdf>

Thresholds: <https://cfs.nrcan.gc.ca/pubwarehouse/pdfs/23688.pdf>

# Projections: Summer Climate Moisture Deficit



2011-2040

up to 15 mm

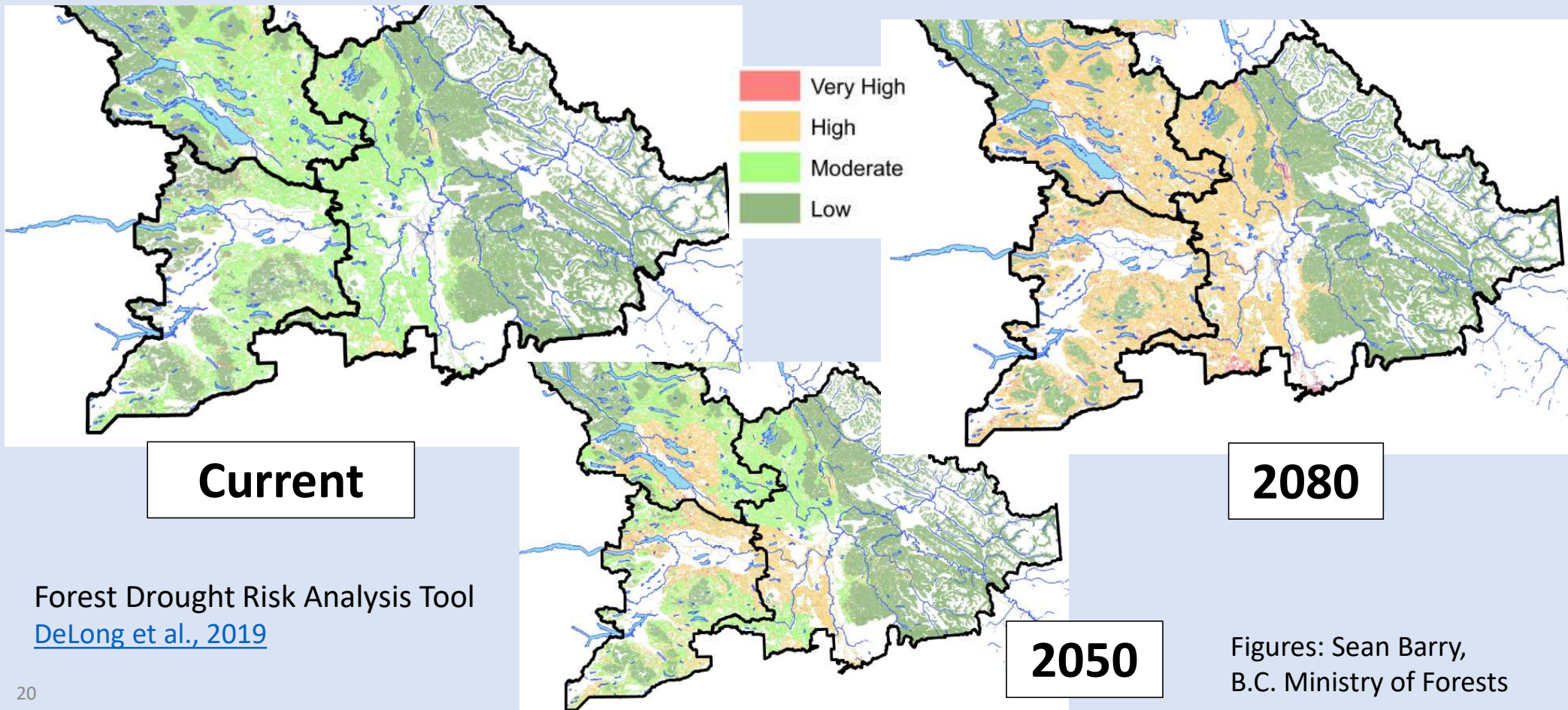
2041-2070

up to 30 mm

Data source: <https://climatebc.ca/> , figures from Jordan Foy, BC Ministry of Forests

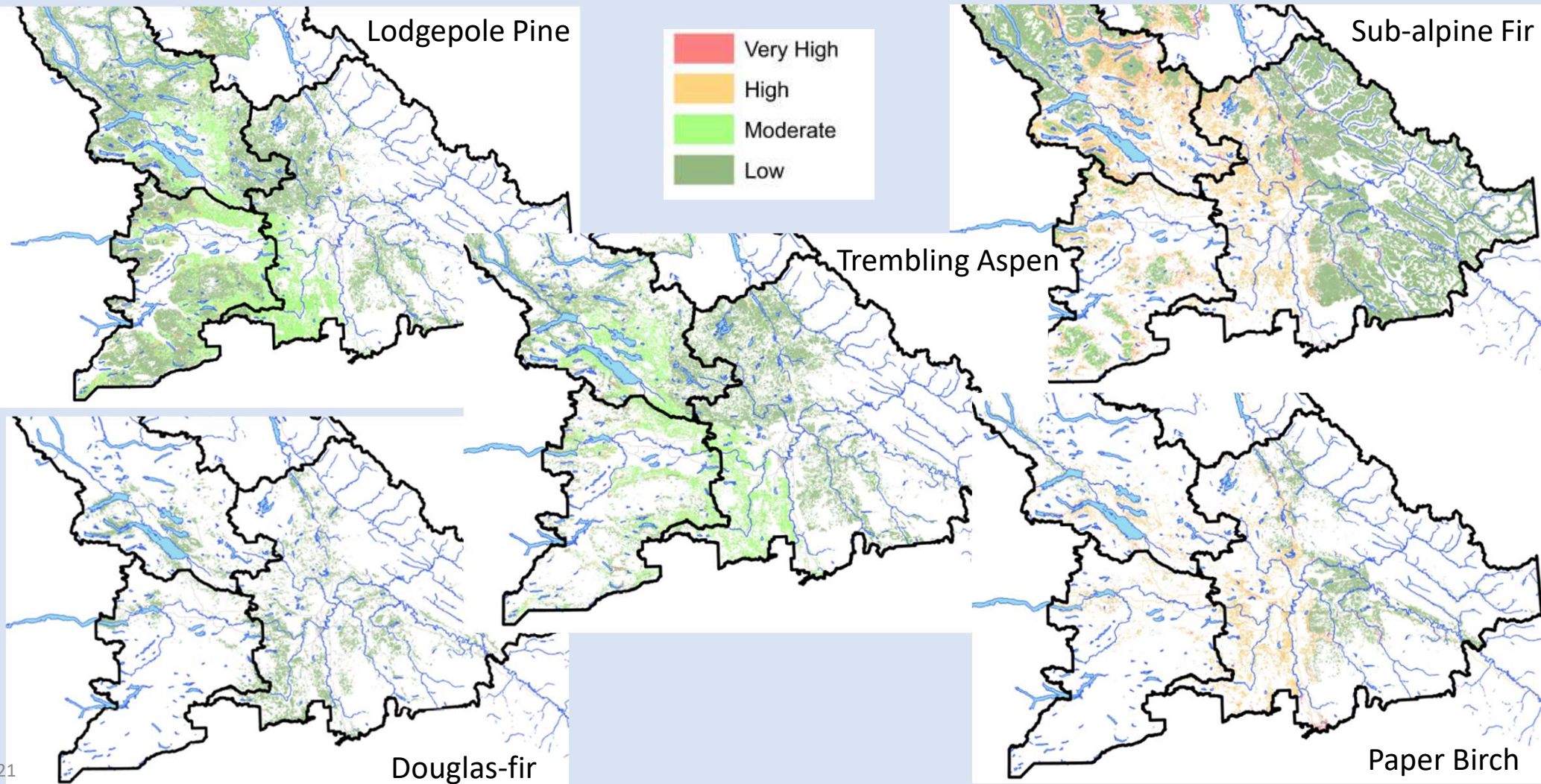


# Future Forest Drought Risk in spruce-leading stands – Central Interior B.C.





# Future Forest Drought Risk by species: 2041-2070





Questions?

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