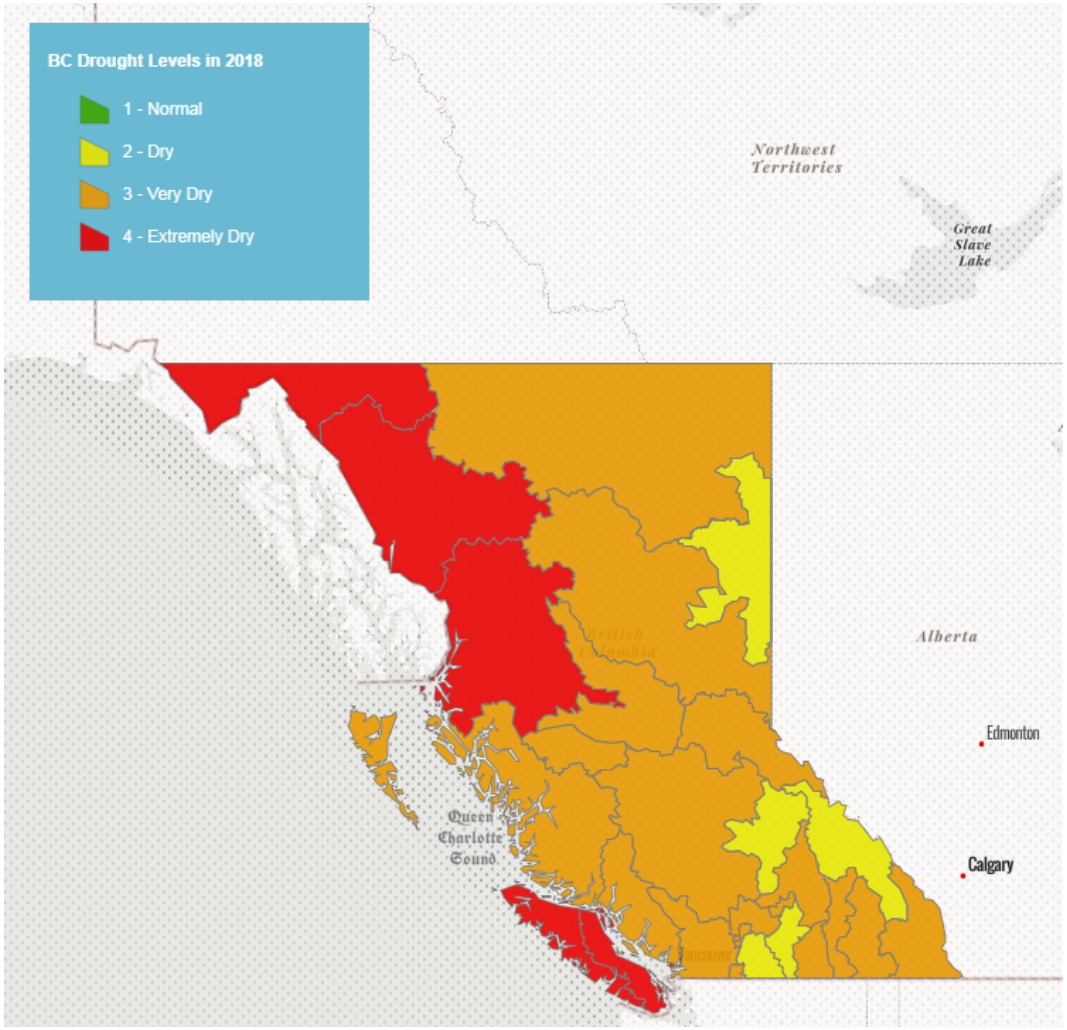
Modeling stand-level drought hazard in British Columbia

ITAC Extension Meeting
January 23, 2020
Hardy Griesbauer, BC MoFLNRORD

Drought in BC



In BC, can be a function of low snowpacks, hot/dry weather, and lack of precipitation, resulting a water shortage.

Models predict increase in drought frequency and intensity

Source: BC Drought Information Portal

Drought in BC forests

- Drought damage leading to mortality affected a record 118,000 ha in 2018
  - Mostly Pli and Cw
- Drought may be related to aspen decline on 68,000 ha, all in northeast province
- Effects on productivity

BC MFLNRORD. 2018. 2018 Summary of Forest Health Conditions in BC [report]

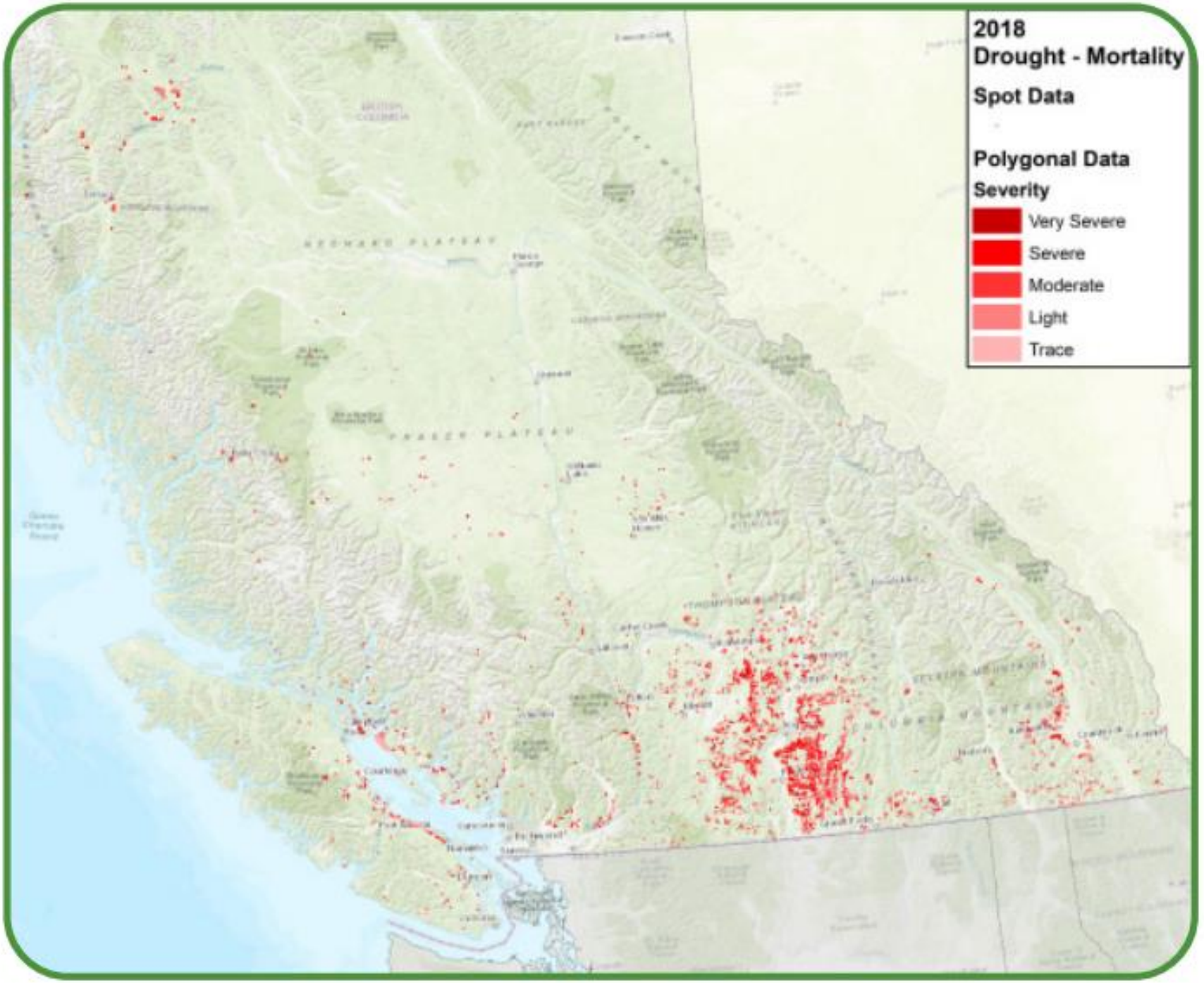

2018
Drought - Mortality
Spot Data
Polygonal Data
Severity
Very Severe
Severe
Moderate
Light
Trace

Photo: Joan Westfall

Drought in southern US

Photo: Nathan Stephenson/USGS
URL: https://environment.yale.edu/news/article/brodersen-drought-and-tree-mortality-science-reveals-harsh-future-for-forests/

Stand-Level Drought Hazard Tool

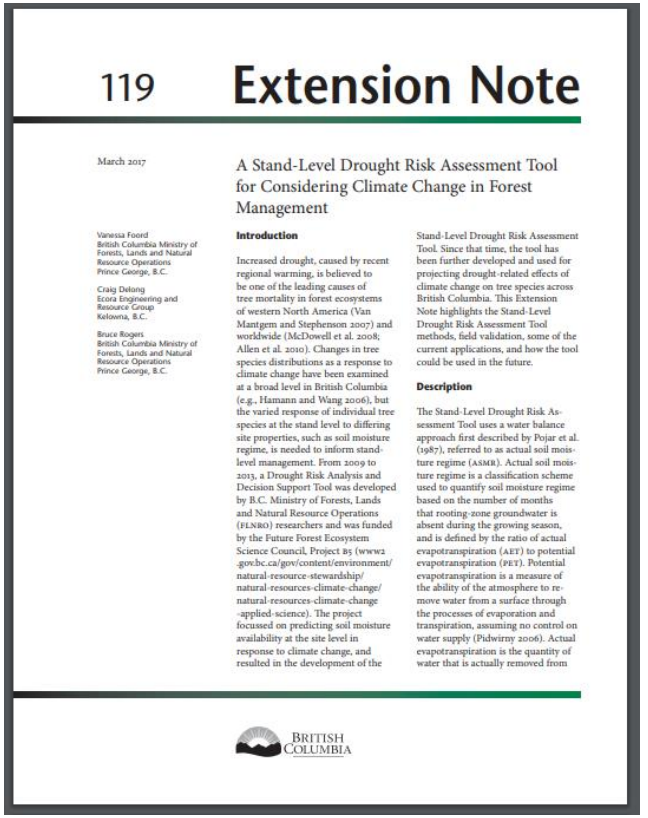
- Project started in 2009
- FFEI funding

Current team:

- Craig Delong (Ecora)
- Vanessa Foord (FLNRORD)
- Bruce Rogers (FLNRORD)
- Hardy Griesbauer (FLNRORD)
- Craig Nitschke (U of Melbourne)

Stand-Level Drought Hazard Tool

- Used in several TSAs (PG, Williams Lake, Cranbrook, Dawson Creek)
- Incorporated into TSR for Mackenzie TSA 2020
- Several internal publications, including Technical Report 2019



119 **Extension Note**

March 2017

A Stand-Level Drought Risk Assessment Tool for Considering Climate Change in Forest Management

Vanessa Foord
British Columbia Ministry of Forests, Lands and Natural Resource Operations
Prince George, B.C.

Craig Delong
Ecora Engineering and Resource Group
Kelowna, B.C.

Bruce Rogers
British Columbia Ministry of Forests, Lands and Natural Resource Operations
Prince George, B.C.

Introduction

Increased drought, caused by recent regional warming, is believed to be one of the leading causes of tree mortality in forest ecosystems of western North America (Van Mantgem and Stephenson 2007) and worldwide (McDowell et al. 2008; Allen et al. 2010). Changes in tree species distributions as a response to climate change have been examined at a broad level in British Columbia (e.g., Hamann and Wang 2006), but the varied response of individual tree species at the stand level to differing site properties, such as soil moisture regime, is needed to inform stand-level management. From 2009 to 2013, a Drought Risk Analysis and Decision Support Tool was developed by B.C. Ministry of Forests, Lands and Natural Resource Operations (FLNRO) researchers and was funded by the Future Forest Ecosystem Science Council, Project B5 (www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/natural-resources-climate-change/natural-resources-climate-change-applied-science). The project focussed on predicting soil moisture availability at the site level in response to climate change, and resulted in the development of the Stand-Level Drought Risk Assessment Tool. Since that time, the tool has been further developed and used for projecting drought-related effects of climate change on tree species across British Columbia. This Extension Note highlights the Stand-Level Drought Risk Assessment Tool methods, field validation, some of the current applications, and how the tool could be used in the future.

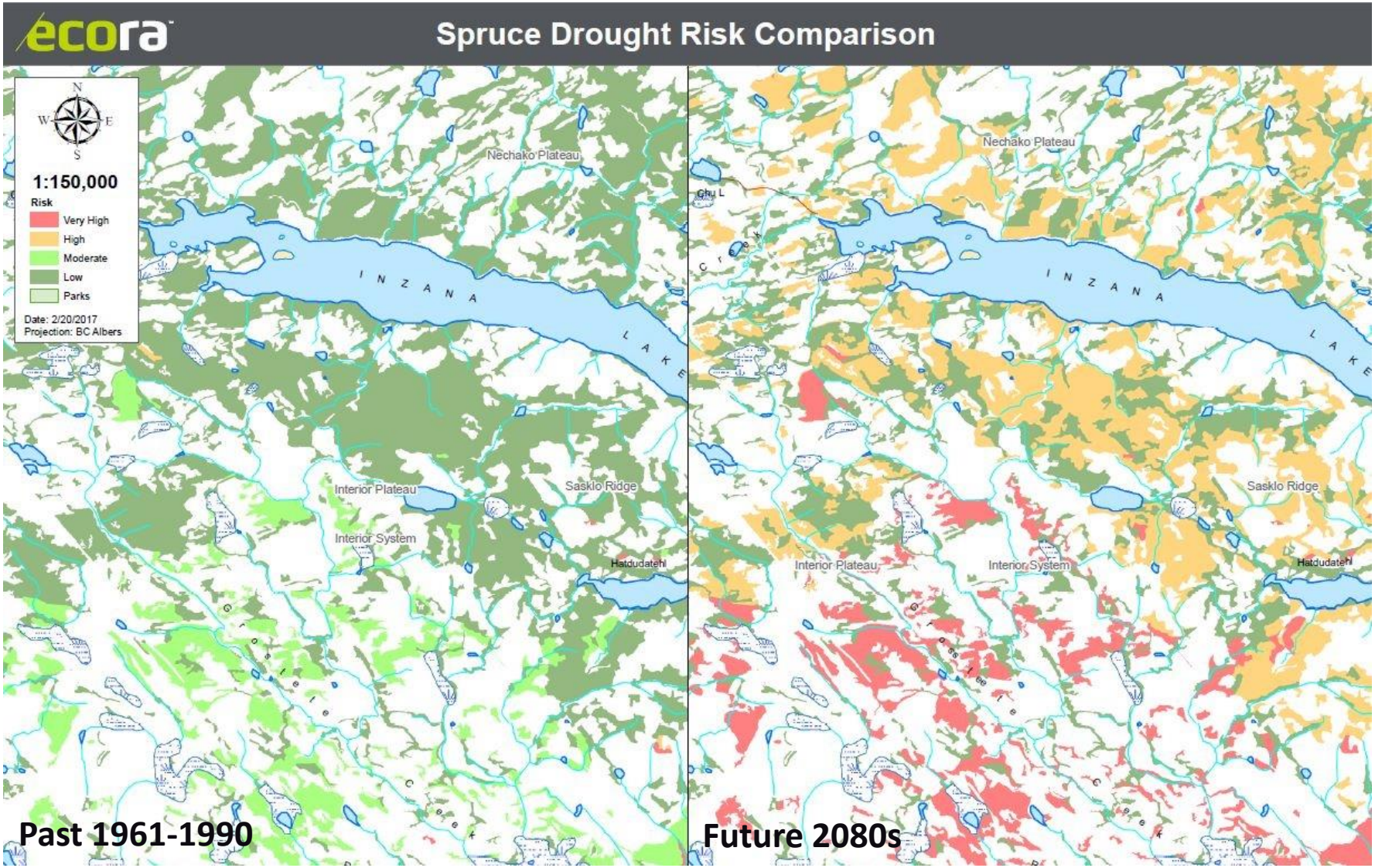
Description

The Stand-Level Drought Risk Assessment Tool uses a water balance approach first described by Pojar et al. (1987), referred to as actual soil moisture regime (ASMR). Actual soil moisture regime is a classification scheme used to quantify soil moisture regime based on the number of months that rooting-zone groundwater is absent during the growing season, and is defined by the ratio of actual evapotranspiration (AET) to potential evapotranspiration (PET). Potential evapotranspiration is a measure of the ability of the atmosphere to remove water from a surface through the processes of evaporation and transpiration, assuming no control on water supply (Pidwirny 2006). Actual evapotranspiration is the quantity of water that is actually removed from

BRITISH COLUMBIA

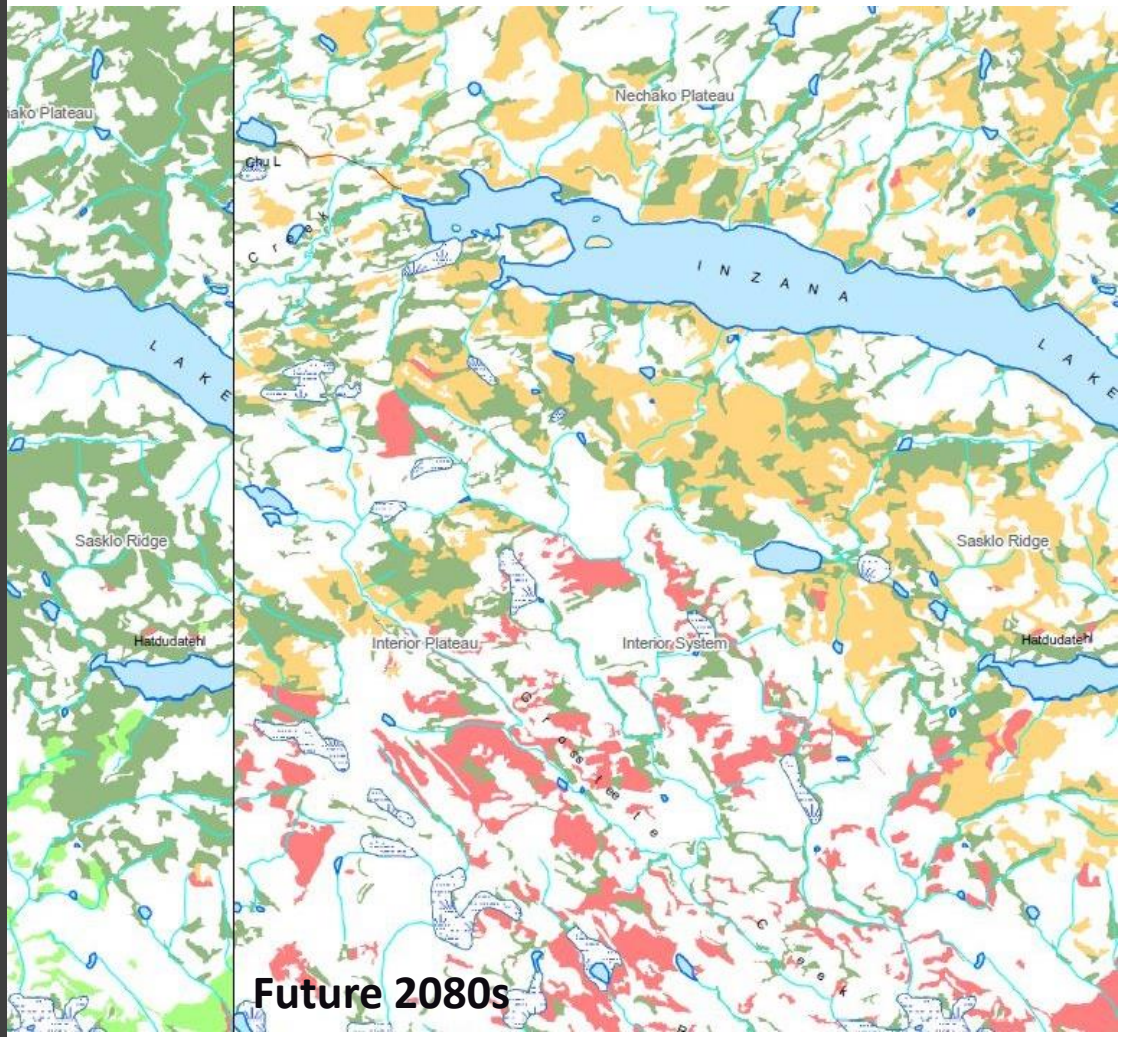
https://www.for.gov.bc.ca/hfd/pubs/Docs/Tr/TR125.pdf

Modeling stand-level drought hazard

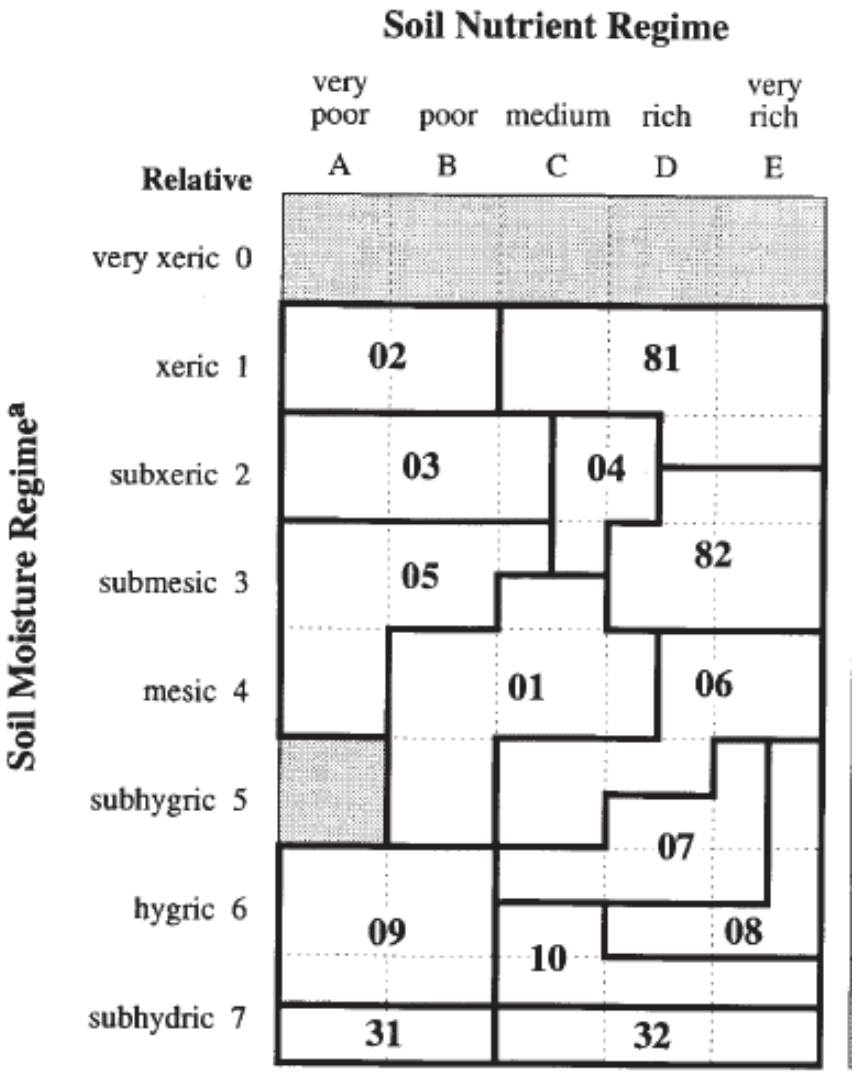


How does the model work?

1. Model is based on BEC system
2. Model uses actual soil moisture regime to define site-level drought conditions
3. Drought hazard for a site is adjusted to reflect tree species



Model is based on BEC system



Actual Soil Moisture Regime

- Water balance approach
- Water demand on site – Potential evapotranspiration
- Available soil moisture – Actual evapotranspiration
- AET/PET ratio

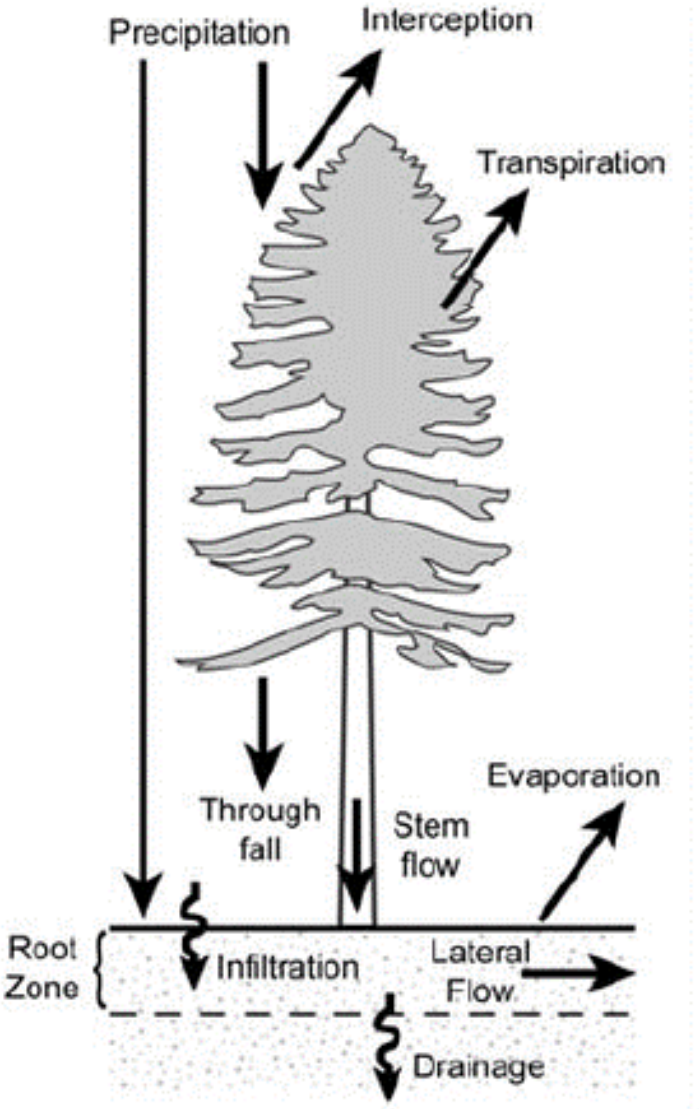


Figure from: Redding et al. 2008. Mountain Pine Beetle and Watershed Hydrology: A Synthesis focused on the Okanagan Basin

Actual soil moisture regime

Actual SMR Category	AET/PET Ratio	Deficit (months)
Excessively dry	<=0.55	5-7
Very dry	0.56 – 0.75	3-5
Moderately dry	0.75 – 0.90	1.5-3
Slightly dry	0.91-1	0-1.5
Fresh/Moist	1+	0

From: Pojar et al. 1987. Biogeoclimatic ecosystem classification in British Columbia.

Modeling process

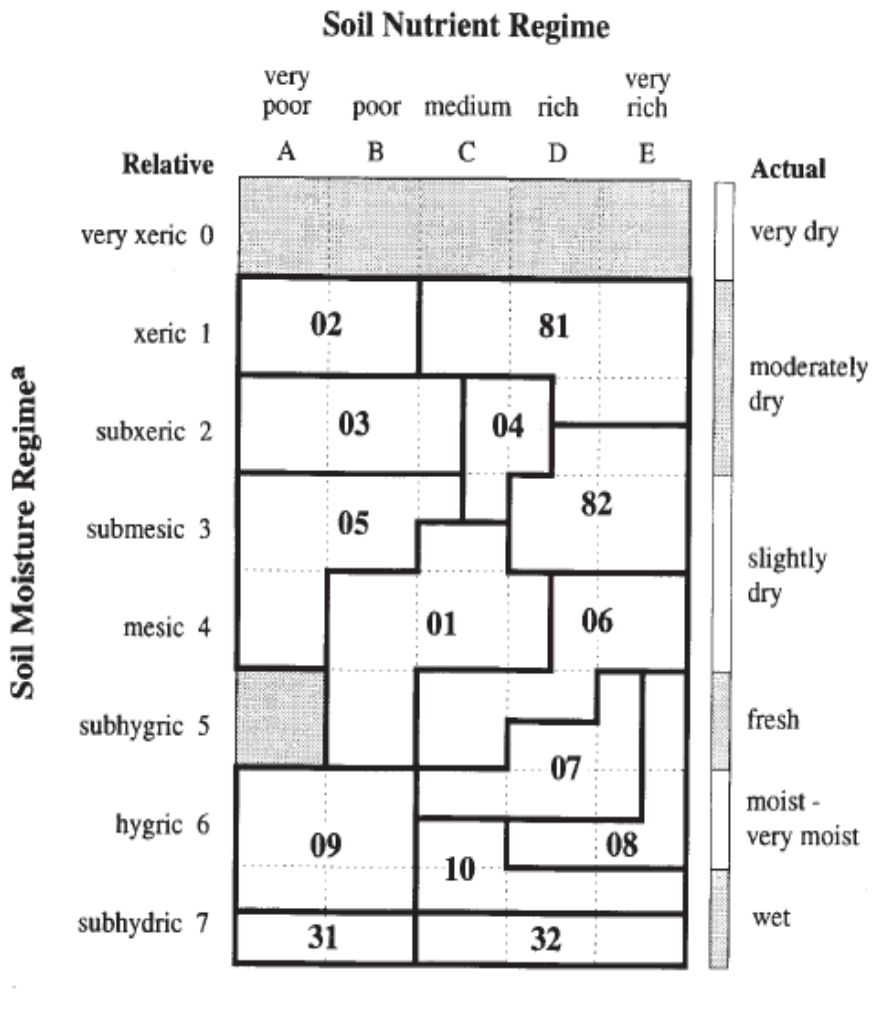
Based on TACA model (Nitschke and Innes 2008)

Select climate station with daily data to represent a BGC unit

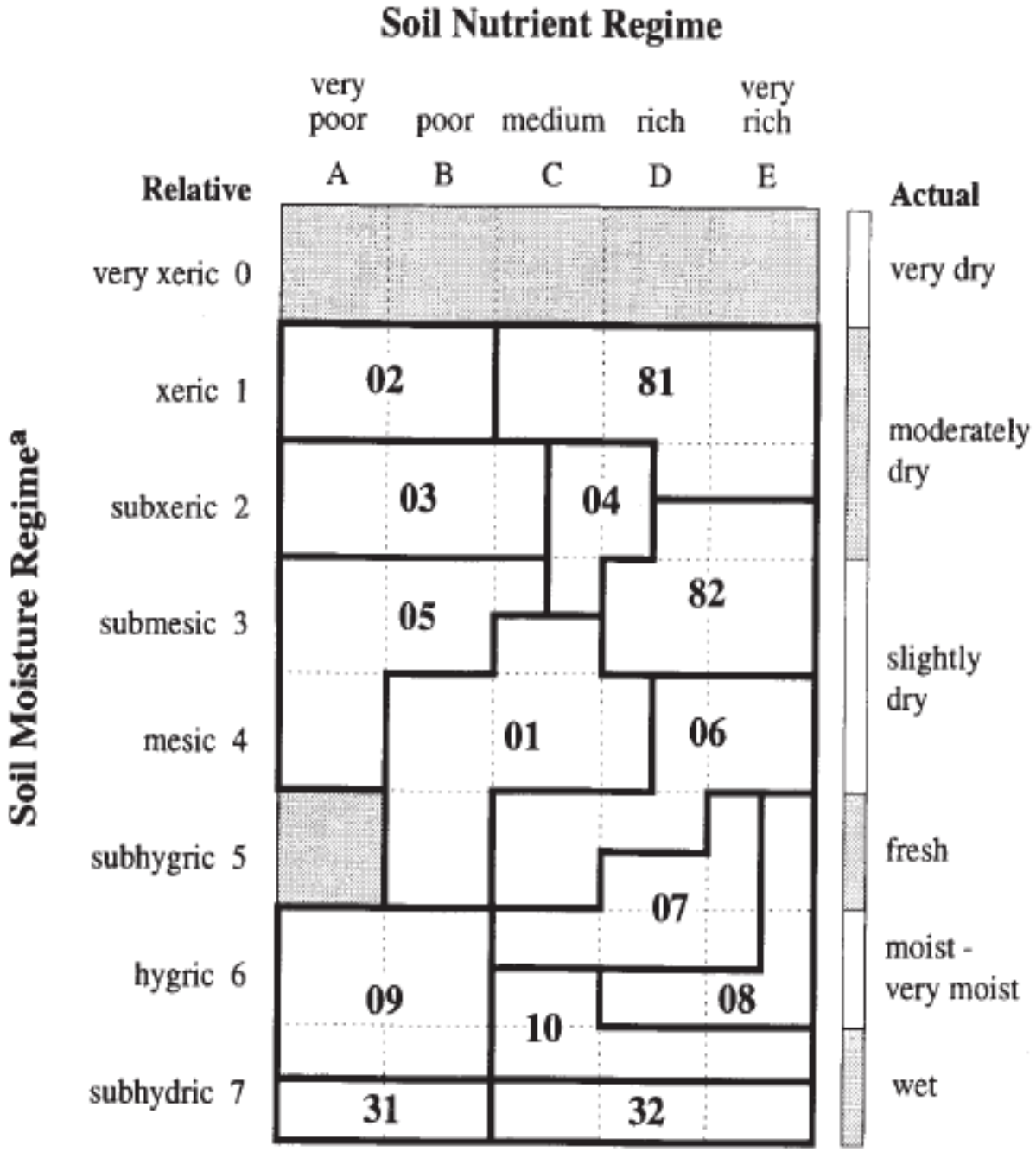
Input site factors (soils, slope position, rooting depth) for different site series

Model current and future AET/PET ratios using future climate scenarios from ClimateBC model (Wang et al. 2006).

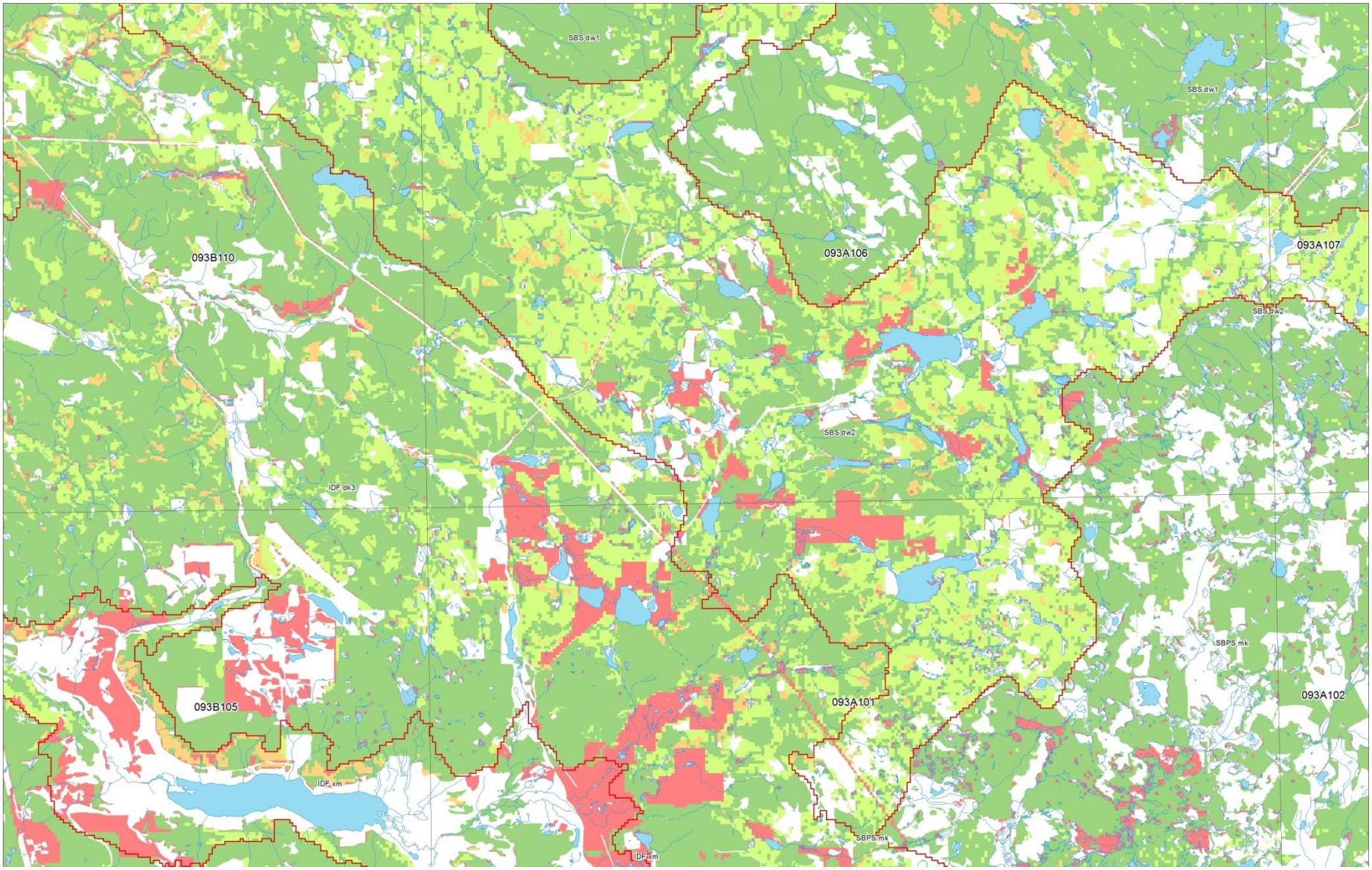
SBSmk1 BGC variant



Actual SMR Category	AET/PET Ratio	Deficit
Excessively dry	<=0.55	5-7
Very dry	0.56 – 0.75	3-5
Moderately dry	0.75 – 0.90	1.5-3
Slightly dry	0.91-1	0-1.5
Fresh/Moist	1+	0


Soil Nutrient Regime
very poor
poor
medium
rich
very rich
A
B
C
D
E
Relative
Actual
very xeric 0
xeric 1
subxeric 2
submesic 3
mesic 4
subhygric 5
hygric 6
subhydric 7
Soil Moisture Regime[a]
very dry
moderately dry
slightly dry
fresh
moist - very moist
wet
02
81
03
04
82
05
01
06
07
09
10
08
31
32

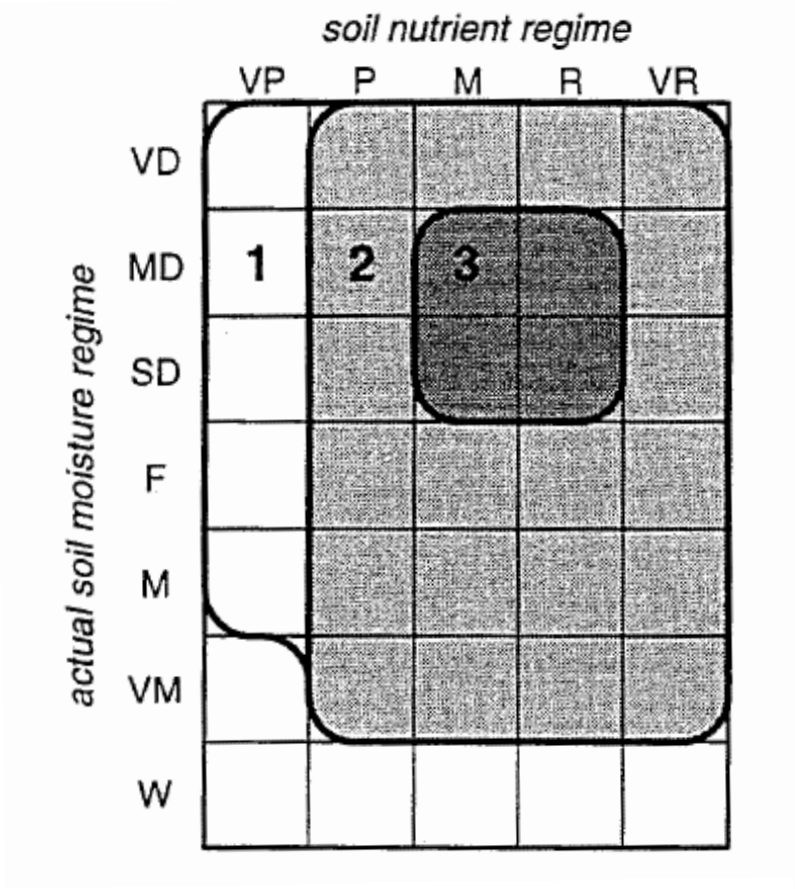
Actual Soil Moisture Regime Map



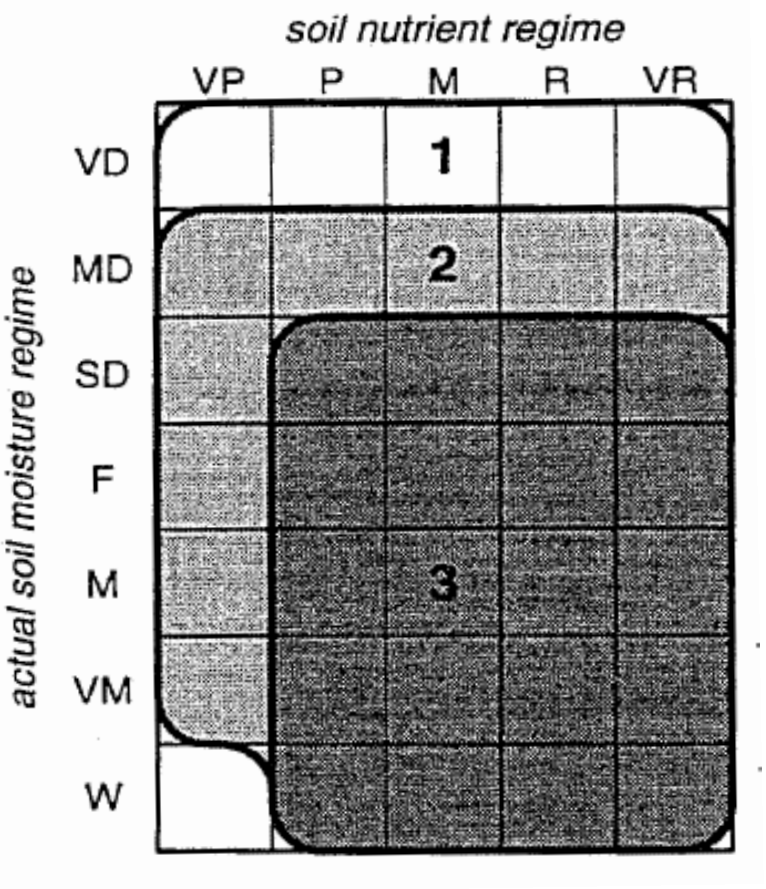
ASMR – tree stress

- Tree species have different drought tolerances
- Can we use ASMR to predict drought stress in trees?

Tree distribution and ASMR



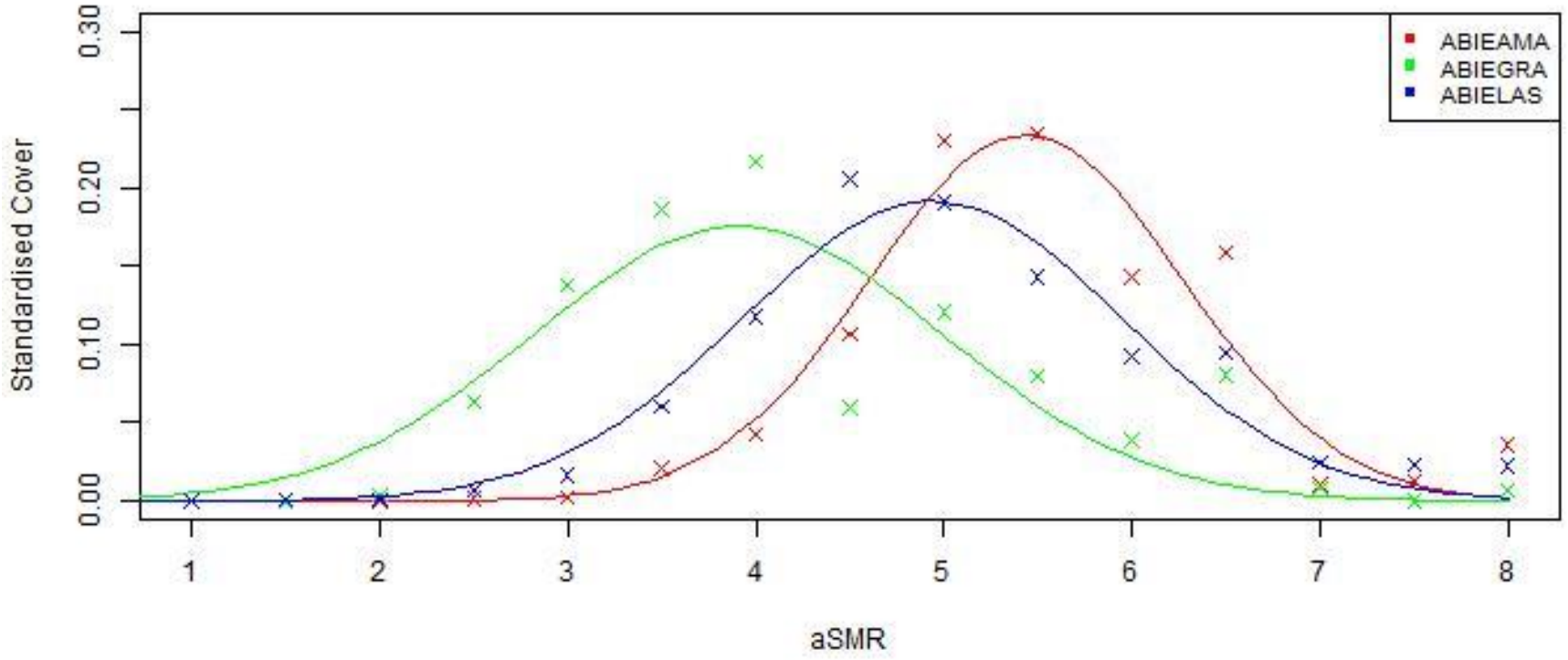
Douglas-fir



Western redcedar

Klinka et al. 2000

Tree distribution and ASMR



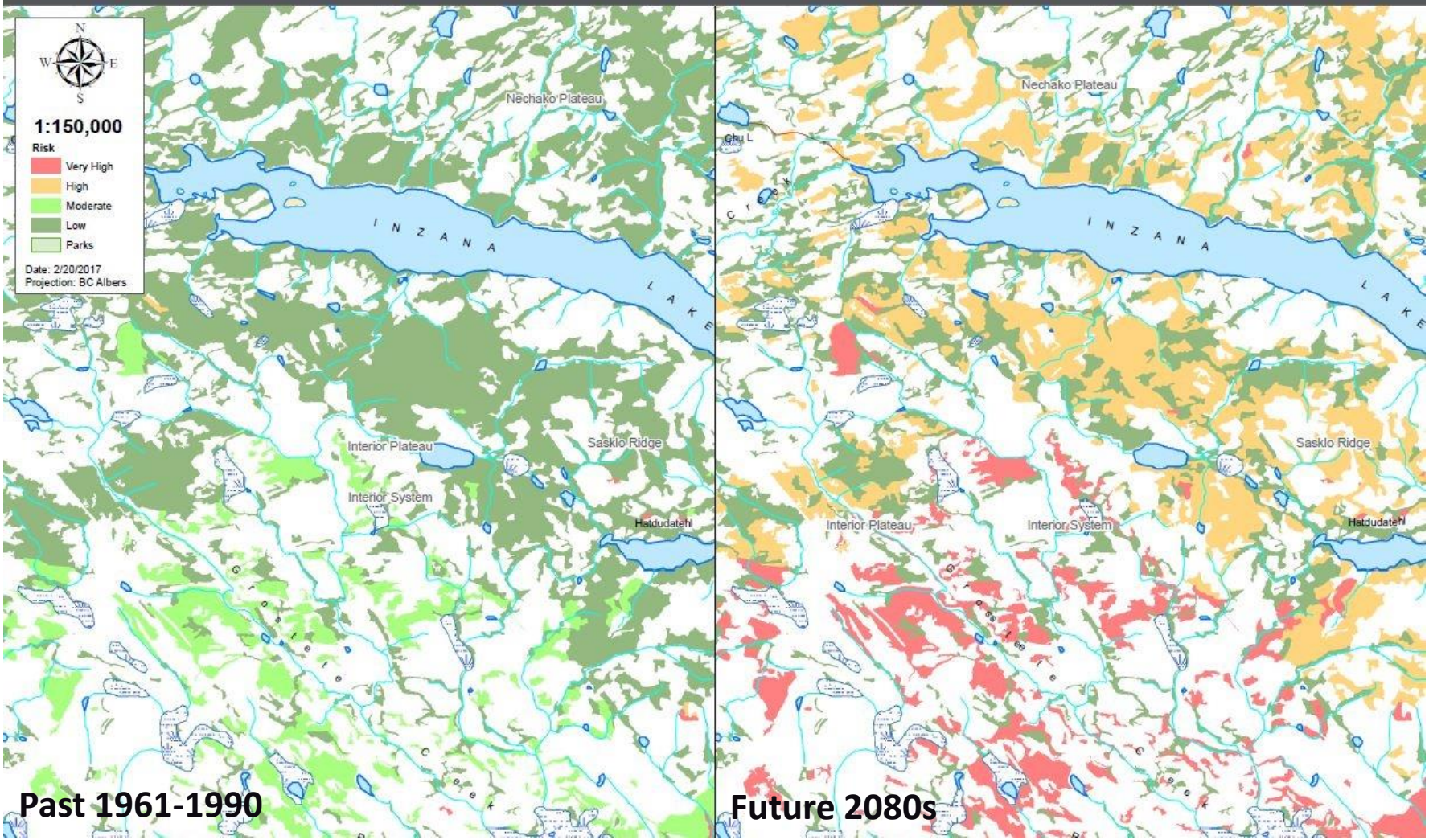
From Will Mackenzie, 2019

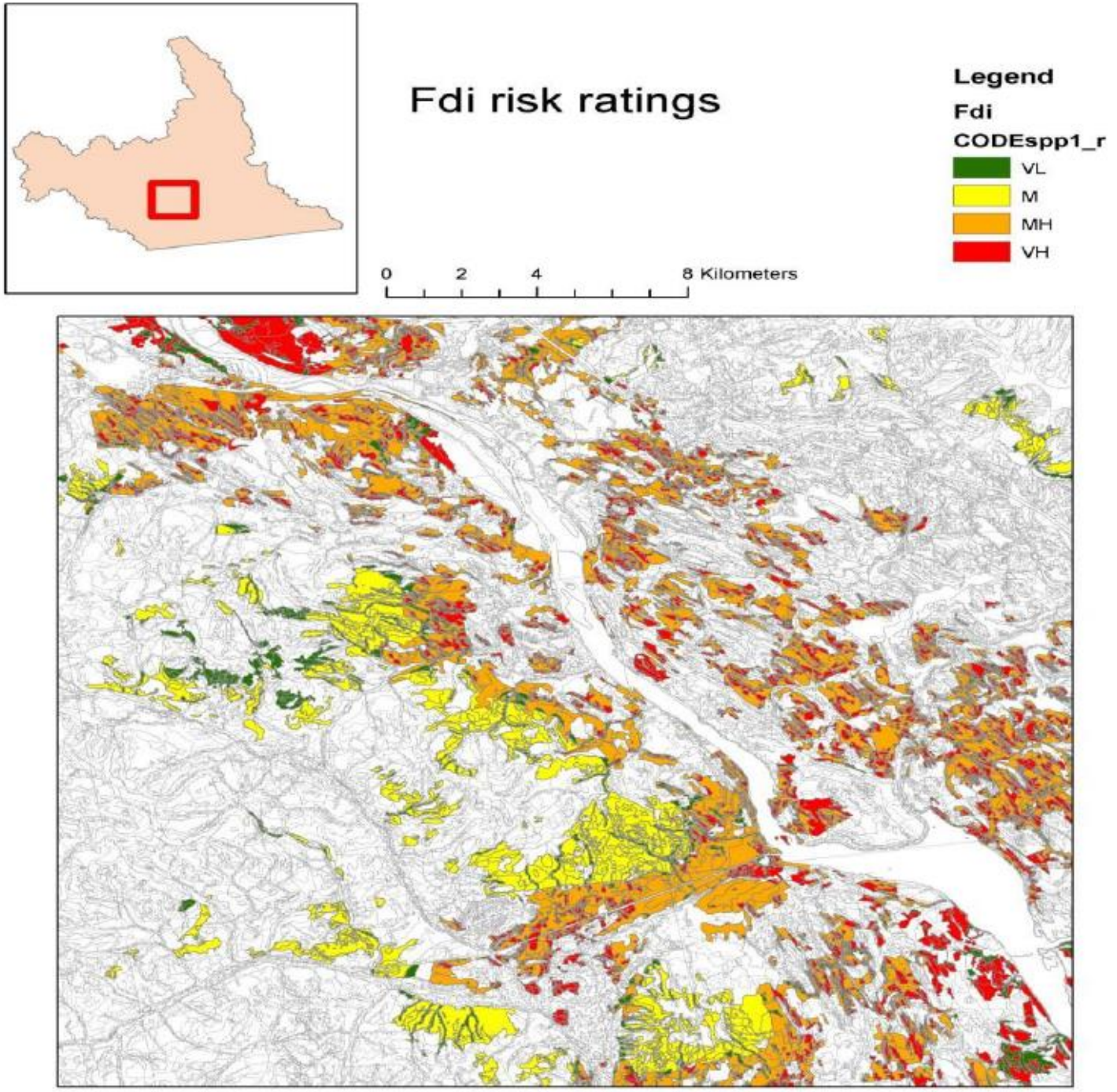
Tree drought risk ratings

	ASMR value by risk category			
Tree species	Very high	High	Moderate	Low
Douglas fir	<0.6	0.60–0.65	0.66–0.71	>0.71
Lodgepole pine	<0.76	0.76–0.81	0.82–0.87	>0.87
Western redcedar	<0.77	0.77–0.82	0.83–0.88	>0.88
Hybrid spruce	<0.8	0.80–0.85	0.85–0.90	>0.90

https://www.for.gov.bc.ca/hfd/pubs/Docs/Tr/TR125.pdf

Spruce Drought Risk Comparison




Fdi risk ratings
Legend
Fdi
CODEspp1_r
VL
M
MH
VH
0
2
4
8 Kilometers

What have we learned?

- In all areas tested so far, soil moisture is predicted to decrease in the future.
- Strongest changes in soil moisture on xeric to submesic sites.
- Widespread increase in drought hazard ratings for tree species

Model limitations

- Does not account for genetic variation in drought tolerance within a species
- Application of model is limited to BGC units with daily climate data
- Spatial products limited to regions with PEM data
- Model requires field data to validate hazard ratings
- Only focuses on drought, limited application for reforestation decisions

Next steps

- Model has been developed in R, and code is available here: https://github.com/bcgov/forestDroughtTool

- Will be developing online tool

- Can ClimateBC data be used in the model?

- Field data to test ASMR/hazard ratings

- Remote sensing approaches to drought stress detection


Thank you!