

Stand Level Risk Analysis and Decision Support Tool

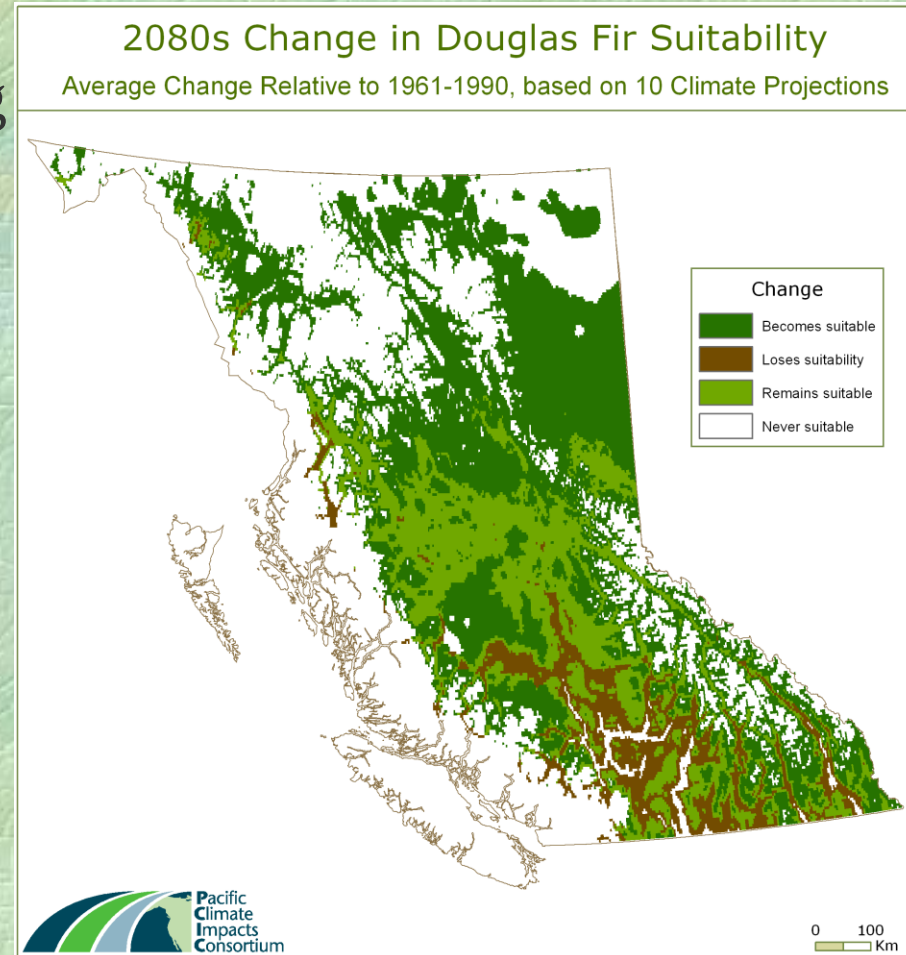


By Craig DeLong, Adjunct professor Univ. of
Northern British Columbia, Canada



Difference from previous work in British Columbia

- Our work focuses on trees that have a high risk of dying on the sites they are currently on rather than where species might be suitable to establish now or in the future.
- Previous work predictions for mesic (average soil moisture) sites only. No site level effects



Focus on Drought

- Drought is likely to be one of the leading causes of forest dieback due to climate change either directly or by stressing trees and making them more susceptible to impact by biological agents (e.g., bark beetles).

Drought Stress = Actual Soil Moisture Regime

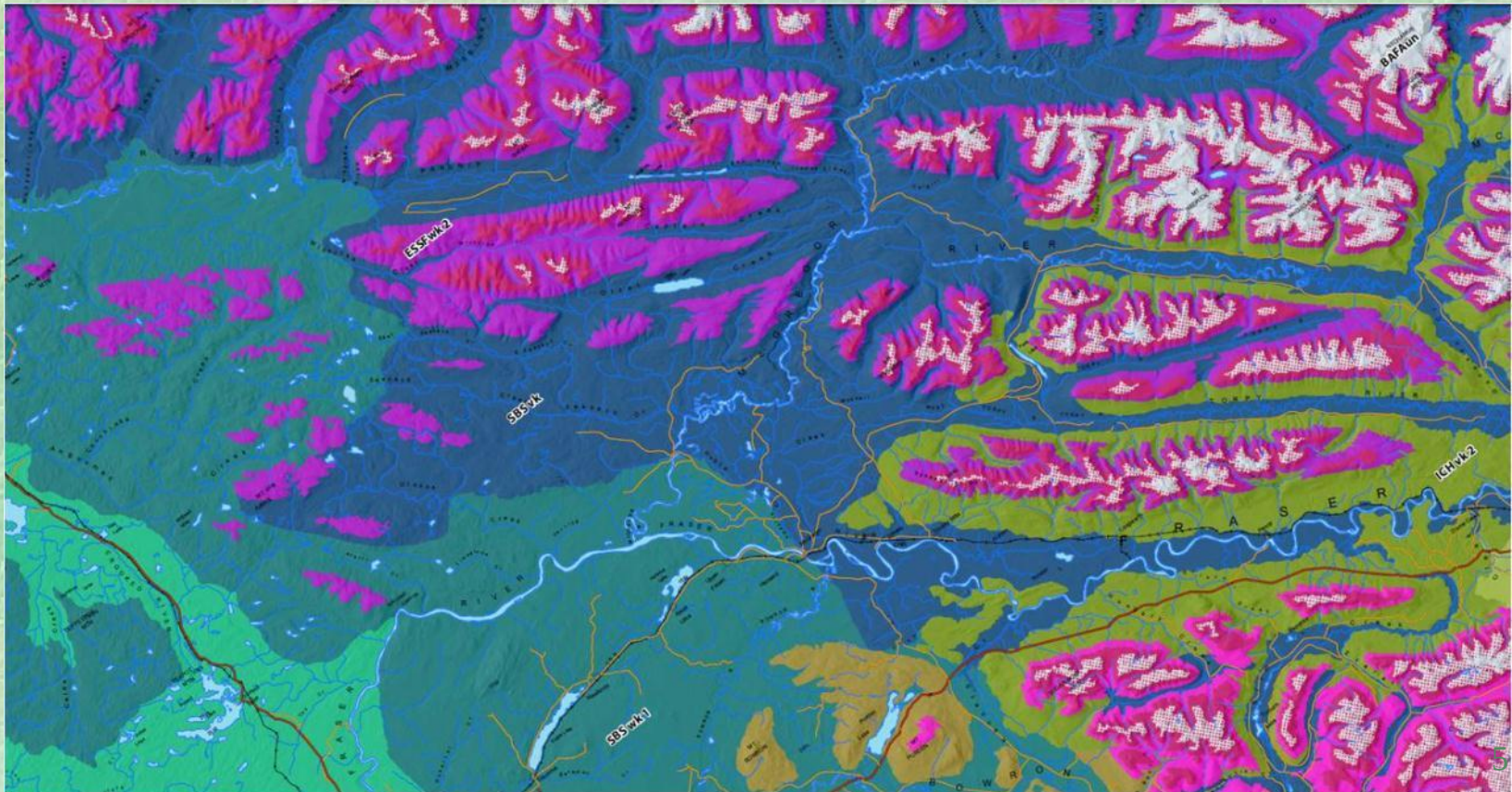
Actual Soil Moisture Regime (ASMR) refers to the moisture regime of a site using a quantitative water balance approach described in Pojar et al. (1987) and is estimated by ratio of actual evapotranspiration (AET) divided by potential evapotranspiration (PET)

A site with a particular ASMR has the same amount of water available for plant growth as all other sites with the same ASMR regardless of climatic unit

Pojar, J., K. Klinka, and D.V. Meidinger. 1987. Biogeoclimatic ecosystem classification in British Columbia. *Forest Ecology and Management* 22:119-154

Relative Soil Moisture Regime

Relative Soil Moisture Regime refers to the moisture regime of a site based on its site and soil characteristics relative to other sites within an area of homogeneous climate. The climatic units in BC are called biogeoclimatic units.



Link between Relative and Actual Soil Moisture Regime

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

Characteristic	Actual SMR
Rooting-zone groundwater absent during the growing season	
Water deficit occurs (soil-stored reserve water is used and drought begins if current precipitation is insufficient for plant needs)	
Deficit >7 months or AET/PET ¹ ≤ 0.30	extremely dry
Deficit >5 but ≤7 months or AET/PET ≤ 0.55 but >0.30	excessively dry
Deficit >3 but ≤5 months or AET/PET ≤ 0.75 but >0.55	very dry
Deficit >1.5 but ≤3 months or AET/PET ≤ 0.90 but >0.75	moderately dry
Deficit >0 but ≤1.5 month or AET/PET >0.90	slightly dry
No water deficit occurs	
Utilization (and recharge) occurs (current need for water exceeds supply and soil-stored water is used)	fresh
No utilization occurs (current need for water does not exceed supply)	moist
Rooting-zone groundwater present during the growing season	
Groundwater table >60 cm deep	moist
Groundwater table >30 but ≤60 cm deep	very moist
Groundwater table >0 but ≤30 cm deep	wet
Groundwater table at or above the ground surface	very wet

¹AET/PET — actual evapotranspiration/potential evapotranspiration ratio.

Actual Soil Moisture Regime

ASMR has been estimated for all BGC unit/RSMR combinations by experienced ecologists based on climate, vegetation, and site conditions and data on length of drought.

					RSMR								
UNIT					0	1	2	3	4	5	6	7	SOURCE
KAM	1	1	BG	xh1	ED	ED	ED	ED	ED	SD	M	W	estimated, Dennis Lloyd
KAM	2	2	BG	xh2	ED	ED	ED	ED	ED	SD	M	W	estimated, Dennis Lloyd
CAR	3	1	BG	xh3	ED	ED	ED	ED	ED	SD	M	W	estimated
KAM	4	3	BG	xw1	ED	ED	ED	ED	ED	SD	M	W	estimated, Dennis Lloyd
CAR	5	2	BG	xw2	ED	ED	ED	ED	ED	SD	M	W	estimated
KAM	6	4	PP	xh1	ED	ED	ED	ED	VD	SD	M	W	estimated, Dennis Lloyd
KAM	7	5	PP	xh2	ED	ED	ED	ED	VD	SD	M	W	estimated, Dennis Lloyd

Actual Soil Moisture Regime Calculation

ASMR or AET/PET can be calculated for a BGC unit/RSMR combination using climate data and site and soil characteristics which represent a RSMR. We used both the Penman Monteith and Hargreaves equation to do this and found the Hargreaves equation gave superior results and was simpler to implement.

1. If temperature < 0 all day then no evapotranspiration
2. If temperature above zero then evapotranspiration demand is driven by temperature and solar radiation ($PET = ET$) based on Hargreaves equation
3. AET is a function of precipitation and available water currently stored and available water stored is a function of soil conditions (%CF, soil texture, rooting depth) and whether site is shedding, receiving or neutral.
4. Drought conditions exist when evapotranspiration demand exceeds available water to be transpired (i.e., $AET < PET$).

Typical slope position/soil conditions for RSMR categories

RSMR	Slope position	Coarse Fragments (%)	Soil texture	Rooting depth (cm)
Xeric	Shedding	55	Sand	25
Subxeric	Shedding	40	Loamy Sand	50
Submesic	Shedding	40	Sandy Loam	50
Mesic	Neutral	40	Loam	50
Subhygric	Receiving	20	Silty Clay Loam	30

ASMR converted to Risk

					RSMR								SOURCE
UNIT					0	1	2	3	4	5	6	7	
KAM	1	1	BG	xh1	VH	VH	VH	VH	VH	H	VL	VL	estimated, Dennis Lloyd
KAM	2	2	BG	xh2	VH	VH	VH	VH	VH	H	VL	VL	estimated, Dennis Lloyd
CAR	3	1	BG	xh3	VH	VH	VH	VH	VH	M	VL	VL	estimated
KAM	4	3	BG	xw1	VH	VH	VH	H	H	M	VL	VL	estimated, Dennis Lloyd
CAR	5	2	BG	xw2	VH	VH	VH	VH	VH	H	VL	VL	estimated
KAM	6	4	PP	xh1	VH	VH	VH	H	H	M	VL	VL	estimated, Dennis Lloyd
KAM	7	5	PP	xh2	VH	VH	VH	H	H	M	VL	VL	estimated, Dennis Lloyd

Risk Altered Based on Direction of Climate Change

		RSMR							
UNIT		0	1	2	3	4	5	6	7
BG	xh1	VH	VH	VH	VH	VH	VH	VL	VL
BG	xh2	VH	VH	VH	VH	VH	VH	VL	VL
BG	xh3	VH	VH	VH	VH	VH	M	VL	VL
BG	xw1	VH	VH	VH	VH	H	M	VL	VL
BG	xw2	VH	VH	VH	VH	VH	VH	VL	VL
PP	xh1	VH	VH	VH	VH	H	M	VL	VL
PP	xh2	VH	VH	VH	VH	H	M	VL	VL

Risk Altered Based on Tree Species in Polygon

Western Red Cedar

	RSMR	0	1	2	3	4	5	6	7
ICH	mm	VD	MD	MD	SD	F	M	VM	W
ICH	wk1	VD	MD	SD	F	F	M	VM	W
ICH	wk3	VD	MD	SD	F	F	M	VM	W
ICH	wk4	VD	MD	SD	F	F	M	VM	W
ICH	vk2	MD	SD	SD	F	M	M	VM	W

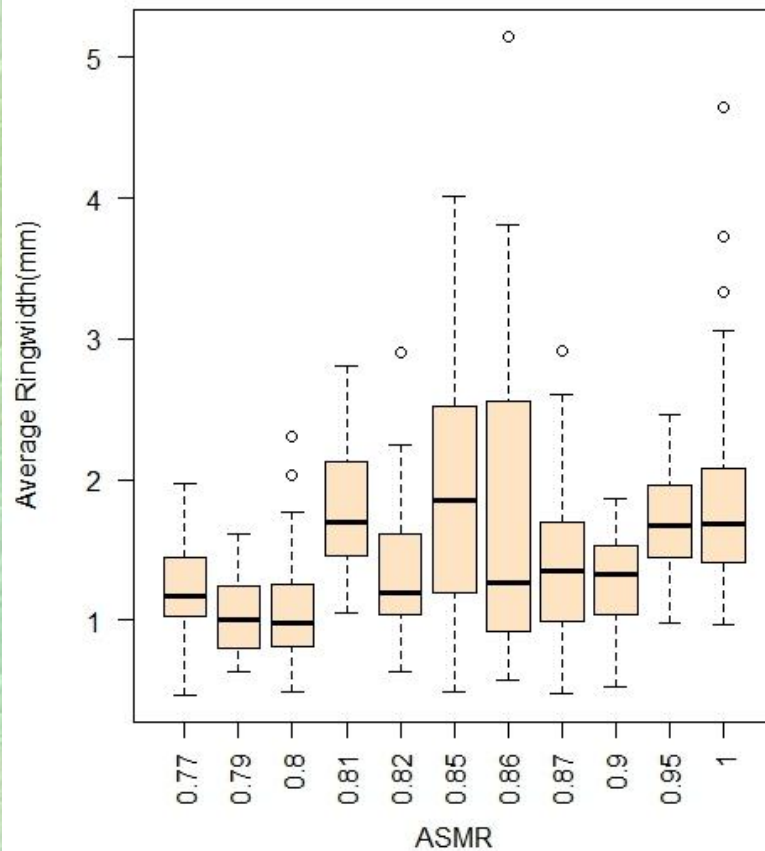
Risk Altered Based on Tree Species in Polygon

Western Red Cedar

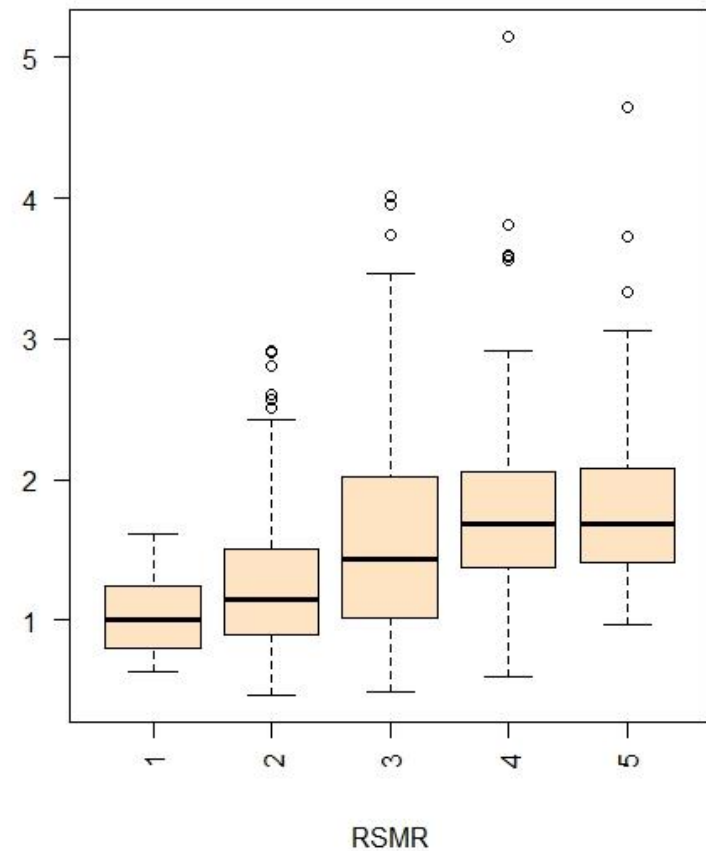
		RSMR	1	2	3	4	5	6	7
ICH	mm	VH	VH	VH	H	M	L	VL	VL
ICH	wk1	VH	VH	H	M	M	L	VL	VL
ICH	wk3	VH	VH	H	M	M	L	VL	VL
ICH	wk4	VH	VH	H	M	M	L	VL	VL
ICH	vk2	VH	H	H	M	L	L	VL	VL

Growth on Sites with Differing ASMR and RSMR

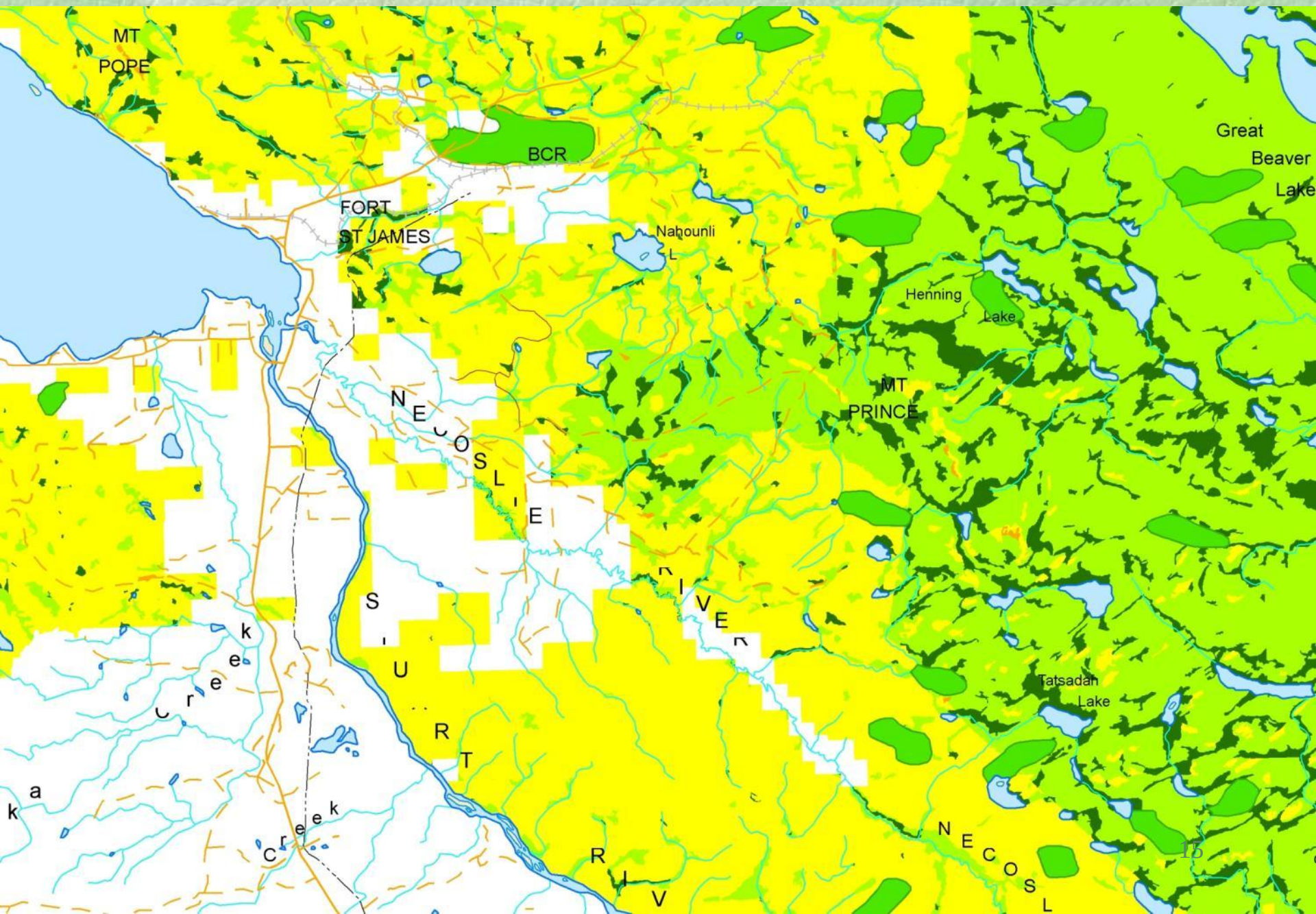
Spruce ringwidths vs. ASMR



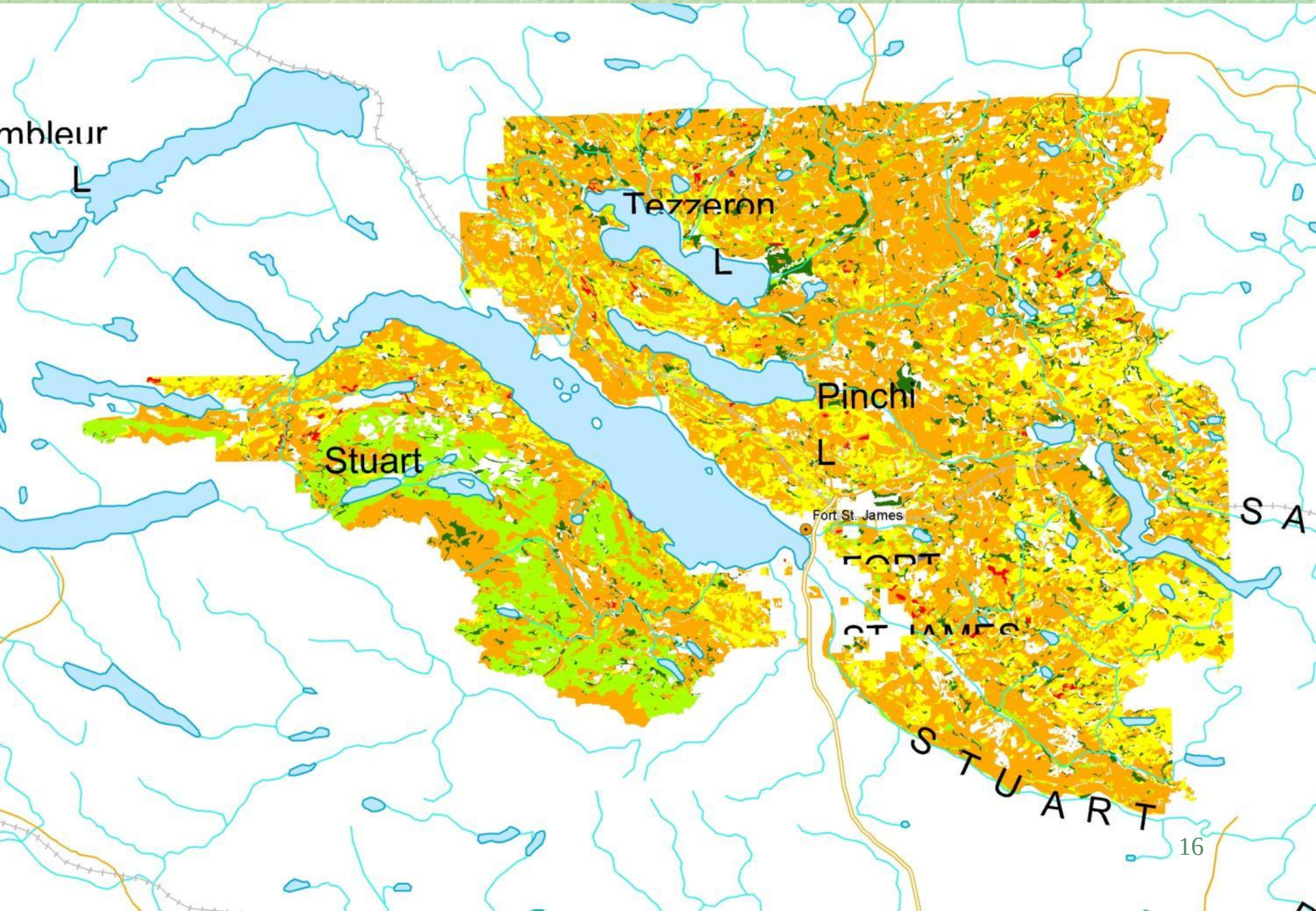
Spruce ringwidths vs. RSMR



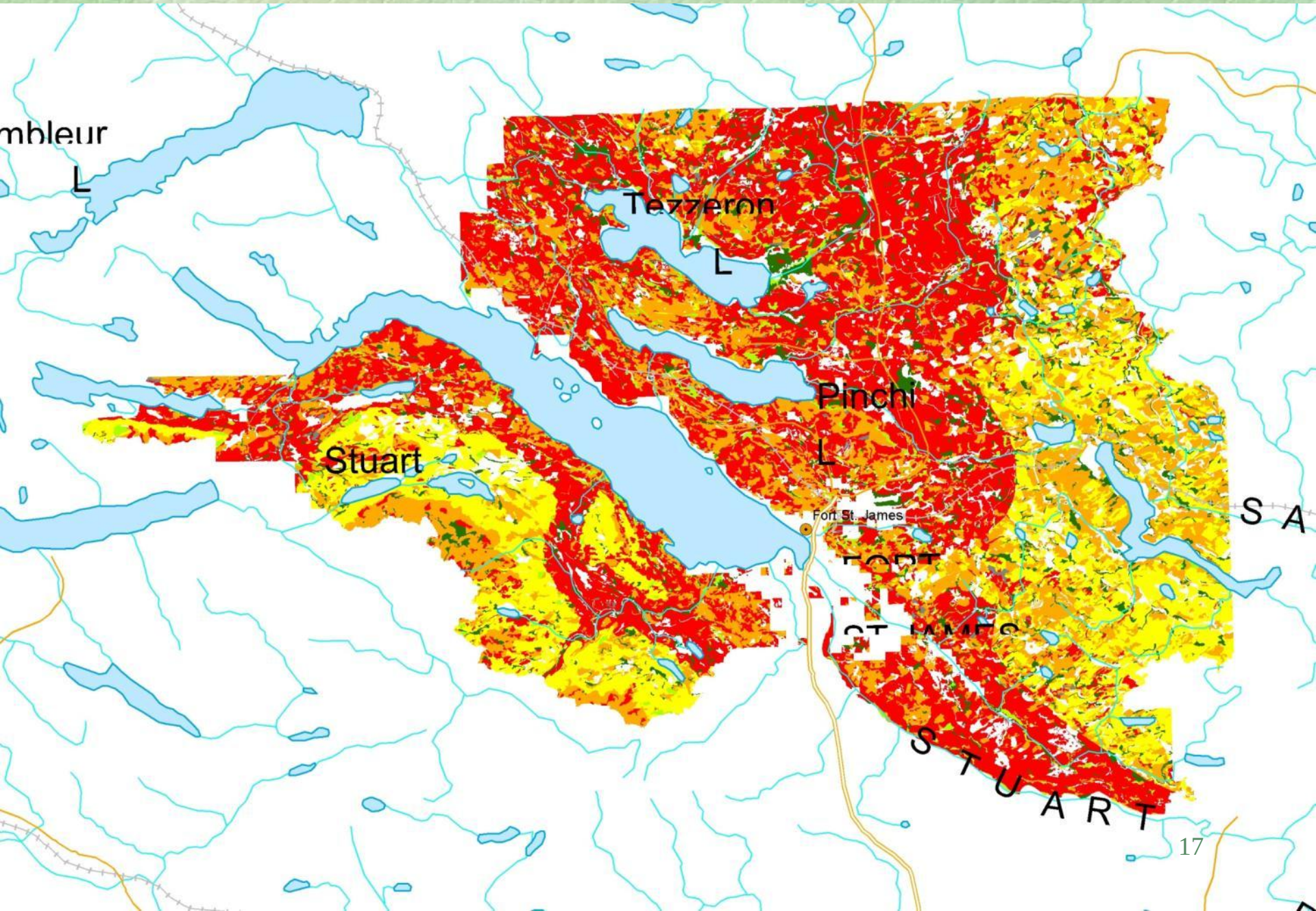
Actual Soil Moisture Regime Map (Recent)

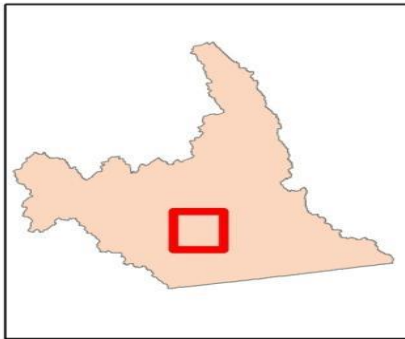


Polygon Risk Map (Recent)



Polygon Risk Map (2020)





Fdi risk ratings

Legend

Fdi

CODEspp1_r

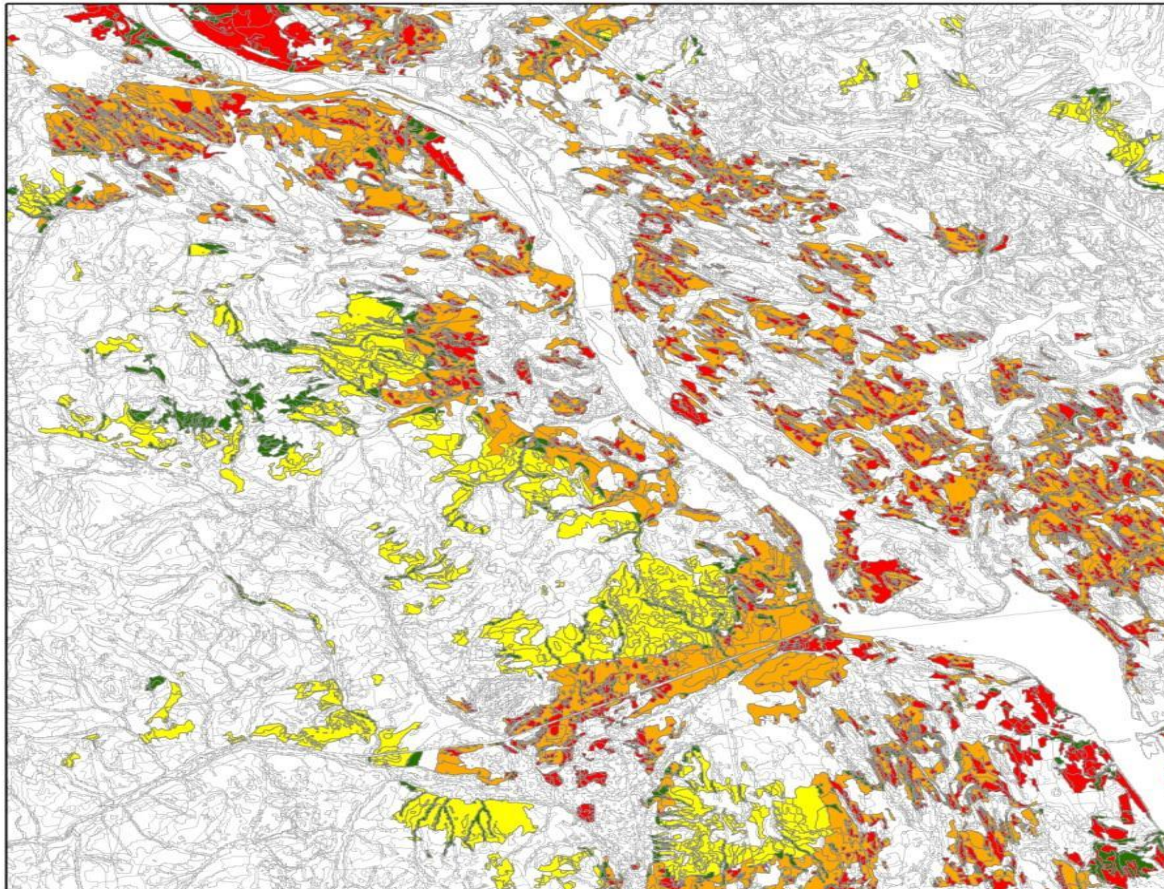
VL

M

MH

VH

0 2 4 8 Kilometers



Requirements for application

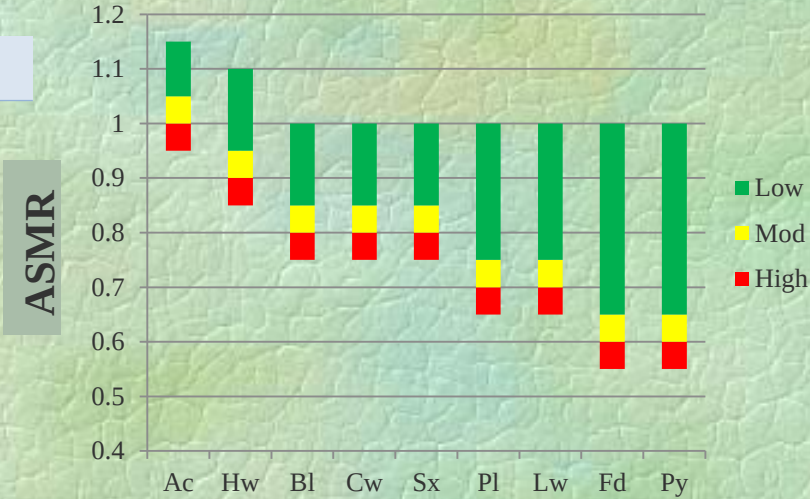
- Existing climatic units or reasonable network of climate stations
- DEM at 15-30m resolution
- Terrain/soils mapping beneficial
- Can be used to assess drought risk for any species with know drought tolerance

Drought risk species selection tool

- Enter the biogeoclimatic unit and RSMR
- Calculates ASMR for present, 2020, 2050 and 2080
- Allows you to see risk of drought related mortality for different tree species

BEC	BWBSmw1
RSMR	4

Values			
Current ASMR	ASMR 2020	ASMR 2050	ASMR 2080
0.92	0.88	0.85	0.83



TREE SPECIES

	High	Mod	Low	
Ac	0.95	0.05	0.05	0.1
Hw	0.85	0.05	0.05	0.15
Bl	0.75	0.05	0.05	0.15
Cw	0.75	0.05	0.05	0.15
Sx	0.75	0.05	0.05	0.15
Pl	0.65	0.05	0.05	0.25
Lw	0.65	0.05	0.05	0.25
Fd	0.55	0.05	0.05	0.35
Py	0.55	0.05	0.05	0.35

Frost Study

- Preliminary data from mid June to mid October
- For SBSdw3 min temp -3.3 to -10.5, 0 -16 frosts < -4
- Strong influence of large lakes, rock faces, and basins
- Future focus on where cedar is and isn't and where Douglas-fir is and isn't and slope transects