Current limits and future potential range of northern whitebark pine under a changing climate

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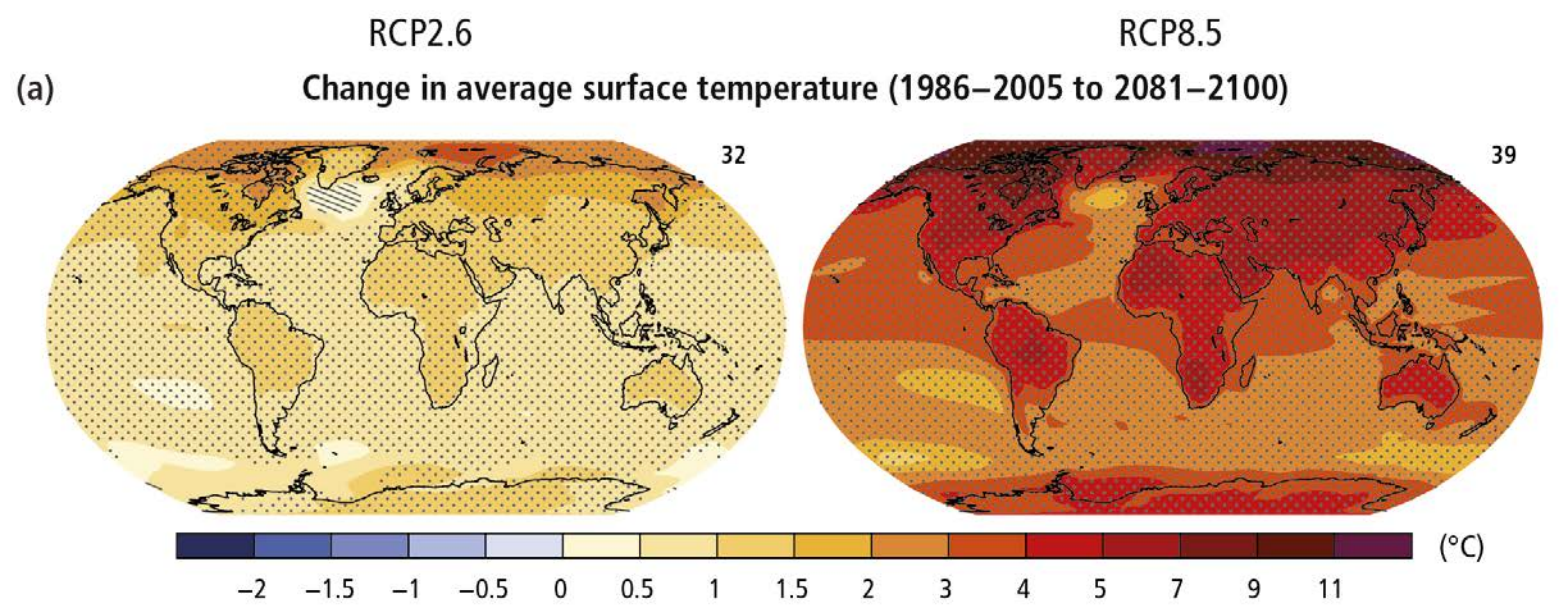
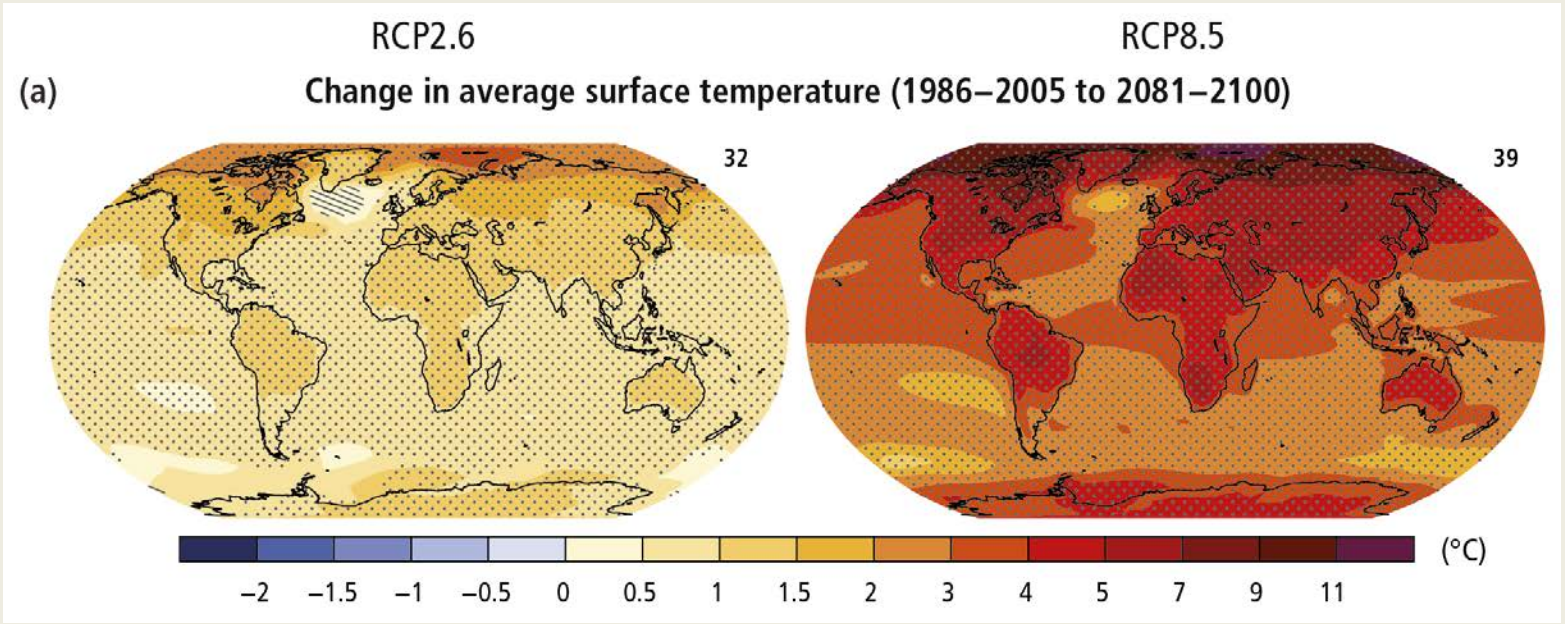
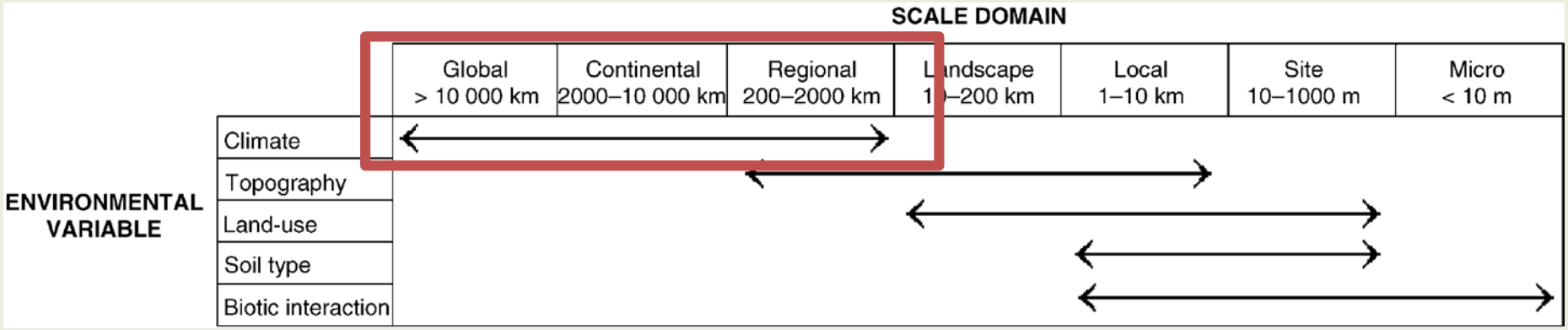


Climate is changing

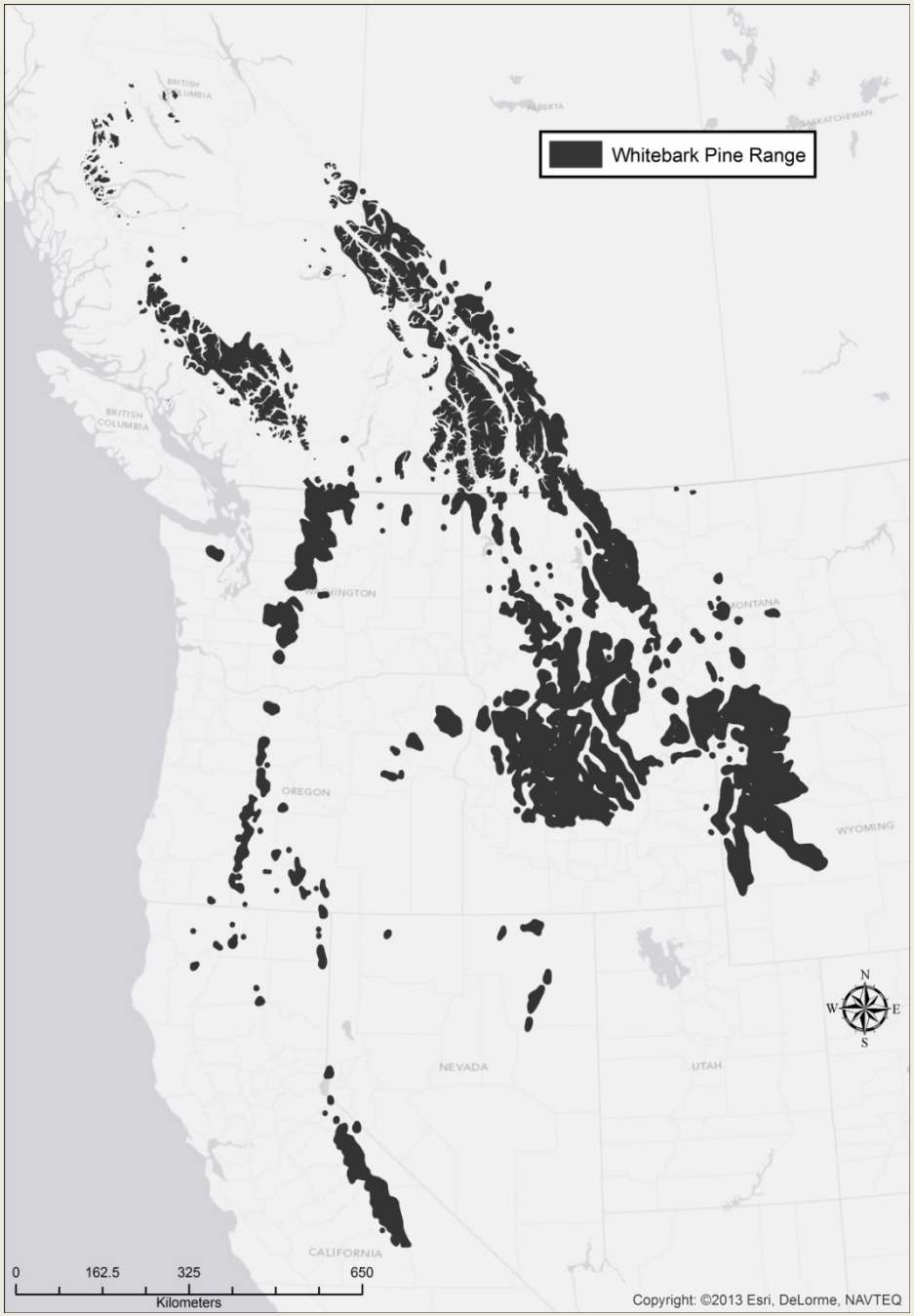


We expect polar migration of species with warming



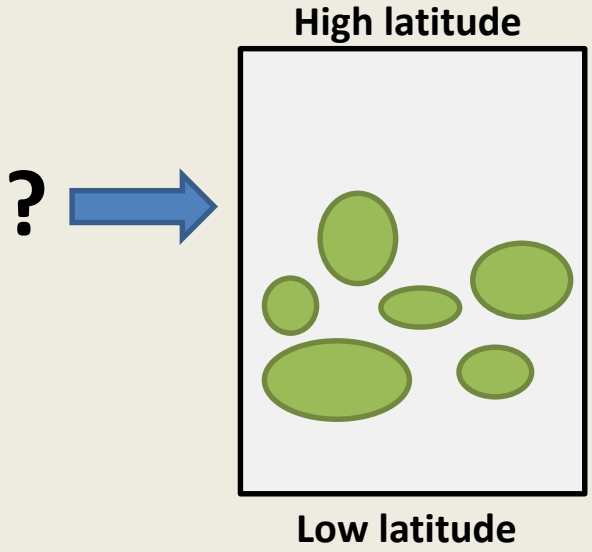
Pearson and Dawson, 2003

This is based on the idea that Climate is the broadest-scale driver of species distributions

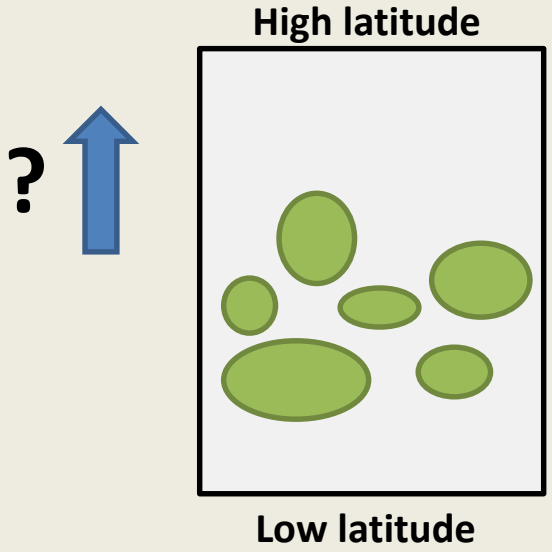

Whitebark Pine Range
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
WASHINGTON
MONTANA
OREGON
WYOMING
NEVADA
UTAH
CALIFORNIA
N
W
E
S
0
162.5
325
650
Kilometers
Copyright: ©2013 Esri, DeLorme, NAVTEQ

Questions:

1. **What** currently limits the northern distribution of whitebark pine?



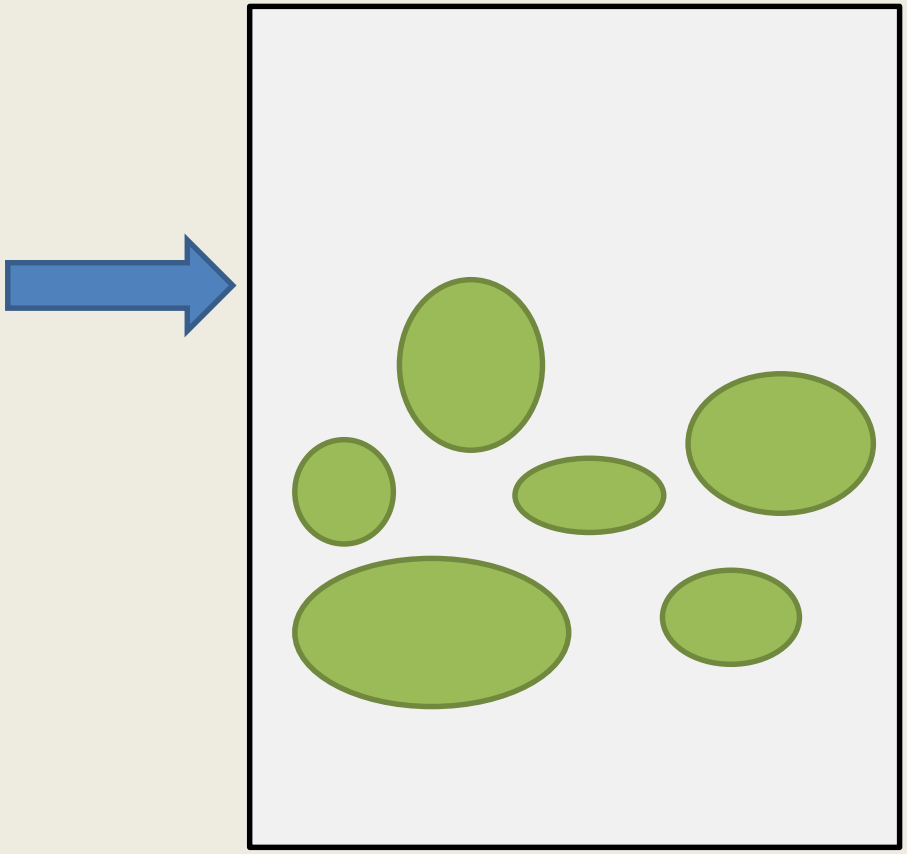
2. **Where will the range shift** at its northern edge with climate change?



Does Climate limit the northern limit?

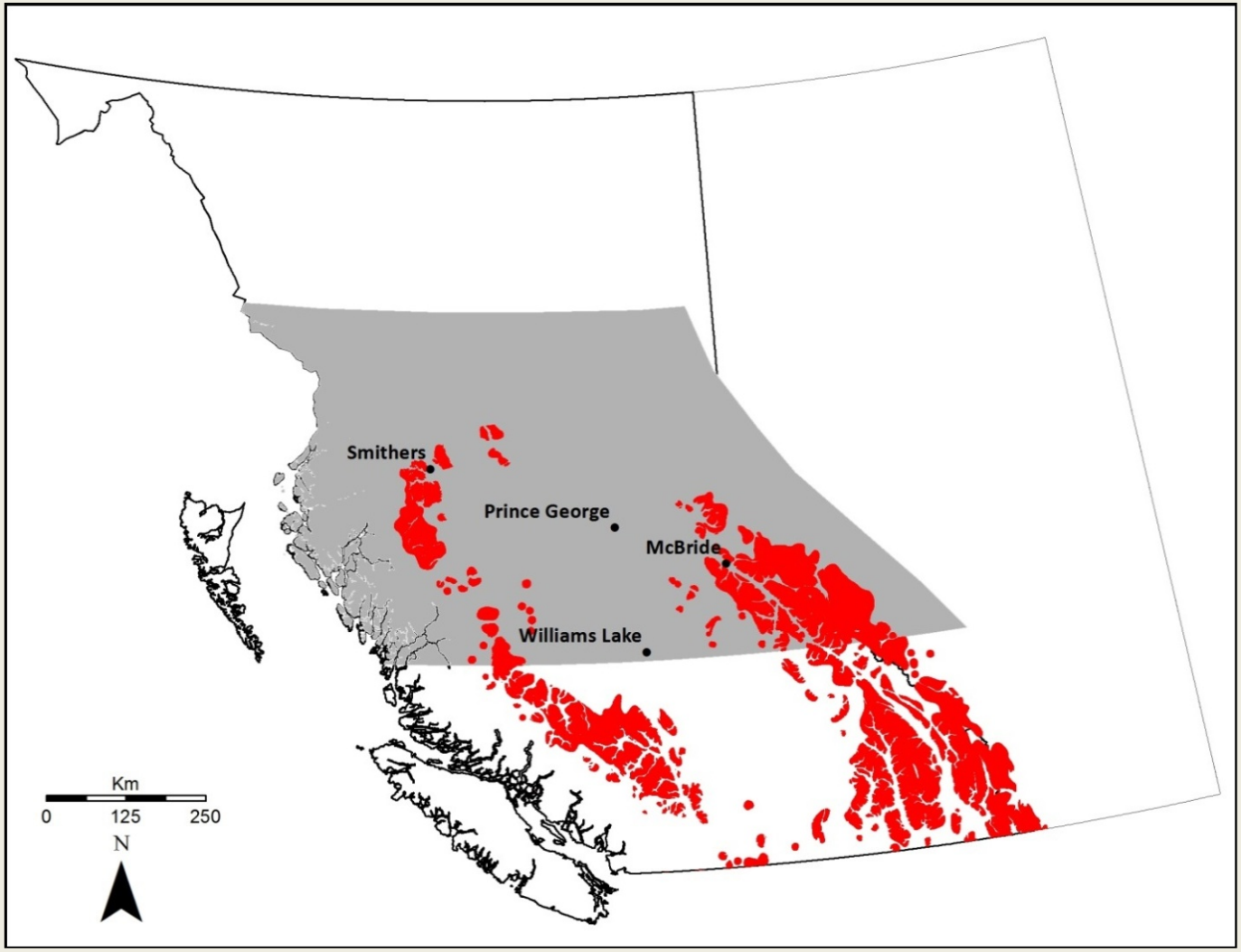
High latitude

Climate ?



Low latitude

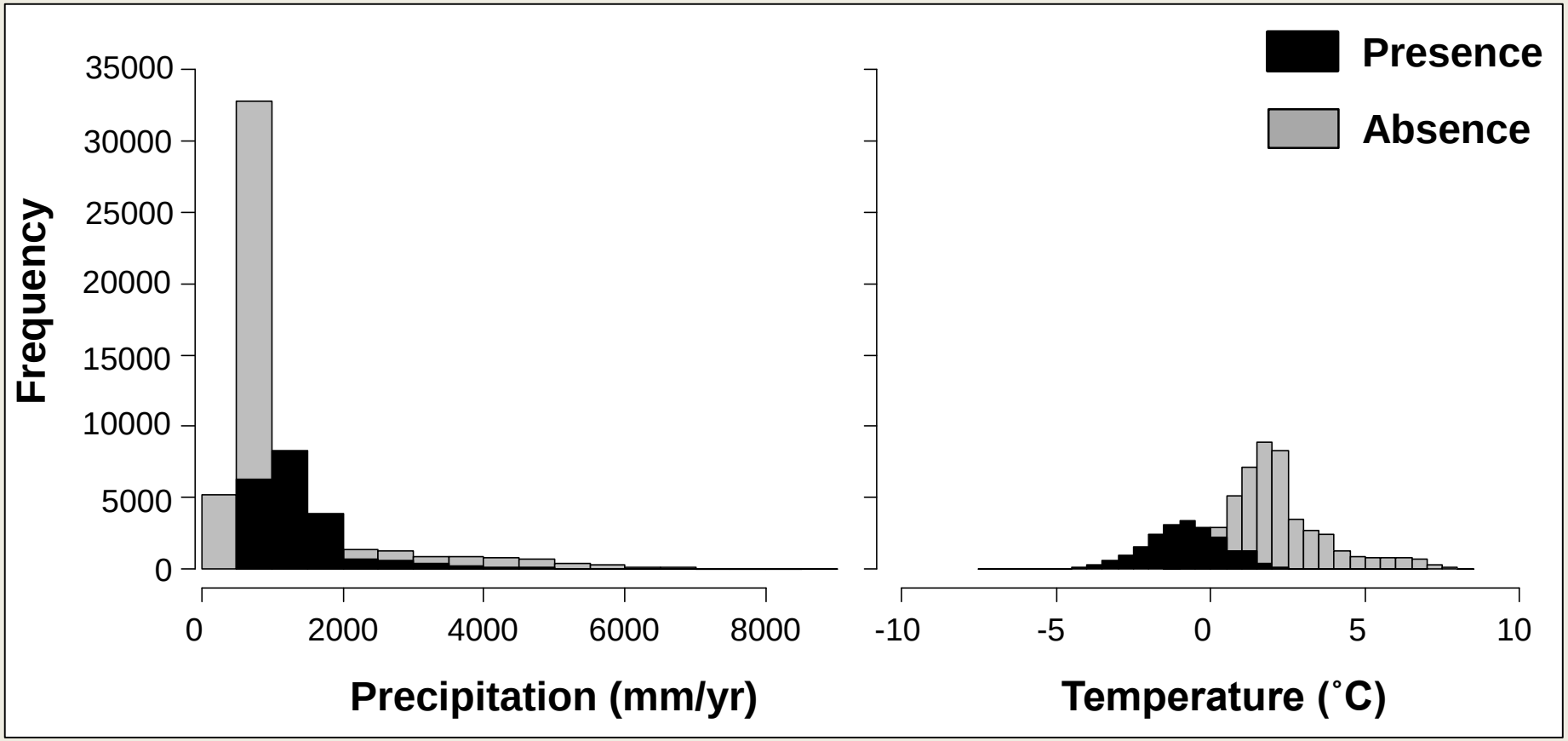
Study Area – North Central BC/Alberta
“At” and “Beyond” the current range



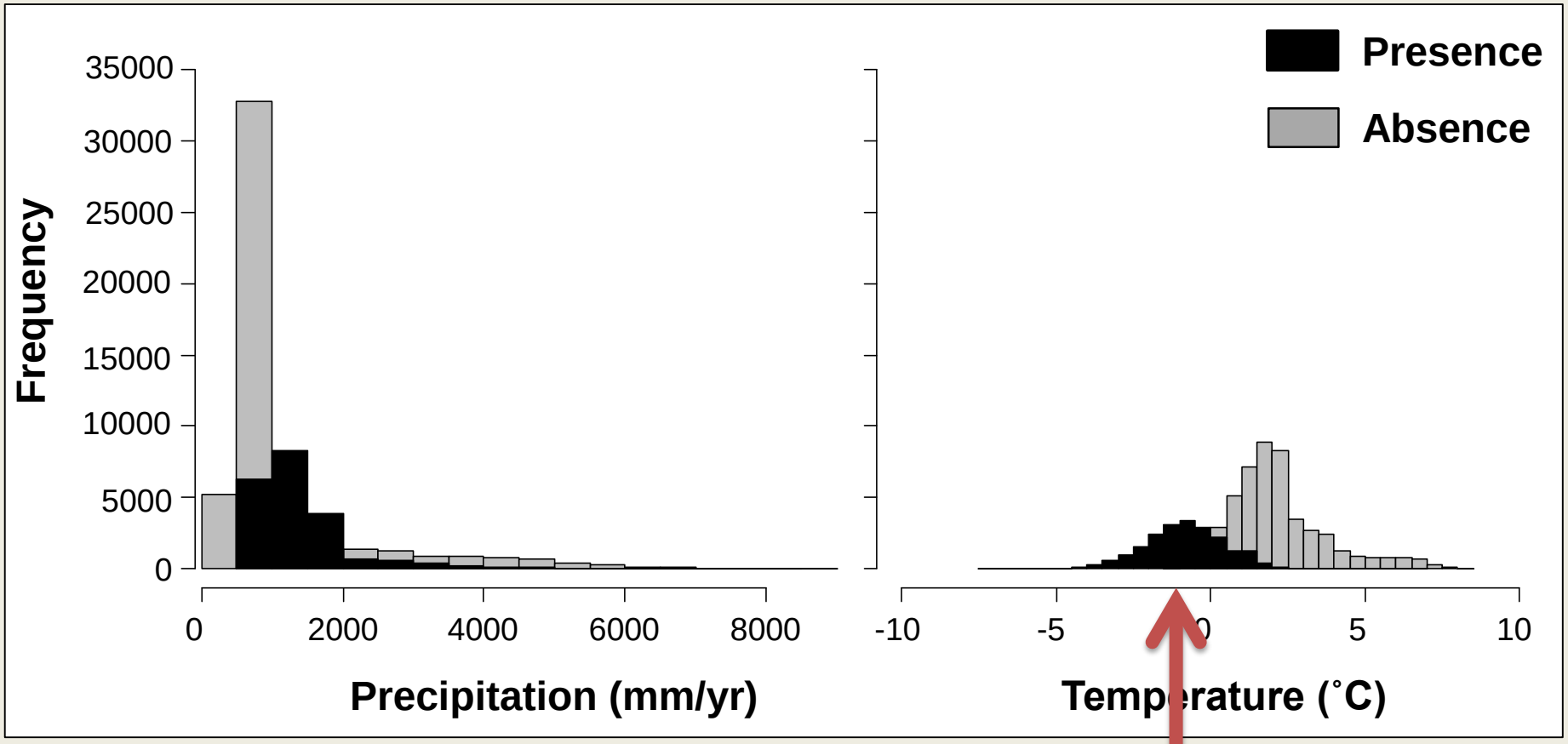
Compilation of datasets across 4 decades, across the northern part of WBP range

Data Source	No. of Plots	General Location	Date	Data Type	Mean Adult Density (#/ha)	Mean Juvenile Density (#/ha)	Adult Mean Mortality
Alberta Parks	15	Willmore	2006-2008	P, AD, JD, H	777	394	0.04
A.Clason	136	BC, Alberta	2011-12	P/A, AD, JD, H	213	481	0.34
FLNRO	2	BC	2013	P, AD, JD, H	245	1063	0.55
S.Haeussler, A.Clason	6	Smithers, BC	2007-2009	P, AD, JD, H	78	1033	0.35
BEC	160	BC	1977-2008	P, AC, JC	5.63*	1.29*	n/a
BEC	7367	BC	1977-2008	A, AC, JC	0*	0*	n/a
C.Wong	95	Jasper, Willmore	2006-2007	P/A, AD, JD	341	3134	n/a
E.Campbell	4 (averaged)	McBride, Smithers	1995	P, AD, JD, H	481	418	0.64
M. Gelderman	69	Jasper, Willmore	2012-2013	P, JD	n/a	1398	n/a
National Parks	34	Jasper, Banff	2003-2009	P, AD, JD	1035	291	n/a
R.Moody	171	Jasper, Banff	2004-2005	P/A, AD, JD, H	17	38	0.32
S.Zeglen	75	BC	1998-2000	P, H	n/a	n/a	0.34

Raw data: Conditions where species is present and absent

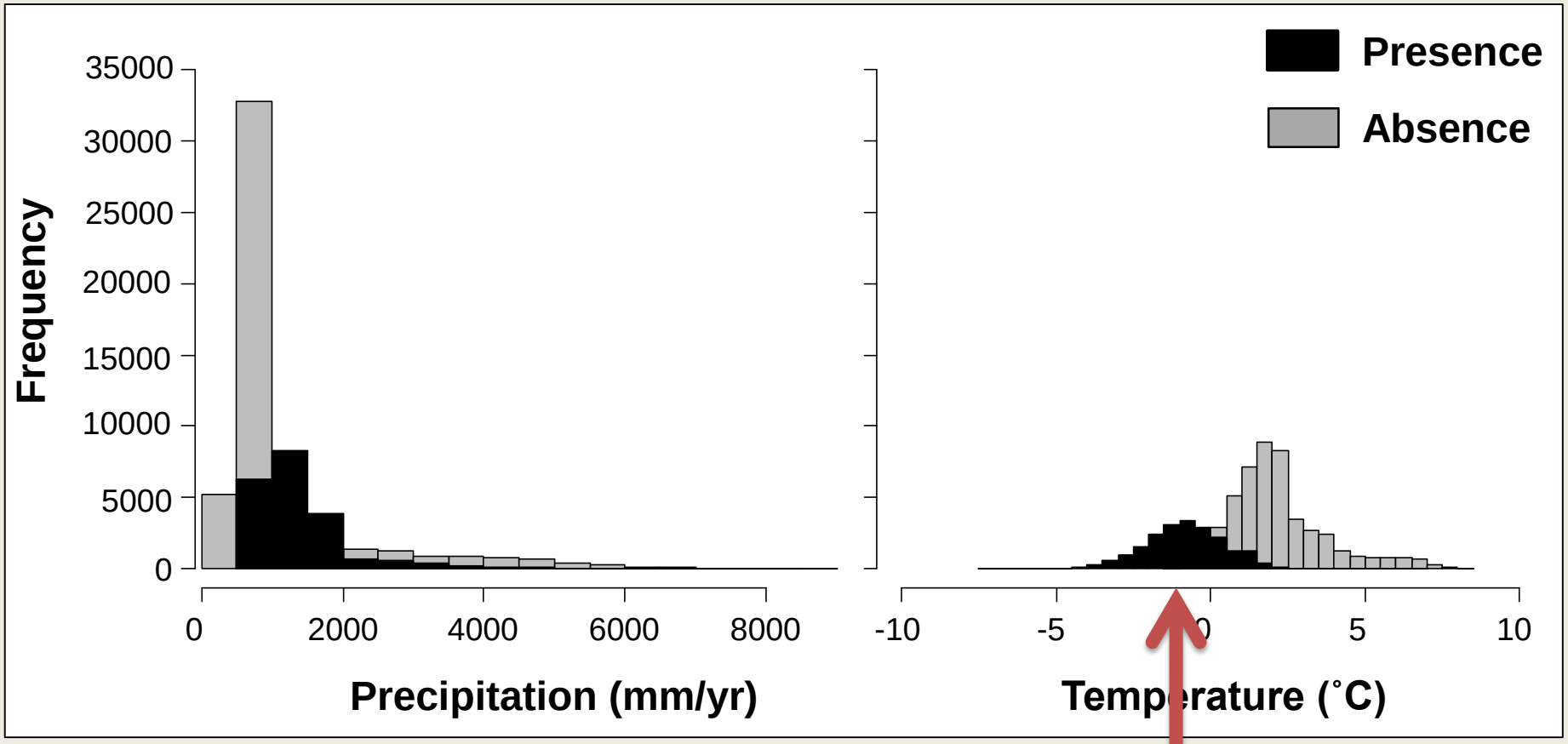


Raw data: Conditions where species is present and absent



Colder is better

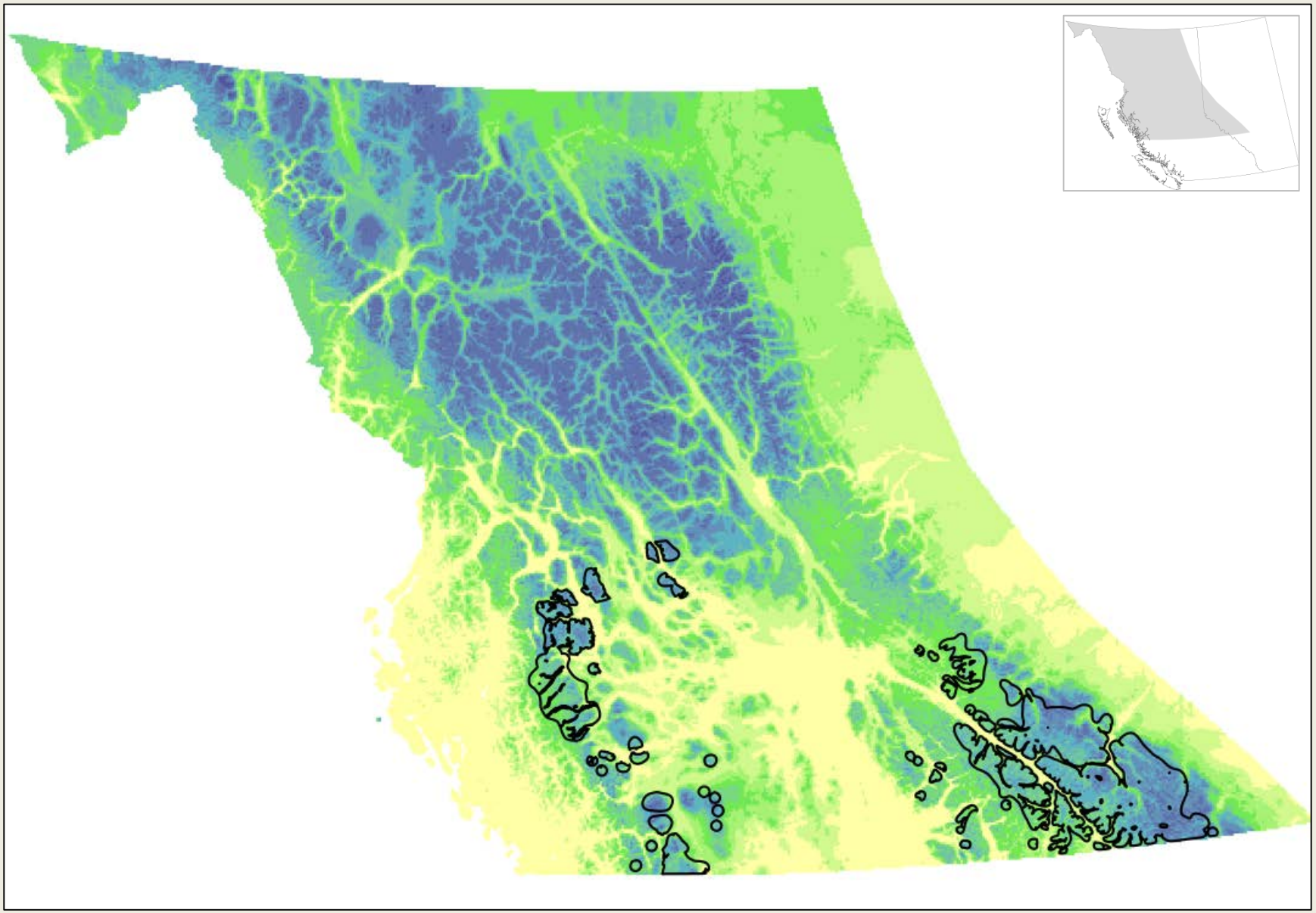
Conditions where species is present and absent



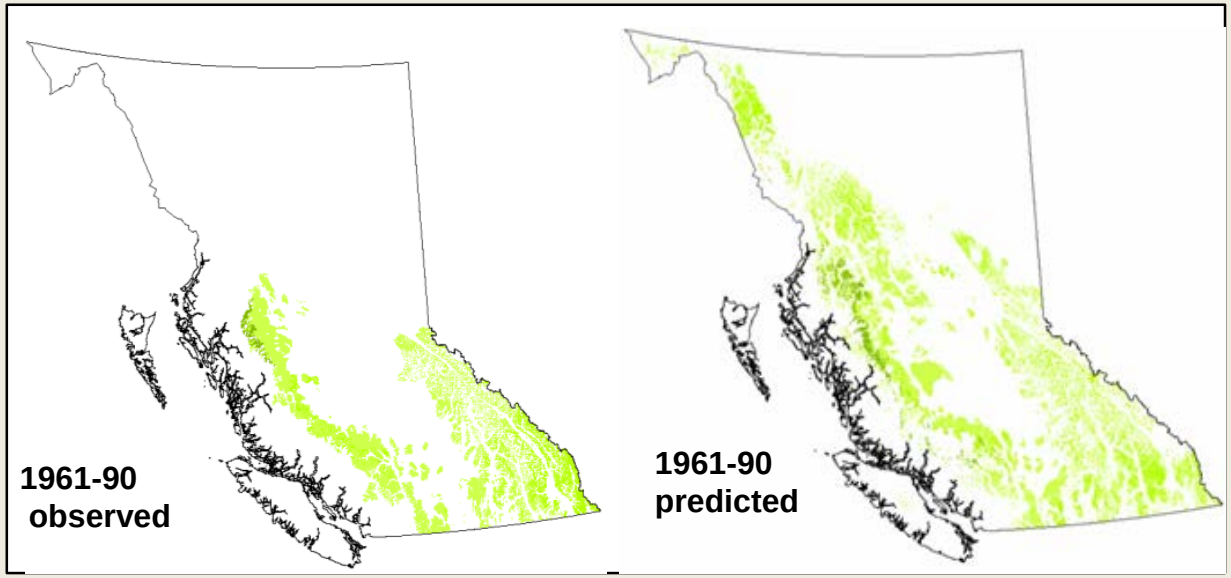
WBP is already in the coldest places, but not wettest or driest

Colder is better

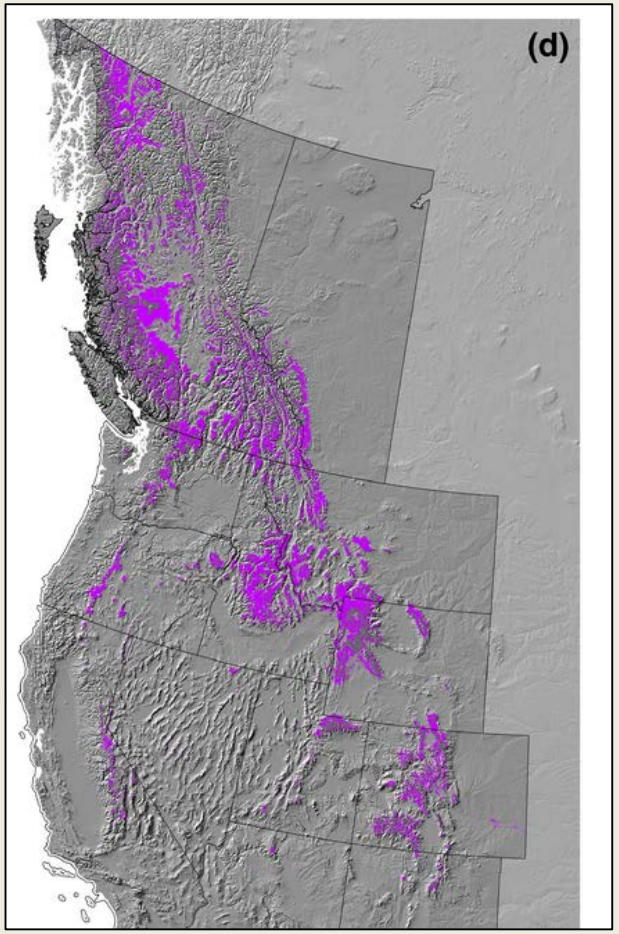
Whitebark pine does not occupy suitable habitat north of range



Consistent with others

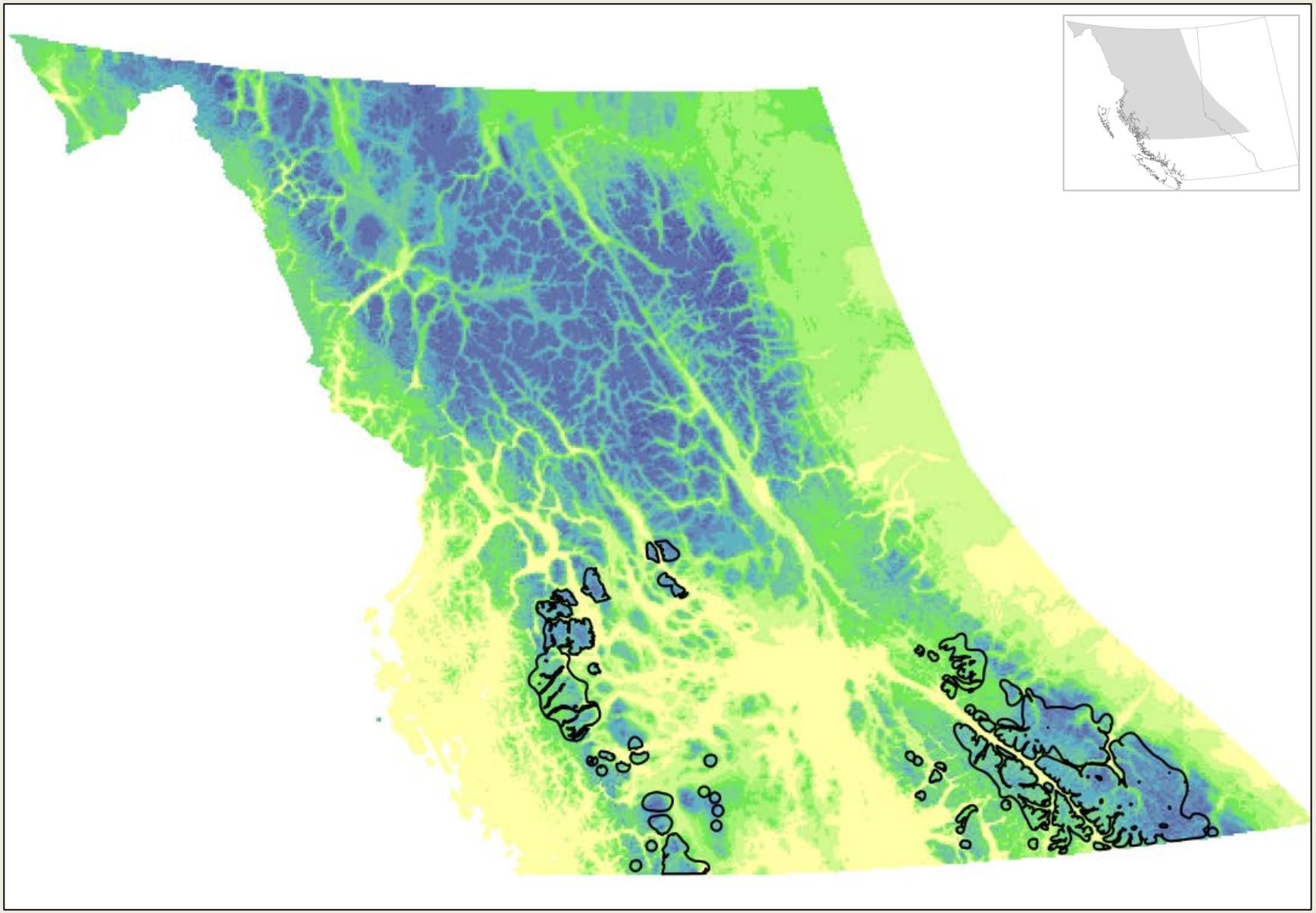


Hamann and Wang, 2006

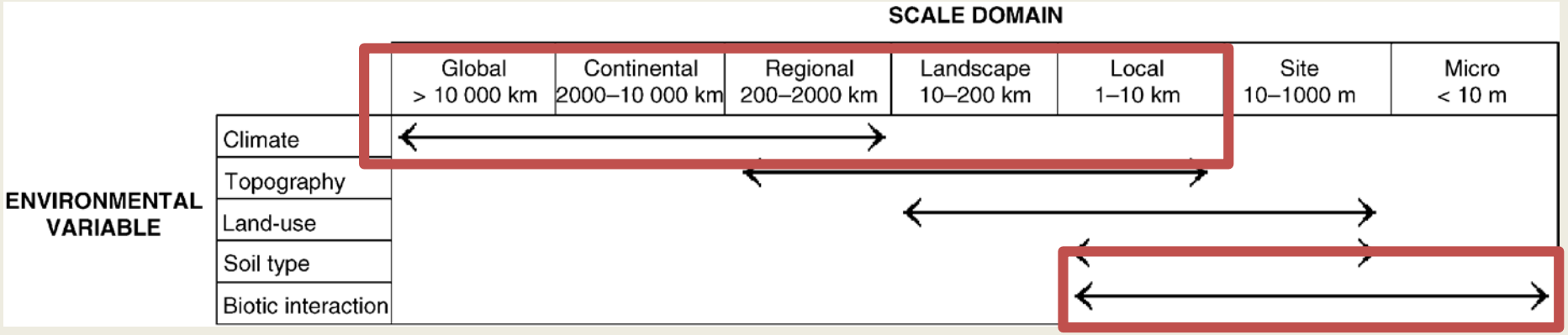


Mathys et al., 2016

Northern limit ≠ Cold limit



What about biotic interactions?



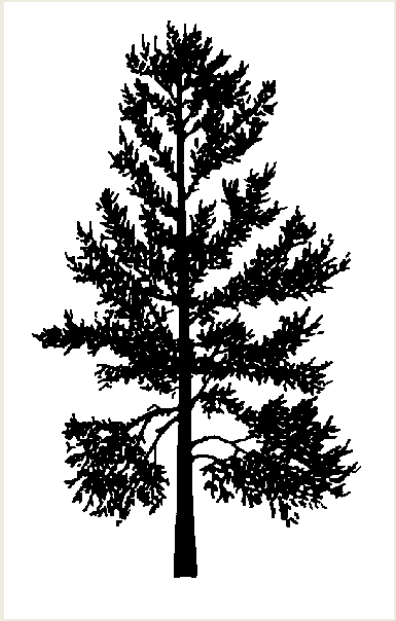
Pearson and Dawson, 2003

Biotic Interactions

Grizzly bears

http://switchboard.nrdc.org/blogs/awetzler/as_go_whitebark_pine_so_go_gri.html

Whitebark pine



Clark's Nutcracker

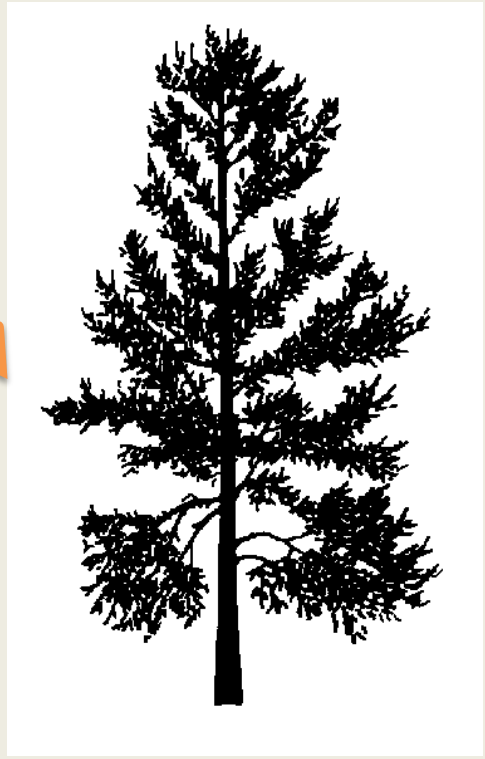
Photo: C. Wong

Red squirrels

http://www.treefight.org/whitebark-pine-of-the-gye/

Clark's Nutcracker

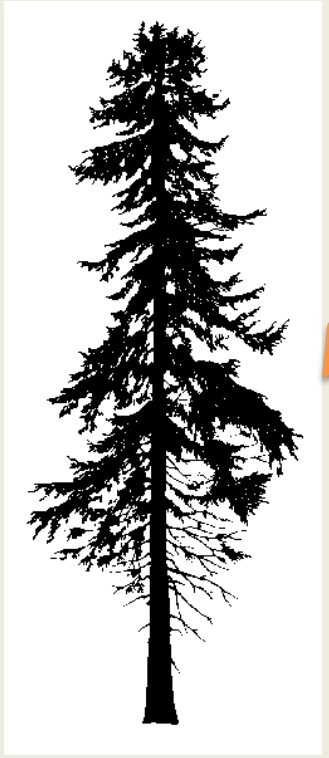
Photo: C. Wong

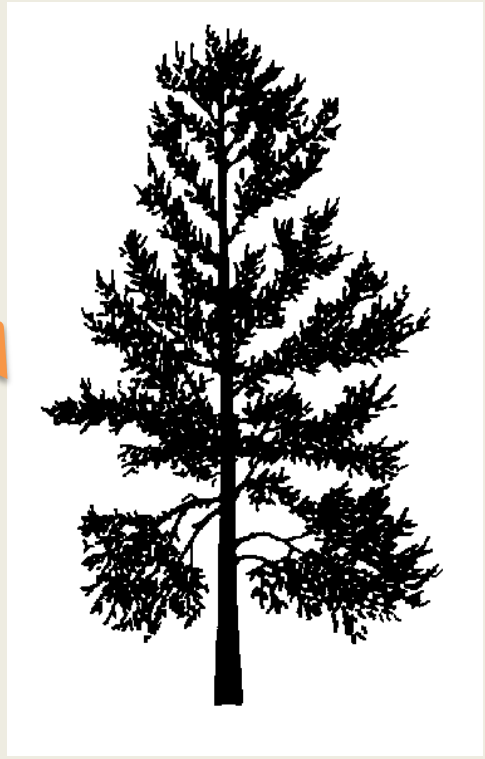


Whitebark pine

Clark's Nutcracker

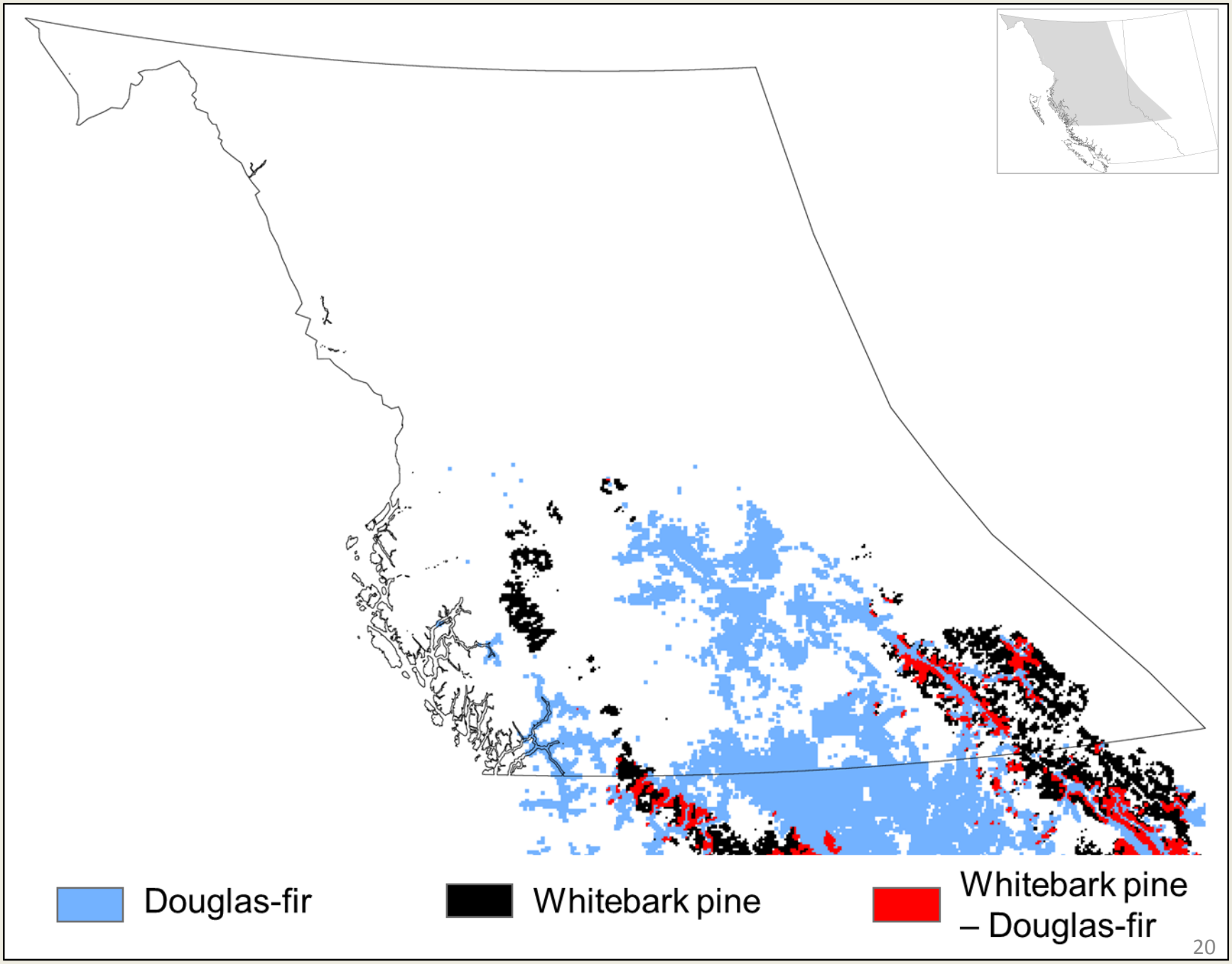
Photo: C. Wong





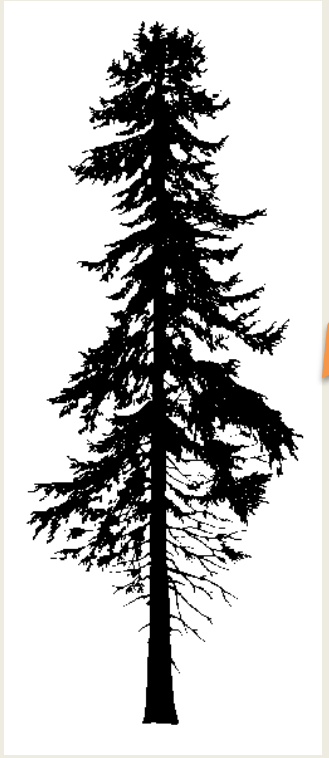
Alternative Food (Douglas-fir)

Whitebark pine


Douglas-fir
Whitebark pine
Whitebark pine – Douglas-fir

Clark's Nutcracker

Photo: C. Wong



Alternative Food (Douglas-fir)

~~**Reproduce**~~

Schaming, 2015

Whitebark pine

1. What currently constrains the northern limit of whitebark pine?

Mechanism	Hypothesis	Species
Habitat (abiotic)	Habitat	-

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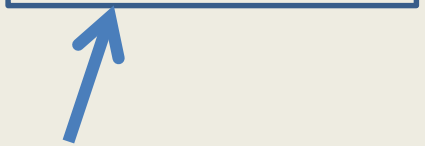
Competition (biotic) & Habitat (abiotic)	Competition	Lodgepole pine

1. What currently constrains the northern limit of whitebark pine?

Mechanism	Hypothesis	Species
Habitat (abiotic)	Habitat	-
Competition (biotic) & Habitat (abiotic)	Competition	Lodgepole pine
Dispersal (biotic) & Habitat (abiotic)	Seed source – within-pixel only	Whitebark pine
	Seed source – within-pixel and long-distance dispersal	Whitebark pine
	Alternate food sources	Douglas-fir
	Seed source and alternate food sources	Whitebark pine, Douglas-fir



A joint double dispersal kernel

Mechanism	Hypothesis	Species	AIC
Habitat (abiotic)	Habitat	-	6831
Competition (biotic) & Habitat (abiotic)	Competition	Lodgepole pine	6884
Dispersal (biotic) & Habitat (abiotic)	Seed source – local dispersal only	Whitebark pine	6751
	Seed source – local and long-distance dispersal	Whitebark pine	6737
	Alternate food sources	Douglas-fir	6828
	Seed source and alternate food sources	Whitebark pine, Douglas-fir	6732

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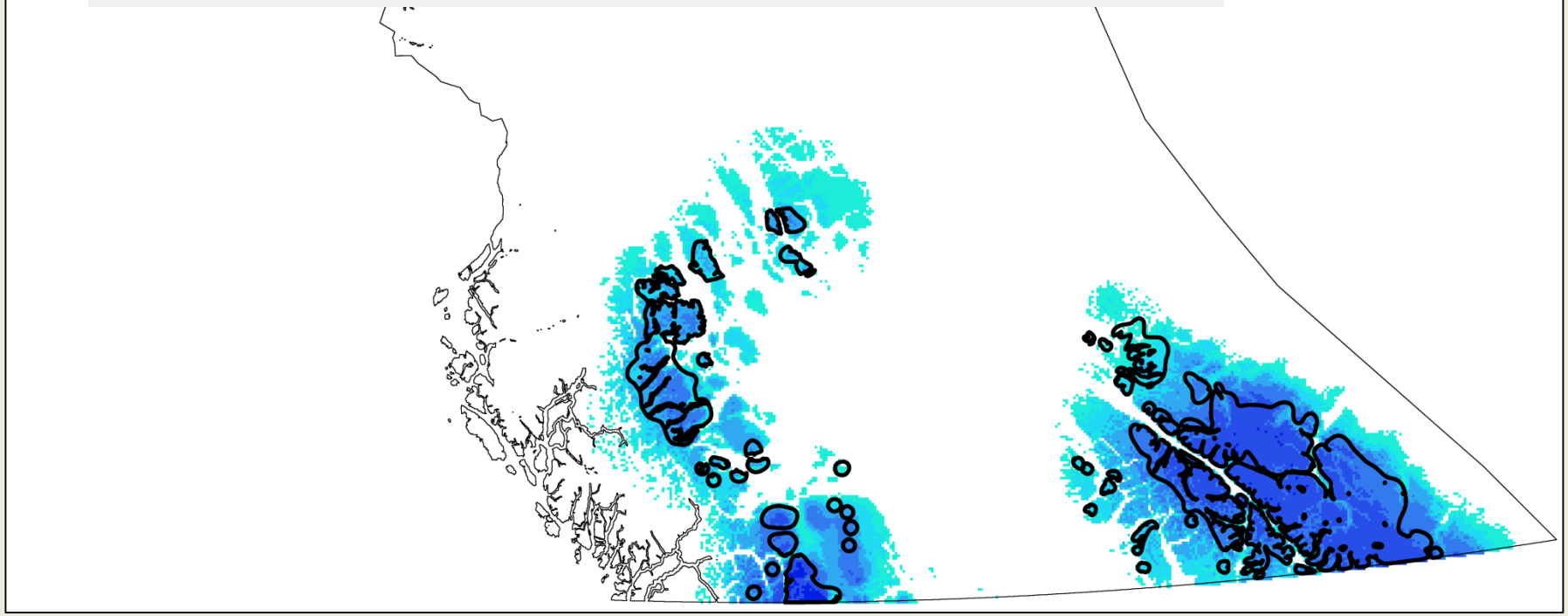
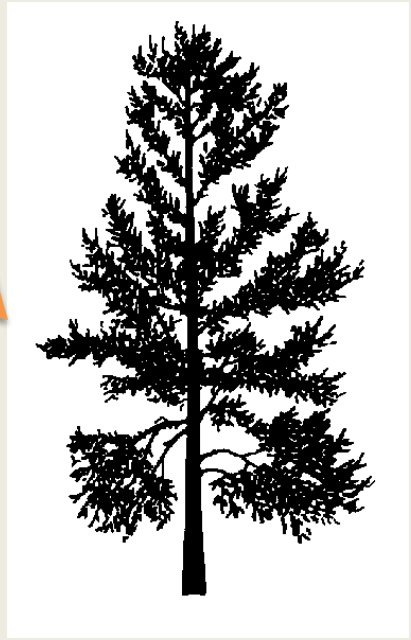
	Seed source and alternate food sources	**Whitebark pine, Douglas-fir**	**6732**

Predicted WBP abundance with dispersal from Douglas-fir and WBP, constrained by climate, topography – Good Fit!



Clark's Nutcracker

Photo: C. Wong

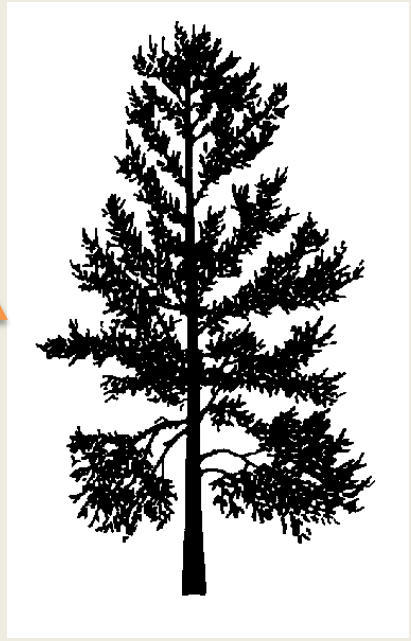


Whitebark pine

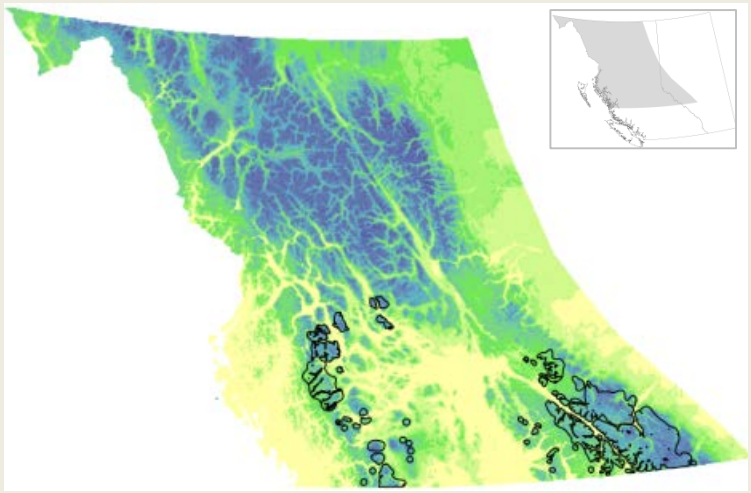
Clark's Nutcracker & Alternative Host Currently best explanation for Northern Limit

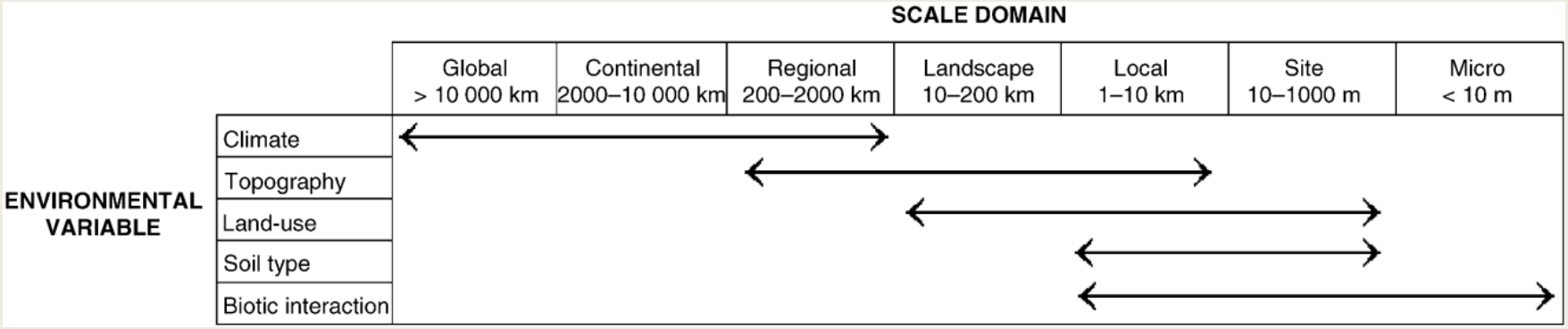
Photo: C. Wong

Douglas-fir



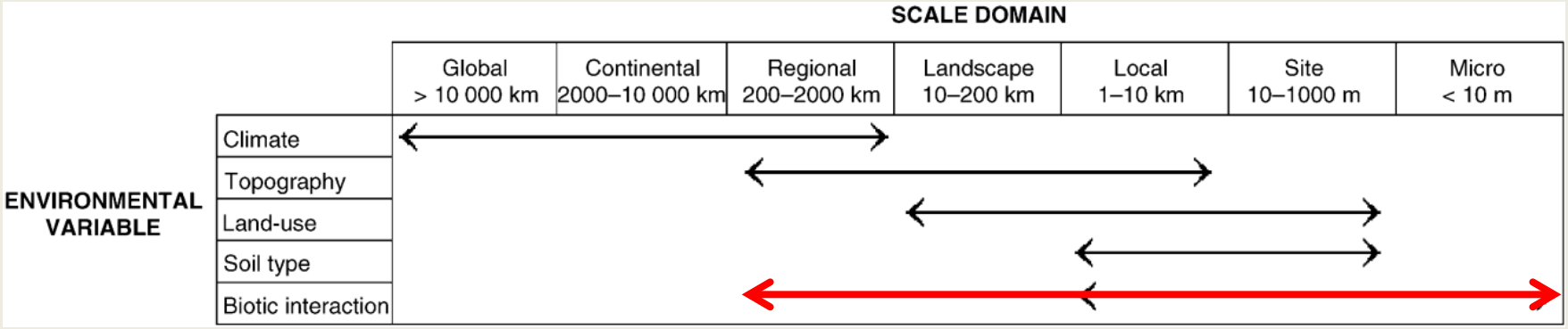
Whitebark pine





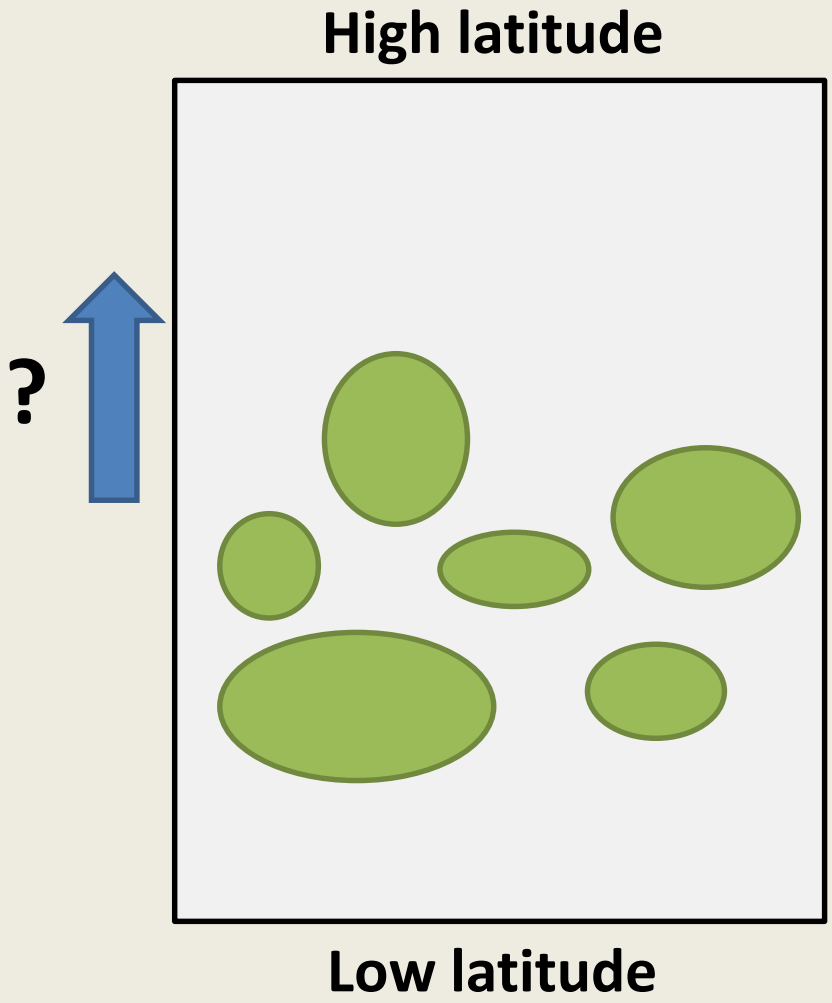
Pearson and Dawson, 2003

Continental-scale positive biotic interaction constrains species northern limit



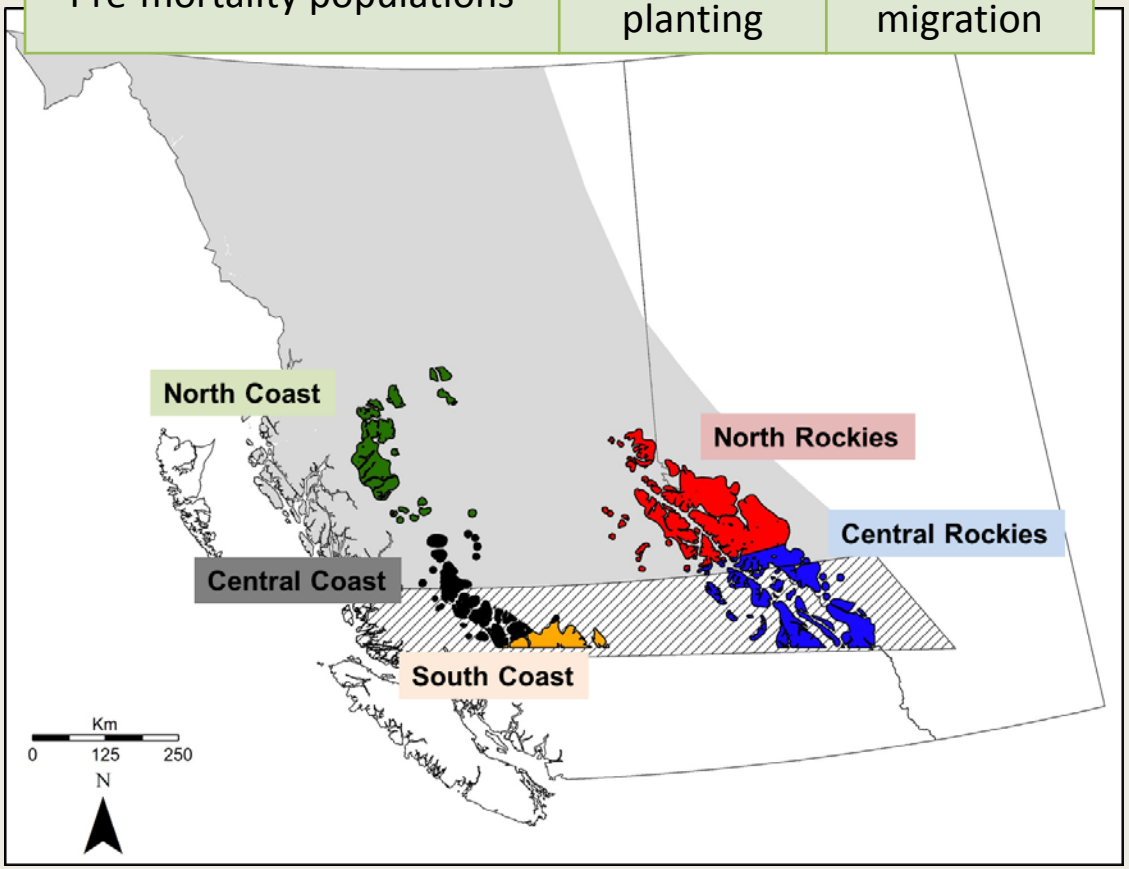
Pearson and Dawson, 2003

2. Where will whitebark pine's range shift under climate change at its northern limit?

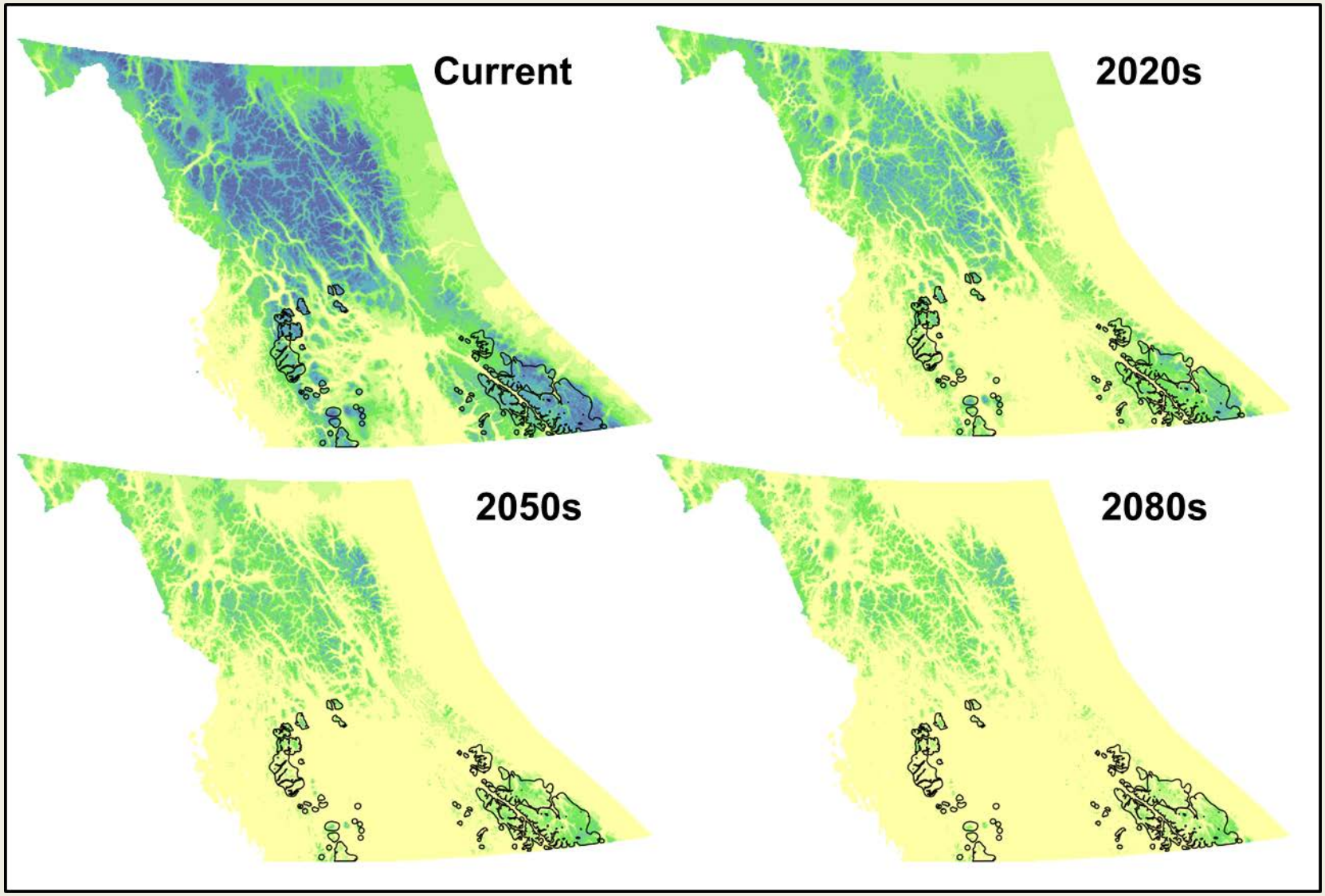


4-way simulation experiment – Test: Climate, Restoration, DouglasFir, WBP Mortality

Climate Change		Mortality	
RCP 4.5	RCP 8.5	Nutcracker visitation	
Restoration		**Douglas-fir Management**	
Pre-mortality populations		Increased planting	Assisted migration

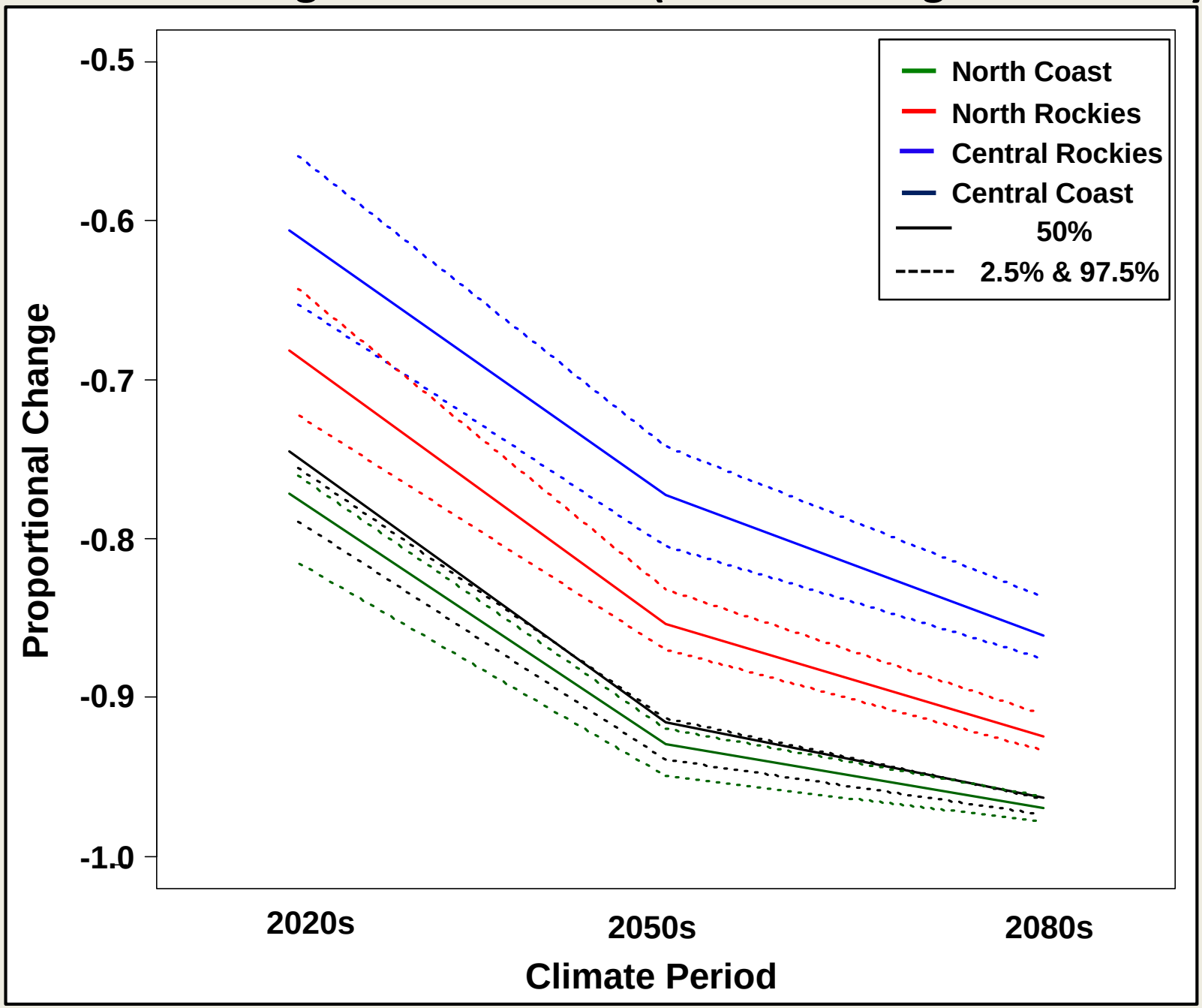


Massive decline in Suitable Habitat (RCP 4.5)

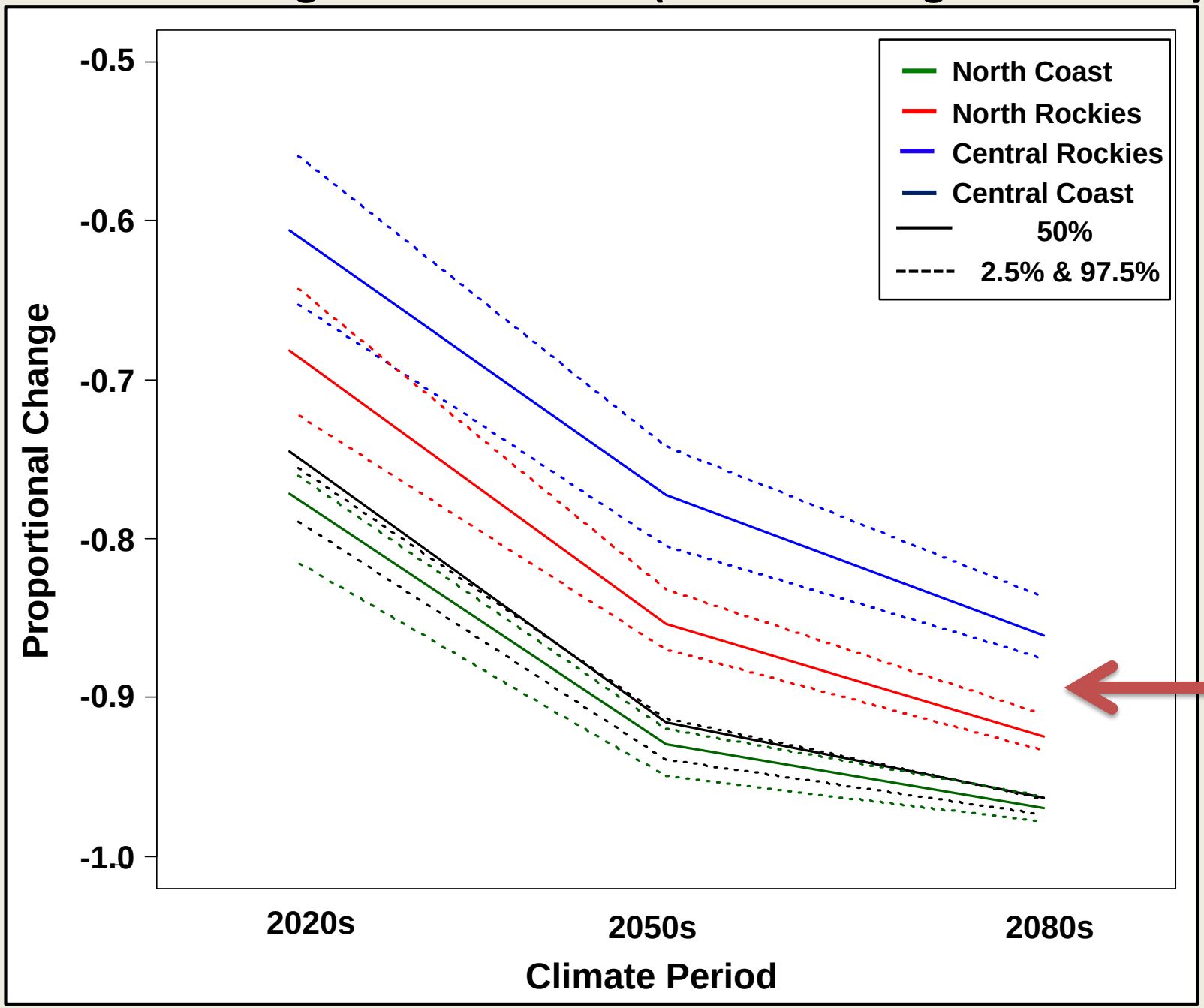


(note: this is the less extreme GCM!)

Change in Distribution (Climate change & mortality)

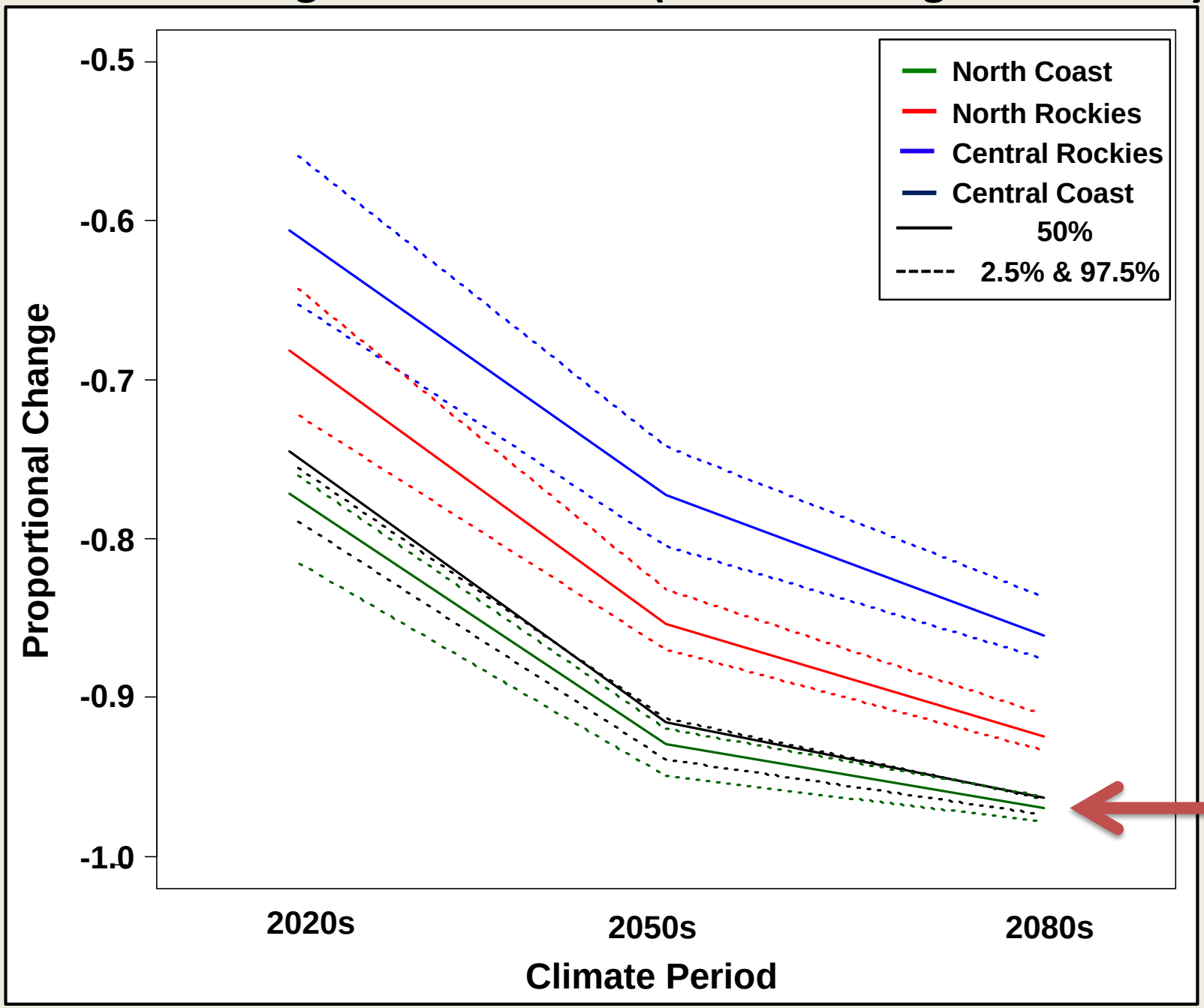


Change in Distribution (Climate change & mortality)

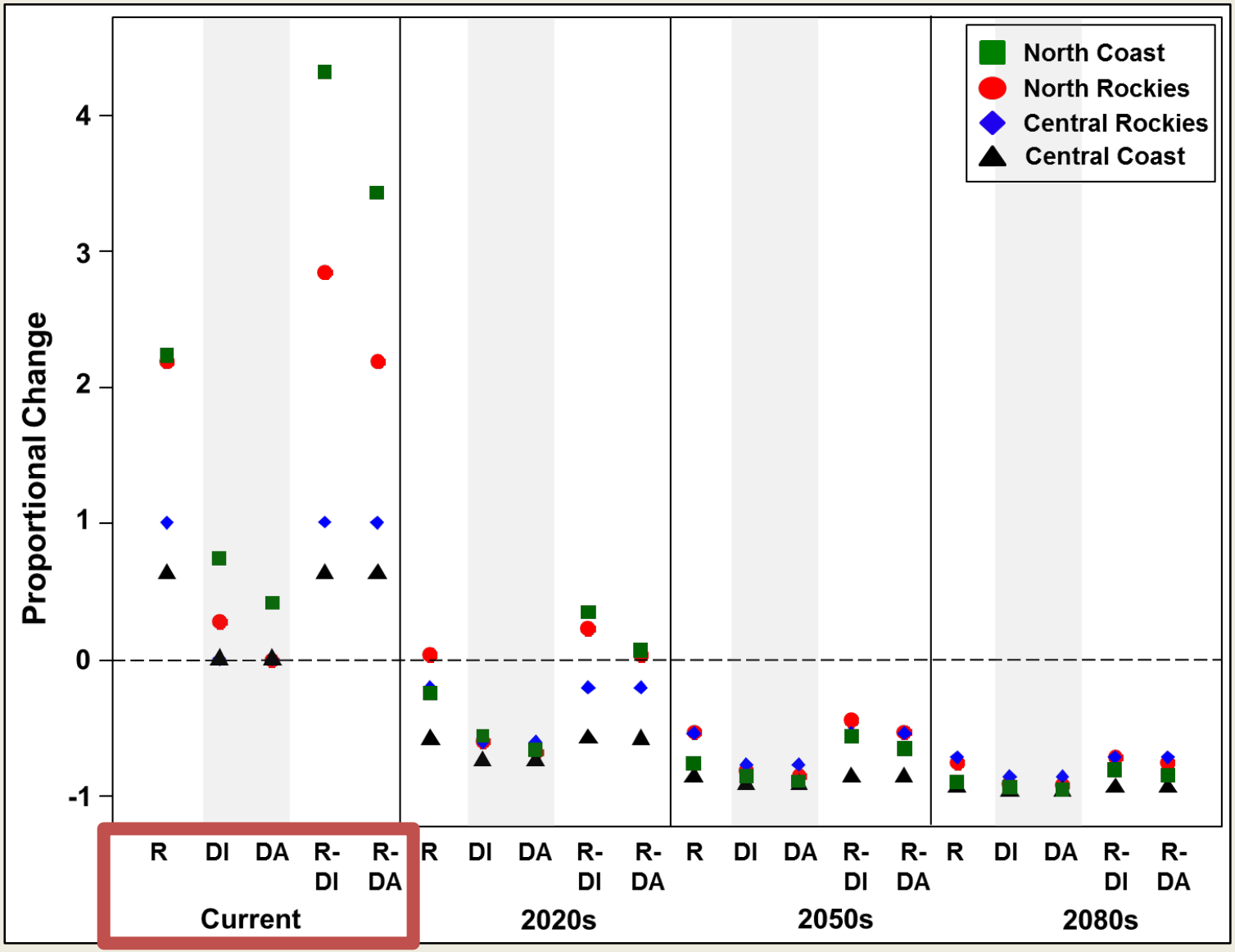


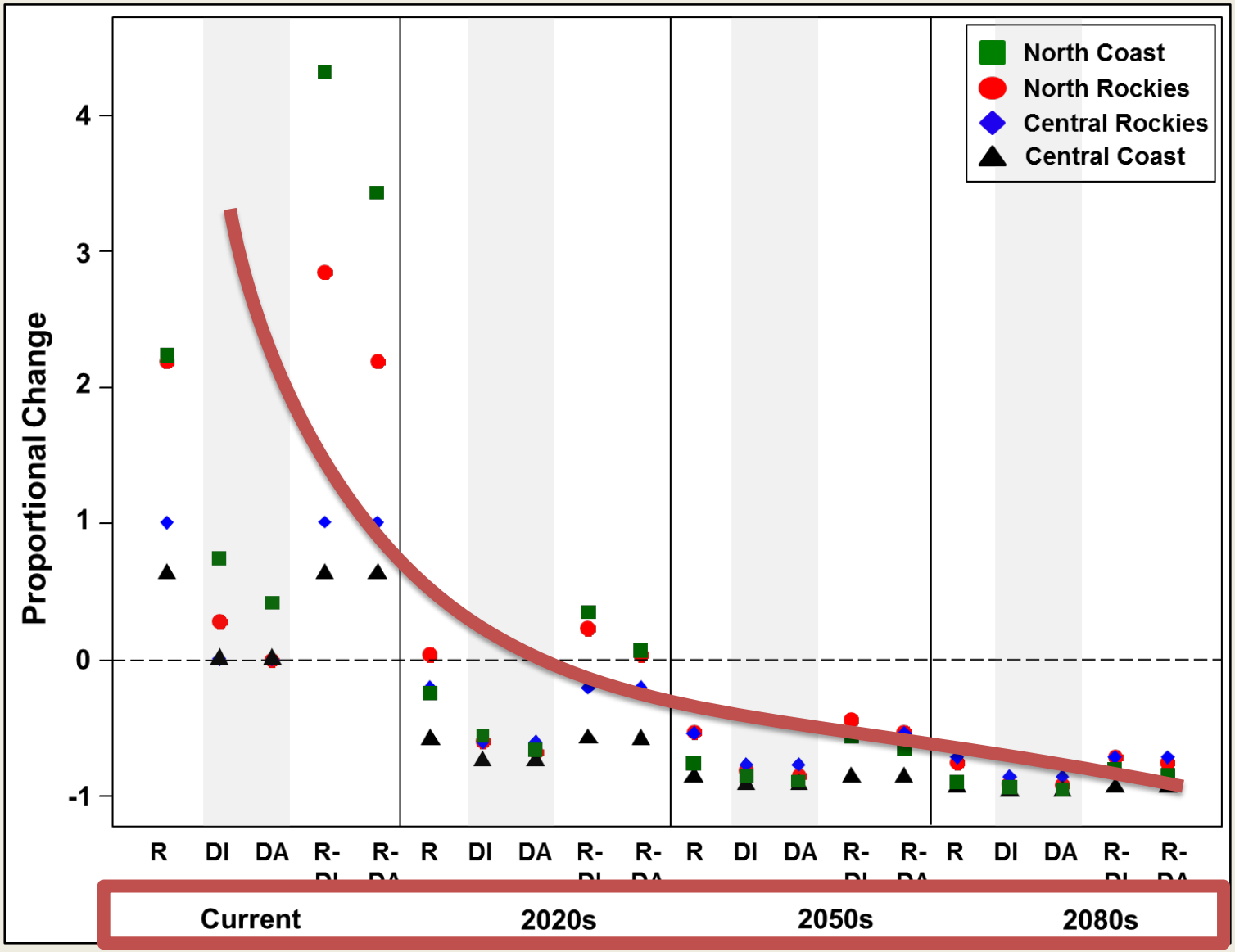
Loss of distribution across the northern range

Change in Distribution (Climate change & mortality)



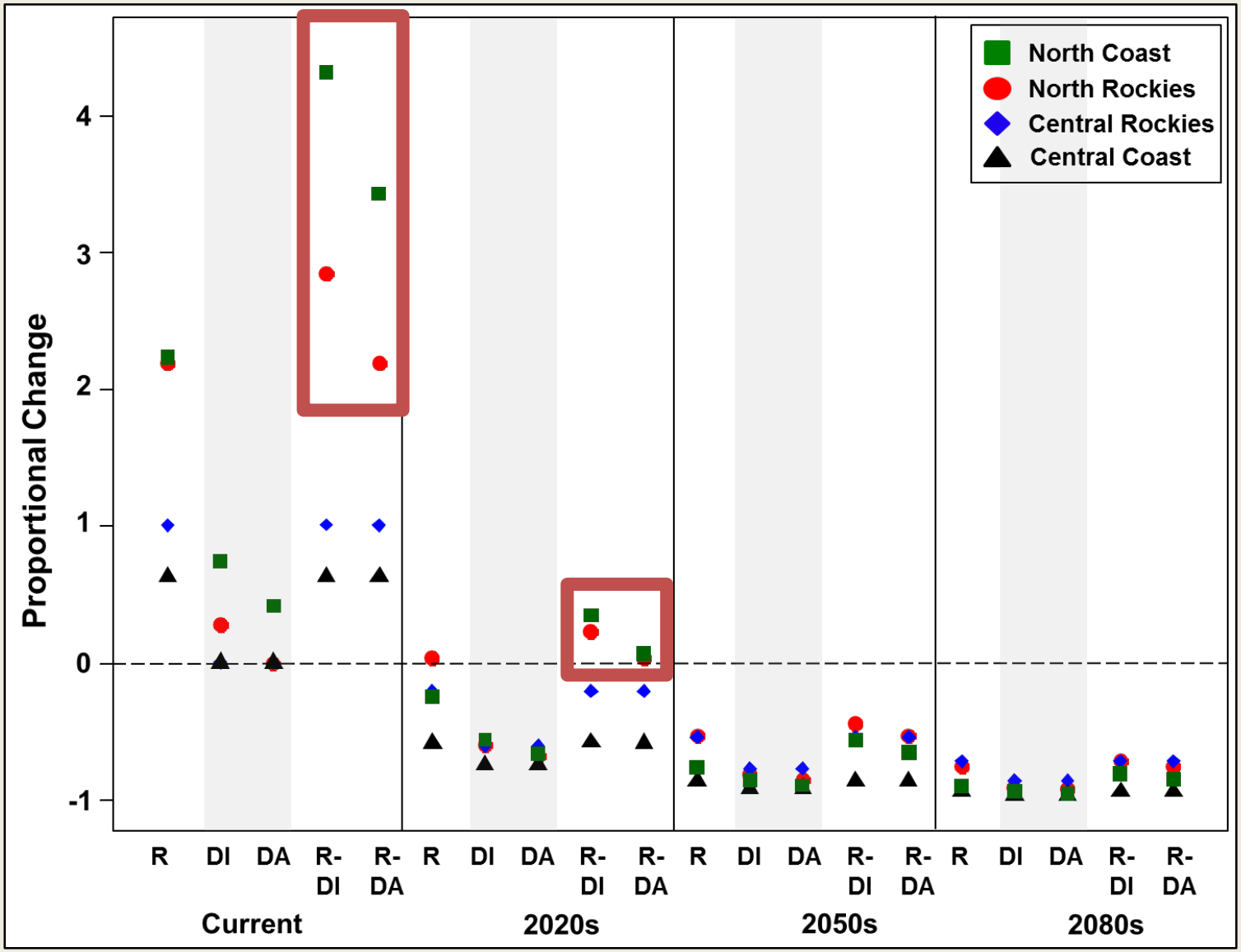
Coastal Regions lose more


North Coast
North Rockies
Central Rockies
Central Coast
Proportional Change
4
3
2
1
0
-1
R
DI
DA
R-DI
R-DA
Current
2020s
2050s
2080s



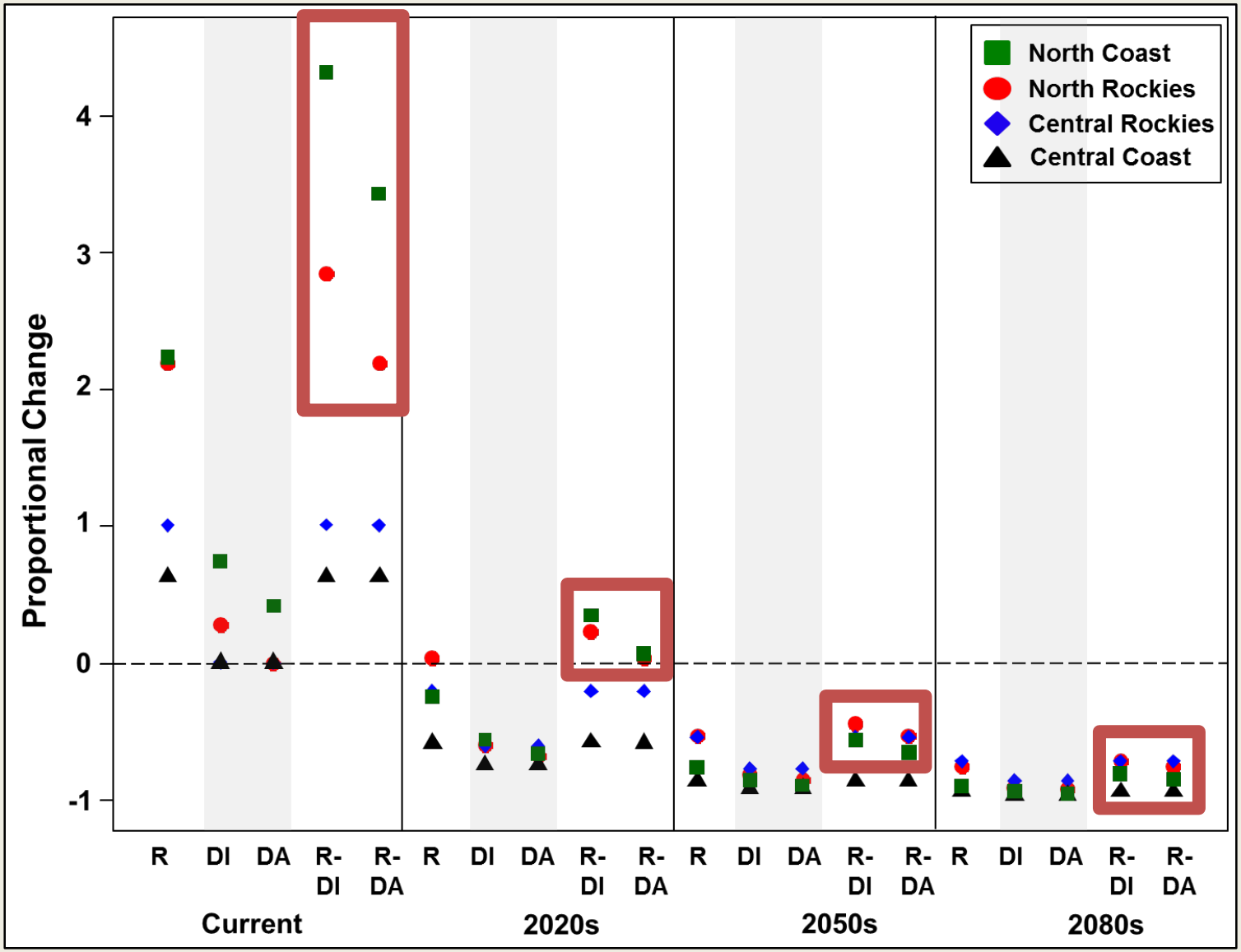
Distribution decline

Treatments: **R**estoration, **D**ouglas-fir **I**nfilling & **D**ouglas-fir **A**ssisted migration



Distribution decline

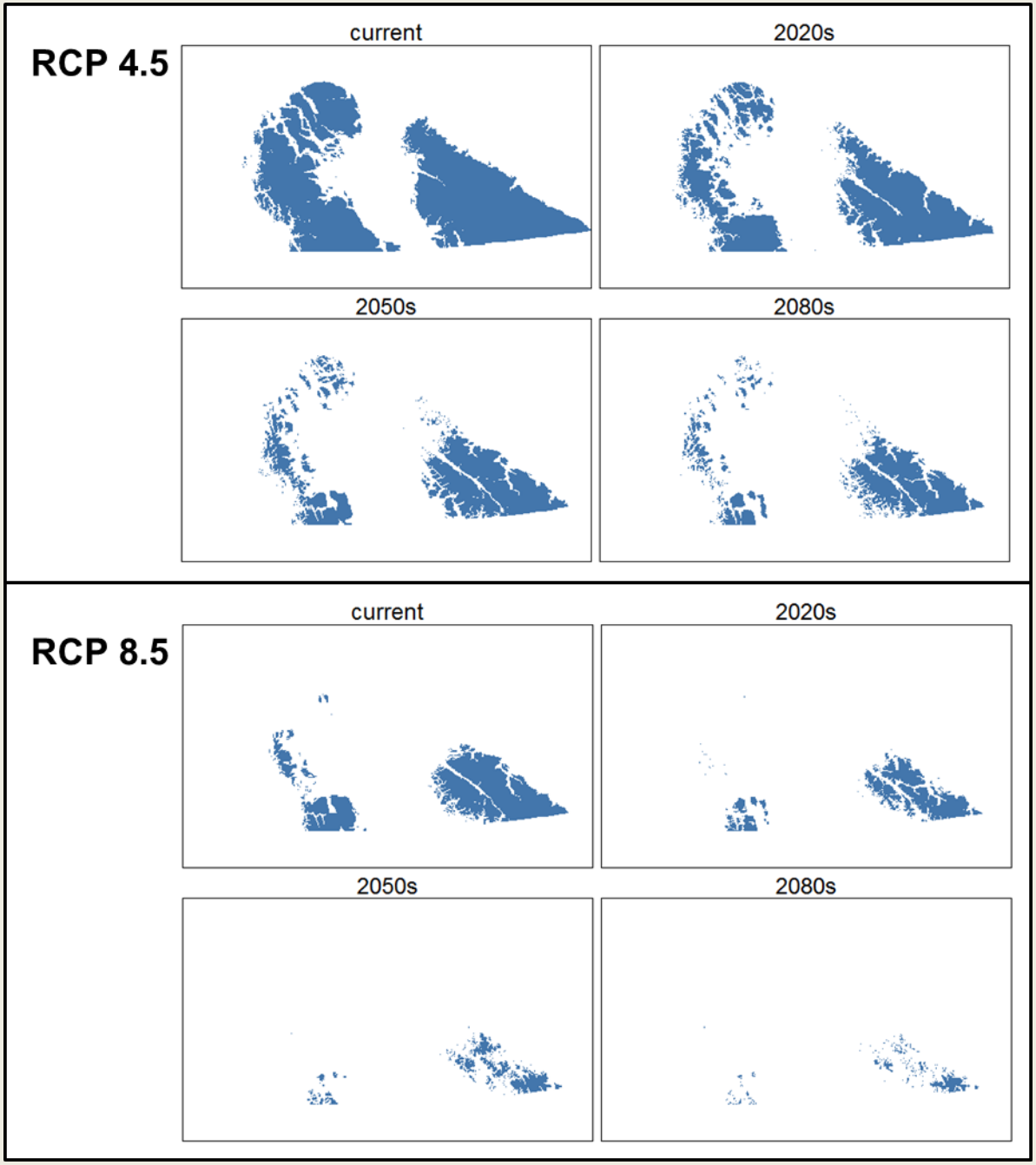
N Coast and N Rockies most responsive to treatments



Distribution decline

N Coast and N Rockies most responsive to treatments

But still decline in longer term



Extreme distribution contraction

Habitat disappearing – too warm everywhere

One coherent picture of climate-based decline

- Biotic drivers constrained current distribution
- This meant that species *did not make it* to its northern climatic limit (i.e., it could have been Alaska/Yukon)
- So, with coming warming, core conditions will be disappearing

Managing ecosystem based on relationships, not stand alone

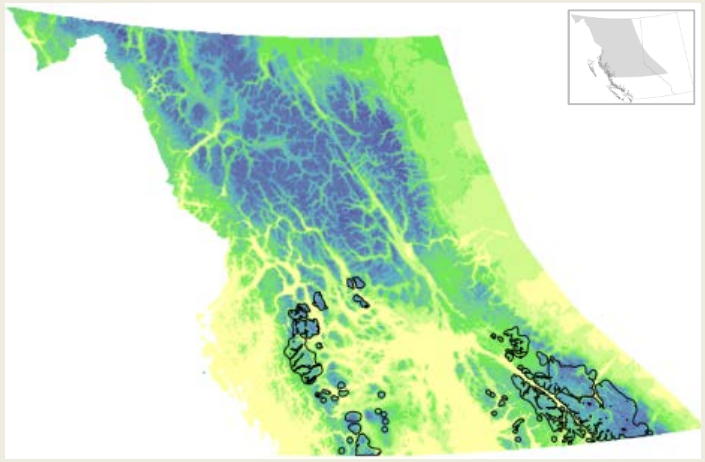
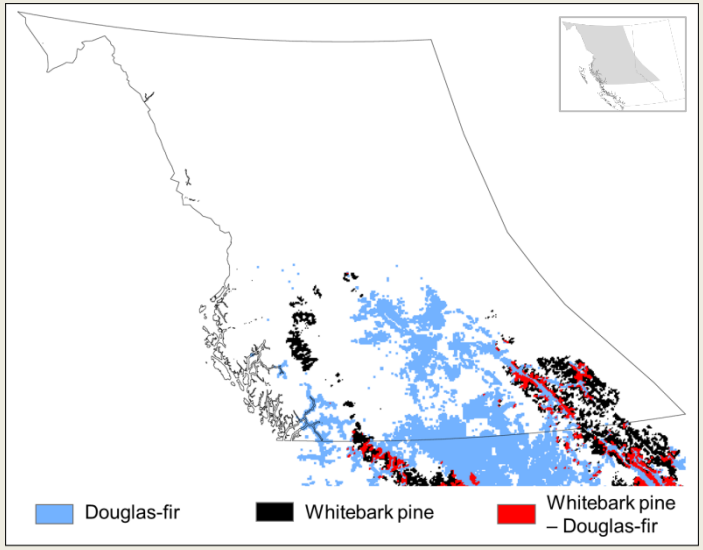
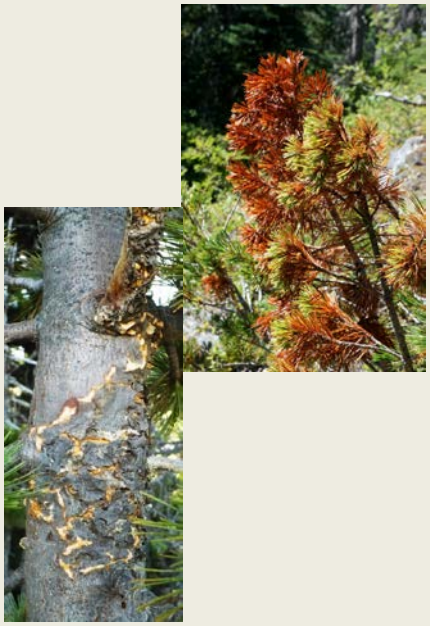


Photo: S. Haeuessler

Photo: C. Wong



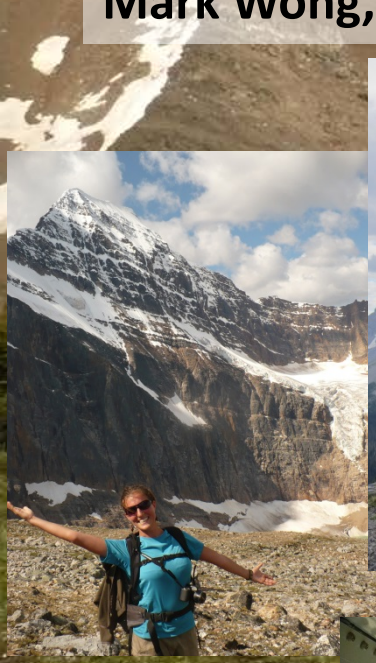


Understanding context will help: Local, regional abiotic habitat, proximity to alternative food sources

Acknowledgements

Co-Supervisor: Phil Burton

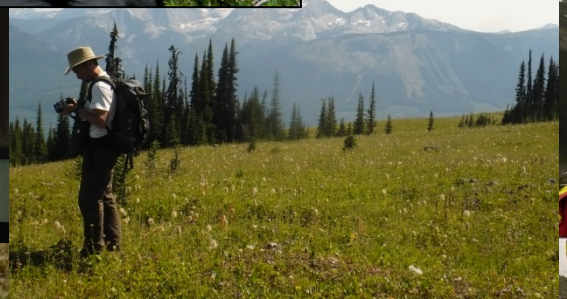
Field assistants: Andrew Sheriff, Laura Super, Coralie Lenne, Nata de Leeuw, Mark Wong, Nick Thum







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Co-Supervisor: Phil Burton

Field assistants: Andrew Sheriff, Laura Super, Coralie Lenne, Nata de Leeuw, Mark Wong, Nick Thum

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