Development of a Climate Bases Seed Transfer System for British Columbia

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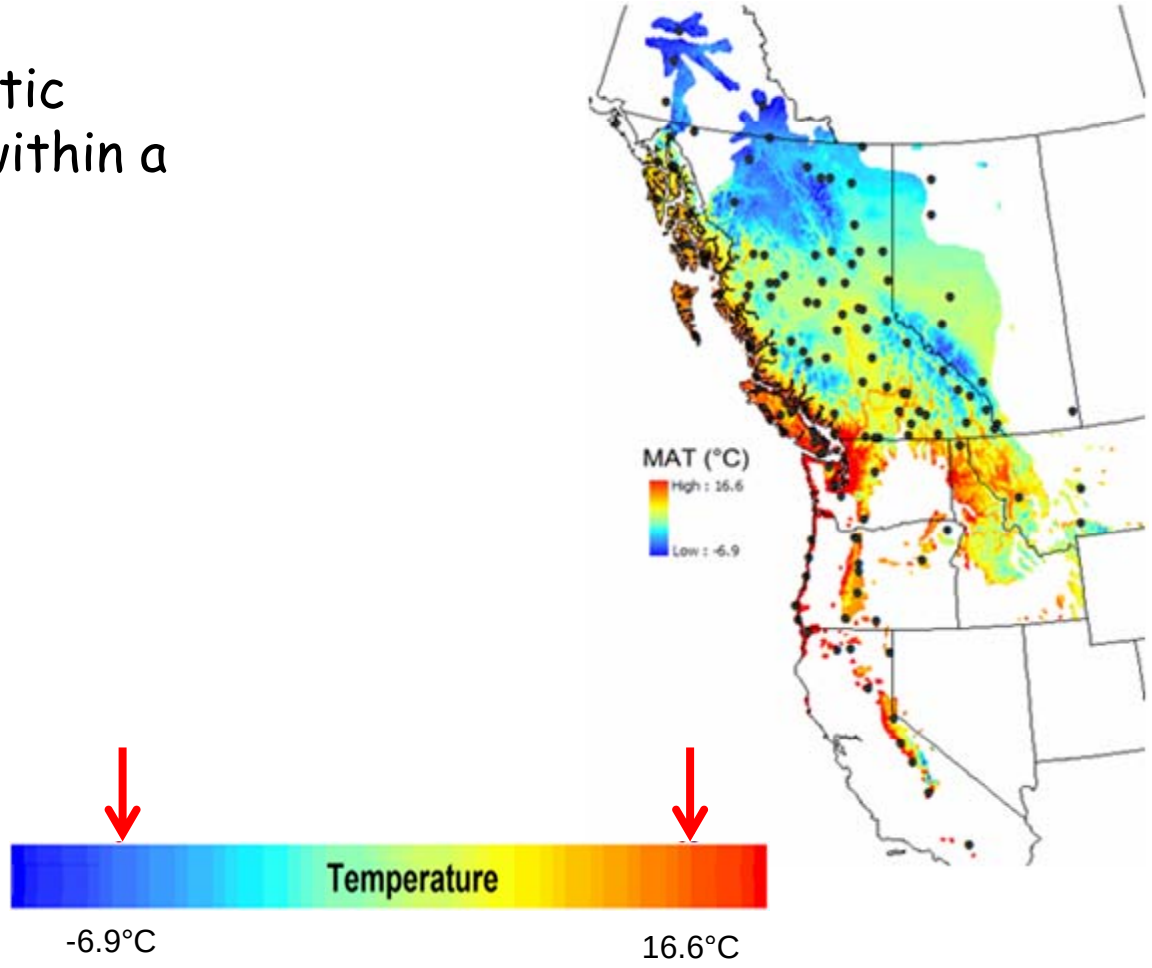
Why a seed transfer system?

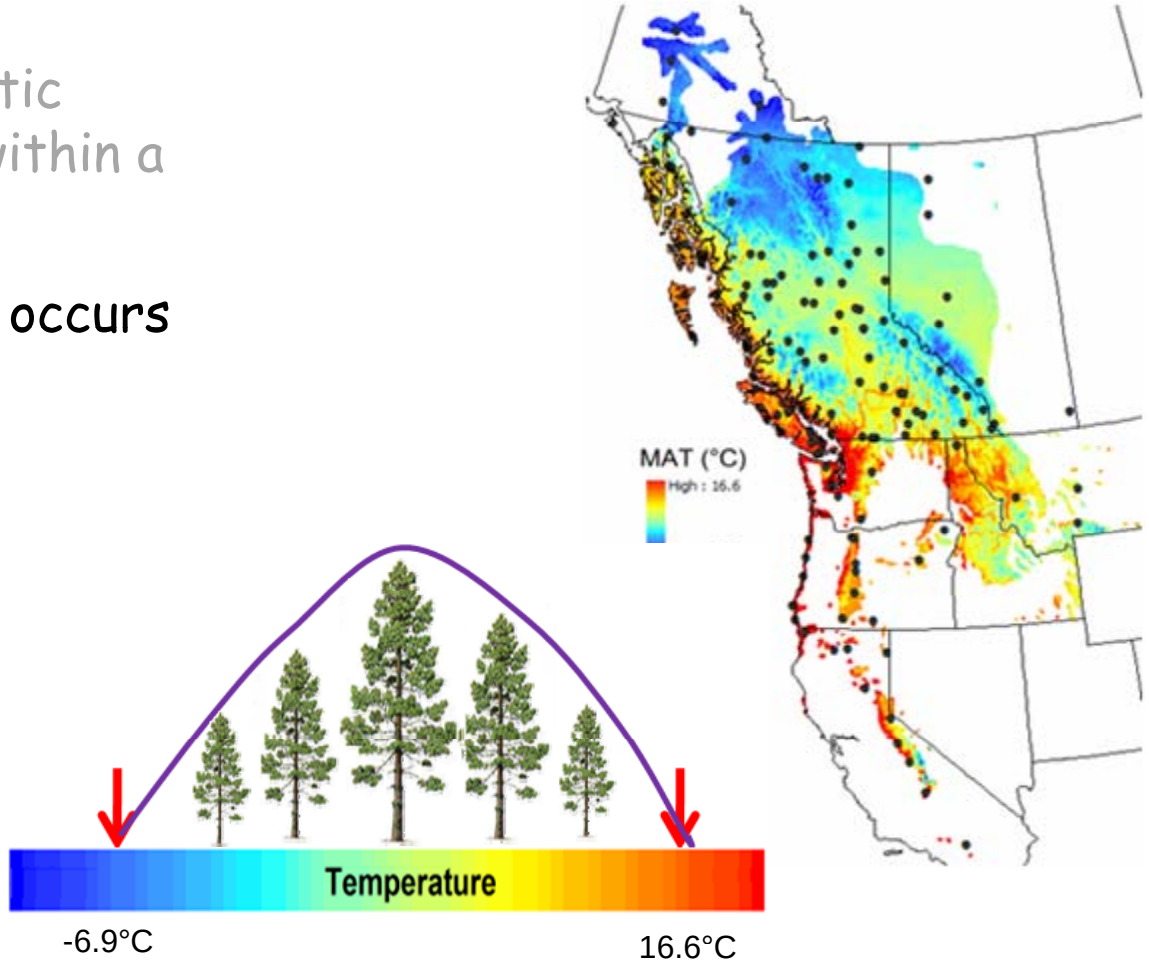
- Substantial climatic variation exists within a species range



Geographic and climatic distributions of Lodgepole pine

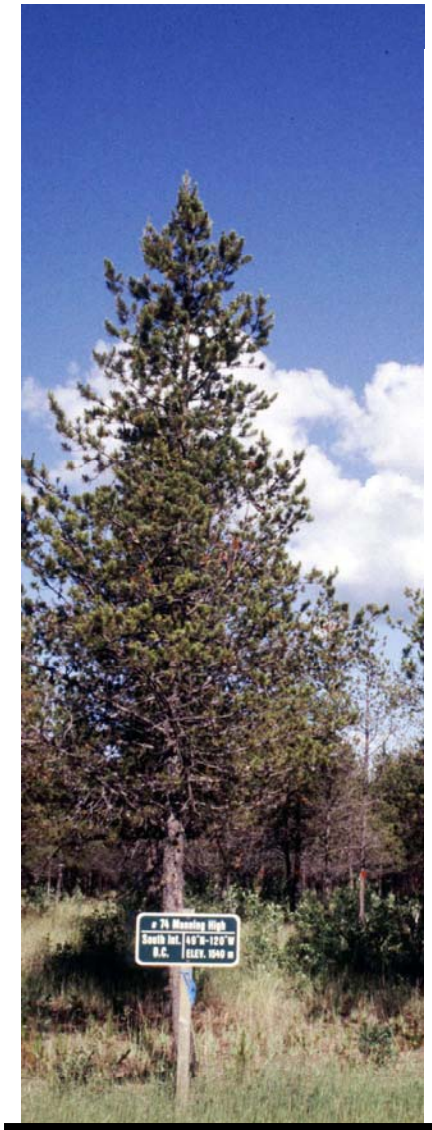
Why a seed transfer system?

- Substantial climatic variation exists within a species range
- Genetic variation occurs following climate gradients

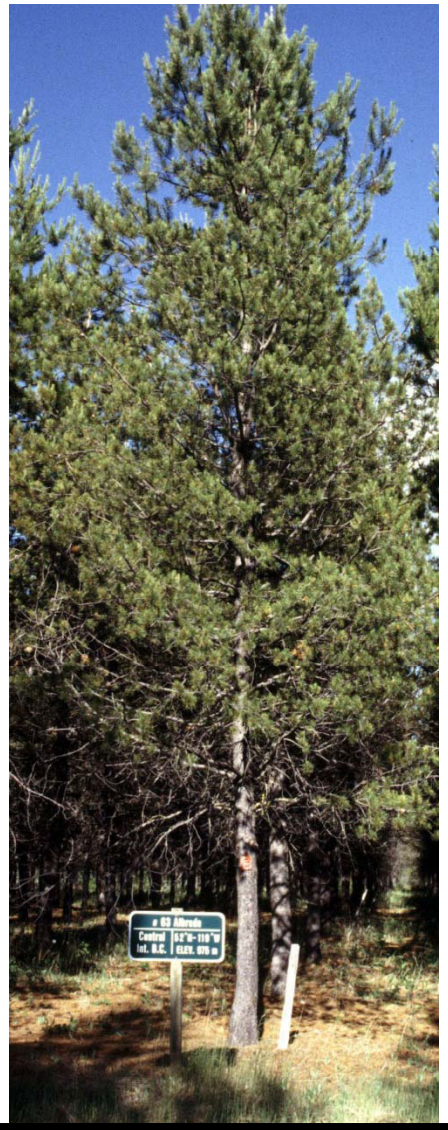


Geographic and climatic distributions of Lodgepole pine

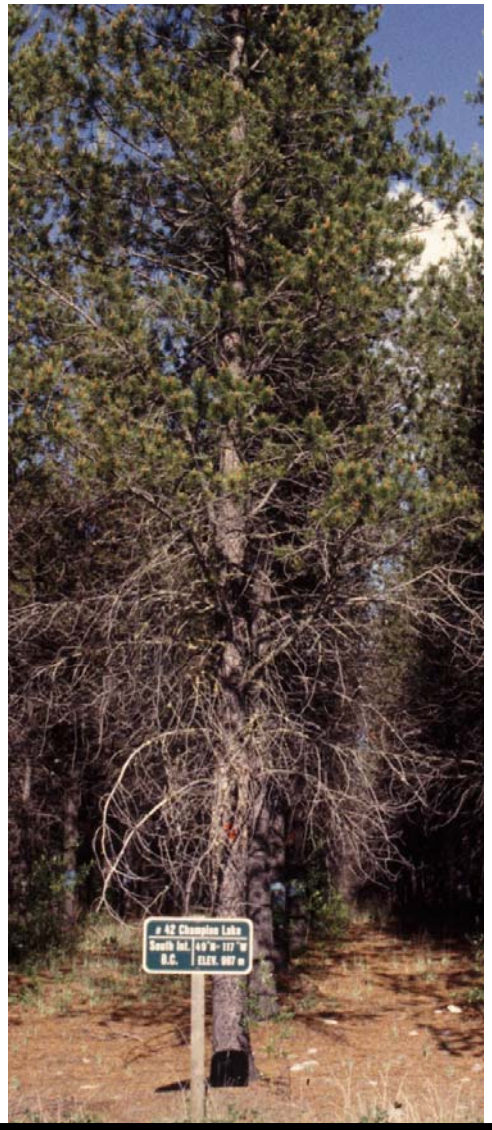
Logepole pine



Manning
49 N



Albreda
52 N



Champion
59 N

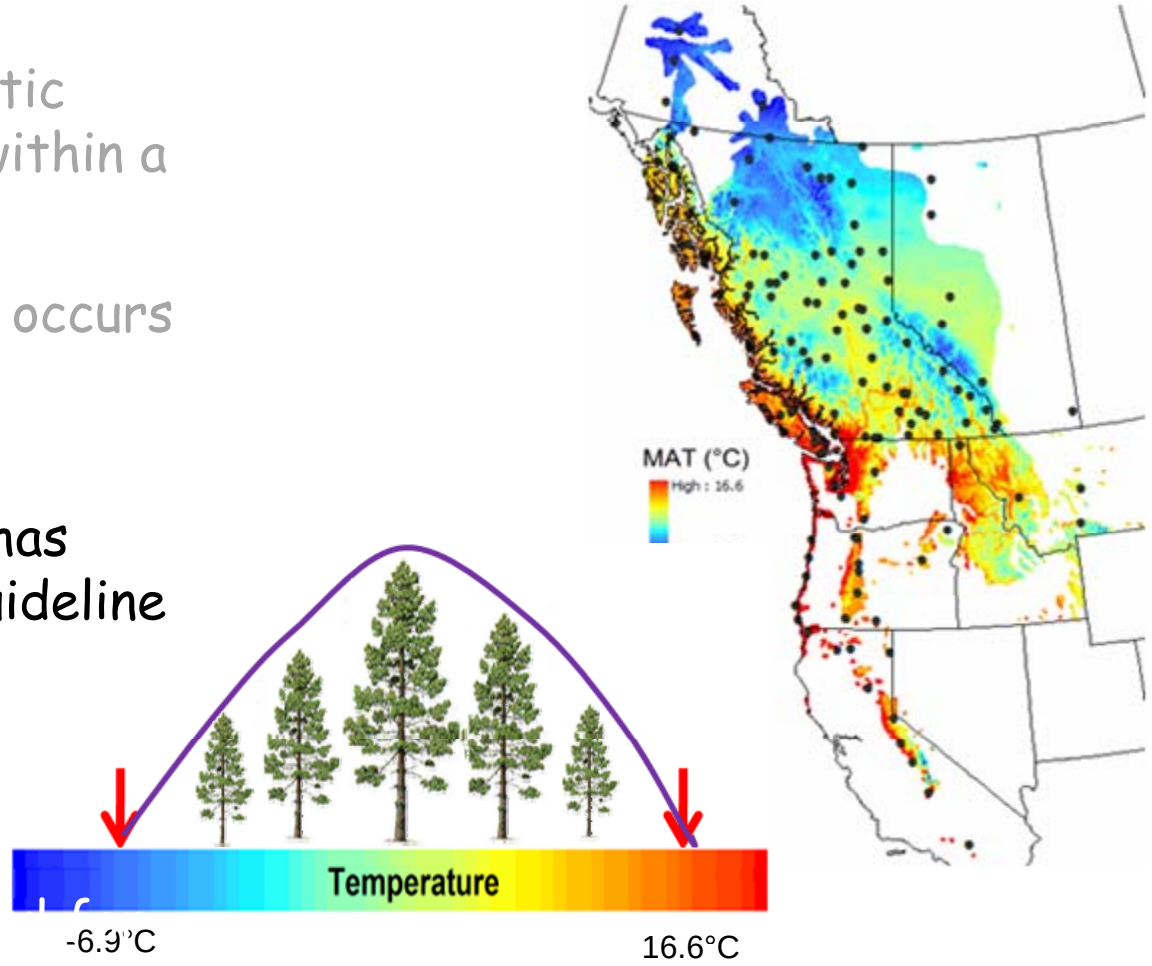
Takhini
60 N

Western hemlock

Sitka Spruce

Why a seed transfer system?

- Substantial climatic variation exists within a species range
- Genetic variation occurs following climate gradients
- Using local seed has been a general guideline

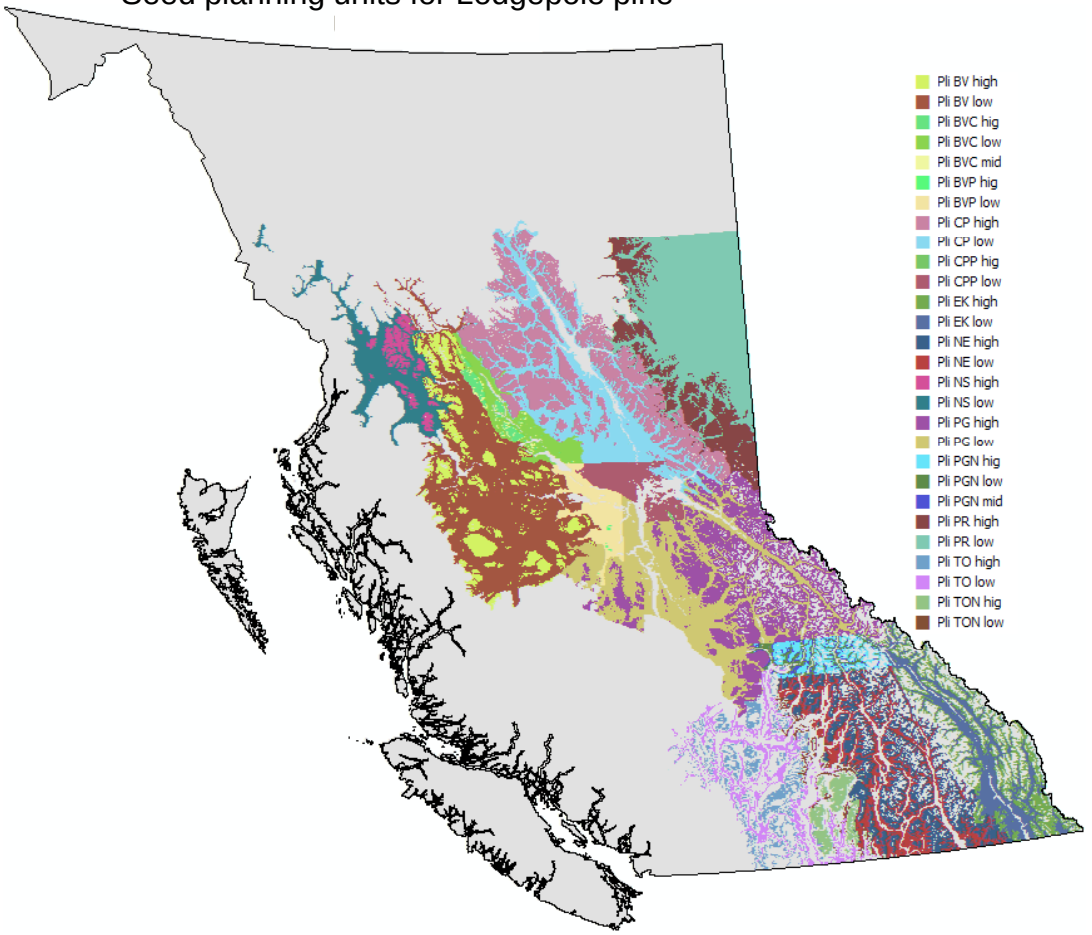


Geographic and climatic distributions of Lodgepole pine

Why a seed transfer system?

- Substantial climatic variation exists within a species range
- Genetic variation occurs following climate gradients
- Using local seed has been a general guideline
- Grouping areas with similar climatic conditions is effective for seed planning
  - Current Seed Planning Units (SPUs)

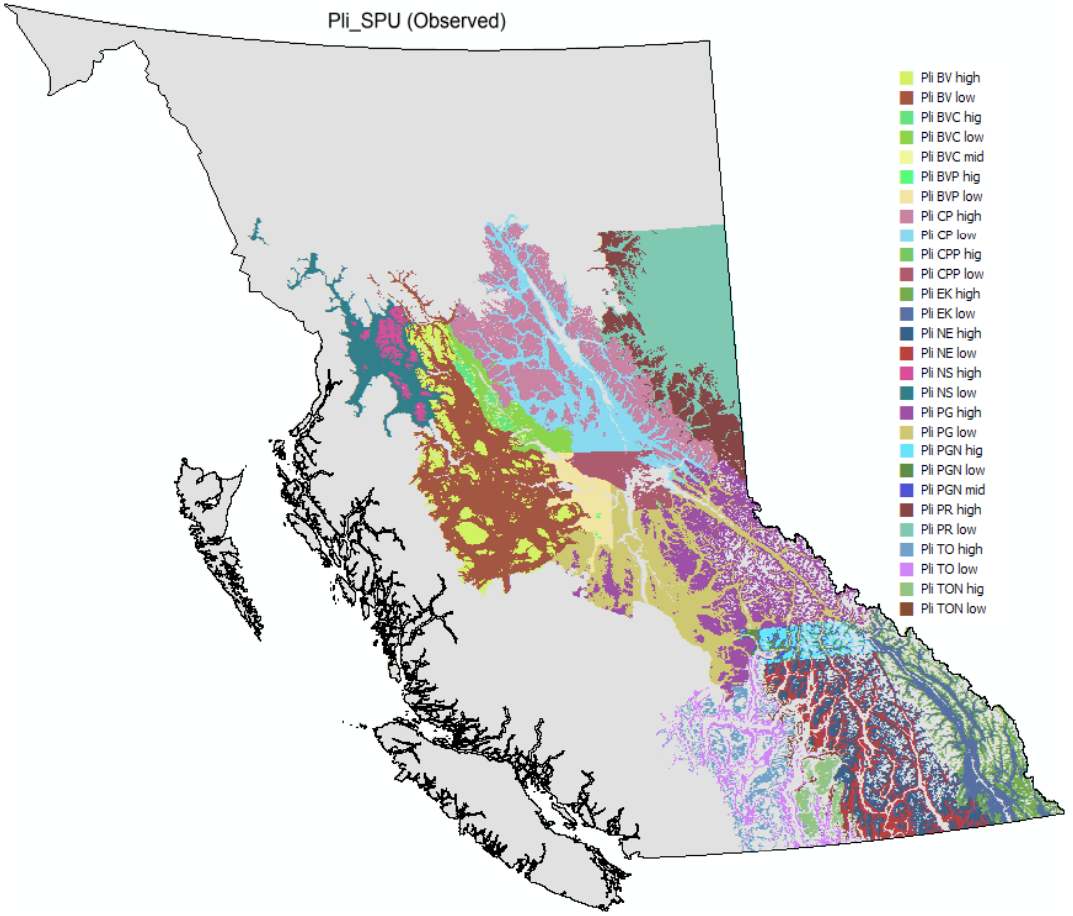
Seed planning units for Lodgepole pine



Ying and Yanchuk (2006)

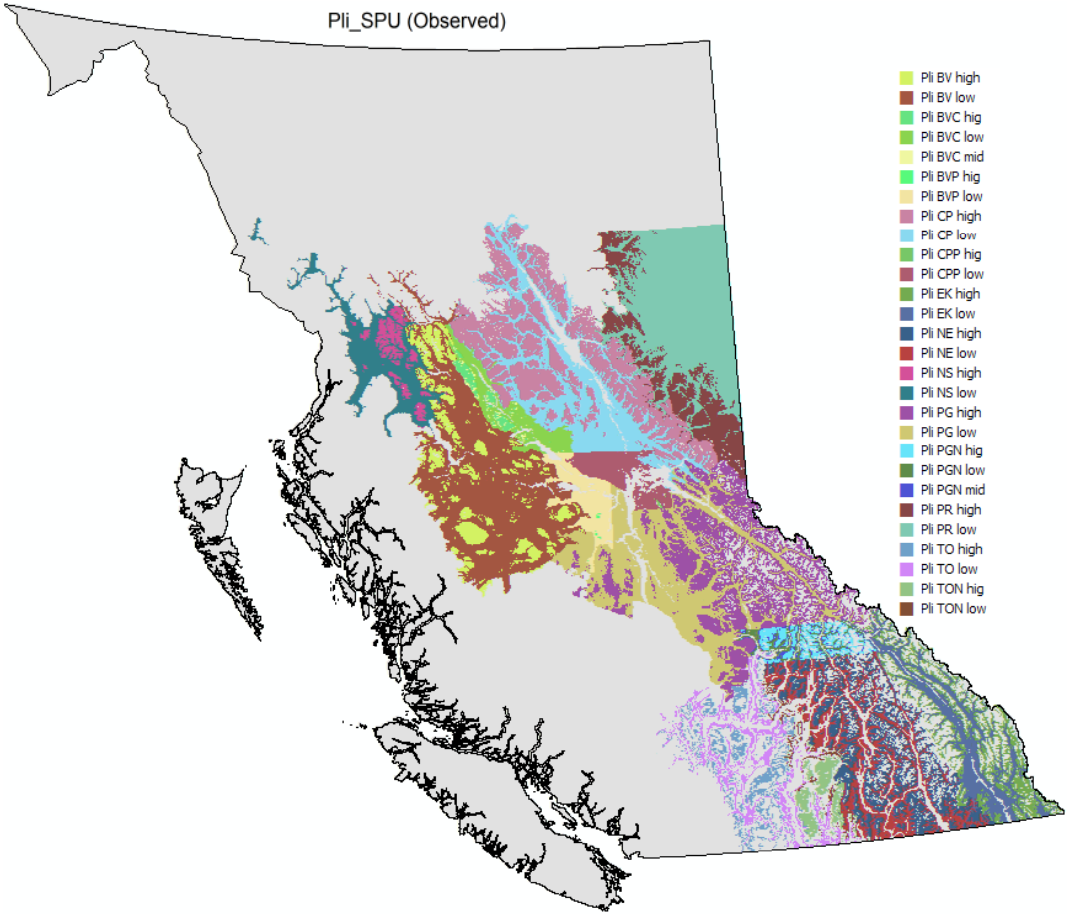
Features and limits of the current SPUs

- Geographic-based and easy to use



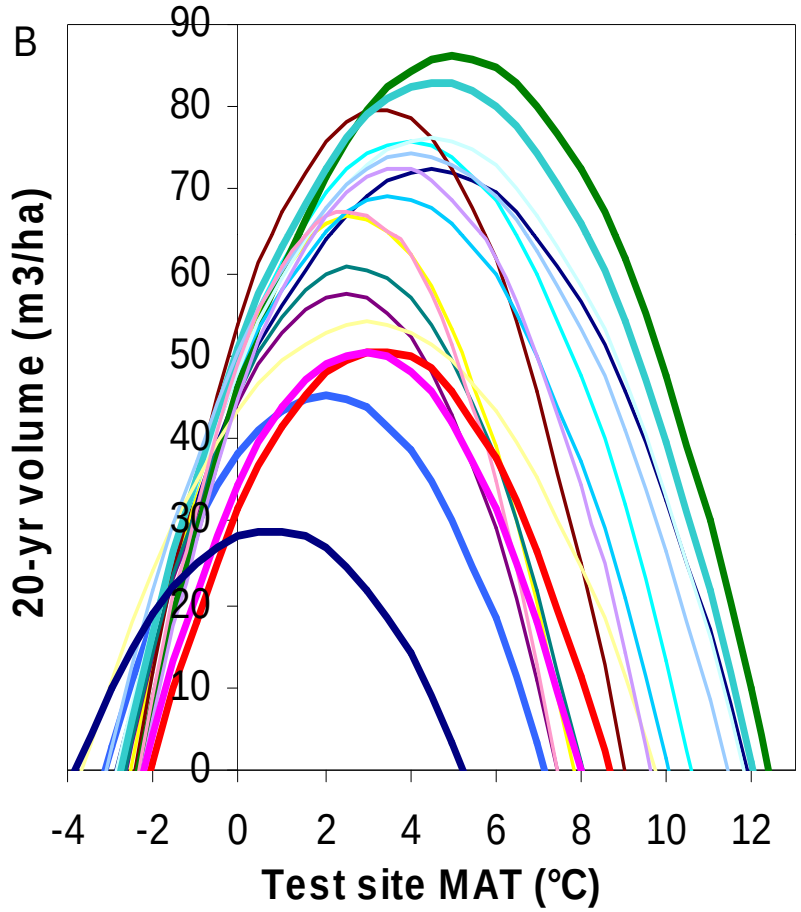
Features and limits of the current SPUs

- Geographic-based and easy to use
- Effective for local adaptation



Features and limits of the current SPUs

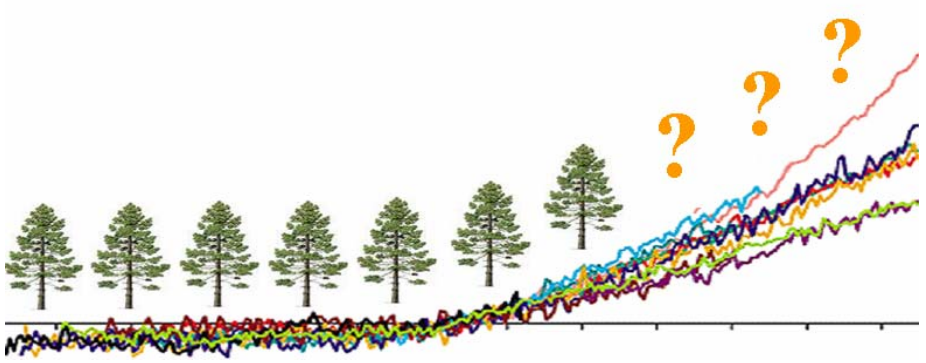
- Geographic-based and easy to use
- Effective for local adaptation
- May limit the use of seed transfer potential



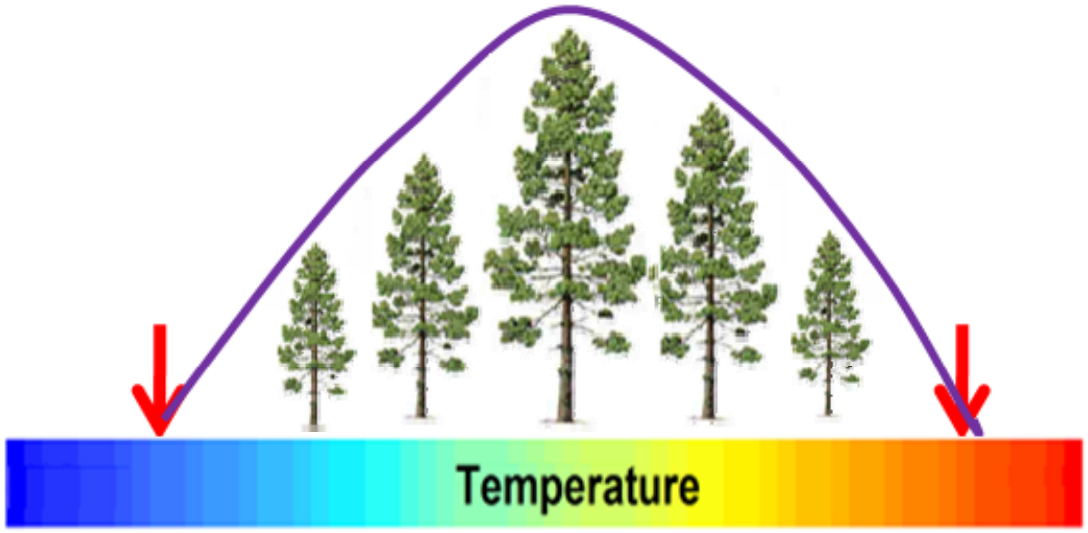
Wang et al. 2006, Global Change Biology

Features and limits of the current SPUs

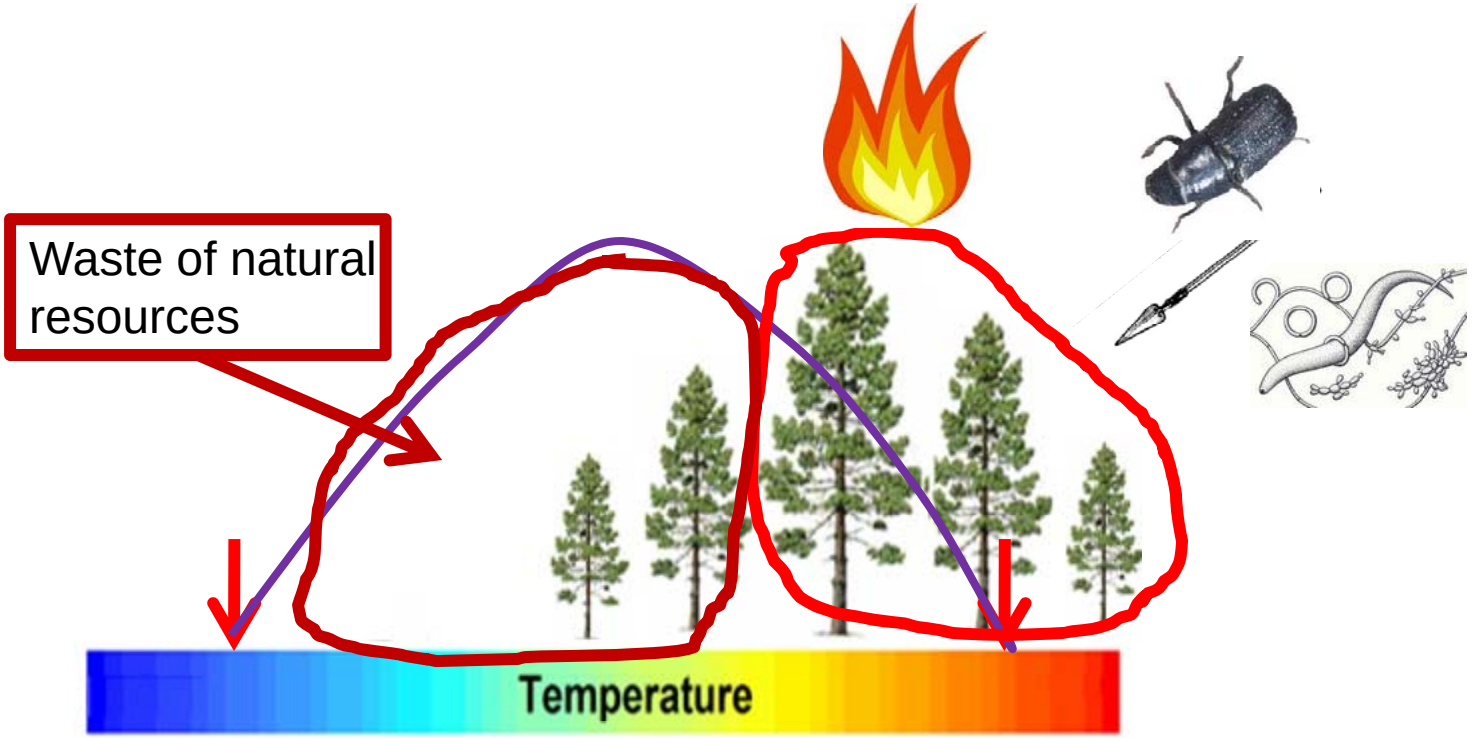
- Geographic-based and easy to use
- Effective for local adaptation
- May limit the use of seed transfer potential
- Not suitable for a changing climate because "the local climate" is moving away



Climate changes causes mismatches between the climate trees adapted and the climate the trees are going to experience



Some existing trees will move out their suitable climate habitat

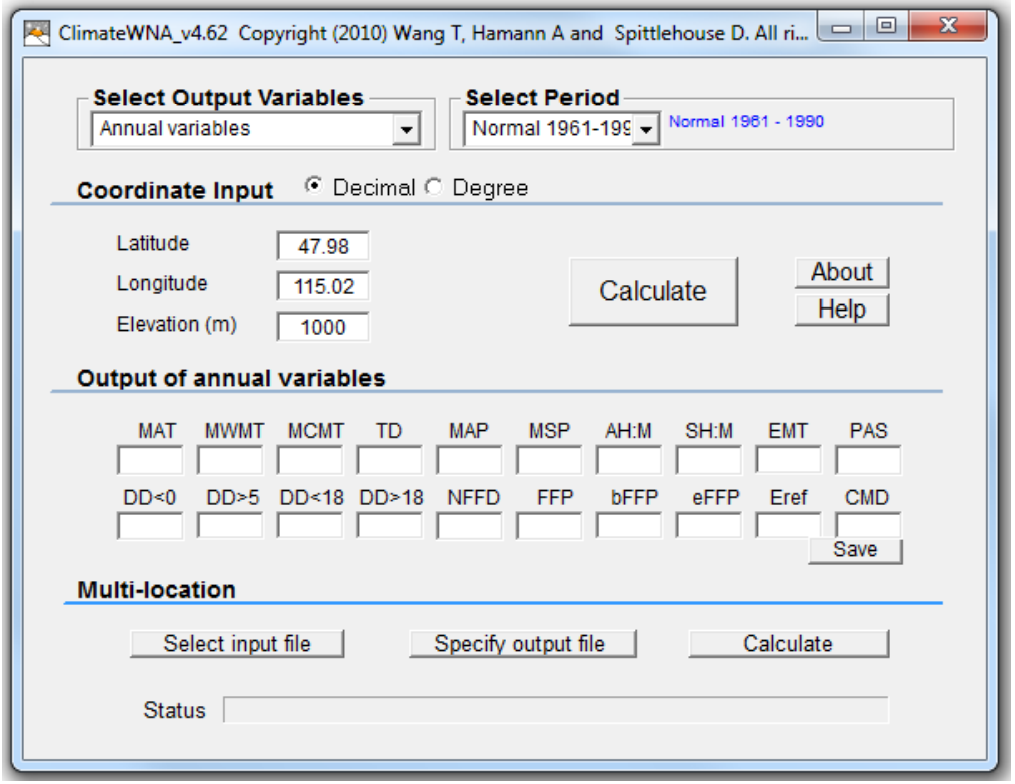


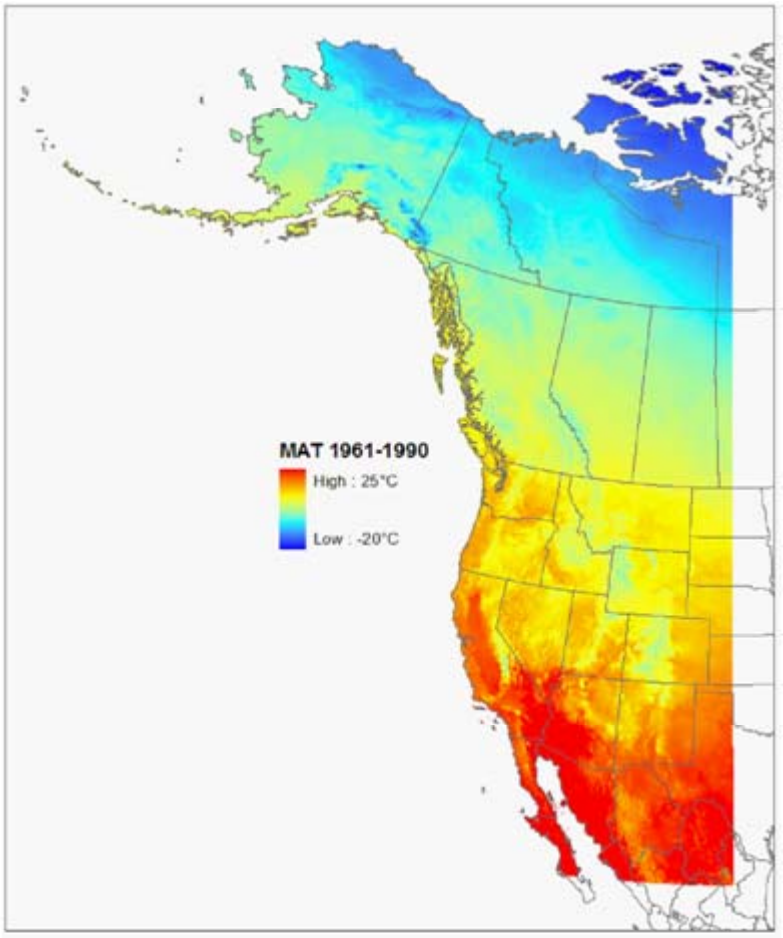
We need a system that can help trees matching their suitable climate

Objectives

- To develop a climate-based seed transfer system (CSTS) that can
  - Take advantage of the current seed transfer system;
  - Optimize the use of seedlots for better adaptability and productivity;
  - Can be dynamically adjusted under a changing climate.

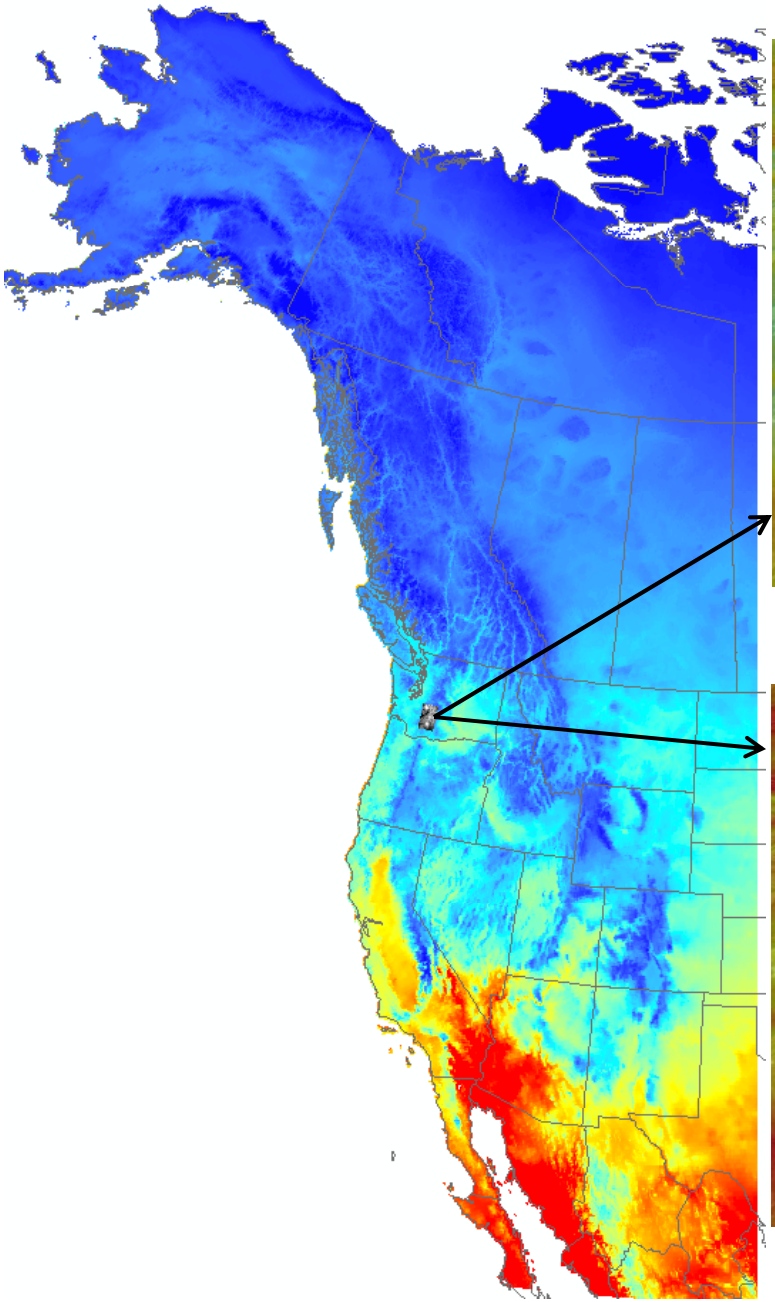
Climate data: ClimateWNA

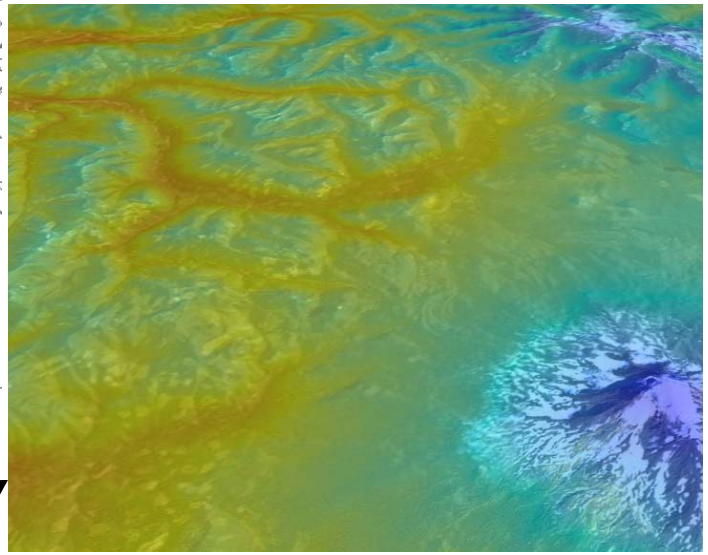




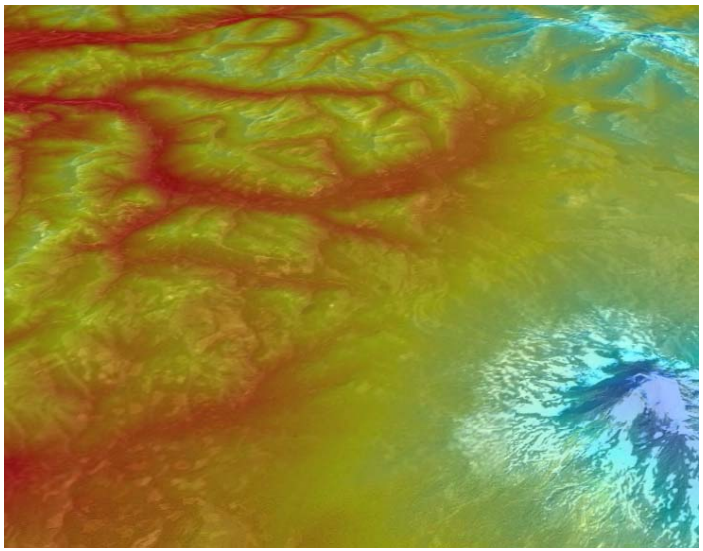
Wang, Hamann, spittlehouse and Aitken, 2006, intl J. Climat.
Wang, Hamann, Spittlehouse and Murdock, 2011, JAMC

ClimateWNA downscales historical and future climate





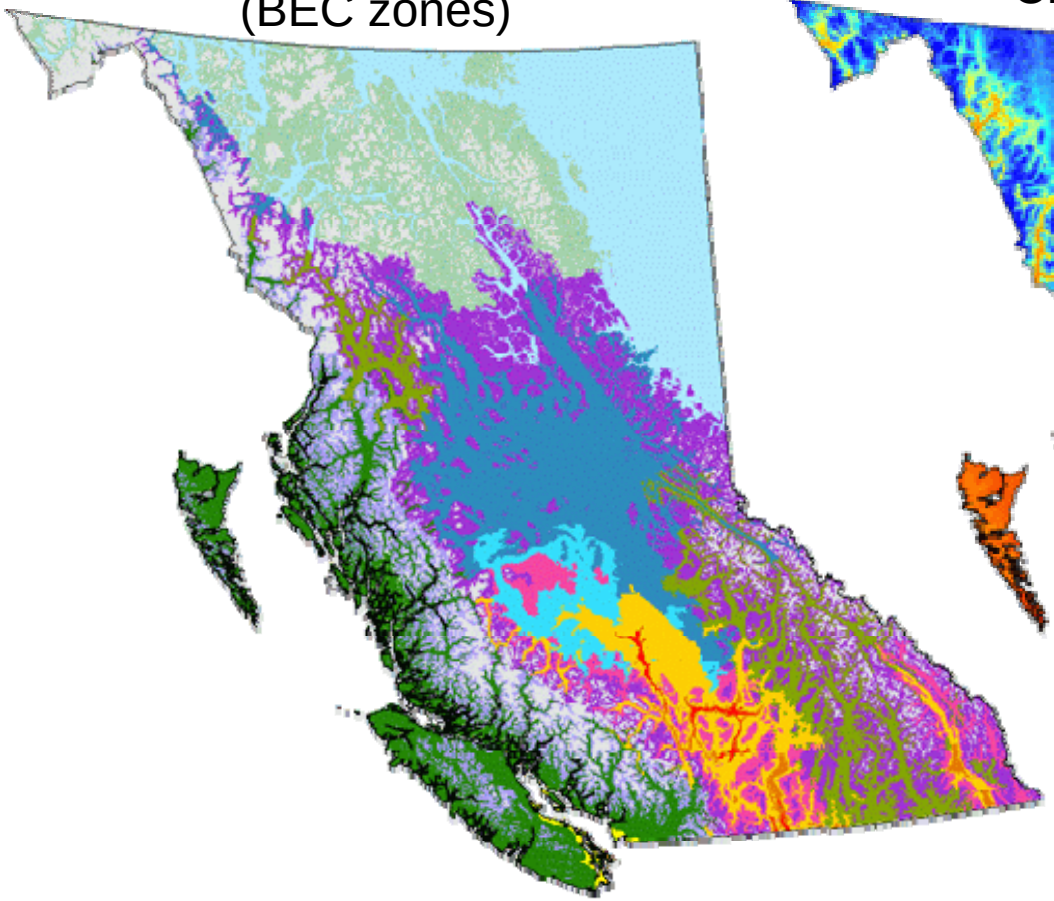
Degree-day above 5°C for 1961-1990



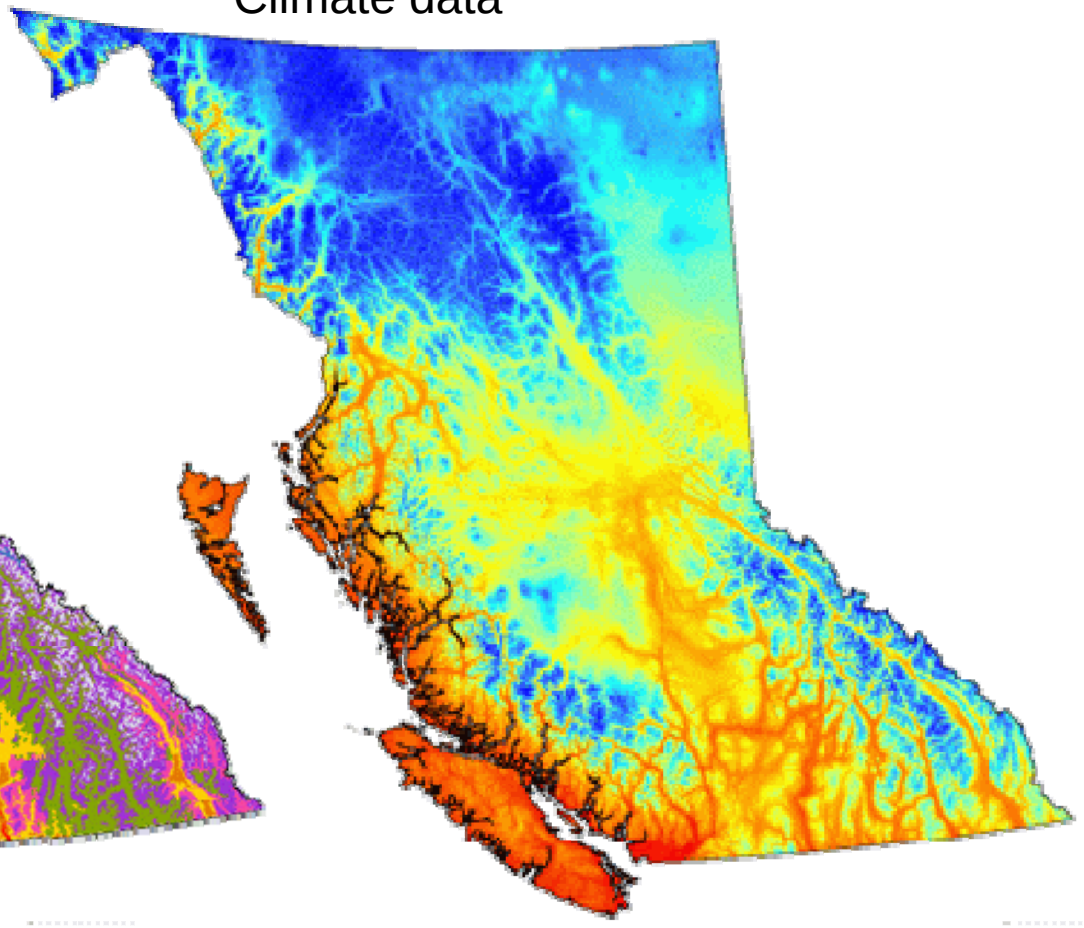
Degree-day above 5°C for 2050s (CGCM3 A2 run4)

BC ecosystems and climate data

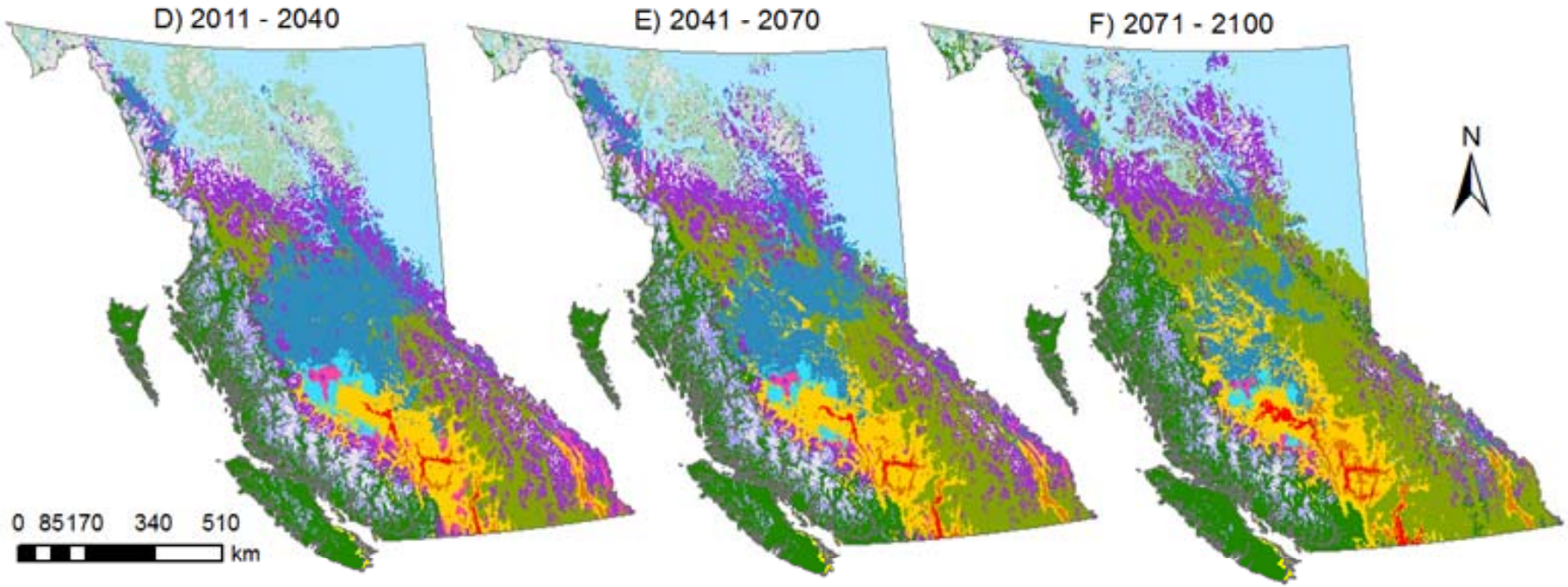
Ecosystem classifications
(BEC zones)



Climate data



Flying BEC zones



Climate change scenarios are translated into forest ecosystem scenarios

Hamann and Wang, 2006. Ecology
Wang et al. (to be submitted)

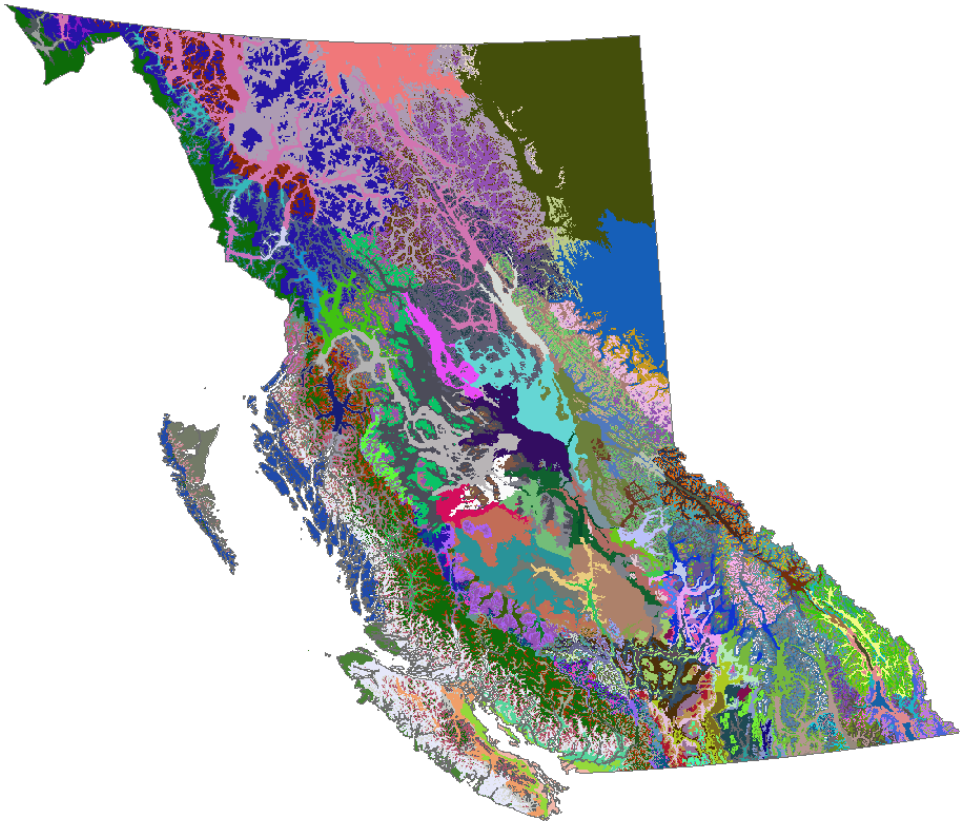
The approach for developing a climate-based seed transfer system:

--Put the SPUs on the "flight" of BEC zones

- To find the right "seats" – BEC units
- To fine tune the "seats" – modifications of the BEC units
- To discipline the "passengers" – modelling the climate envelopes for the SPUs

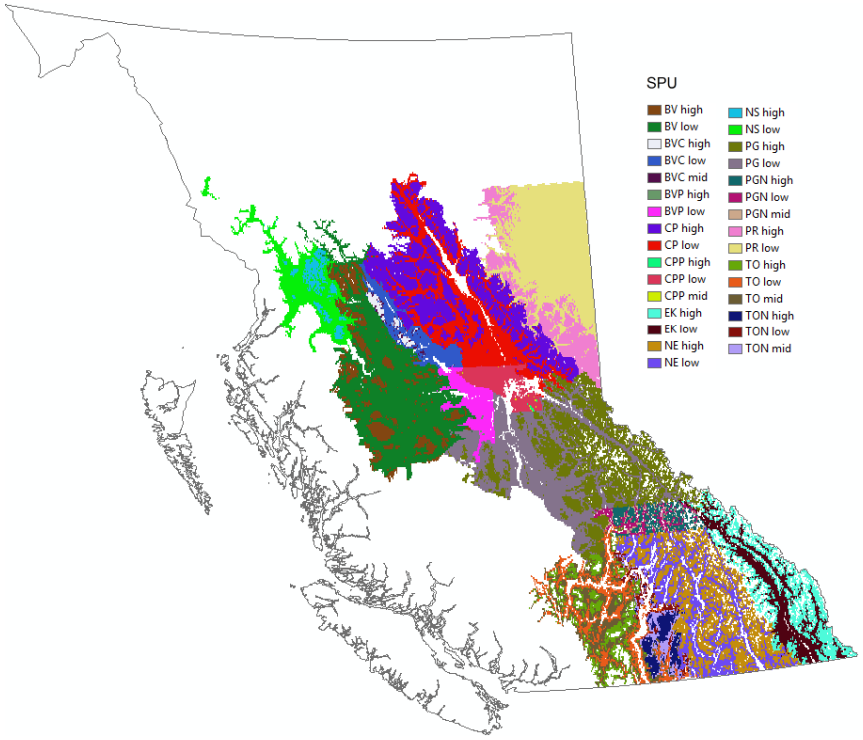
Climate envelopes for BEC variants are the right "seats" for SPUs

- Climatically uniform within each unit in term of supporting the same plant community
- A reasonable number (205) of units
- Some variants need to be modified
  - Fine tune the "seats"

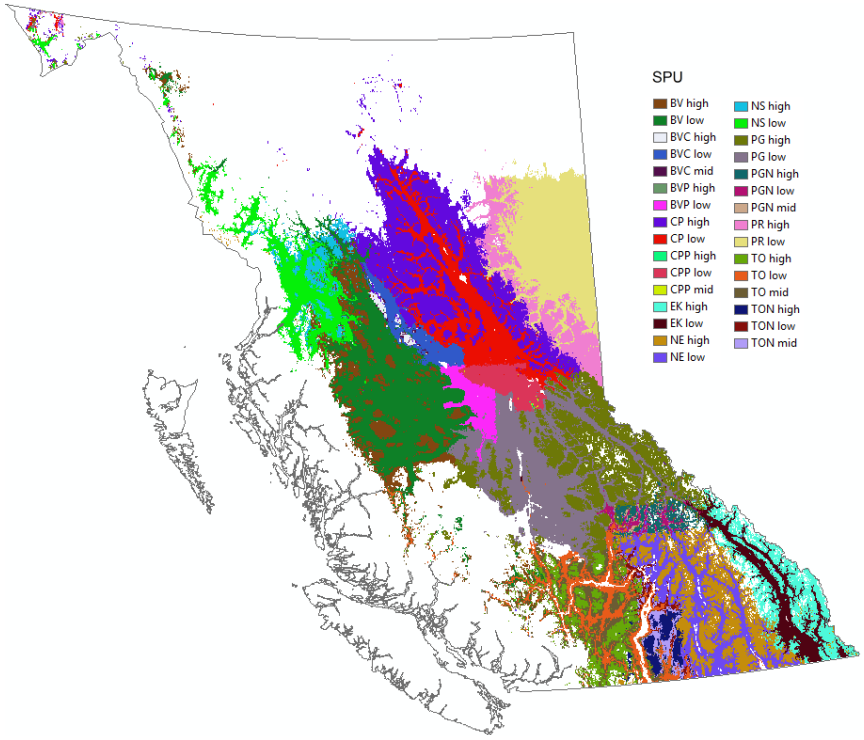


Climate envelopes of the SPUs are predicted using Random Forest (to discipline the "passengers")

Current SPUs

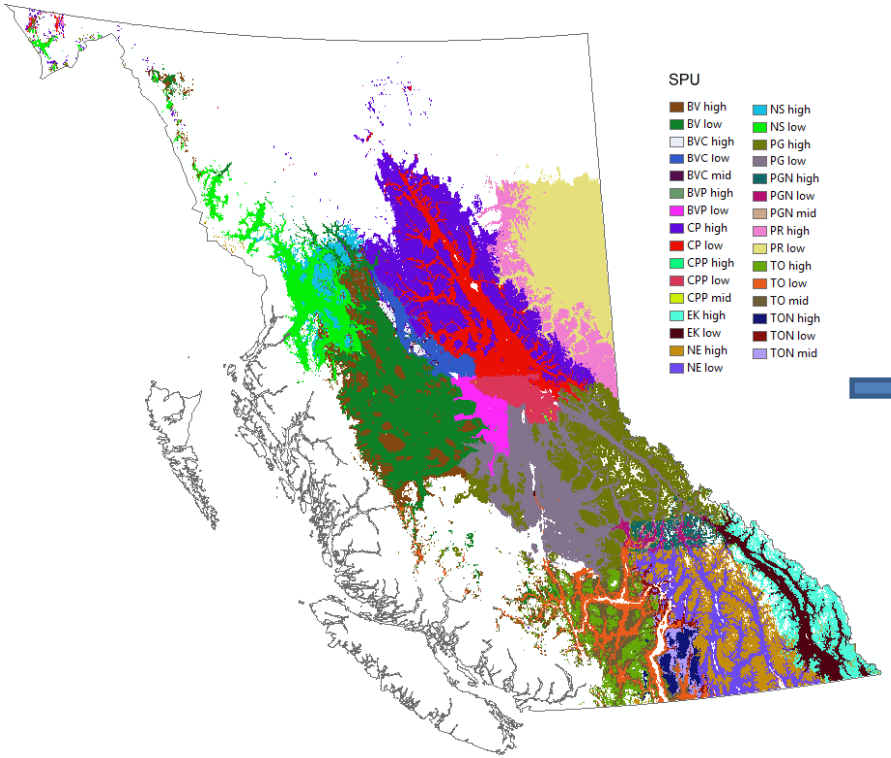


Climate envelopes of SPUs

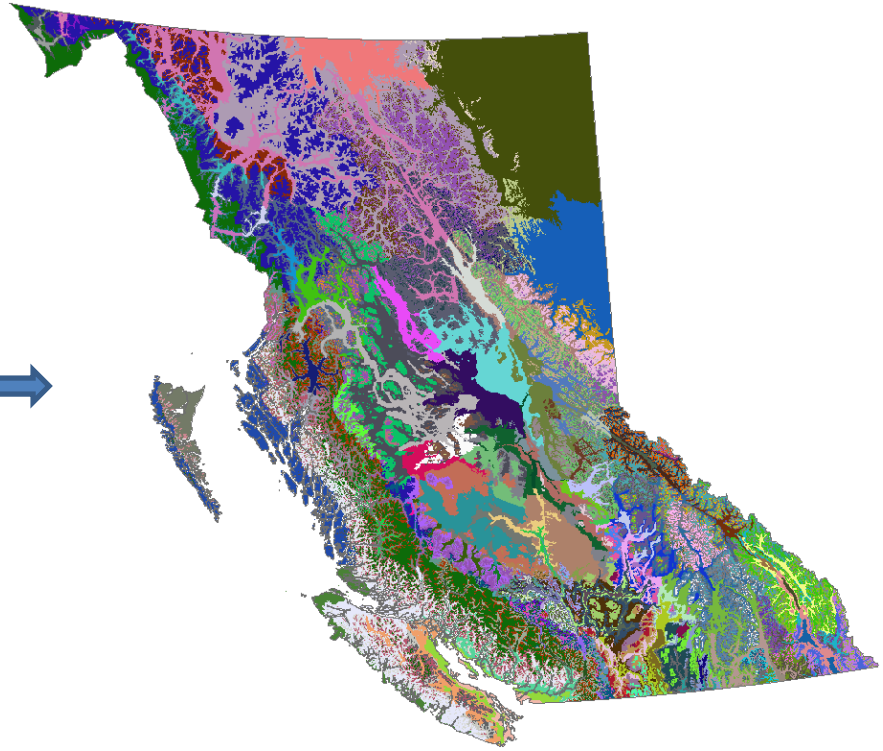


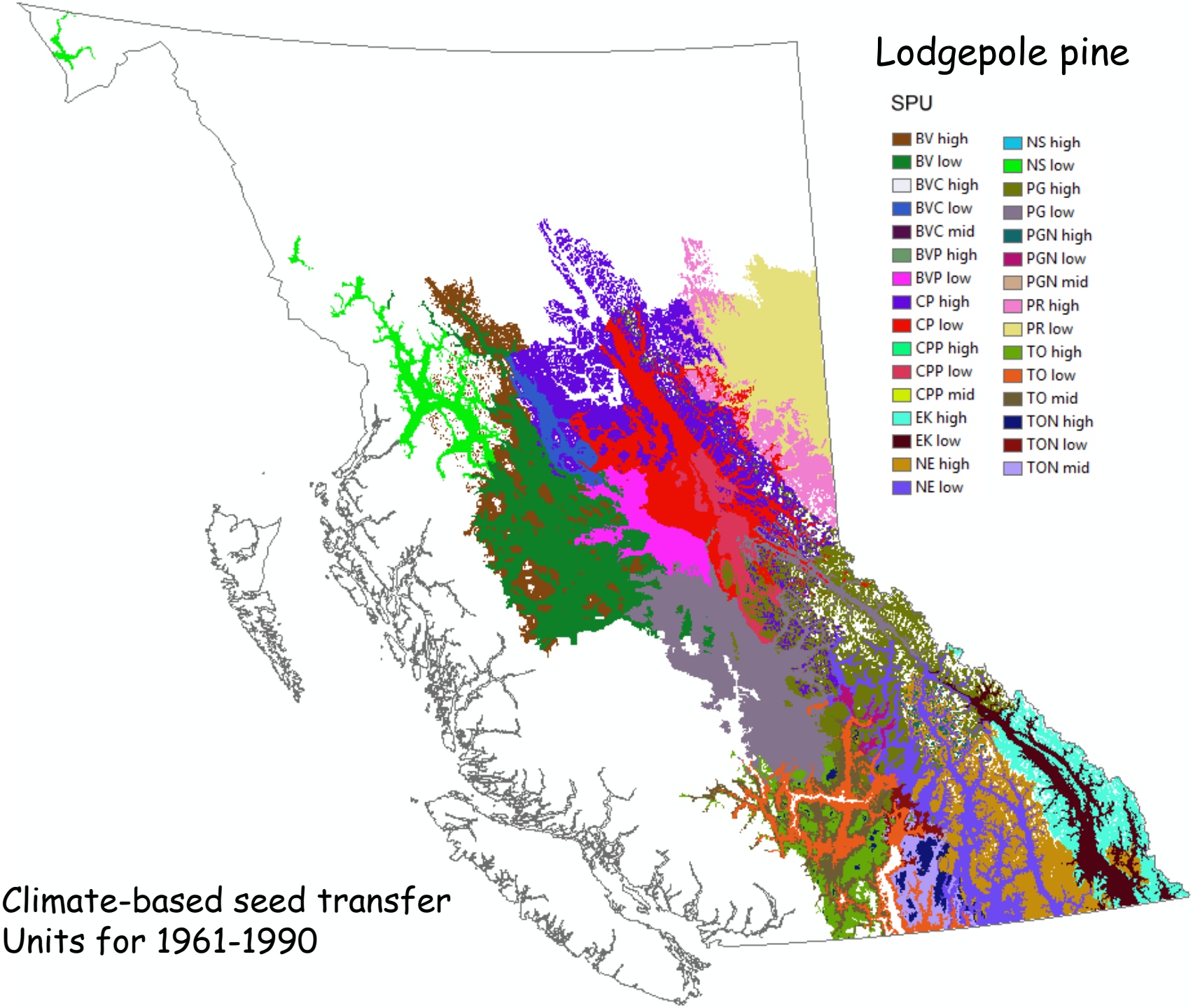
Migrating climate based SPUs to CSTUs

Climate envelopes for current SPUs

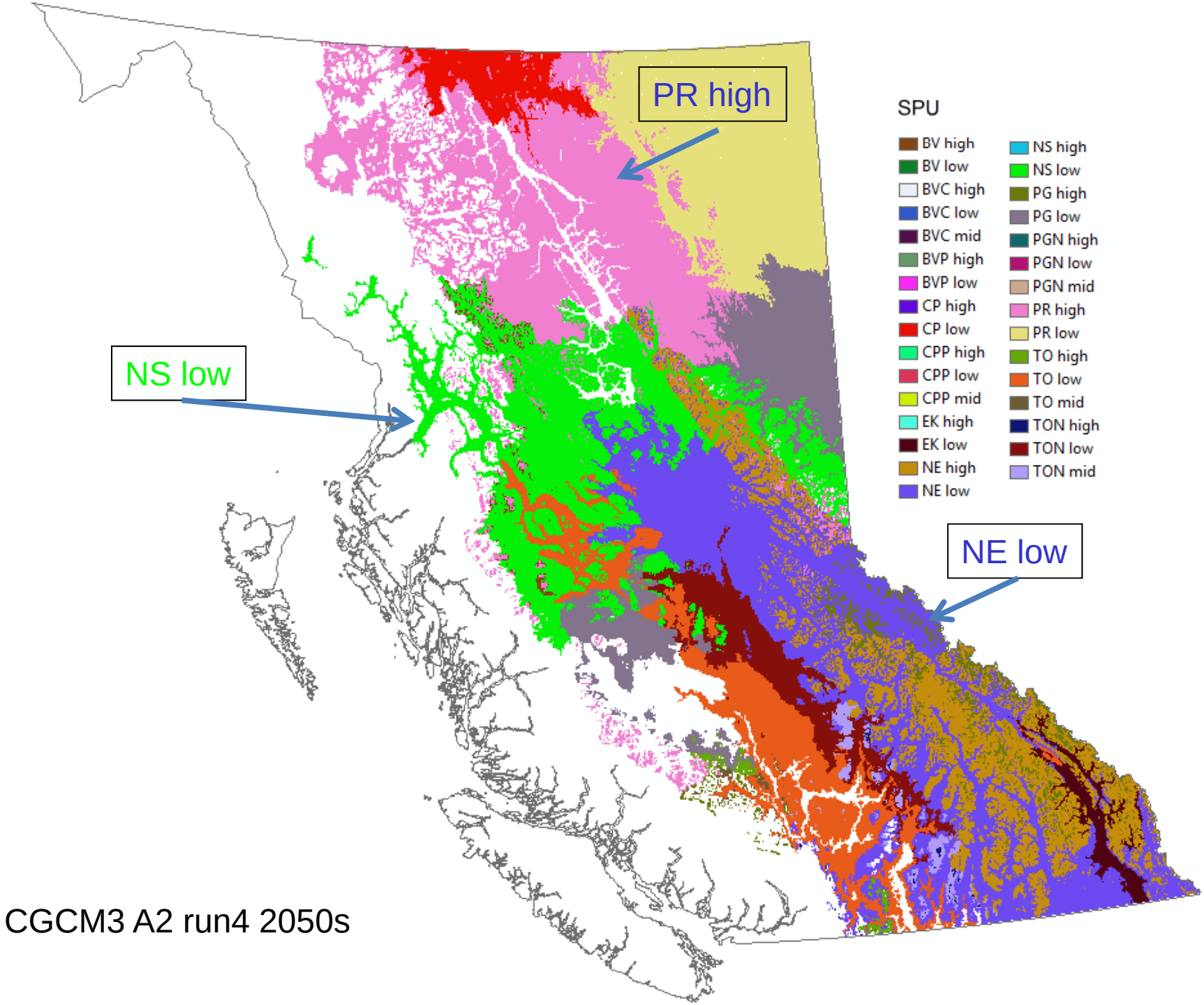


Modified BEC variants

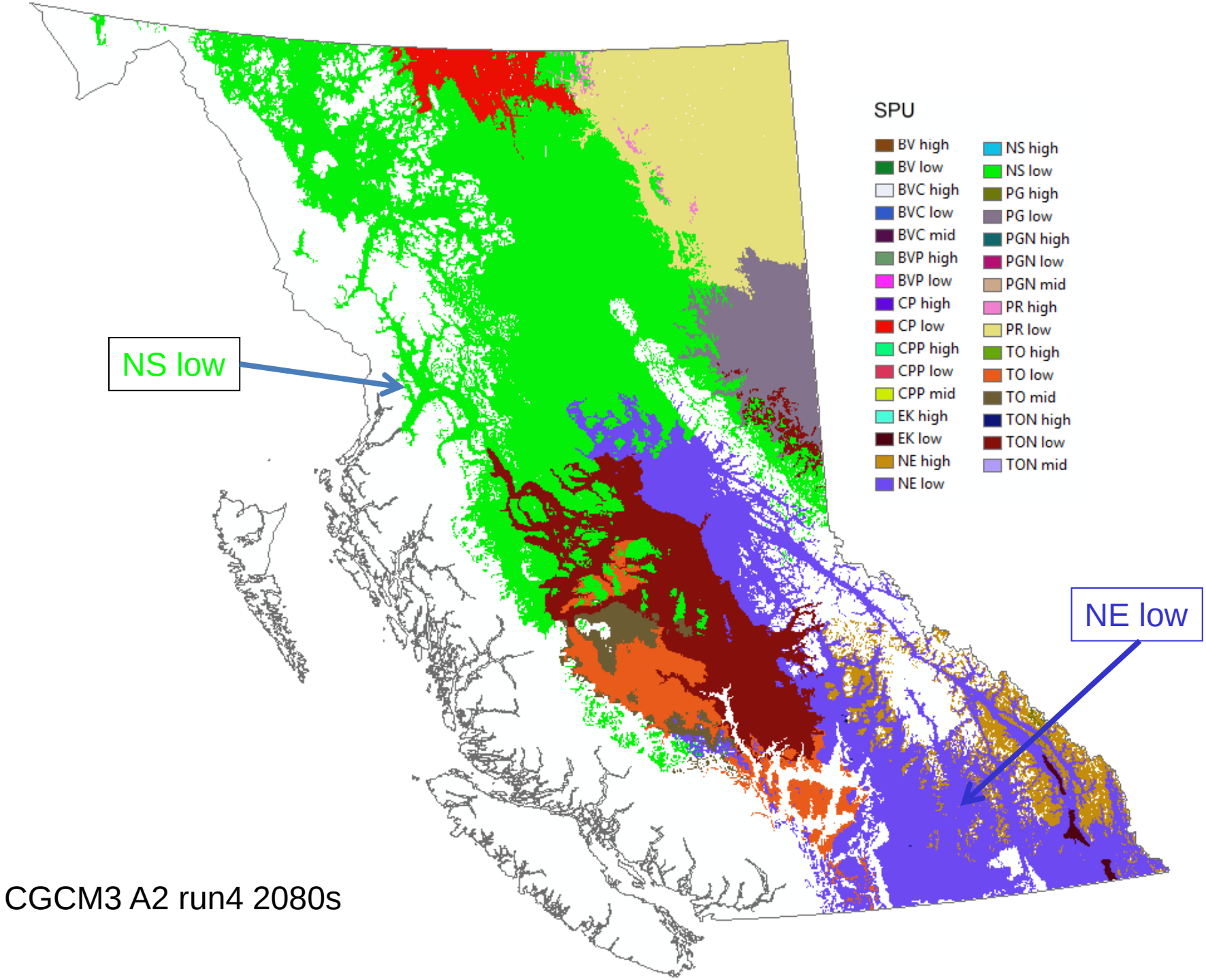




Climate-based seed transfer
Units for 1961-1990



CGCM3 A2 run4 2050s

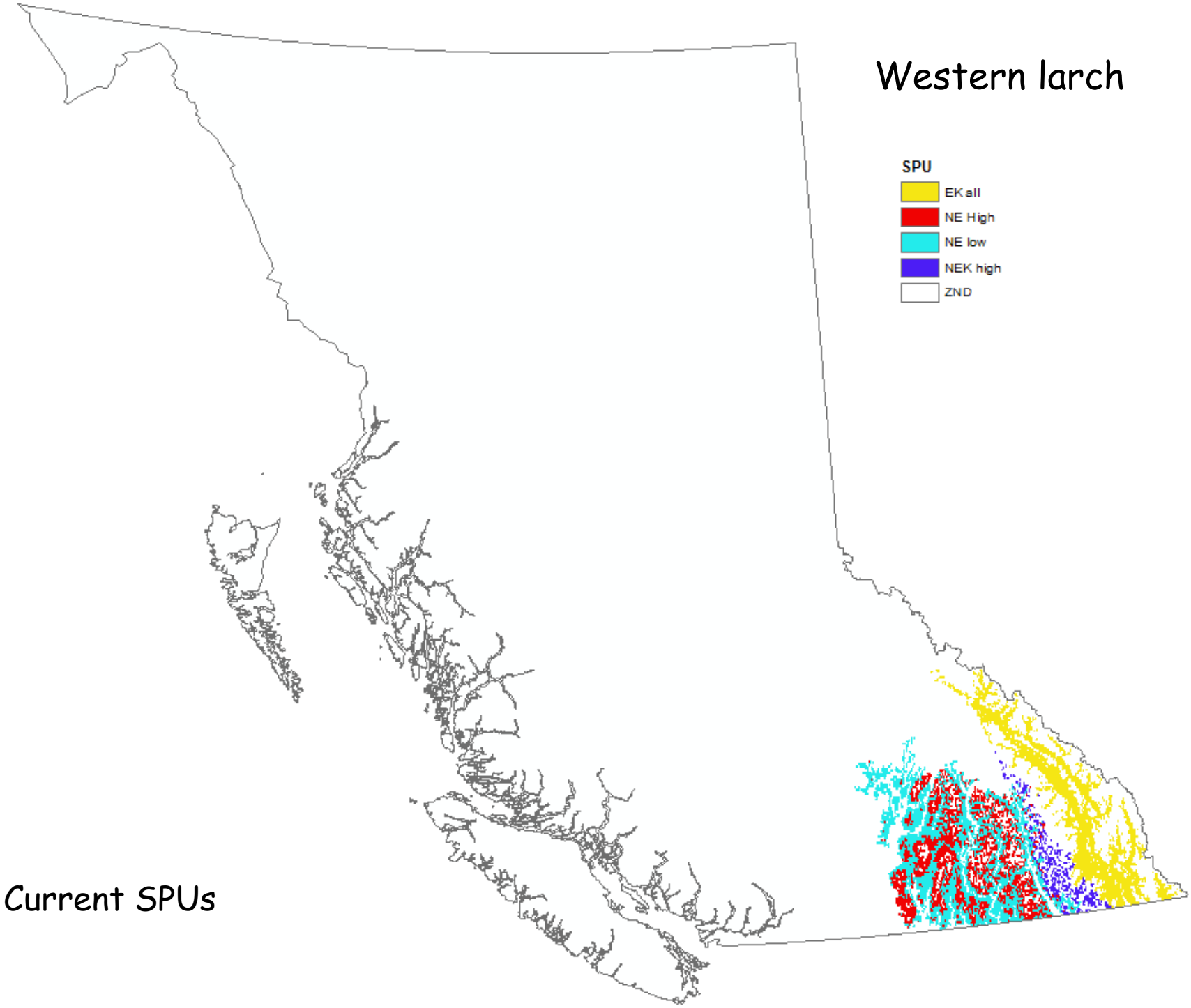


CGCM3 A2 run4 2080s

Table 1. List of CSTUs for each SPU of Lodgepole pine (Pli) for **2010-2039**.

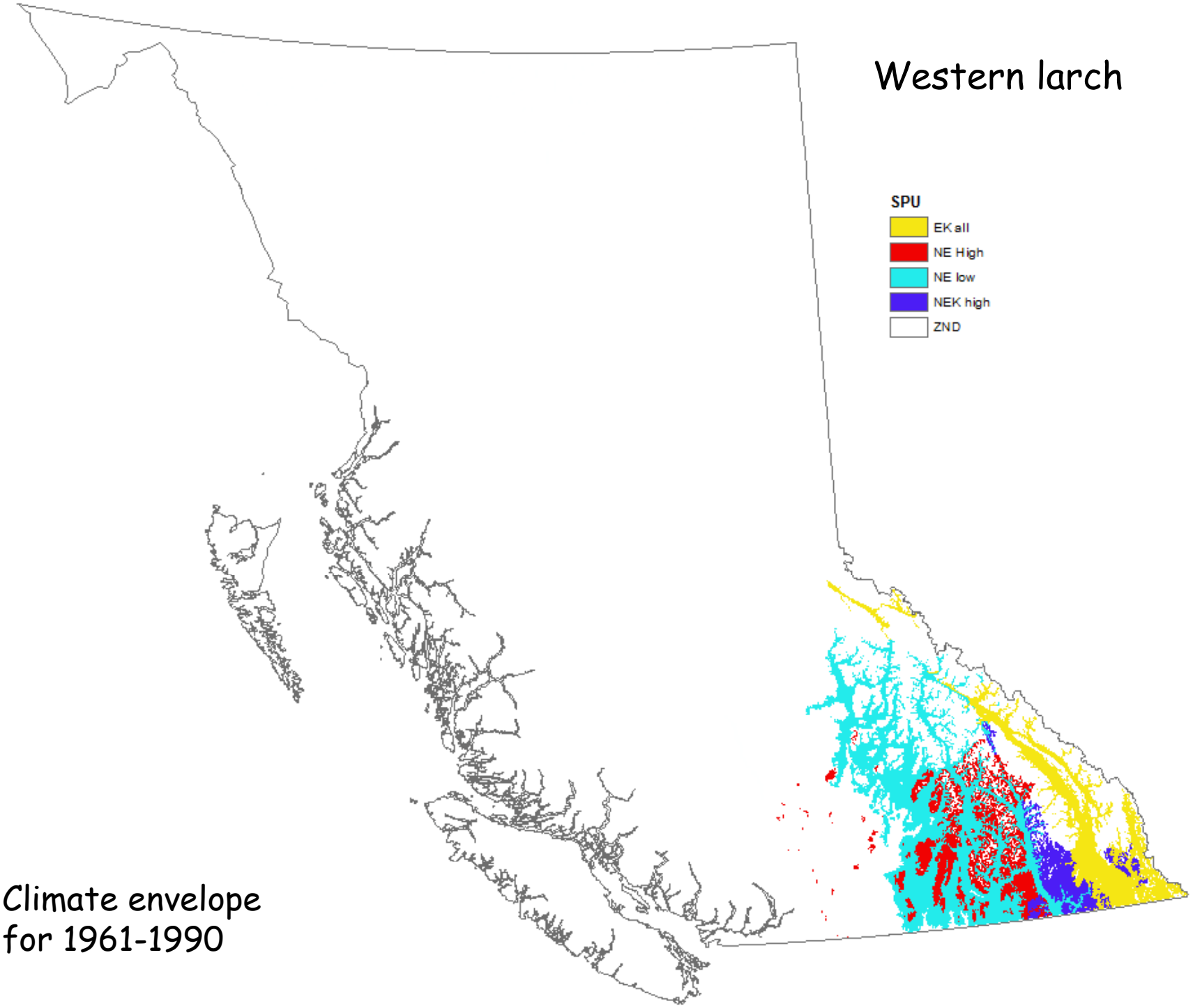
Pli SPU	**BEC variant**
BV high	BAFAun, BAFAunp, BWBSun, ESSFmcp, ESSFmvp1, ESSFmvp3, ESSFmvp4, ESSFwv, ESSFwvp, SWB mk, SWB mks
CP low	BWBSdk 2
EK high	ESSFdku
EK low	IDF dm 2, IDF xk, MS dk 2, PP dh 2
NE high	ESSFdk 1, ESSFdk 2, ESSFdkp, ESSFdkw, ESSFdmp, ESSFdmw, ESSFvc, ESSFvcp, ESSFvcw, ESSFwc 1, ESSFwc 4, ESSFwc 5, ESSFwc 6, ESSFwcp2, ESSFwcp4, ESSFwcp6, ESSFwcw4, ESSFwcw6, ESSFwm, ESSFwmp, ESSFwmw
NE low	ESSFdm, ESSFmm 1, ESSFmm 2, ESSFmmw, ESSFwc 2, ESSFwc 3, ESSFwcw2, ESSFwk 2, ICH dm, ICH dw 1, ICH dw 2, ICH dw 3, ICH mk 4, ICH mm, ICH mw 1, ICH mw 2, ICH mw 3, ICH mw 4, ICH vk 1, ICH vk 2, ICH wk 1, ICH wk 2, ICH wk 3, ICH wk 4, ICH xw, IDF un, MS dk 1, SBS dh 2, SBS vk, SBS wk 1
NS low	BWBSvk, BWBSwk 1, ESSFmc, ESSFmv 1, ESSFmv 2, ESSFmv 3, ESSFmvp2, ICH mc 1, ICH mc 2, ICH vc, SBS mc 2, SBS mk 1, SBS mk 2, SBS wk 2, SBS wk 3
PG high	ESSFdcp, ESSFmmp, ESSFwcp3, ESSFwcw3, IMA un
PG low	SBPSdc, SBPSmc, SBPSmk, SBS mc 3
PGN low	SBS dh 1, SBS dw 3
PR high	BWBSwk 2, BWBSwk 3, ESSFmv 4
PR low	BWBSmw 1, BWBSmw 2
TO high	ESSFdc 3, ESSFxc 1, ESSFxc 3, MS xk 1, MS xk 3, SBS mc 1, SBS mm
TO low	BG xh 3, BG xw 1, IDF dc, IDF dk 1, IDF dk 2, IDF dk 5, IDF dm 1, IDF mw 2, IDF xc, IDF xh 1, IDF xh 2, IDF xh 4, IDF xw, MS dc 1, MS dc 3, MS dm 1, MS xk 2, PP xh 3, SBS dk, SBS dw 1, SBS dw 2, SBS mh, SBS mw
TO mid	ICH mk 2, IDF dk 3, MS dm 2, MS dm 3
TON high	ESSFdc 1, ESSFdcw, ESSFwk 1, ESSFxc 2
TON low	ICH dk, ICH mk 3, IDF mw 1
TON mid	ICH mk 1

Western larch



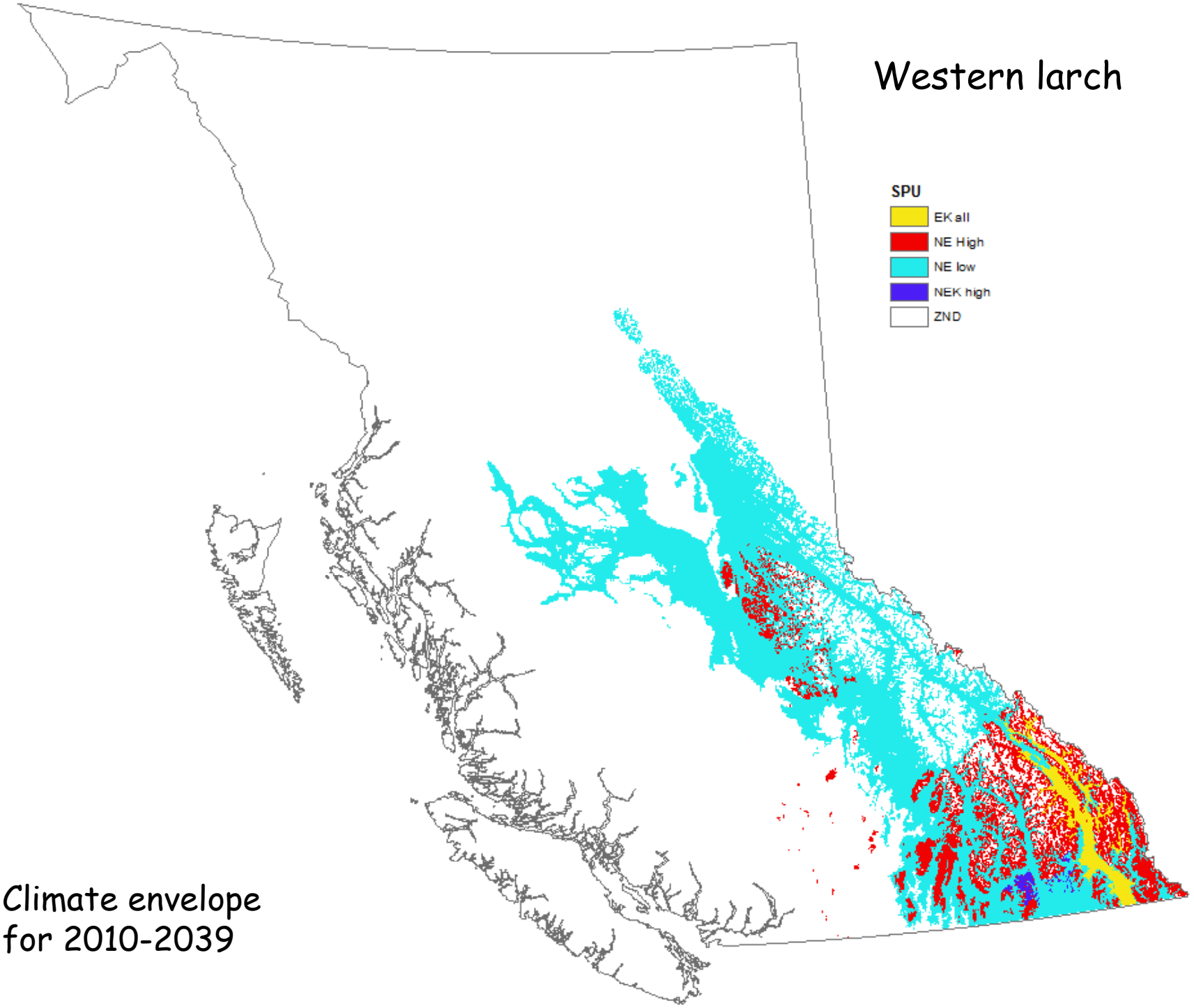
Current SPUs

Western larch



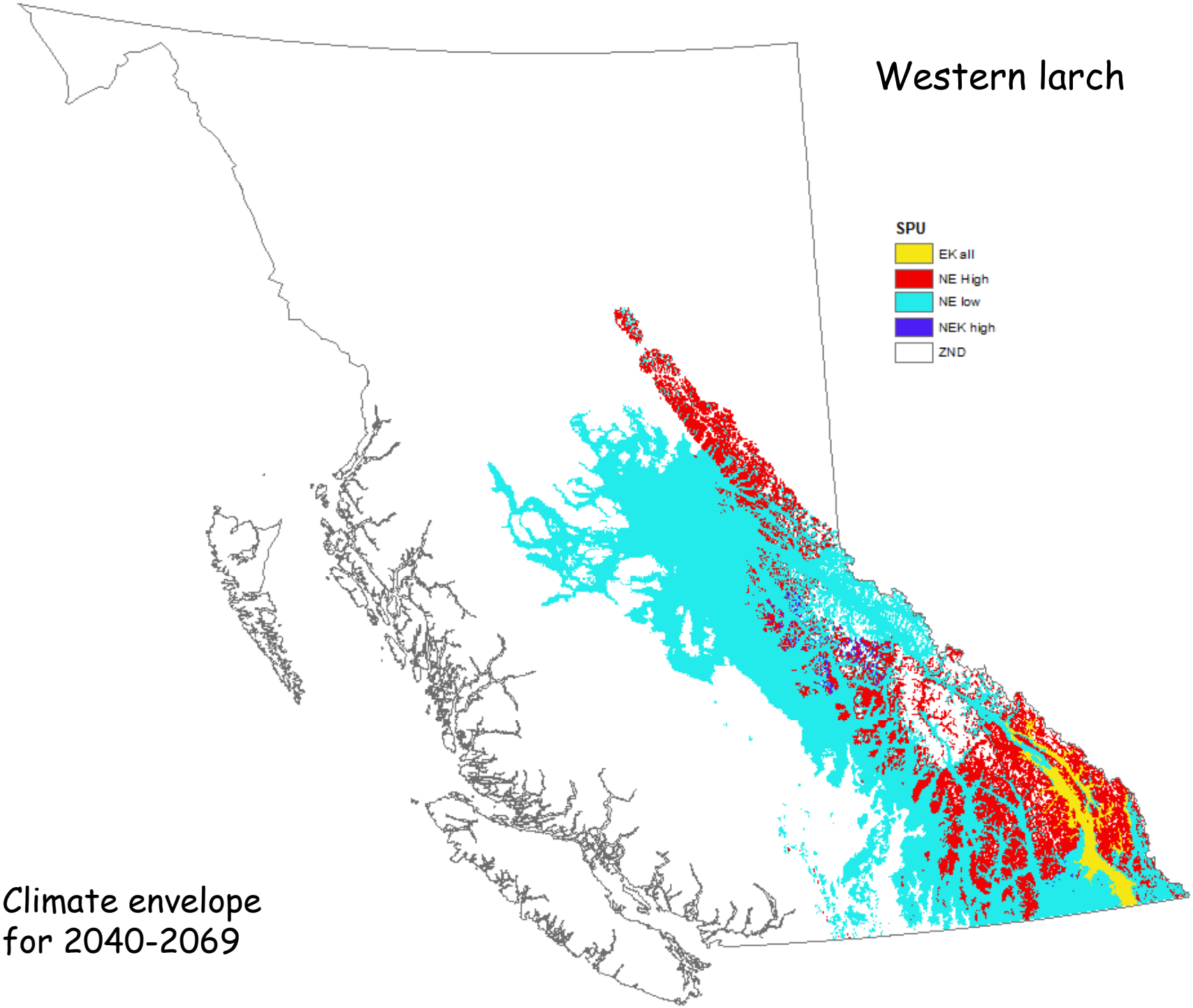
Climate envelope
for 1961-1990

Western larch



Climate envelope
for 2010-2039

Western larch



Climate envelope
for 2040-2069

Summary of the CST system

- Maintain "local is the best", but in term of climate rather than geographic locations
  - Use local seed to match the "flying" local climate
- Can be dynamically adjusted under a changing climate
- Easy to implement

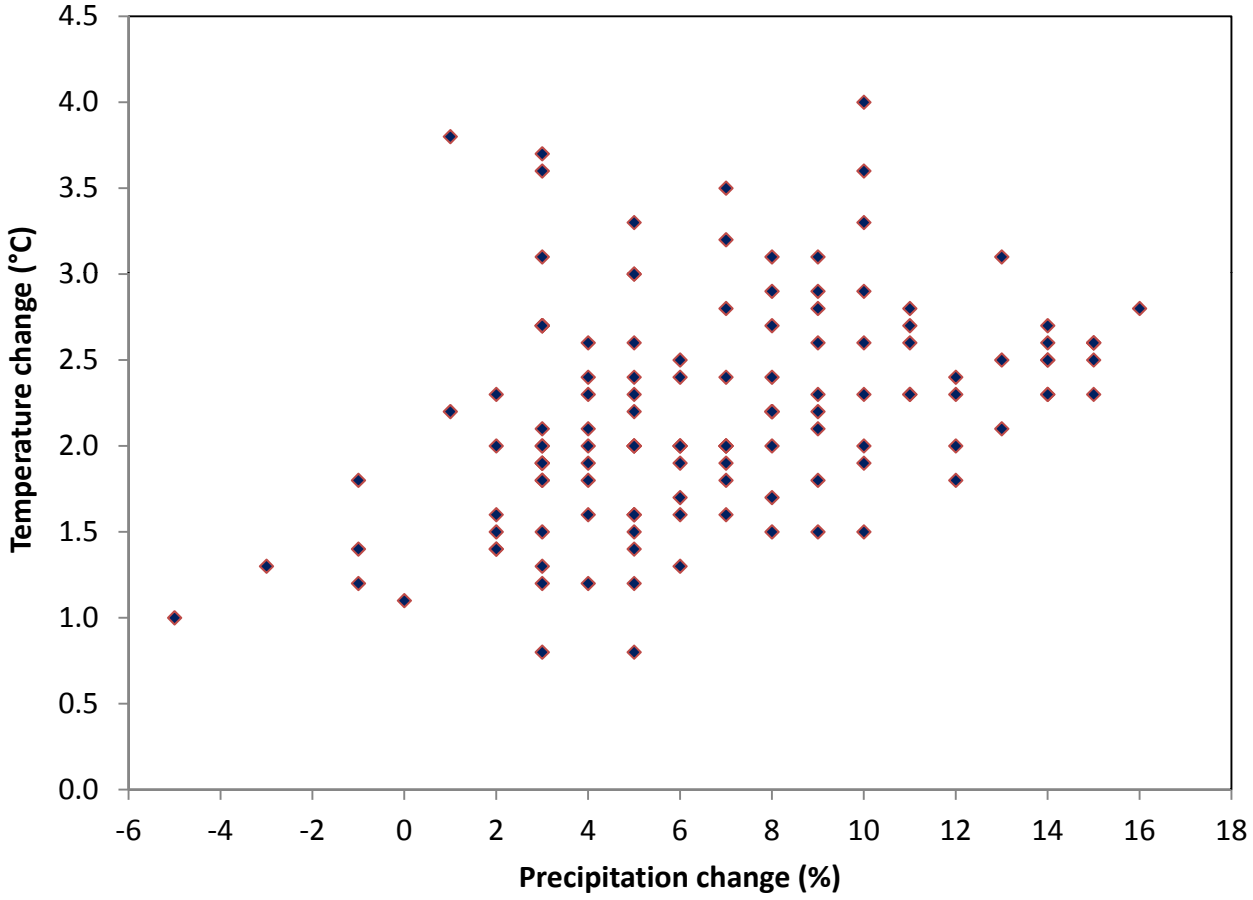
What is the next?

- Multiple GCMs: probability based projections

A large number of GCM projections for future climates from IPCC AR4

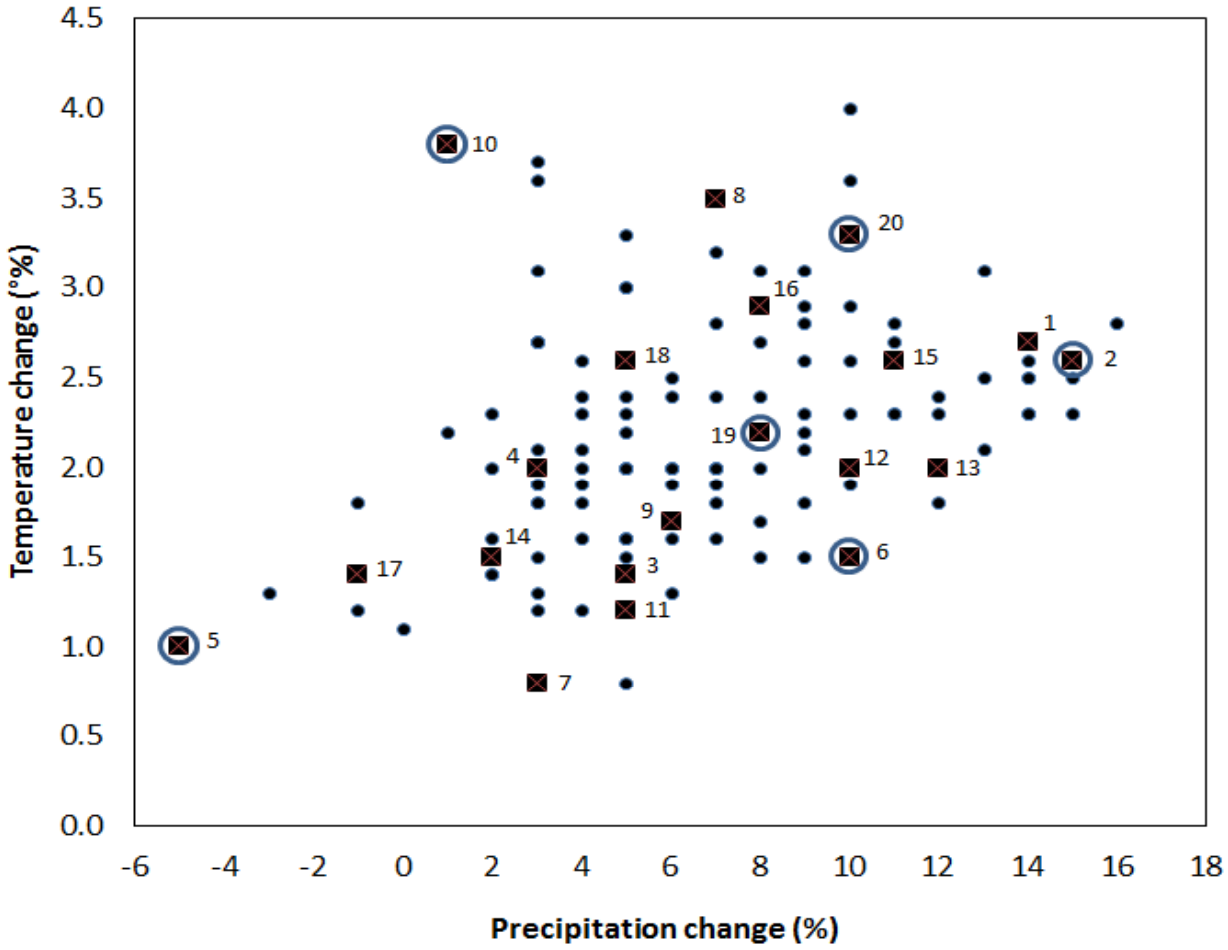
Center	Center Acronym	Model	COM-MIT	PI-cntrl	20C3M	A2	A1B	B1	1%-2X	1%-4X		add. data
Beijing Climate Center China	BCC	CM1		run_1 run_2	run_1		run_1	run_1	run_1			
Bjerknes Centre for Climate Research Norway	BCCR	BCM2.0	run_1	run_1	run_1	run_1	run_1	run_1	run_1			
Canadian Center for Climate Modelling and Analysis Canada	CCCma	CGCM3 (T47 resolution)	run_1 run_2 run_3	run_1	run_1 run_2 run_3	run_1 run_2 run_3	run_1 run_2 run_3	run_1 run_2 run_3	run_1	run_1		
		CGCM3 (T63 resolution)		run_1	run_1		run_1	run_1	run_1			
Centre National de Recherches Meteorologiques France	CNRM	CM3	run_1	run_1	run_1	run_1	run_1	run_1	run_1	run_1		
Australia's Commonwealth Scientific and Industrial Research Organisation Australia	CSIRO	Mk3.0	run_1	run_1 run_2	run_1 run_2 run_3	run_1	run_1	run_1	run_1			
Max-Planck-Institut for Meteorology Germany	MPI-M	ECHAM5-OM	run_1 run_2	run_1	run_1 run_2 run_3	run_1 run_2 run_3	run_1 run_2 run_3	run_1 run_2 run_3	run_1 run_2 run_3	run_1		compl. set of md"
Meteorological Institute, University of Bonn, Germany Meteorological Research Institute of KMA, Korea Model and Data Groupe at MPI-M, Germany	MIUB METRI M&D	ECHO-G	run_1 run_2 run_3	run_1	run_1 run_2 run_3	run_1 run_2 run_3	run_1 run_2 run_3	run_1 run_2 run_3	run_1 run_2	run_1		
Institude of Atmospheric Physics China	LASG	FGOALS-g1.0	run_1 run_2 run_3	run_1 run_2 run_3	run_1 run_2 run_3		run_1 run_2 run_3	run_1 run_2 run_3	run_1 run_2 run_3			
Geophysical Fluid Dynamics Laboratory USA	GFDL	CM2.0	run_1	run_1	run_1 run_2 run_3	run_1	run_1	run_1	run_1	run_1		
		CM2.1	run_1	run_1	run_1 run_2 run_3	run_1	run_1	run_1	run_1	run_1		
Goddard Institute for Space Studies USA	GISS	AOM		run_1 run_2	run_1 run_2		run_1 run_2	run_1 run_2				
		E-H		run_1	run_1 run_2 run_3		run_1 run_2 run_3		run_1			
		E-R	run_1	run_1	run_1 run_2 run_3	run_1	run_1 run_2 run_3	run_1	run_1	run_1		
Institute for Numerical Mathematics Russia	INM	CM3.0	run_1	run_1	run_1	run_1	run_1	run_1	run_1	run_1		
Institut Pierre Simon Laplace France	IPSL	CM4	run_1	run_1	run_1 run_2	run_1	run_1	run_1	run_1	run_1		
National Institute for Environmental Studies	NIES	MIROC3.2 hires		run_1	run_1		run_1	run_1	run_1			
					run_1	run_1	run_1	run_1	run_1	run_1		

A wide range of climate conditions are projected for the future



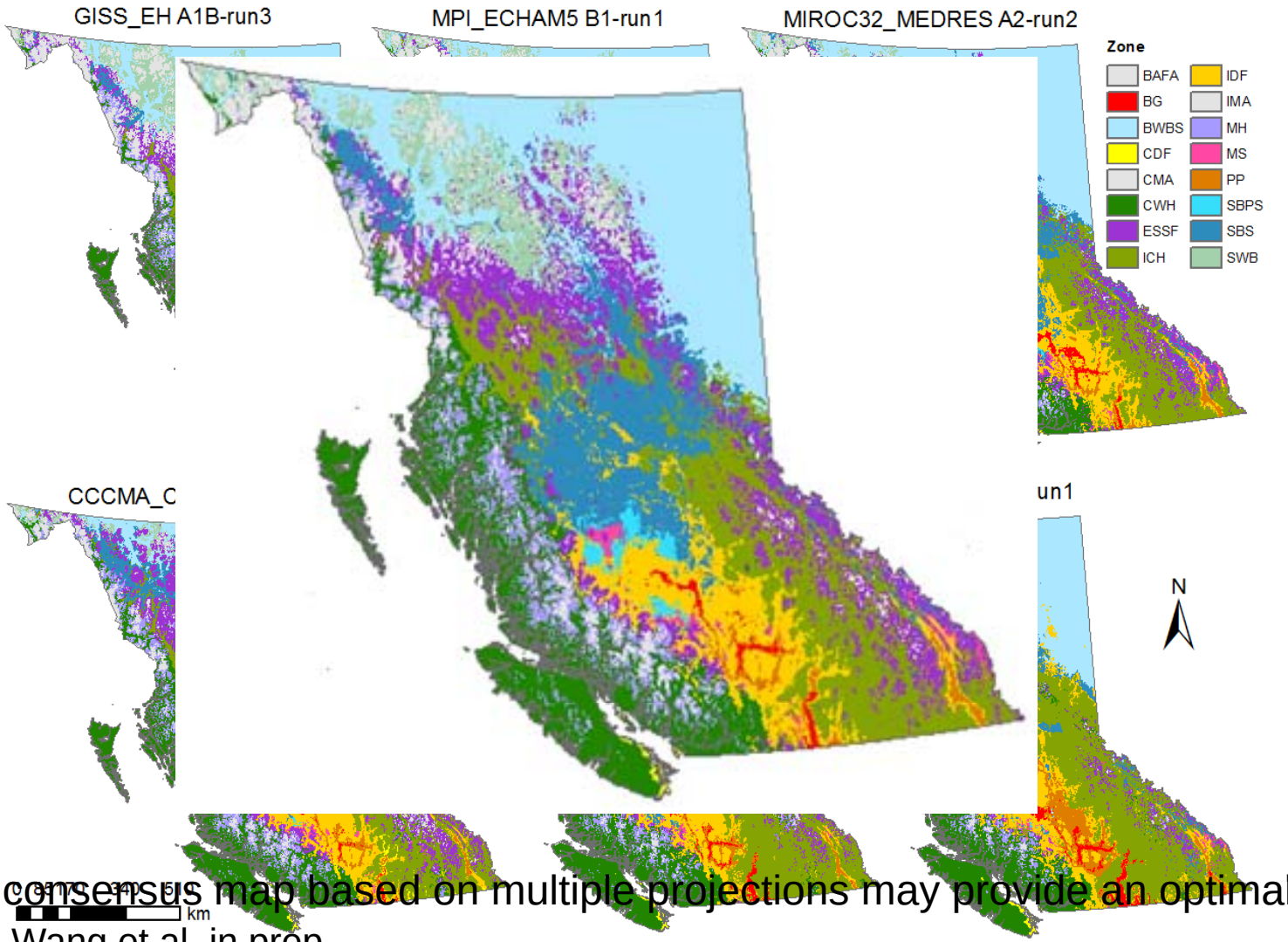
134 climate projections for BC for 2050s (Data source: PCIC)

We chose 20 scenarios to represent the range and distribution



Predicted changes in temp. and precip. for BC by 134 climate changes scenarios for 2050s

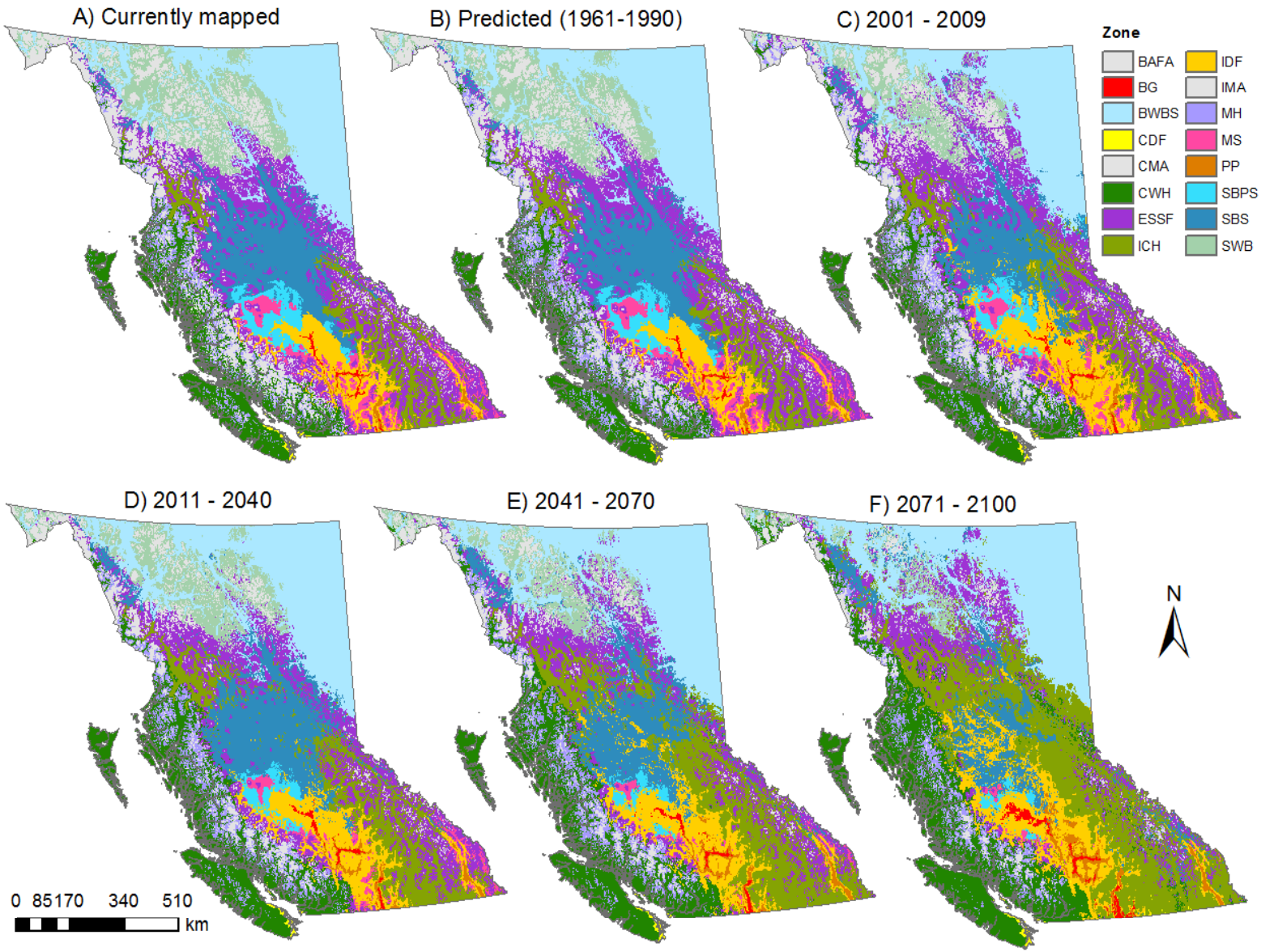
Substantially different projections leave scientists and policy makers too many options for decision making



A consensus map based on multiple projections may provide an optimal solution

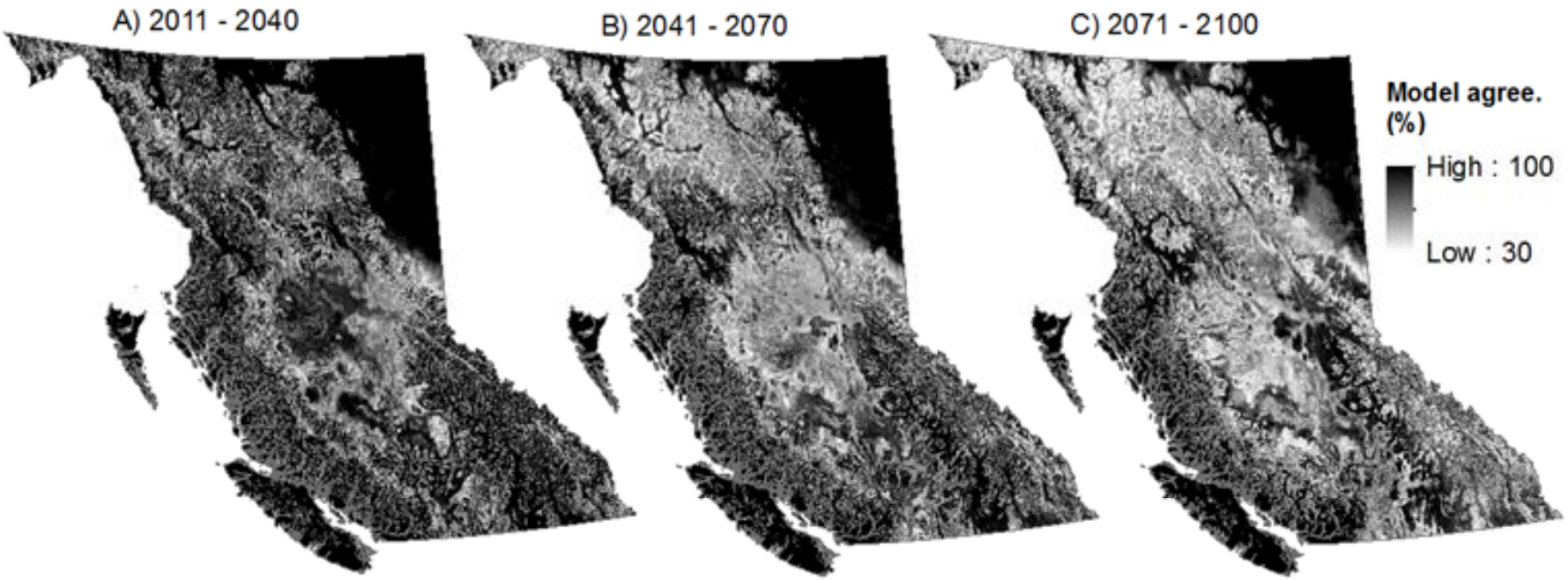
Wang et al. in prep.

Projected ecological responses to six selected climate change scenarios for 2050s



Ensemble predictions with the best-model agreement among 20 selected climate change scenarios

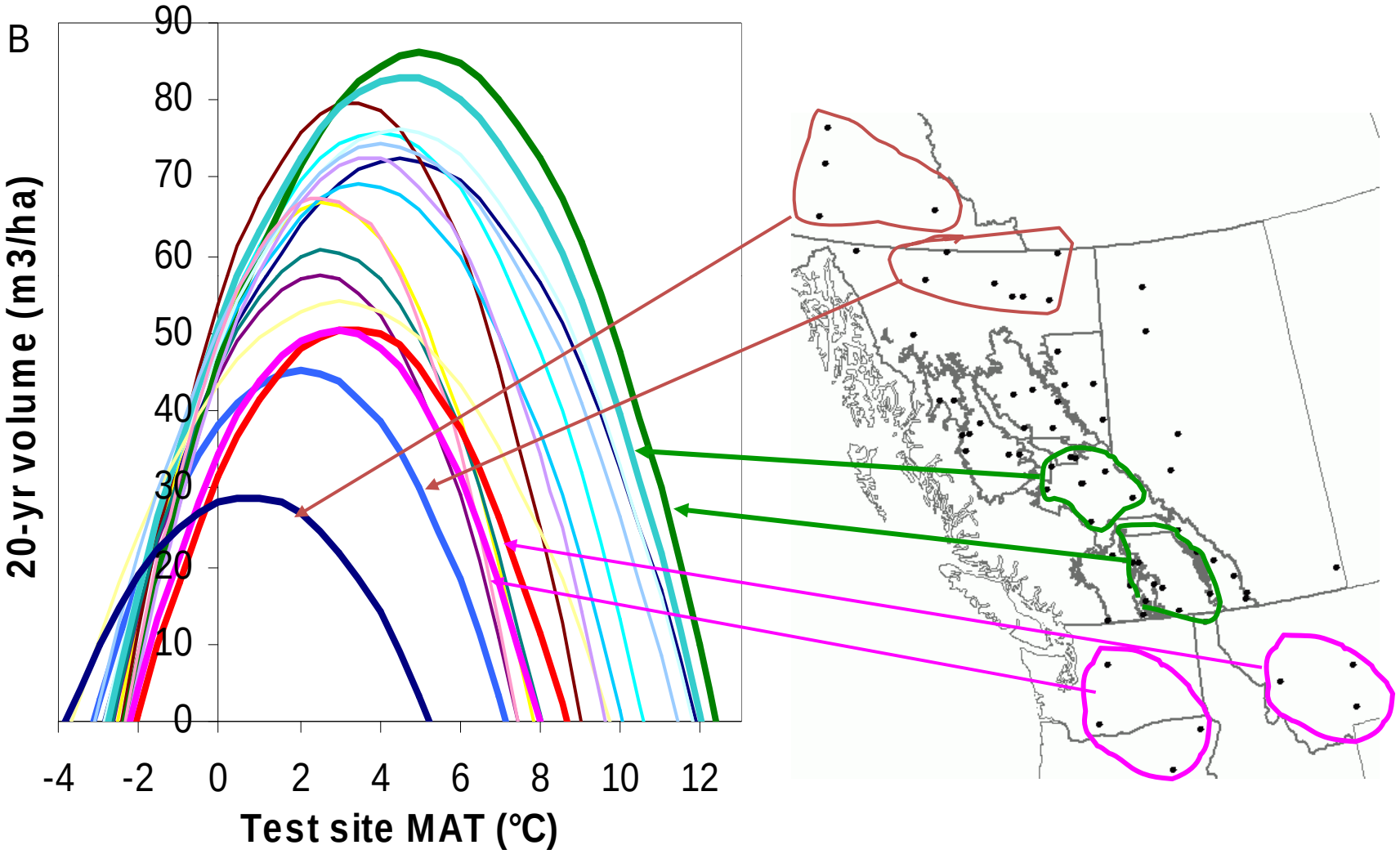
Model-agreement among the projections based the 20 selected climate change scenarios



What is the next?

- Multiple GCMs: probability based projections
- Move from "local is the best" to an optimal seed transfer system
  - Integrating genecology results

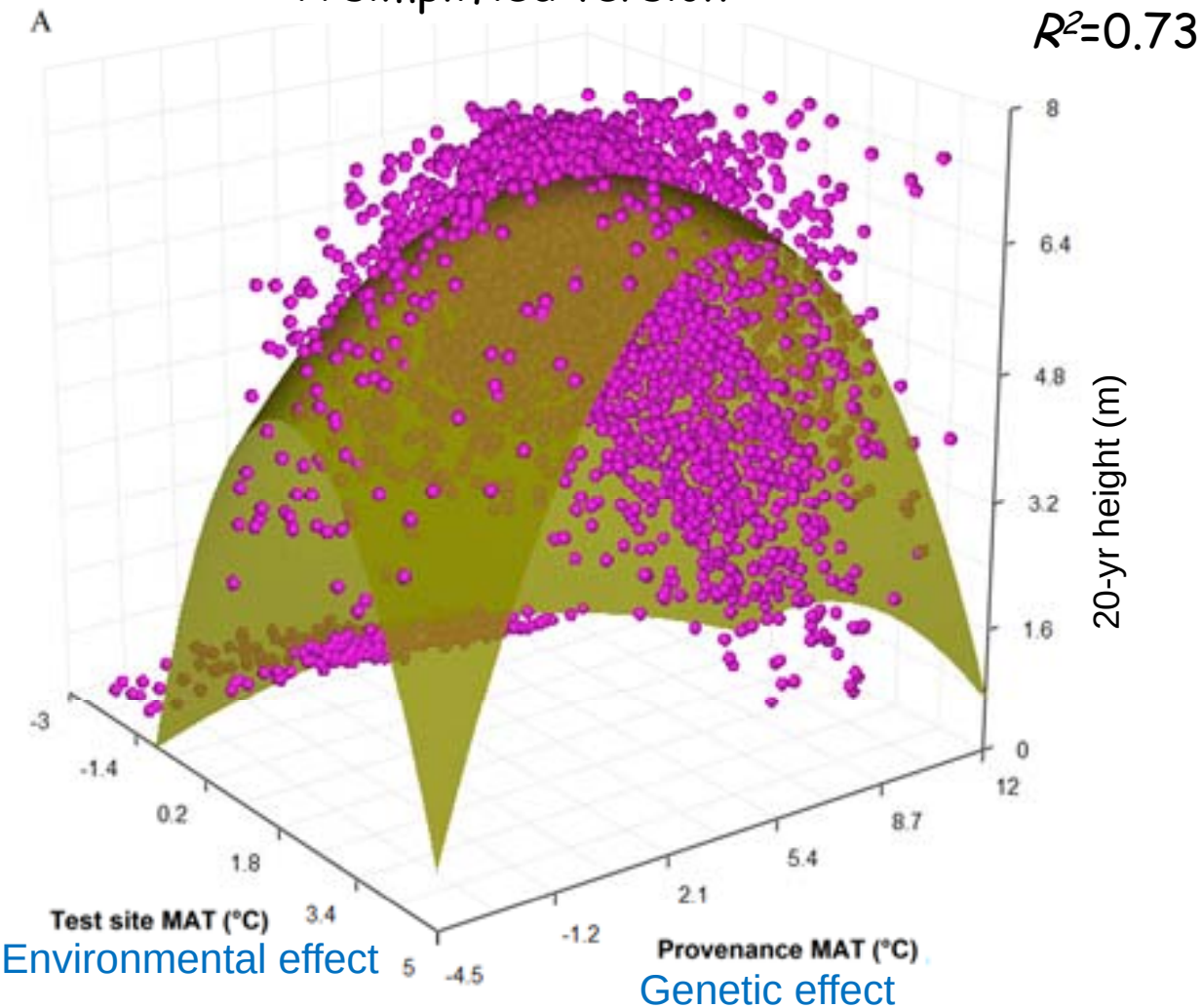
Variation in response of lodgepole pine populations to climate change



Wang et al. 2006. Global change Biology

A universal response function

A simplified version



Wang et al. Ecol. Appl. 2010

What is the next?

- Multiple GCMs: probability based projections
- Move from "local is the best" to optimal seed deployment
  - Integrating genecology results
- A multi-million Genome Canada project, led by Aitken and Hamann, to improve the climate-based seed transfer system

AdapTree

Acknowledgements

- Greg O'Neill, Dave Spittlehouse, Andreas Hamann and Trevor Murdock
- Funding:
  - BC Seed Transfer TAC
  - FGC
  - BC FFESC