Using genetic variation in trees to adapt to climate change

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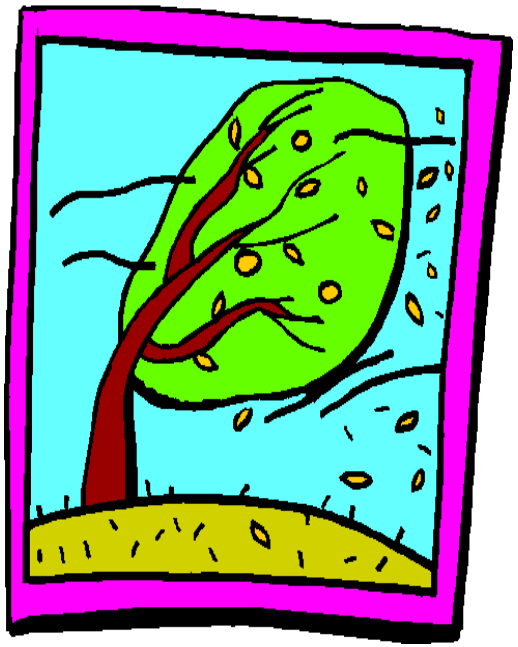
•CFCG•

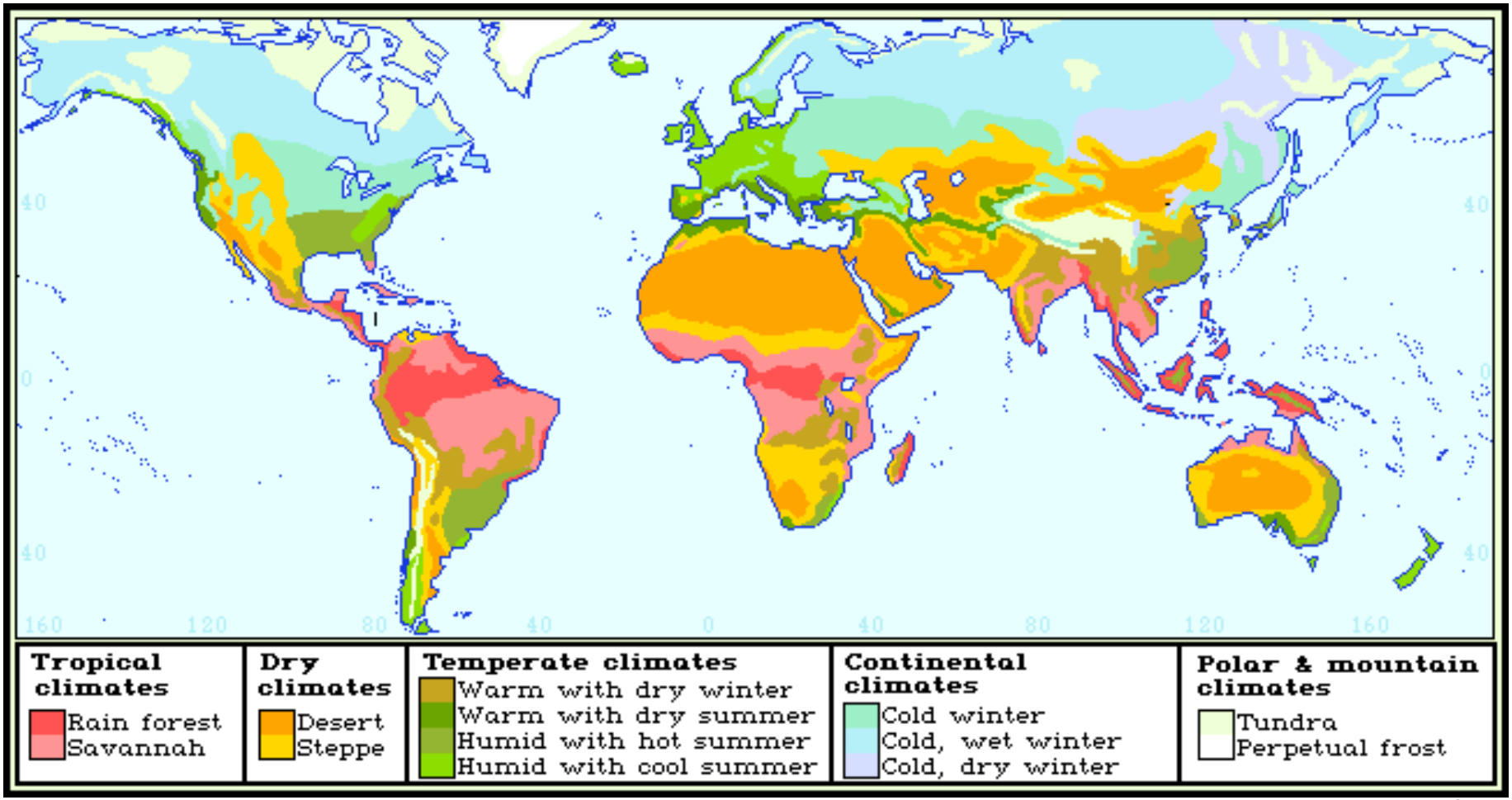
Effects of climate on forest trees

- Climate is a major environmental factor affecting the performance of trees (**environmental effect**)

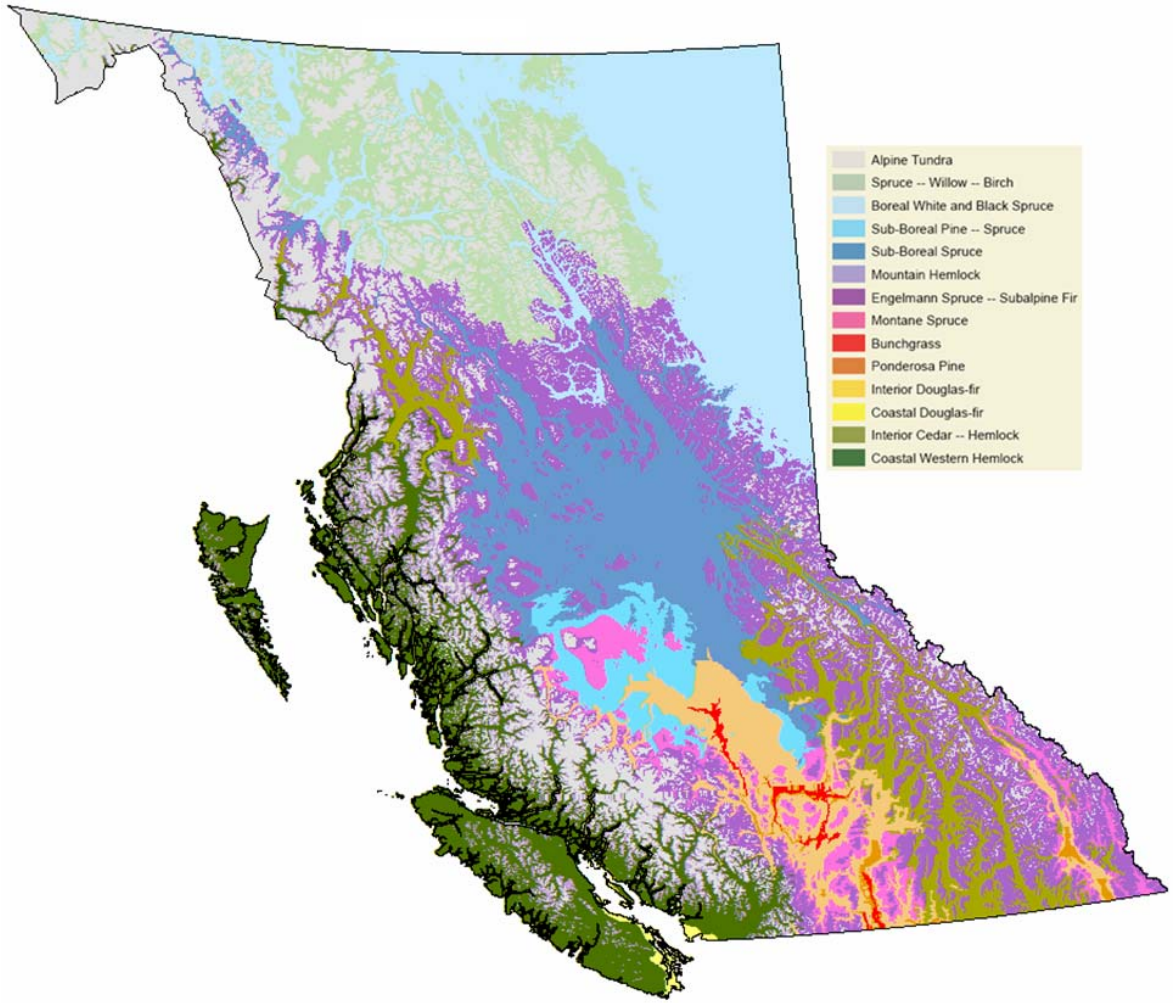


- Climate is also the most important evolutionary force molding among- and within-species variation (**genetic effect**)

Climate determines forest types (among-species variation) at the global scale



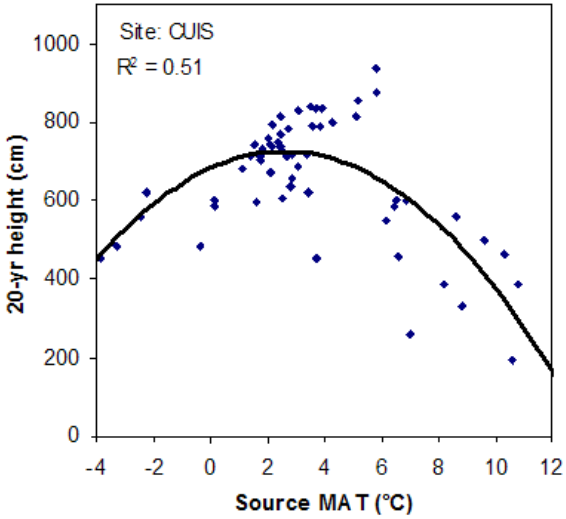
Climate controls species distribution (among-species variation) in a region

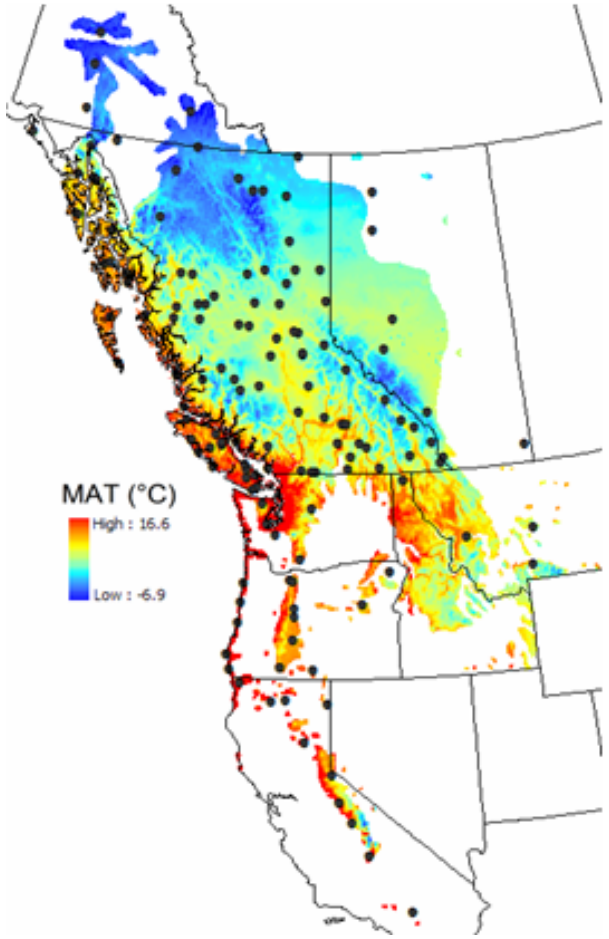


Biogeoclimatic Ecosystem Classification (BEC) in British Columbia

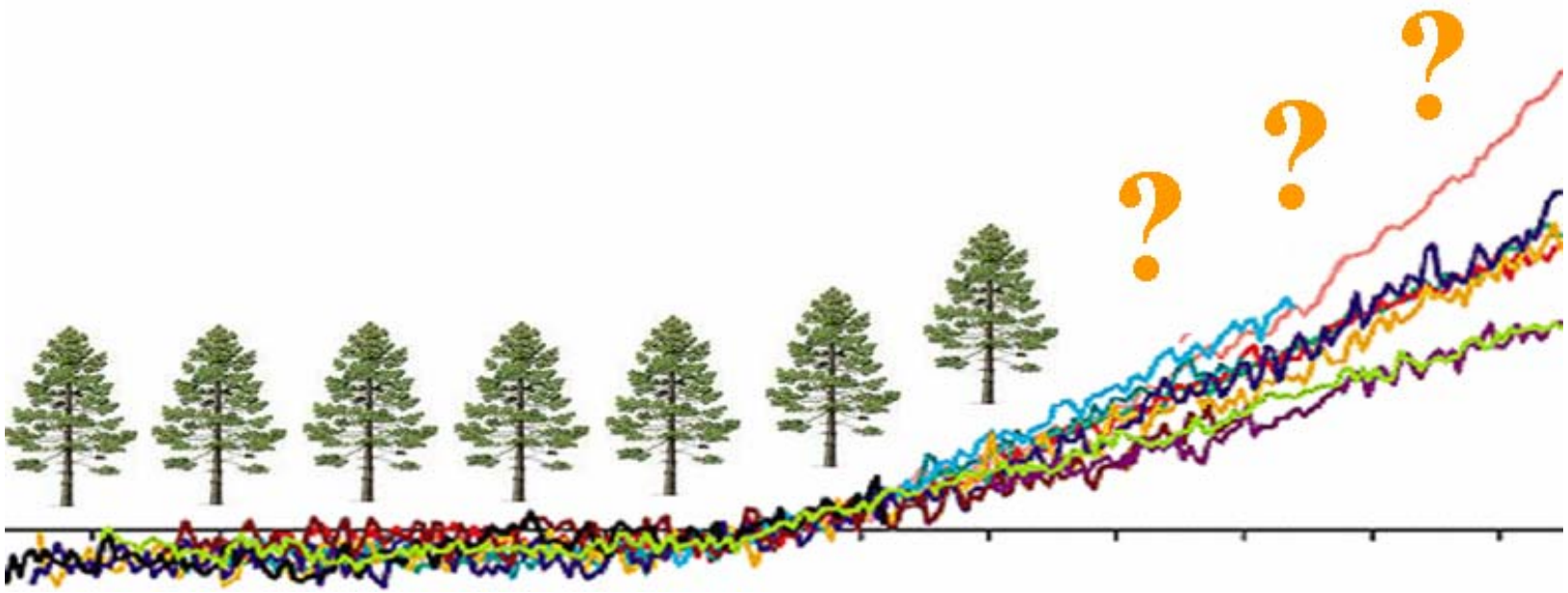
Climate also drives among-population variation within a species

- Among-population variation is often observed along climatic gradients





Can our trees adapt to their new climates?



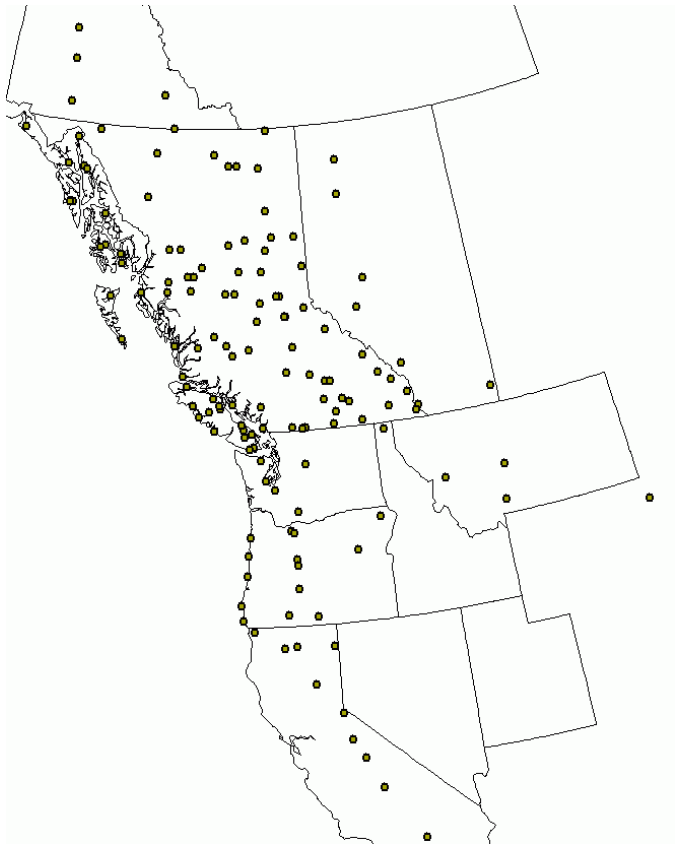
To help trees to adapt to climate change

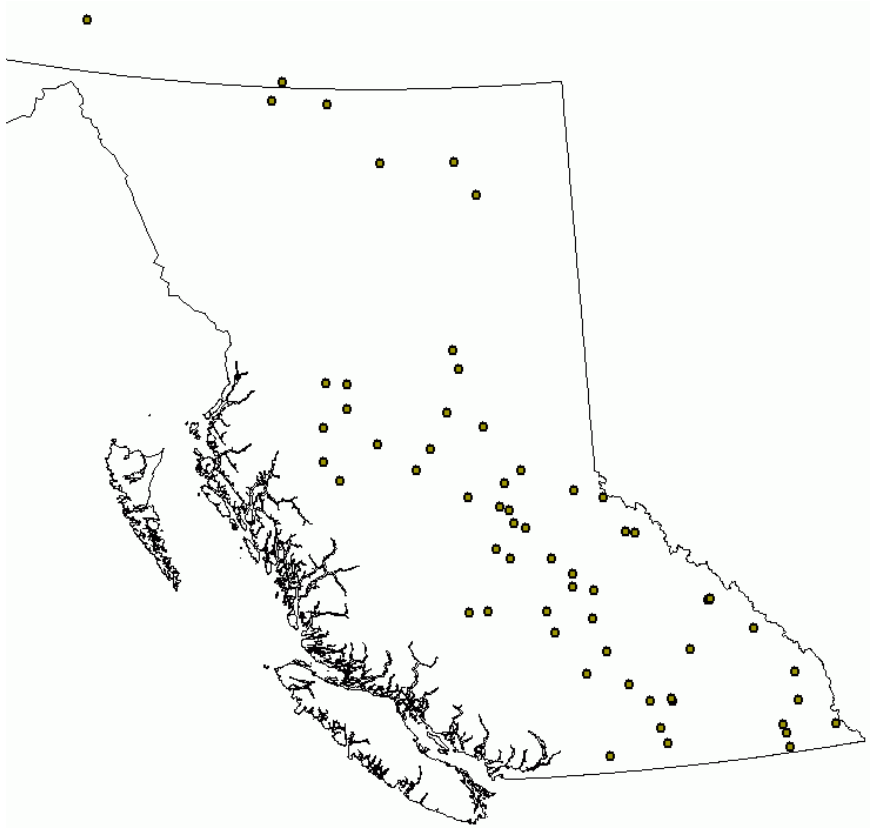
- Determine plant-climate relationships
- Predict responses of trees to climate change
- Develop management strategies to adapt to climate change

Provenance trials are used in climate change studies

140 provenances

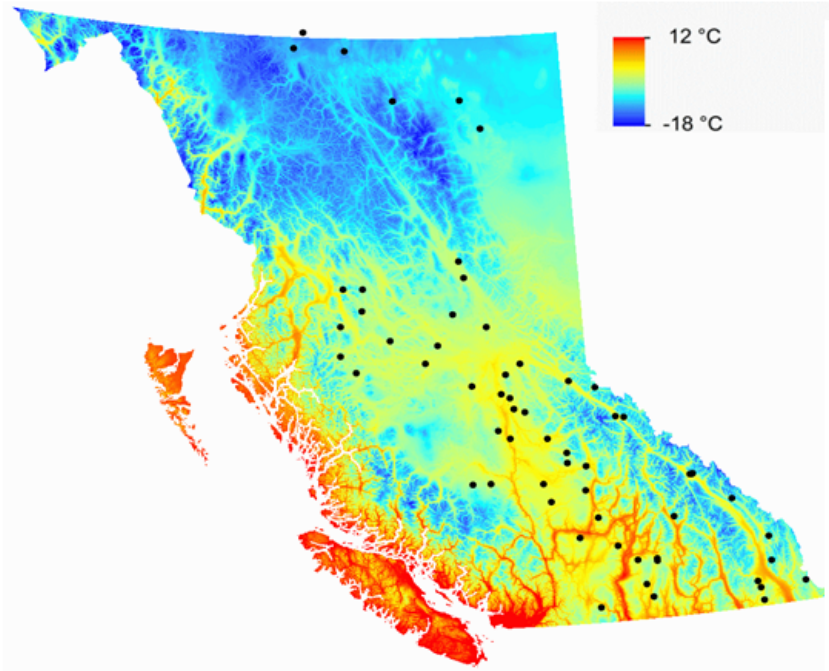
60 test sites

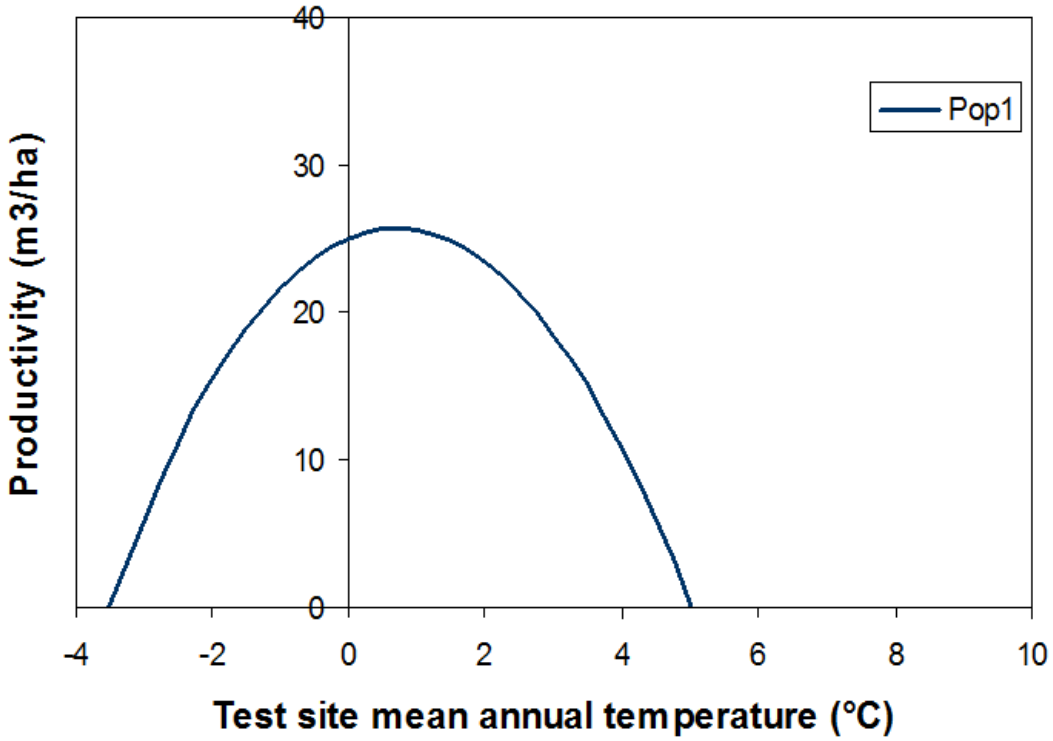




Lodgepole pine provenance trial in BC (established in 1974)

Among-population variation in response to climate





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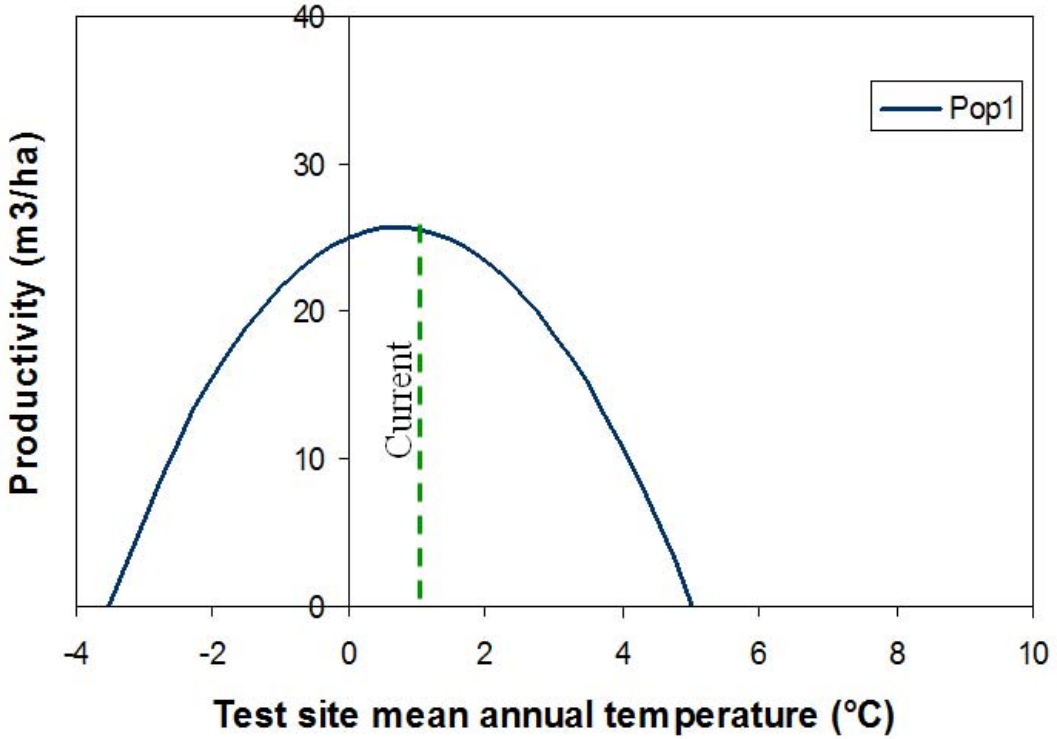

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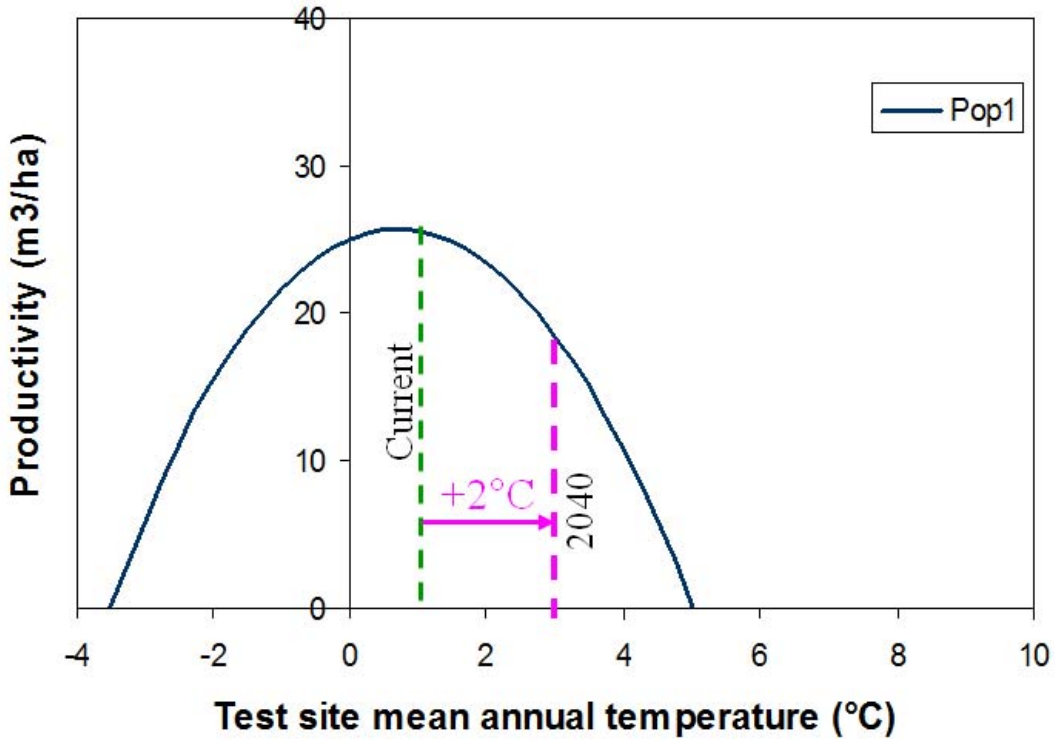
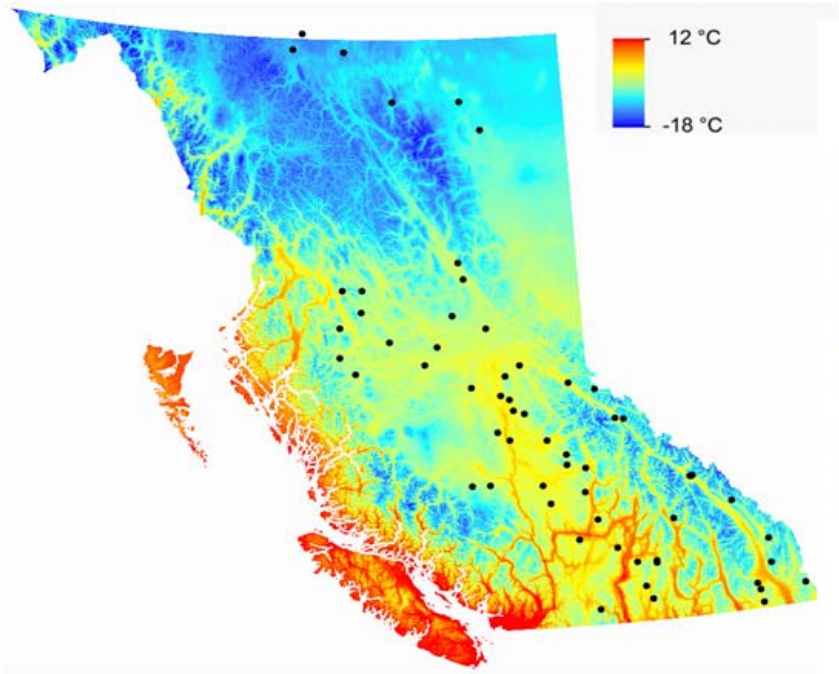
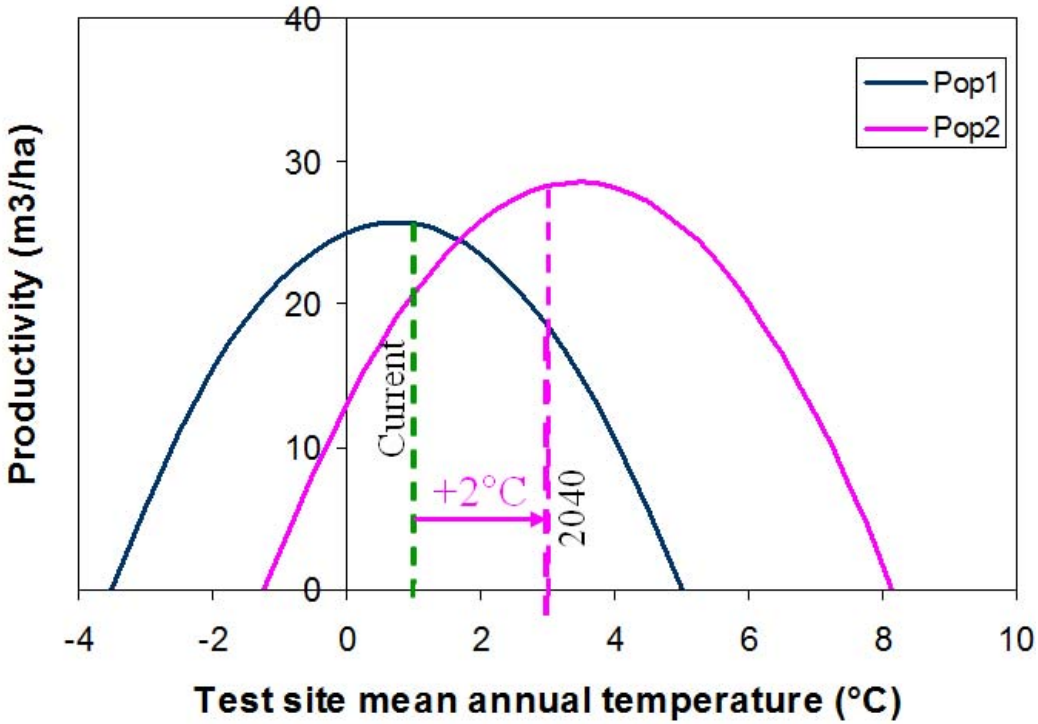
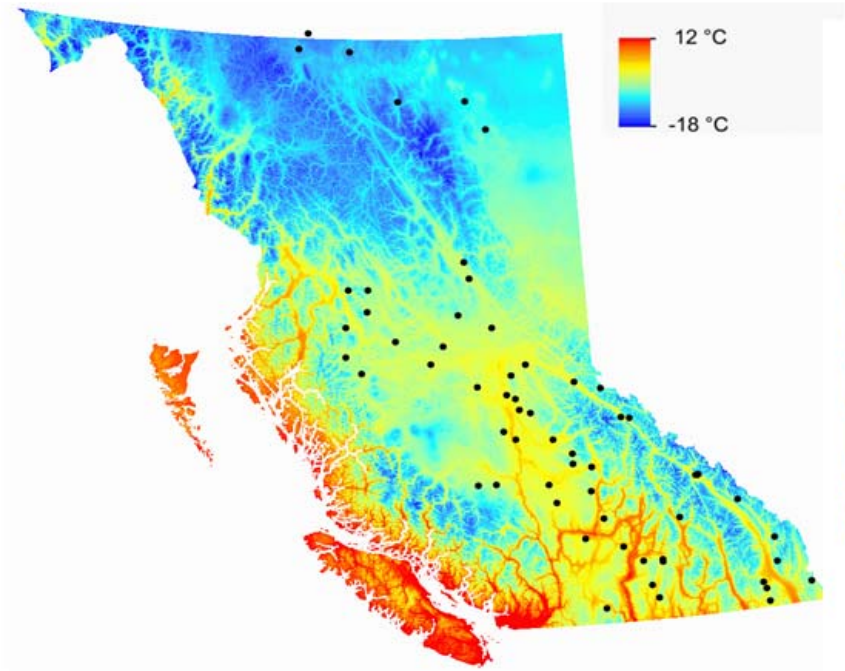


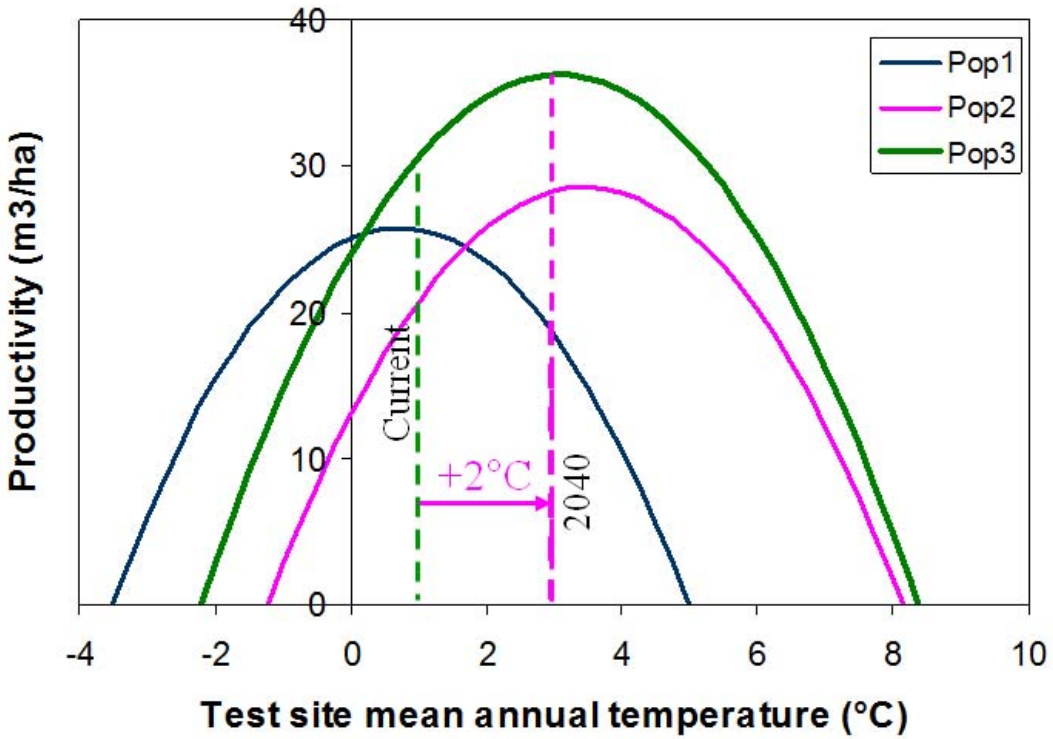
Among-population variation in response to climate



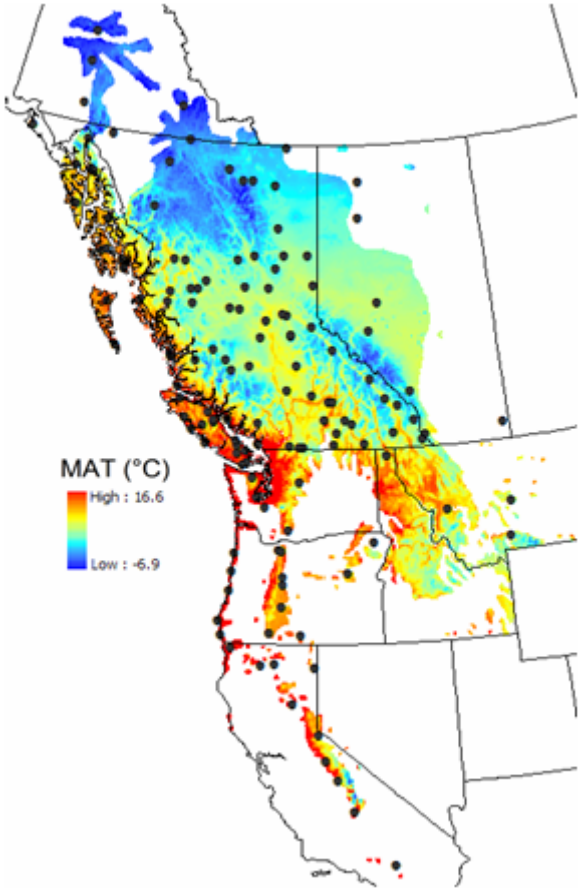


Among-population variation in response to climate

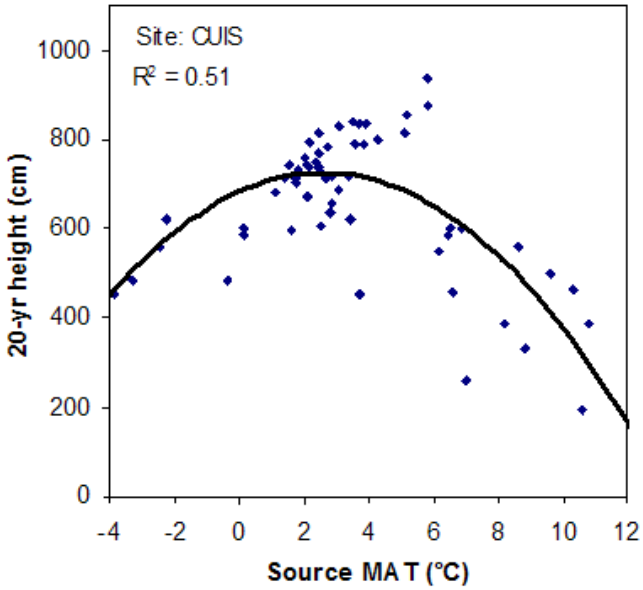




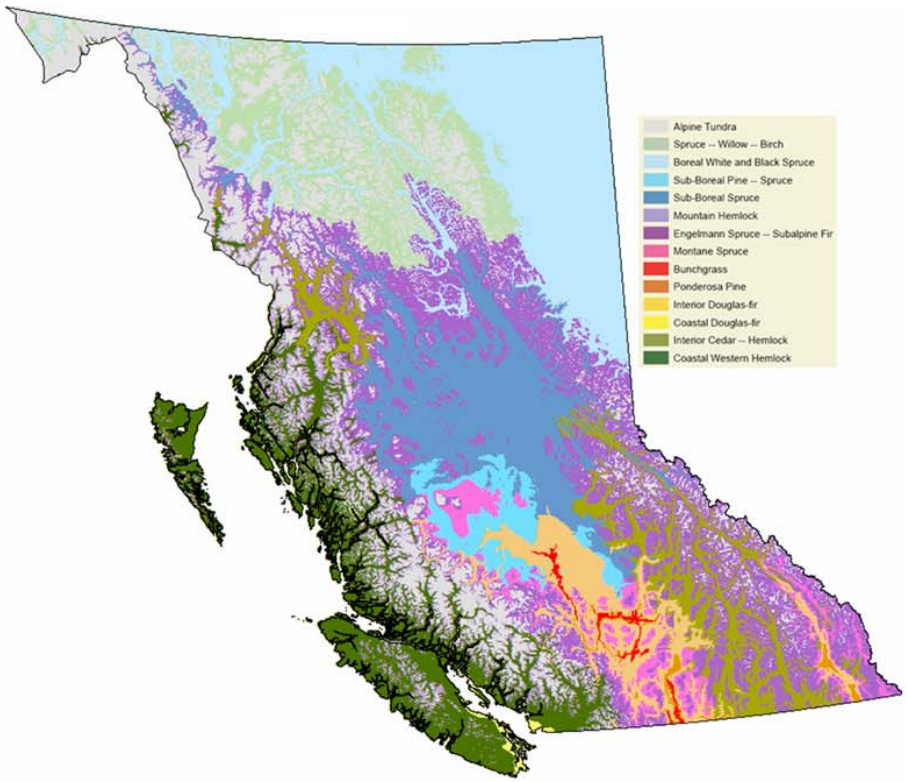
Among-population variation at a test site

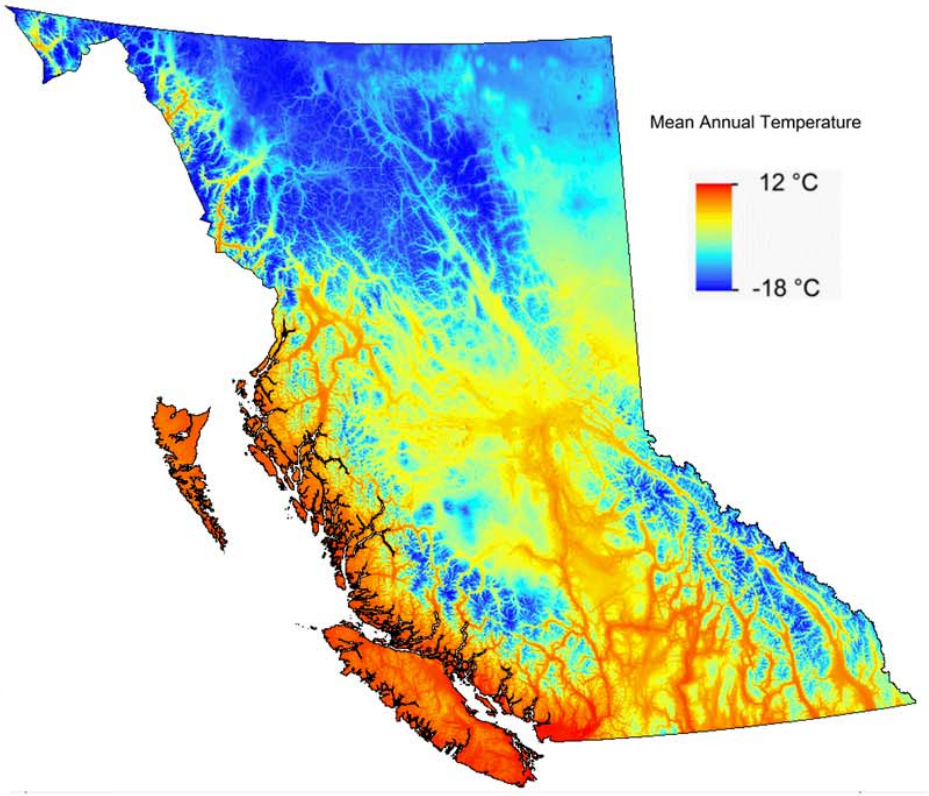


An individual transfer function



Use of plant-climate relationships to predict future climate envelopes for ecosystems and species ranges

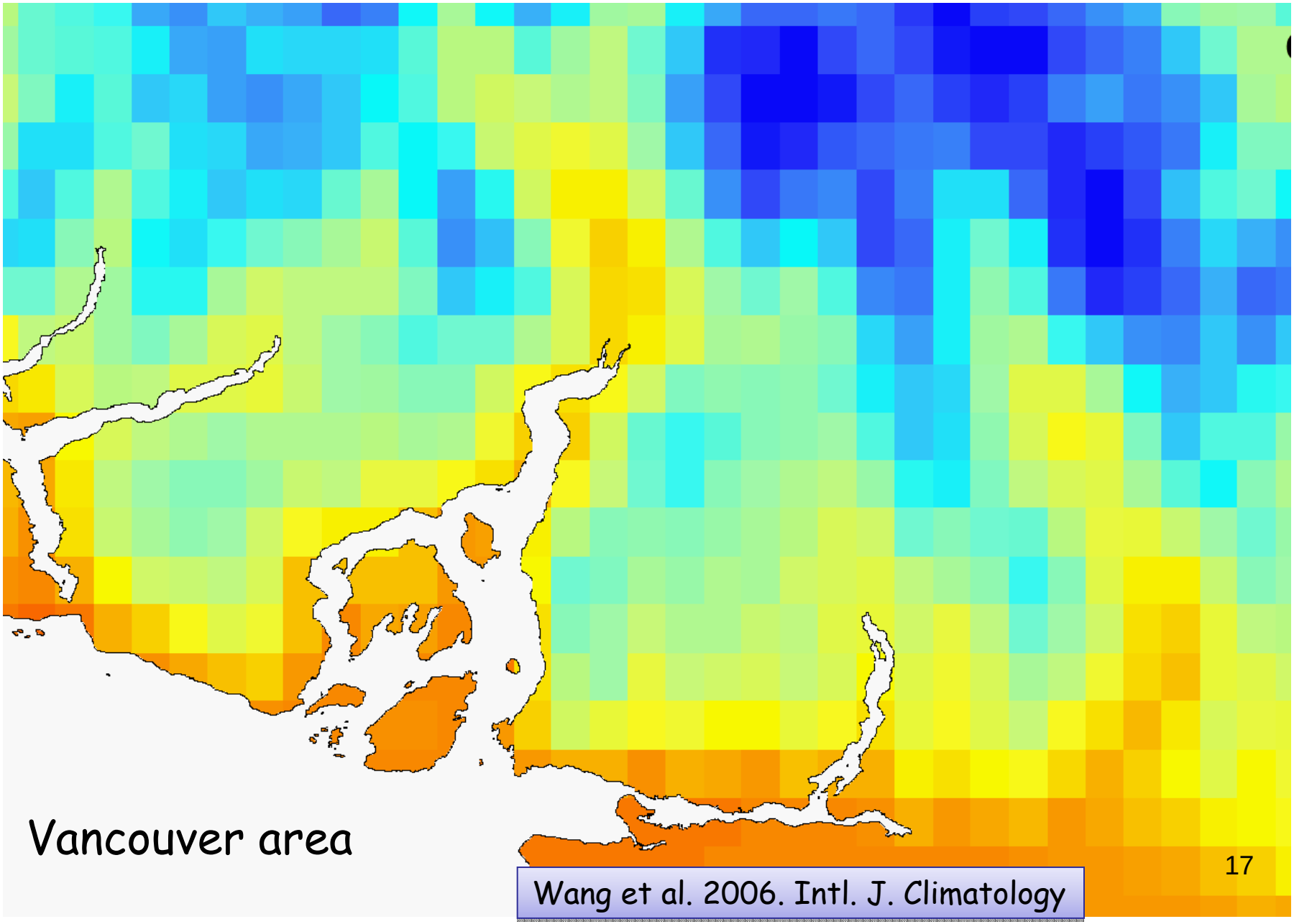




Objectives

- Development of high-resolution climate model
- Development of population response functions to climate
- Predict future climatic envelops for BC ecosystems and species ranges

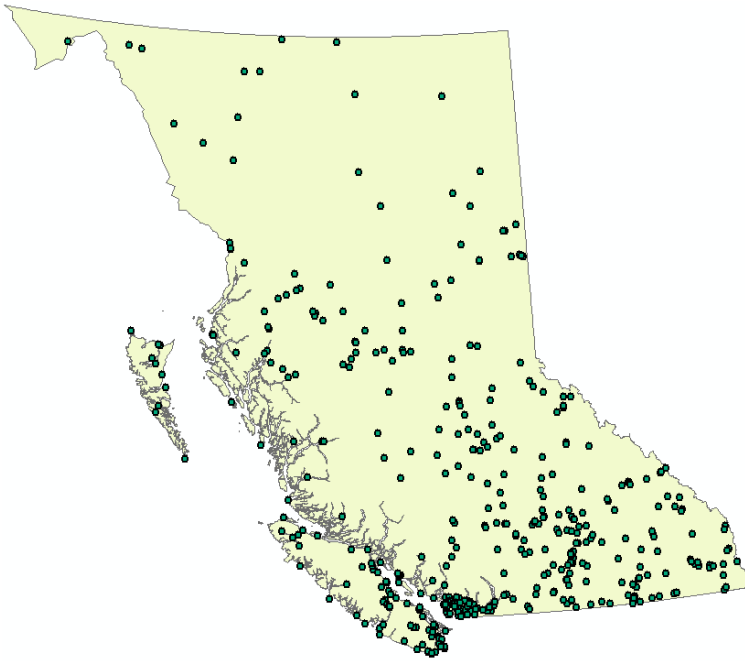
The resolution of PRISM data is low: 4 x 4 km

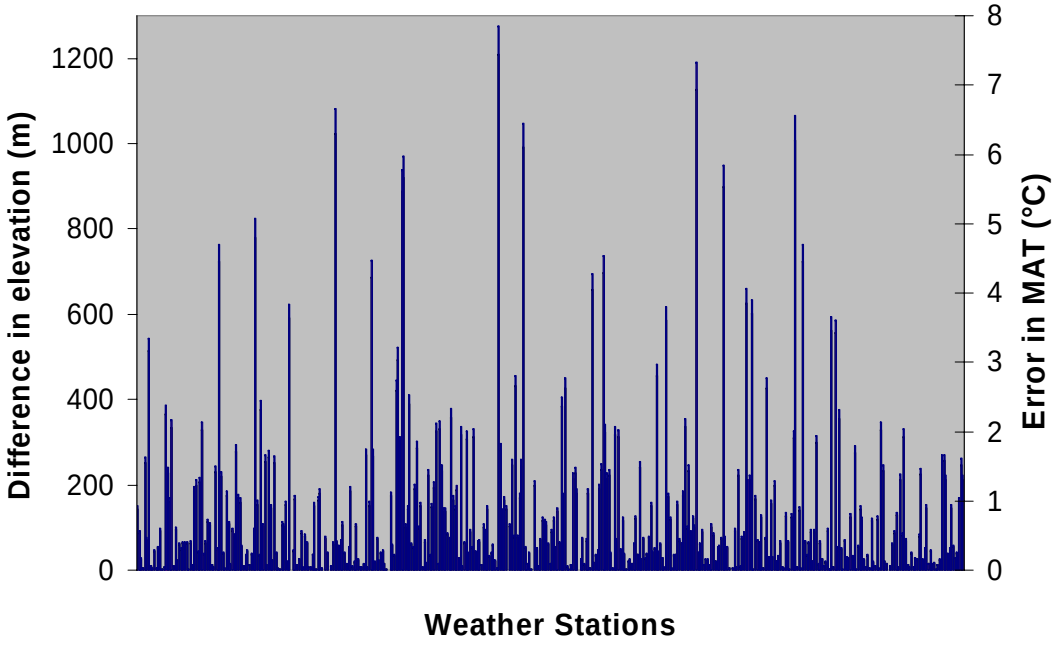


Wang et al. 2006. Intl. J. Climatology

The low resolution can result in huge amount of error in predictions for temperatures

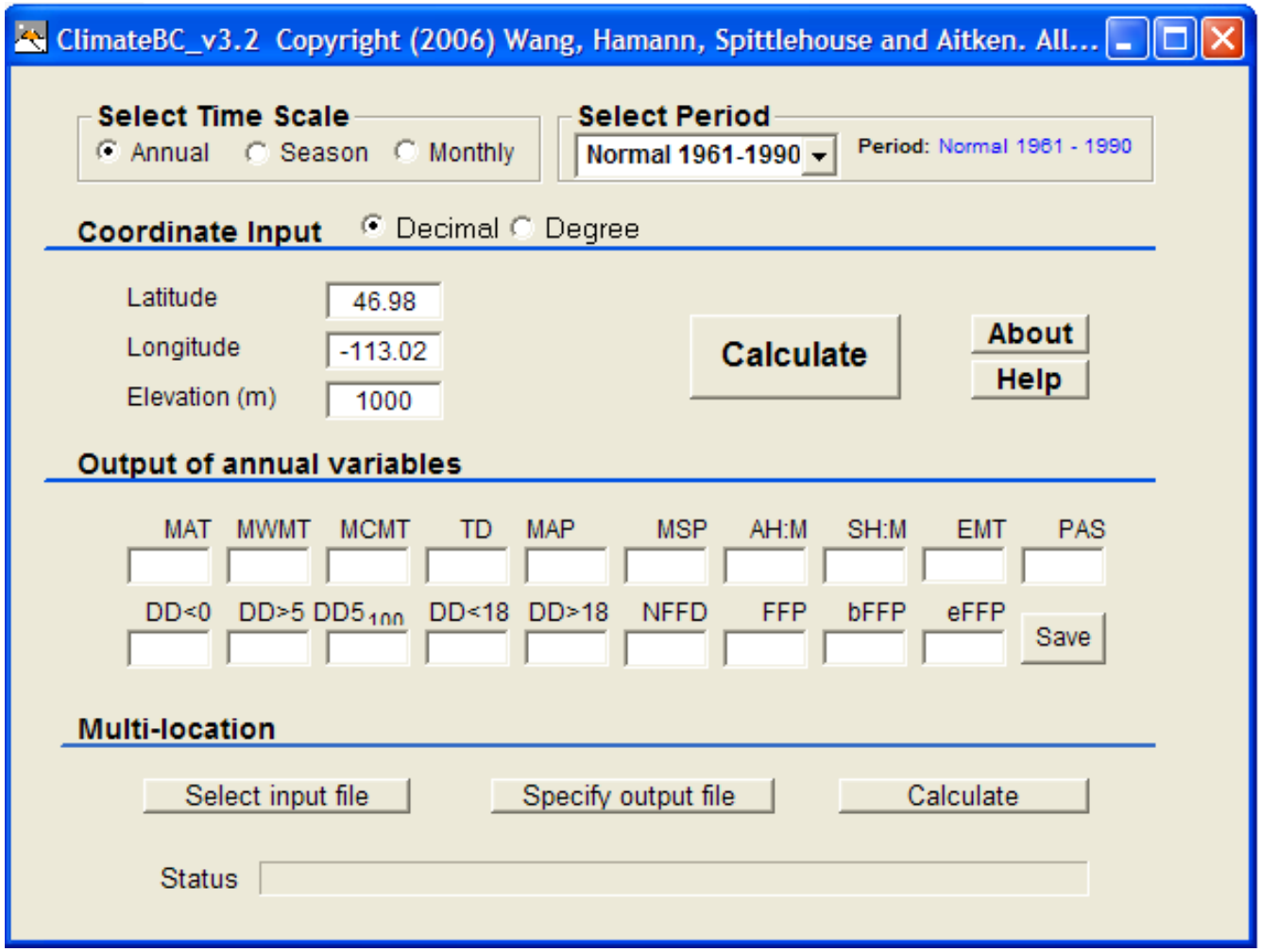
493 Weather stations





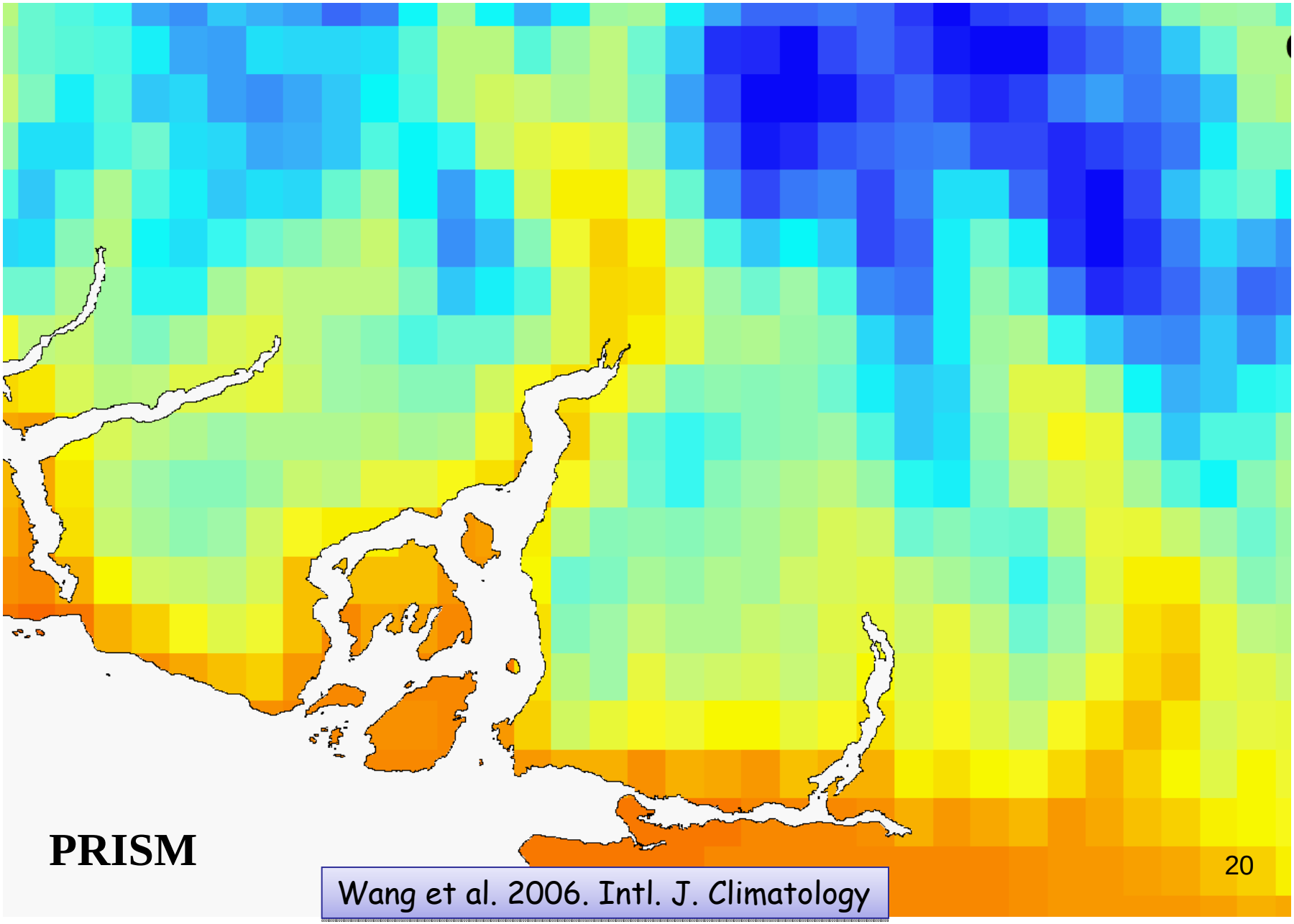
Wang et al. 2006. Intl. J. Climatology

ClimateBC – a computer program for predicting current and future climate data



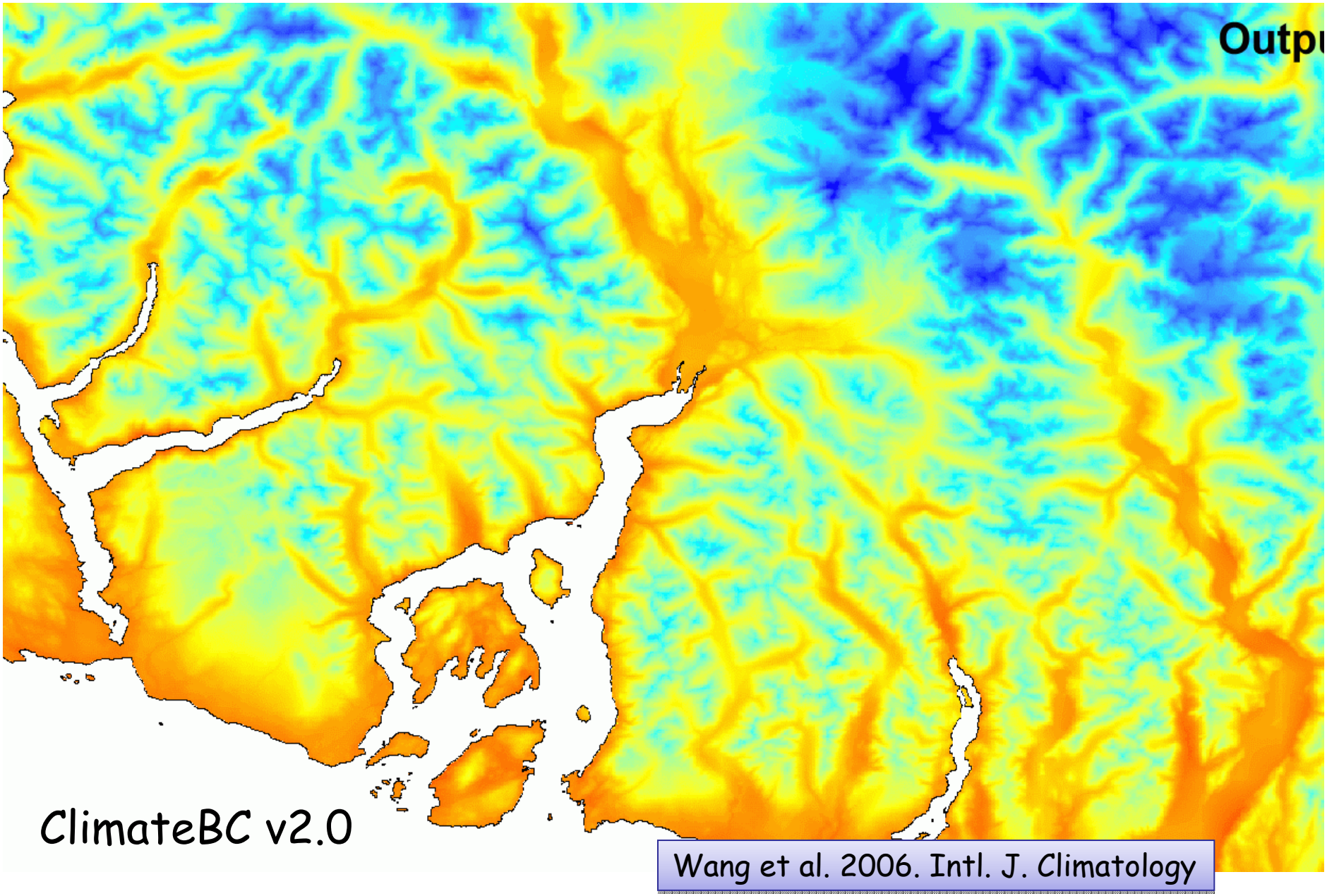
Wang et al. 2006. Intl. J. Climatology

Mean annual temperature for Vancouver area

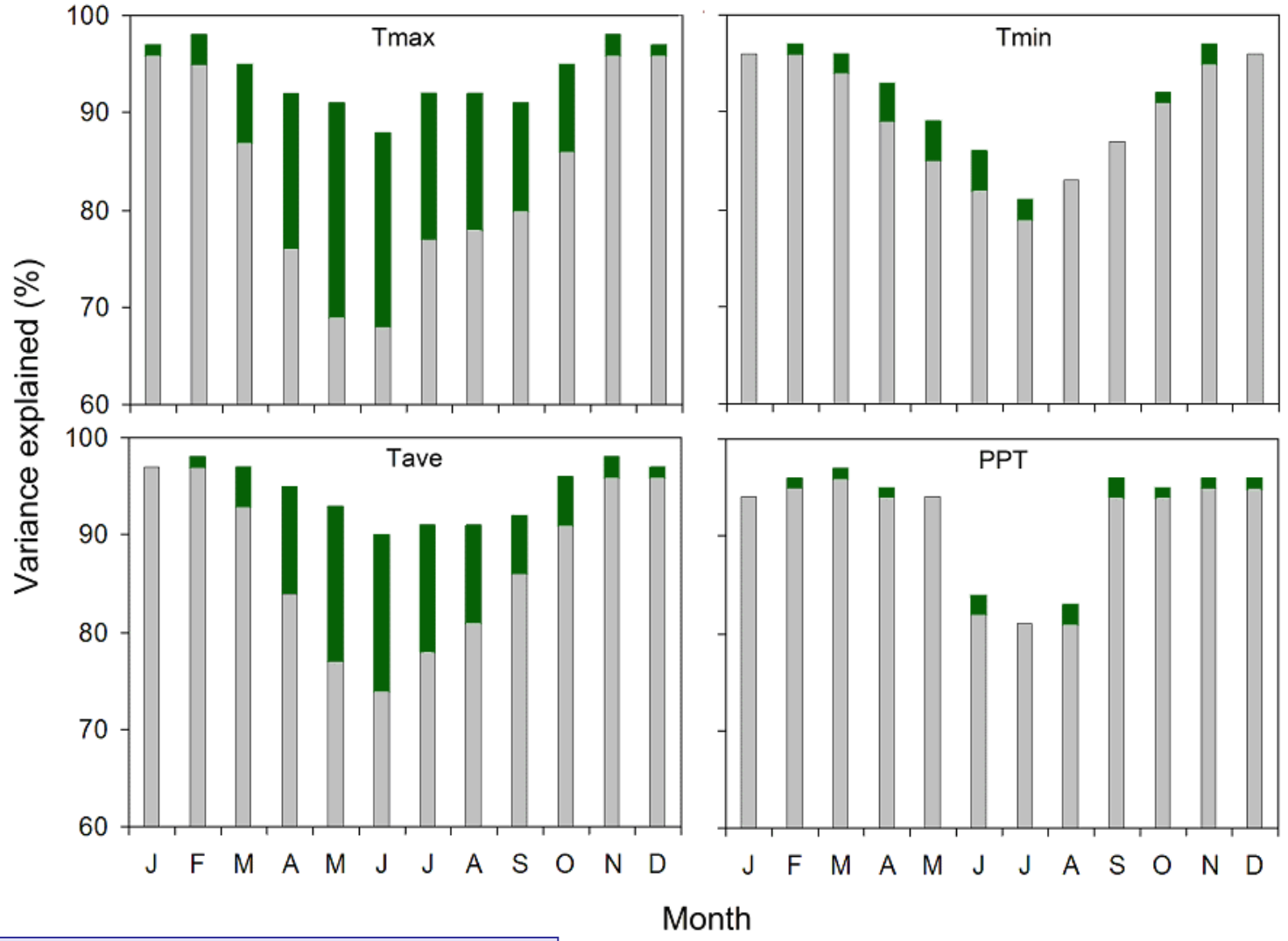


Wang et al. 2006. Intl. J. Climatology

ClimateBC output (100m x100m)

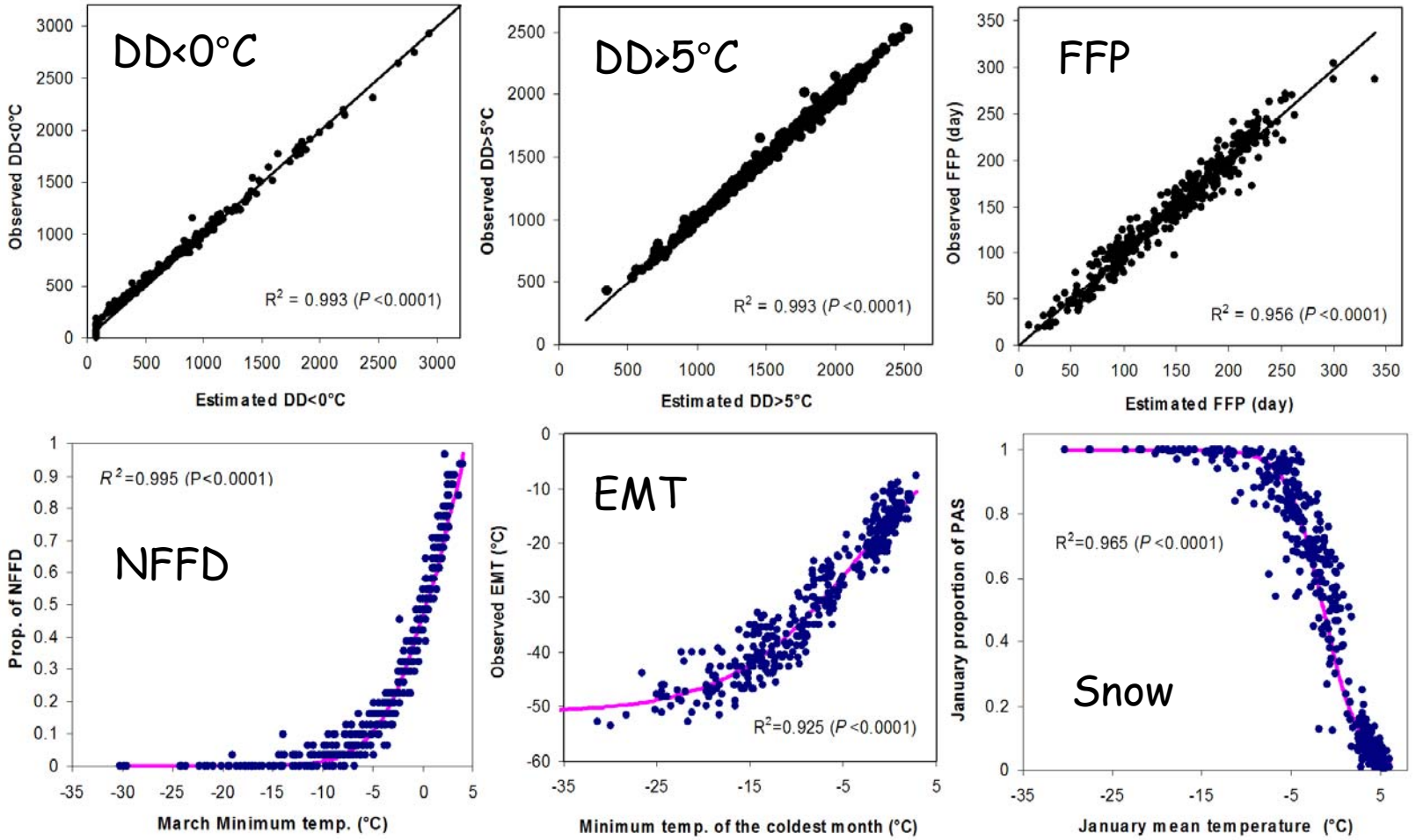


Predictions improved



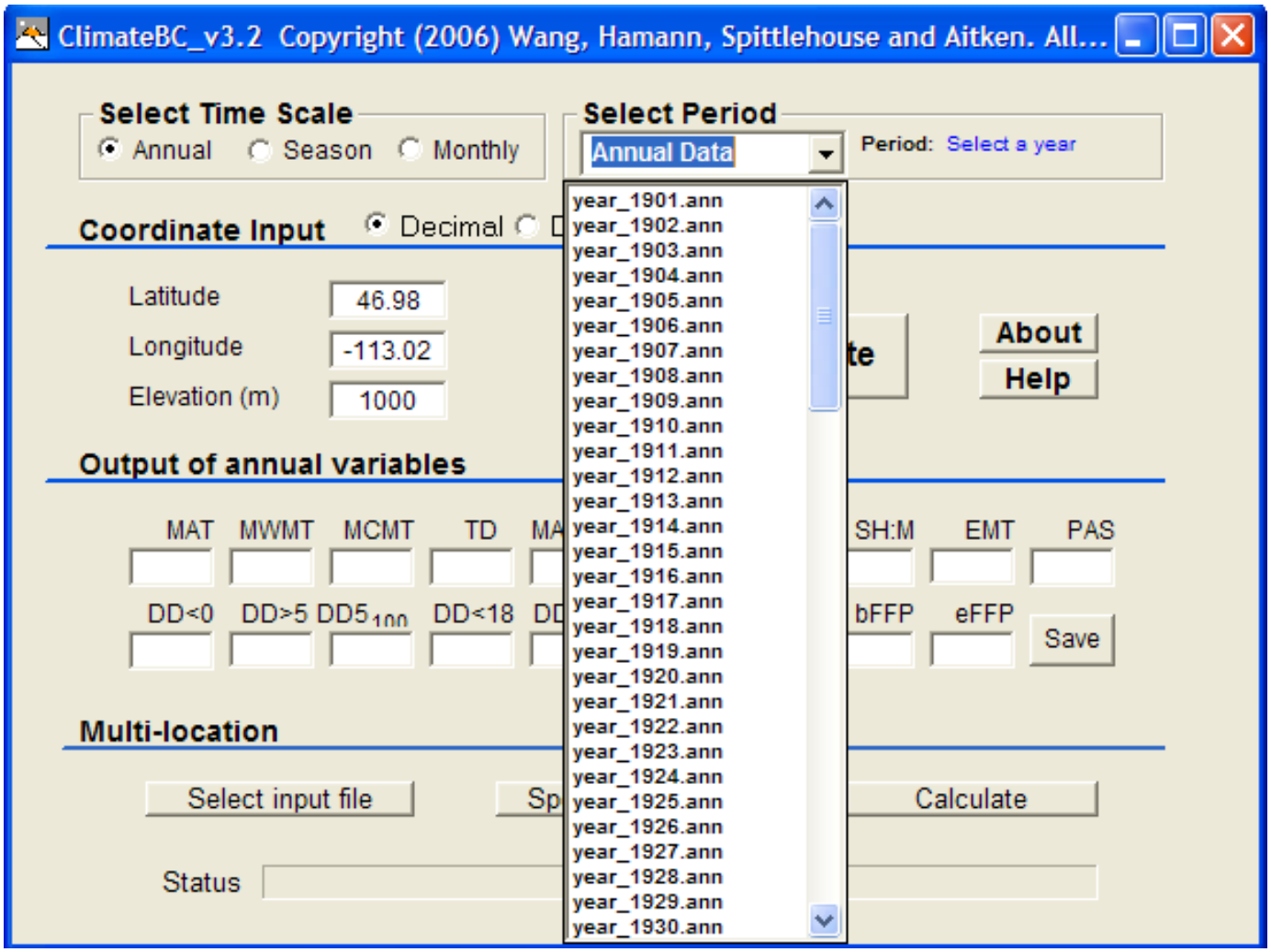
Wang et al. 2006. Intl. J. Climatology

Relationships used to predict derived variables

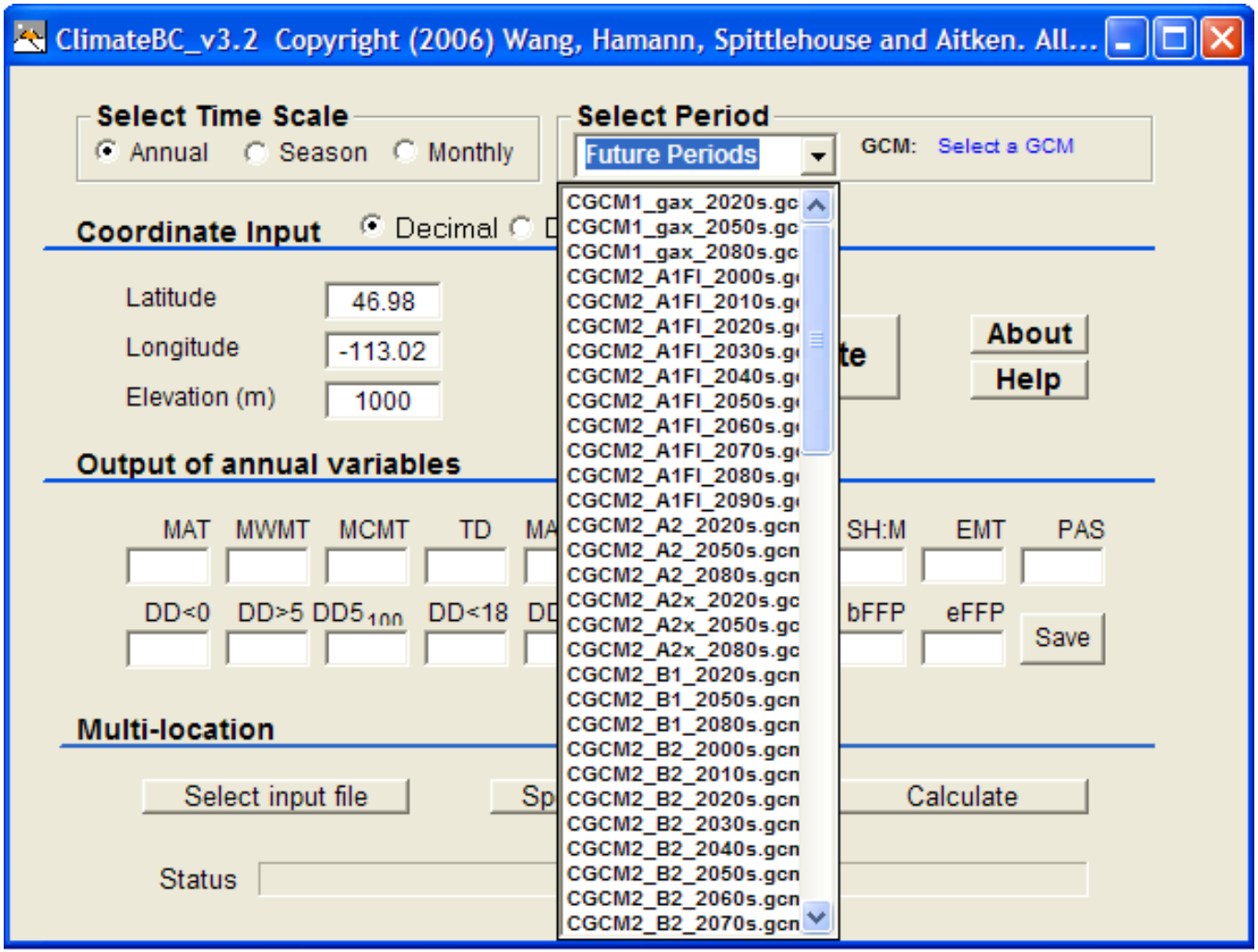


Wang et al. 2006. Intl. J. Climatology

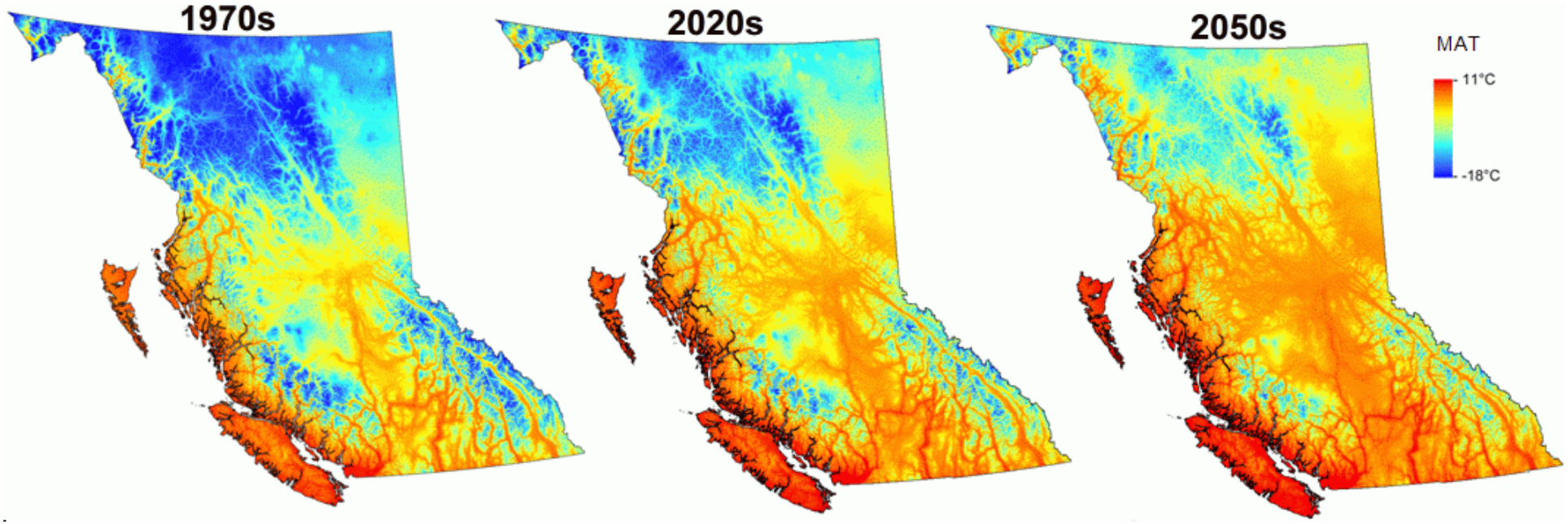
It generates climate data for past 102 years



It predicts climate data for the next 100 years using results from global circulation models



ClimateBC outputs



Maps of Mean Annual Temperature

COMICS | WESTCOAST HOMES | TRAVEL

B.C.'S FUTURE CARDINAL?
WESTCOAST NEWS | B1

CRUISE SHIP ANATOMY
BUSINESS BC | D1

MOZART FROM MADRAS
ARTS & LIFE | F1

CRUNCH TIME IN OTTAWA
SPORTS | H1

WEEKEND EDITION

THE VANCOUVER SUN

FINAL EDITION www.vancouversun.com SERIOUSLY WESTCOAST SINCE 1912 SATURDAY, JUNE 2, 2007

B.C. 2050 What climate change will do to our province

How trees can fuel cars

BY GORDON HAMILTON and SCOTT SIMPSON
VANCOUVER SUN

At a pilot plant located on an isolated corner of the University of B.C. campus, researchers are converting trees killed by the mountain pine beetle into high-grade ethanol, a green alternative to gasoline.

Four hundred kilometres away, north of Kamloops, waste bark fed into a high-tech burner comes out as synthetic natural gas for heating water and drying veneer at a plywood mill.

And in BC Hydro's Vancouver office, staff are sorting through more than 80 expressions of interest from energy and forest companies. They want to produce power from mountains of wood going to waste alongside British Columbian logging roads.

Calling timber-rich B.C. the new green Saudi Arabia without its polluting fossil fuels and gushing oil wells isn't just wild fantasy.

All over the world, scientists, businesses and governments are looking for ways to produce energy without increasing greenhouse gas emissions that are contributing to global warming.

Over the past few weeks, a Vancouver Sun team of reporters, editors and graphic artists has been sifting through interviews, scientific journals, government reports and private sector studies, asking how our province will be transformed in the coming decades by climate change.

We've chosen 2050 as our target date because scientists say it's a pivotal moment in the history of humanity — if we haven't curtailed our fossil fuel emissions by then, warming will be an irreversible trend.

"Whether or not you believe in global warming, we cannot afford to take that risk," deputy forests minister Doug Konkin told a recent Vancouver audience. "We have to start preparing for this. The fact is, be it short term, be it long term, our climate has changed right now."

WEEKEND EXTRA CONTINUES ON A6

WEEKEND EXTRA

Forecasting a hotter future

What the province may be like at mid-century

WEEKEND REVIEW | C6-7

Picture of hope

Artist Robert Bateman refuses to give in to global-warming gloom

WEEKEND REVIEW | C1

2007/02/06

Q[illegible] revolution

Surrey's mayor is determined to change her city's image. B1

INSIDE

Firing a $400,000 ticket for lotto head

BY CHAD SKELTON
VANCOUVER SUN

executive officer Vic Poleschuk. He also suggested more health could roll after the conclusion

Champions of the poor or just malcontents?

Its website says it exists to give a voice to the city's underprivileged — the poor, the drug-addicted and the homeless. Its members oppose capitalism and

C6 C THE VANCOUVER SUN, SATURDAY, JUNE 2, 2007

WEEK

B.C. 2050 OUR CH

What will the province look like at mid-century? To answer that question, the Sun's B.C. 205 sources. The stark picture that emerges on these pages will come as a shock to anyone expec

Climate change is about more than just longer summers and warmer winters. A transformation has begun that goes right to the heart of who we are and where we live. Icons of the West Coast – the rainforests we fought so hard to preserve, the salmon whose annual migration to our shores and rivers we celebrate – will be dying or dead. Our winters will no longer be cold enough to discourage diseases like malaria and dengue fever from finding a niche in new eco-systems. Massive dyking projects like those in Holland will be needed to keep Delta, Richmond and Vancouver International Airport from being inundated by rising sea levels. If climate change models are accurate, temperatures in B.C actually 3.5 degrees C. That's the differen benchlands of the upper Fraser River ide taken place. Eco-systems that have been the void is anybody's guess.

Picturing a warmer time

Average annual temperature

+11° C

0° C

-18° C

BRITISH COLUMBIA in the 2050s has undergone a temperature metamorphosis. The extreme differences in temperatures between the Lower Mainland and the northern Interior so evident by the swath of blue across the top and band of orange across the bottom in map of the 1970s, are not as pronounced by the 2050s.

This series of maps, prepared by the University of B.C.'s Centre for Forest Gene Research, is one of the tools researchers are using as an aid in determining future climate zones for plant species.

The maps show average annual temperatures, which in turn are based on average monthly and daily temperatures. They are an approximation giving viewers an immediate sense of the scope of change the province faces.

The cold blue zones, where average annual temperatures are -18 degrees Celsius, have almost disappeared by 2050, a sign that average low temperatures are climbing faster than average highs. Winters are warming faster than summers. The North goes through more temperature change than the South and on the Coast, mountain temperatures are climbing.

Most striking, the maps show how Prince George, located at the northern bend of the Fraser River, has become the hub of an Interior zone warm enough for a variety of crops by 2050. By the 2080s, the land is as warm as the southern Okanagan is today. The creator of the maps, UBC forestry professor Tongli Wang cautions, however, that temperature increases will not be matched by increases in precipitation, so whether there will be enough moisture to take advantage of the warmer climate is still an open question.

2050s

Global warming has affected the entire province dramatically by the 2050s. This map helps us to understand what will happen to species and ecosystems in the future by showing the degree of climate change.

1970s

The north is noticeably cooler in this snapshot of average annual temperatures from 1961 to 1990.

2020s

The trend to higher temperatures, which will affect distribution of plants and animals, is already evident in this map of the near future.

2050s

Climate zones will no longer fall within the climatic envelope of many of the species they currently support.

Human health

Forestry

Rising temperatures will disrupt the equilibrium of forest eco-systems that have taken millennia to fine-tune. From Victoria to Haida Gwaii, the giant cedars will be dying of thirst during the longer, drier summers. In the Interior, fires will be more frequent and more intense. In the north, a host of new fungi and insect pests will flourish in the warmer, moister winters.

Grasslands overtake previously forested lands. Deciduous trees take over coastal rainforest regions because the climate is not longer suited to evergreens.

Snowpack

Snowfall will continue to vary from year to year as the climate naturally fluctuates, but the International Panel on Climate Change predicts decreasing snow cover in the Northern Hemisphere during the 21st century.

These maps show the projected chan er in the northerly part of the Columb tury. Higher temperatures mean that the snowpack builds later in the ye

2007/02/06

Free to download

THE UNIVERSITY OF BRITISH COLUMBIA

Forestry

Centre for Forest Conservation Genetics

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- Overview
- Web-based
- ClimateBC v3
- References
- Predictions
- Monthly data

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ources

ClimateBC: A program to generate climate normal data for genecology and climate change studies in western Canada

Overview

ClimateBC extracts and downscales PRISM (Daly et al. 2002) monthly data (2.5 x 2.5 arcmin) for the reference period (1961-1990), and calculates seasonal and annual climate variables for specific locations based on latitude, longitude and elevation (optional) for British Columbia, Yukon Territories, the Alaska Panhandle, and part of Alberta and US. This program also downscales and integrates historical (1901-2002) (Mitchell and Jones 2005) and future climate datasets (2020s, 2050s and 2080s) generated by various global circulation models. The output includes both directly calculated and derived climate variables. Methodologies are described in Wang et al. (2006) and Hamann and Wang (2005).

An overview of the ClimateBC is given in Climate Network Vol.10 No.1, April 2005, published by the Canadian Institute for Climate Studies [download] and in TICtalk December 2006 [download]. A recent Vancouver Sun article features output ClimateBC (open pdf).

Google "ClimateBC" to find

A web version is also available

Coordinates Input:

Latitude in Degree: 50 ° 30 ' 30 " Longitude: -120 ° 30 ' 30 "

Elevation: 500 m Select Period: 1961_1990

Calculate Help

Output:

Annual Variables:	Seasonal Variables:	Monthly Variables:
MAT= 6.6	Tave(12-2)= -4	Tave(1)= -4.9
MWMT= 17.5	Tave(3-5)= 7	Tave(2)= -1.3
MCMT= -4.9	Tave(6-8)= 17	Tave(3)= 2.2
TD= 22.4	Tave(9-11)= 7	Tave(4)= 6.6
MAP= 451	Tmax(12-2)= 0	Tave(5)= 11.2
MSP= 216	Tmax(3-5)= 12	Tave(6)= 15.1
AHM= 36.9	Tmax(6-8)= 24	Tave(7)= 17.5
SHM= 81.0	Tmax(9-11)= 12	Tave(8)= 17.3
EMT= -33.1	Tmin(12-2)= -7	Tave(9)= 12.3
PAS= 107	Tmin(3-5)= 1	Tave(10)= 7.4
DD<0= 453	Tmin(6-8)= 9	Tave(11)= 0.5
DD>5= 1756	Tmin(9-11)= 2	Tave(12)= -4.3
DD5_100= 119	PPT(12-2)= 121	Tmax(1)= -1.2
DD<18= 3972	PPT(3-5)= 87	Tmax(2)= 2.9
DD>18= 89	PPT(6-8)= 136	Tmax(3)= 7.1
NFFD= 206	PPT(9-11)= 107	Tmax(4)= 12.5
FFP= 131		Tmax(5)= 18.0
bFFP= 134		Tmax(6)= 22.2

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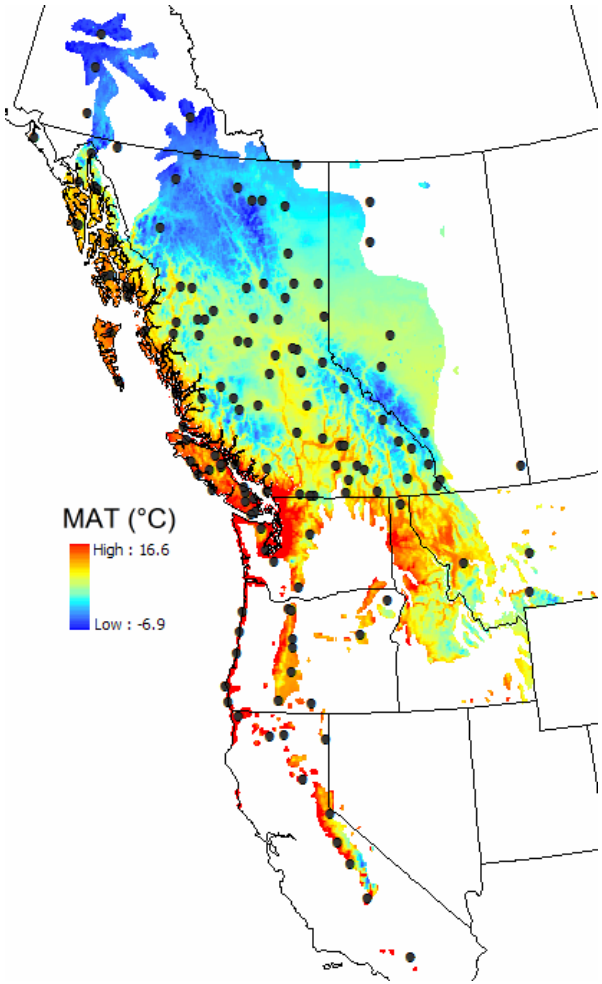
Objectives

- Development of high-resolution climate model
- Development of population response functions to climate
- Predict future climatic envelops for BC ecosystems and species ranges

Plant materials

140 provenances



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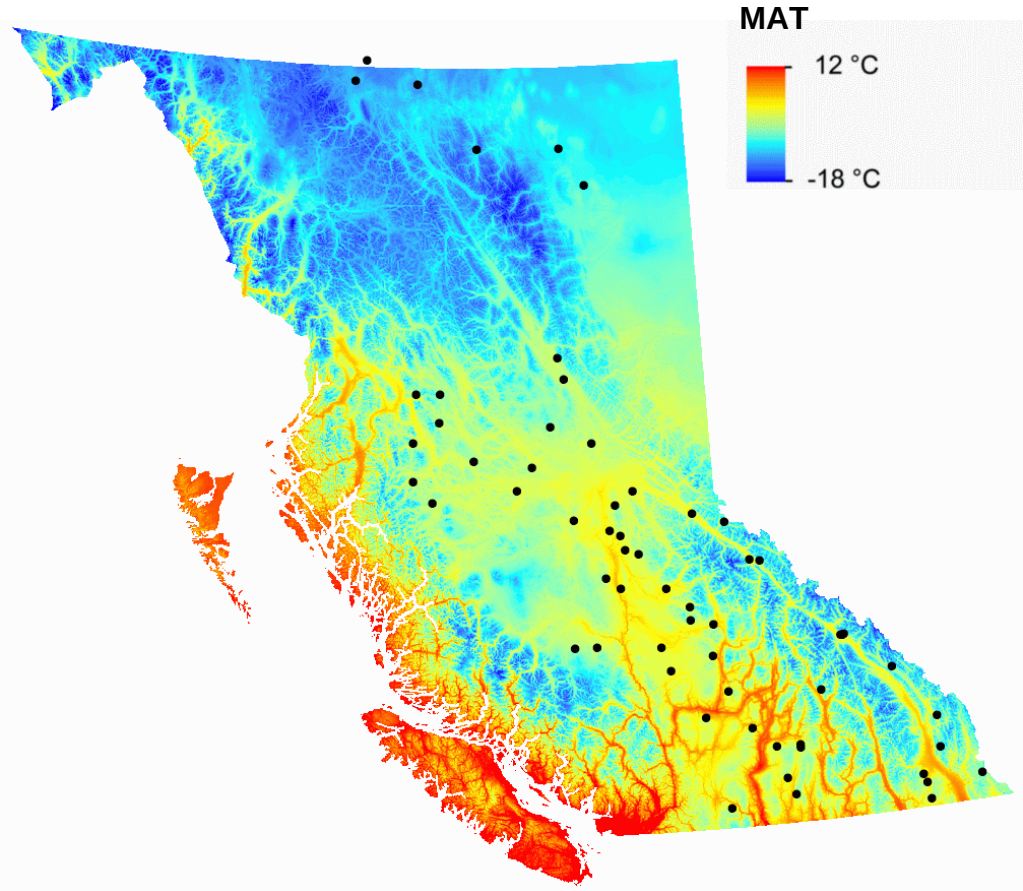
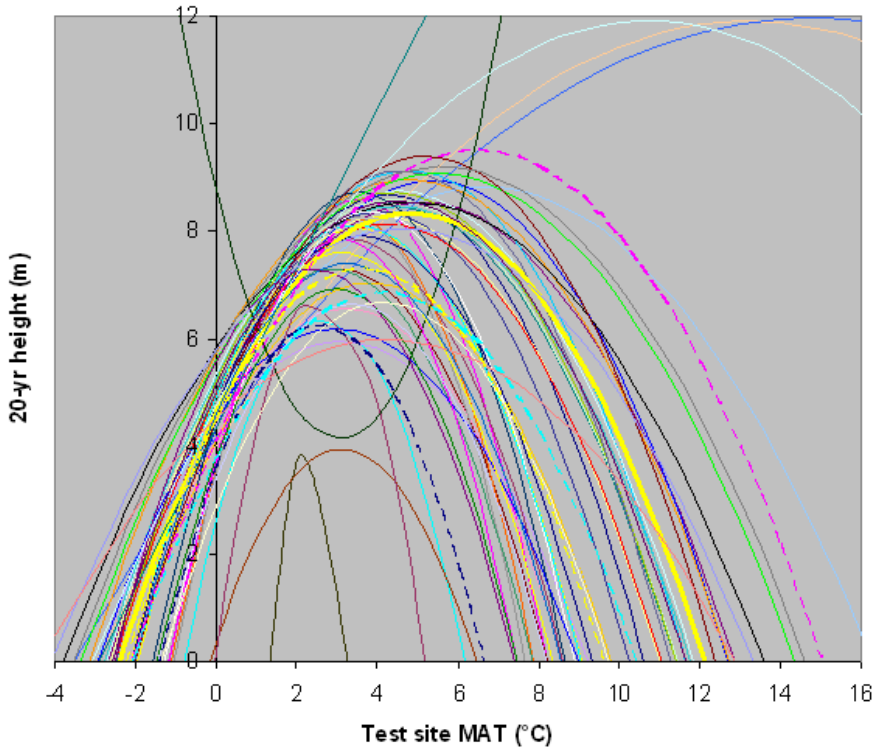


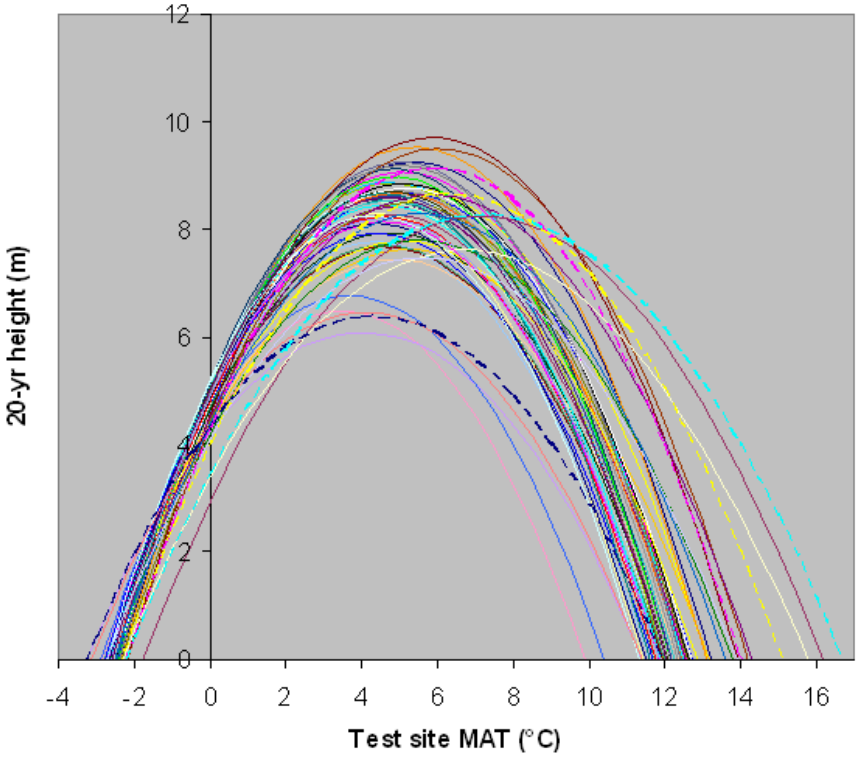
Lodgepole pine provenance trial in BC established in 1974 (Illingworth 1978)

Effects of predicted anchor points on climatic response functions

Without predicted anchor points

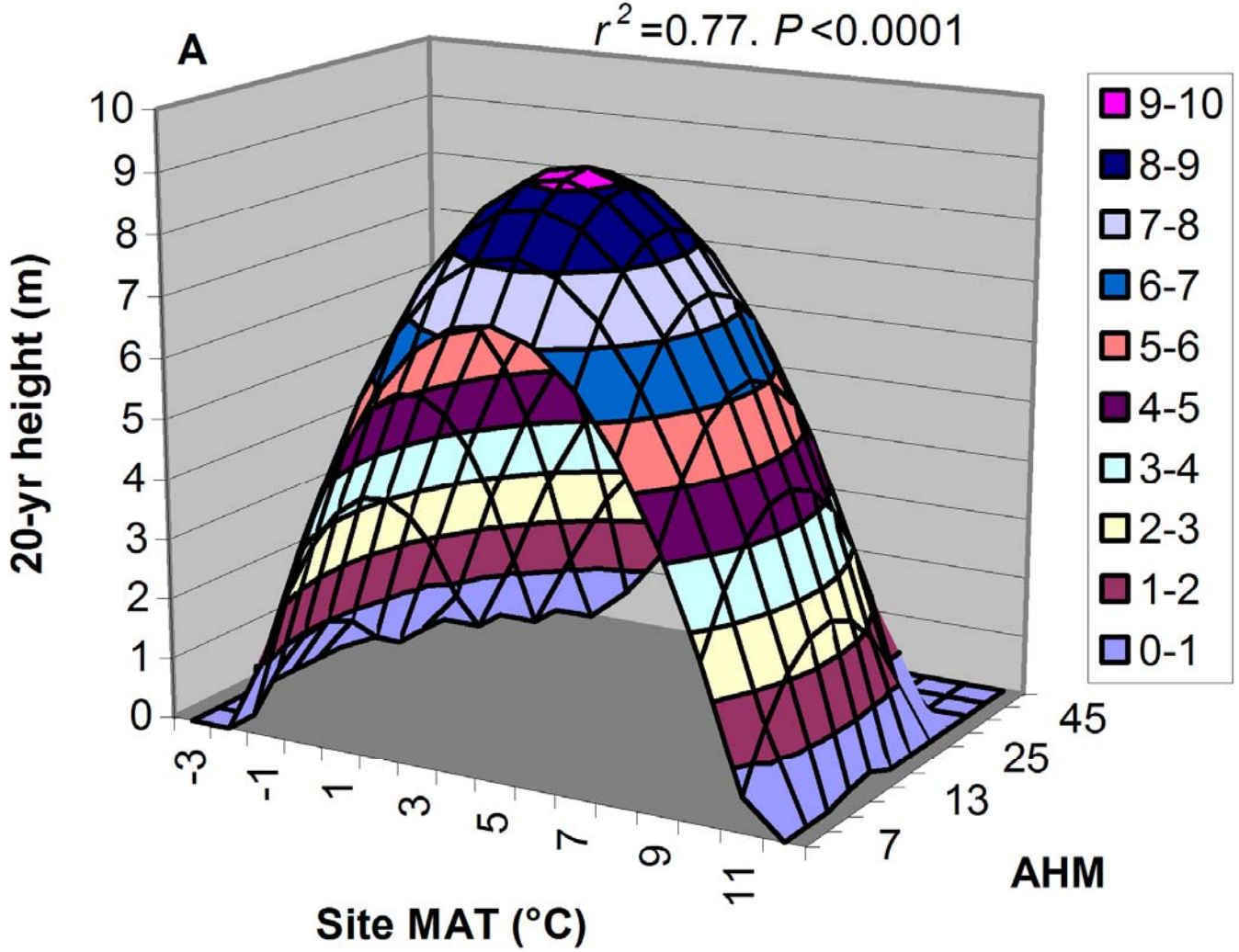


With predicted anchor points



Wang et al. 2006. Global change Biology

Multivariate approach further improved response functions



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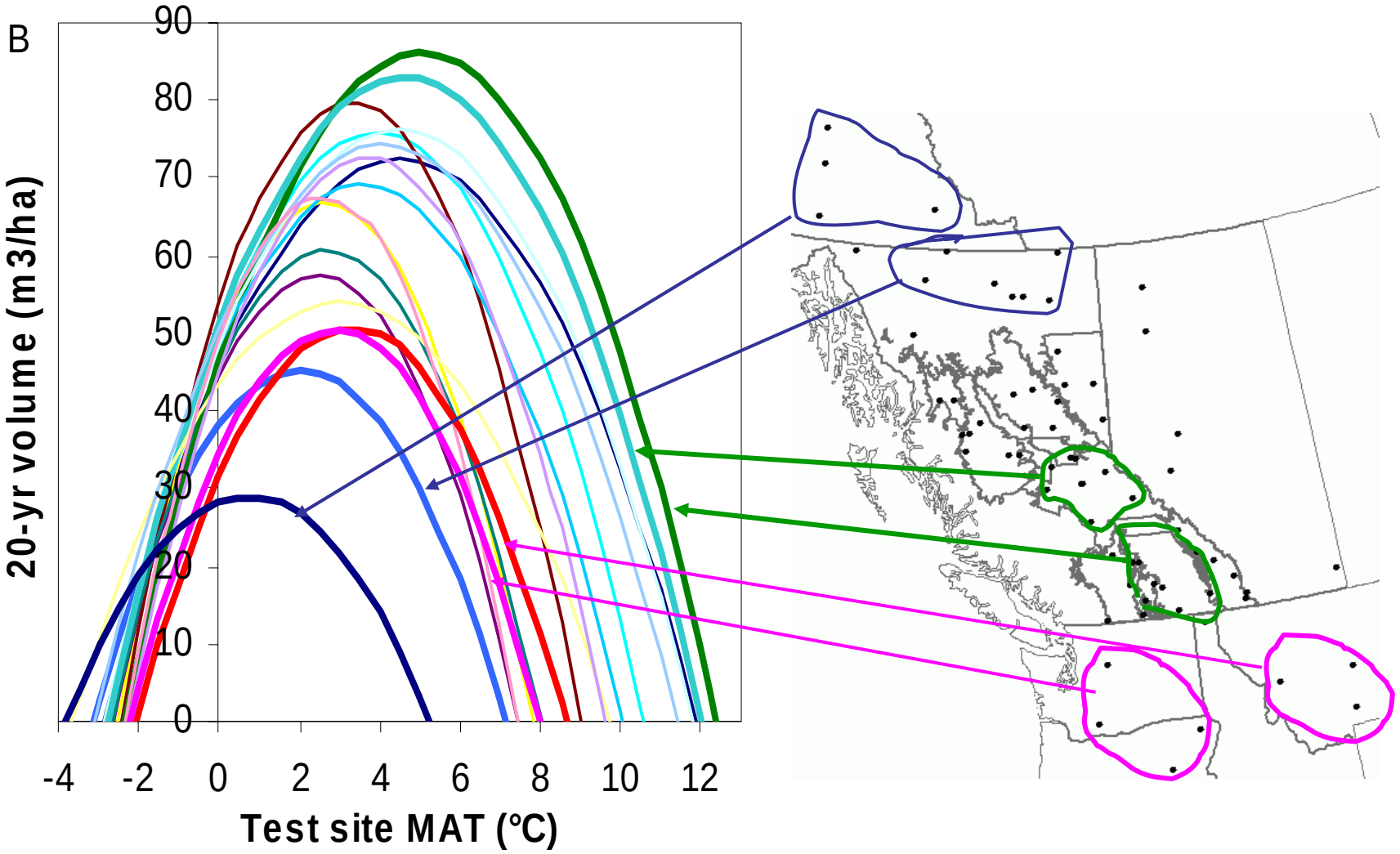
Variation in response of lodgepole pine populations to climate change



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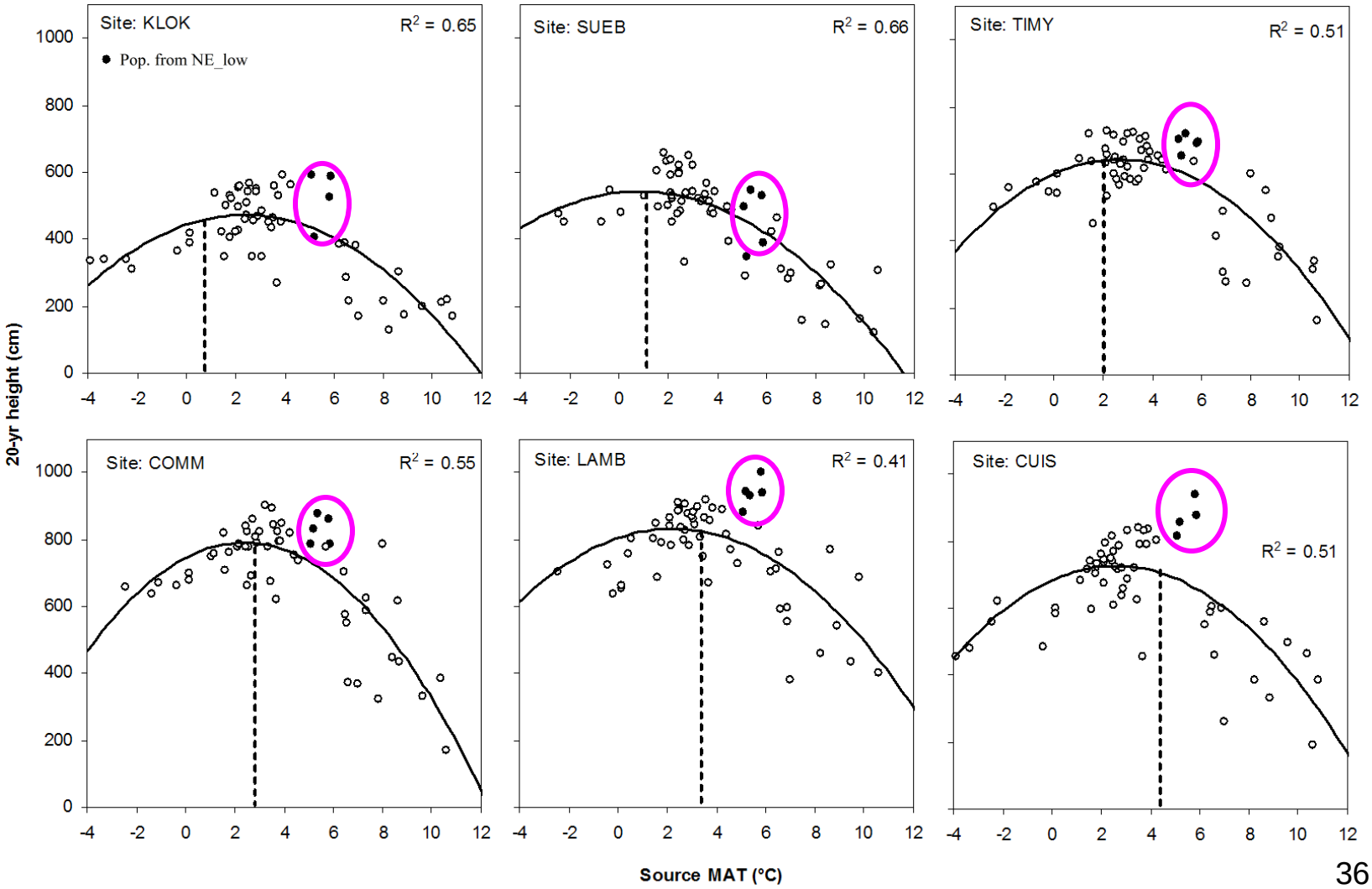
The performance of populations from the best SPU at individual sites



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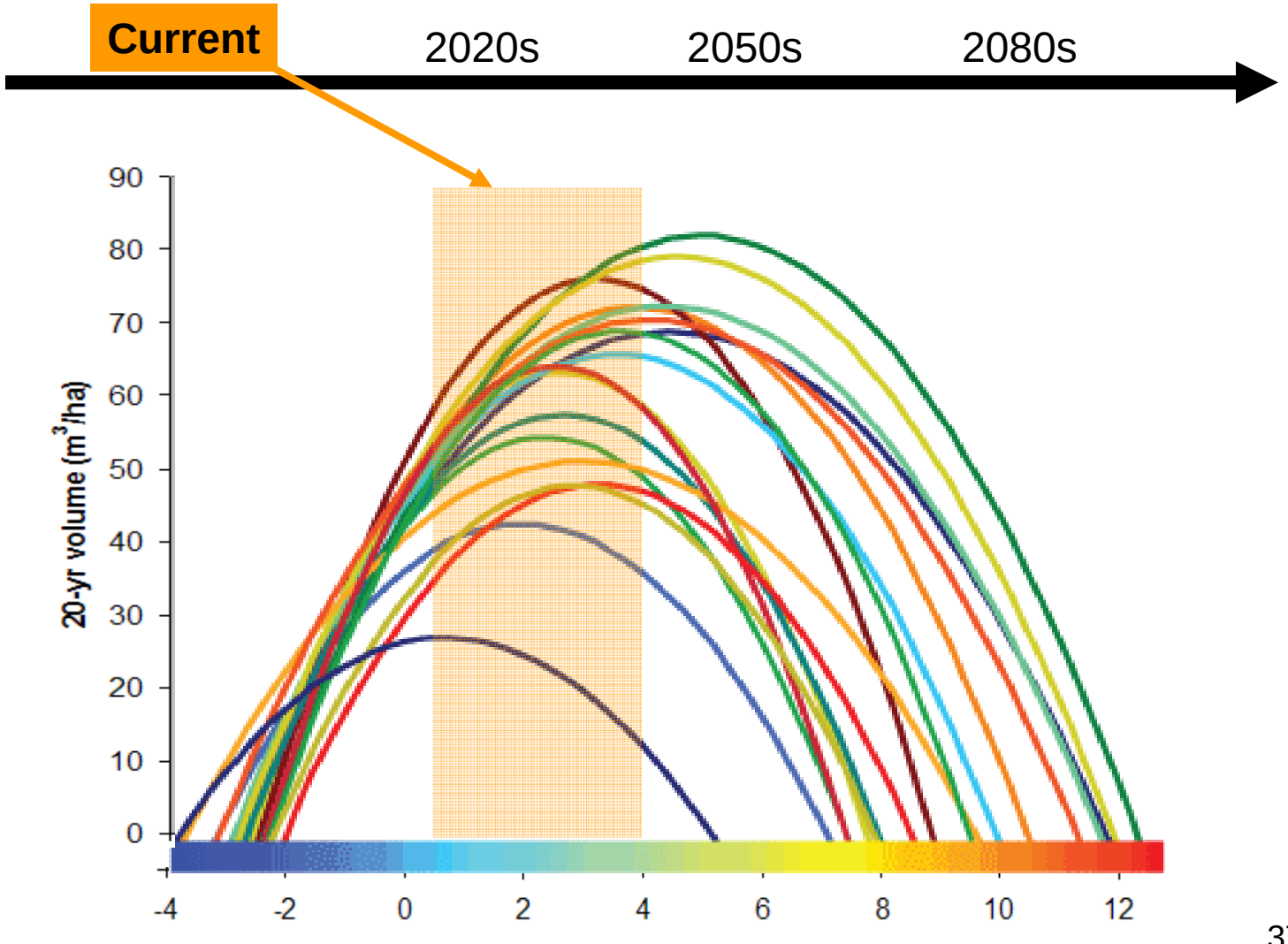
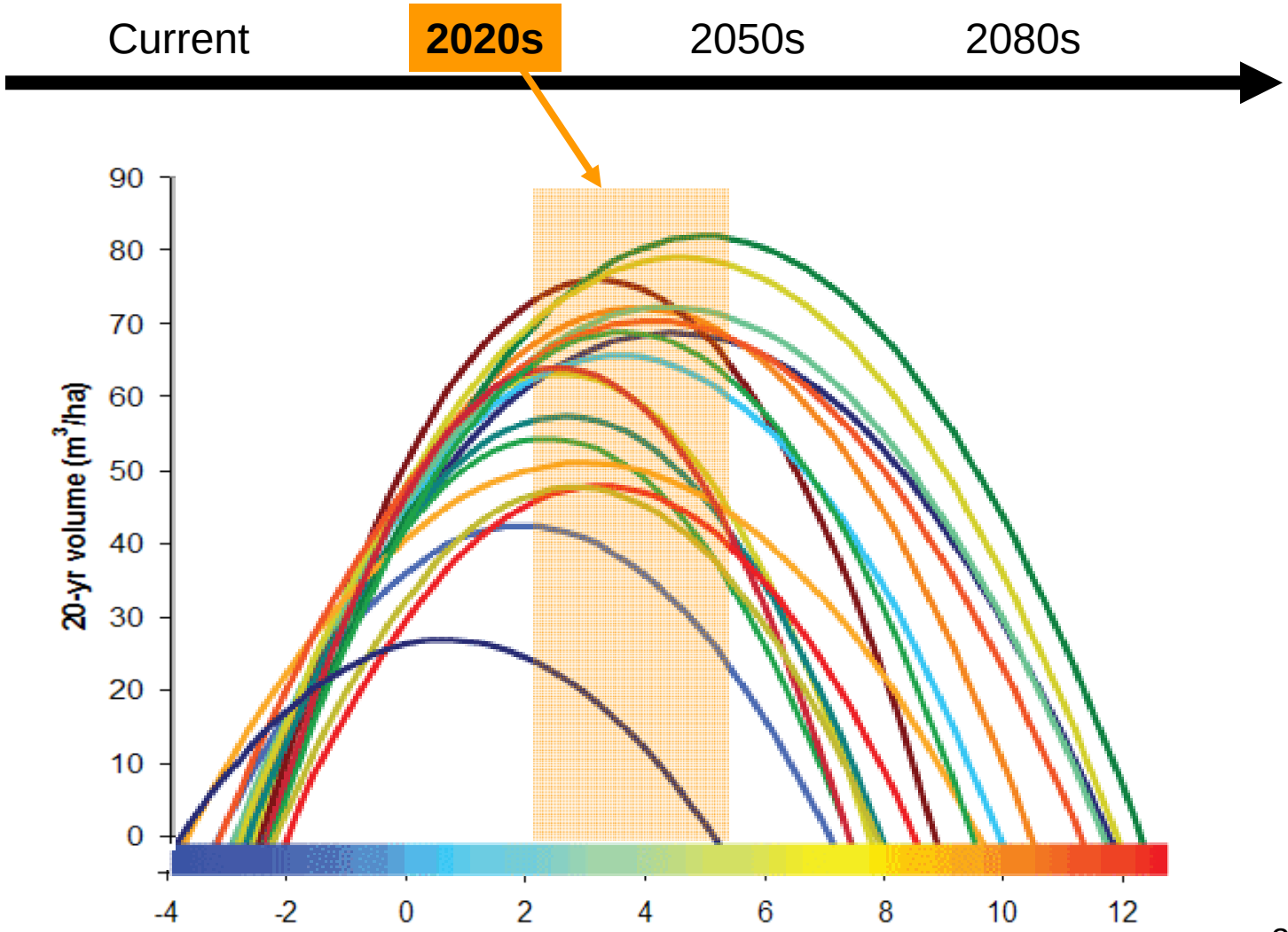
Response of lodgepole pine populations to climate change

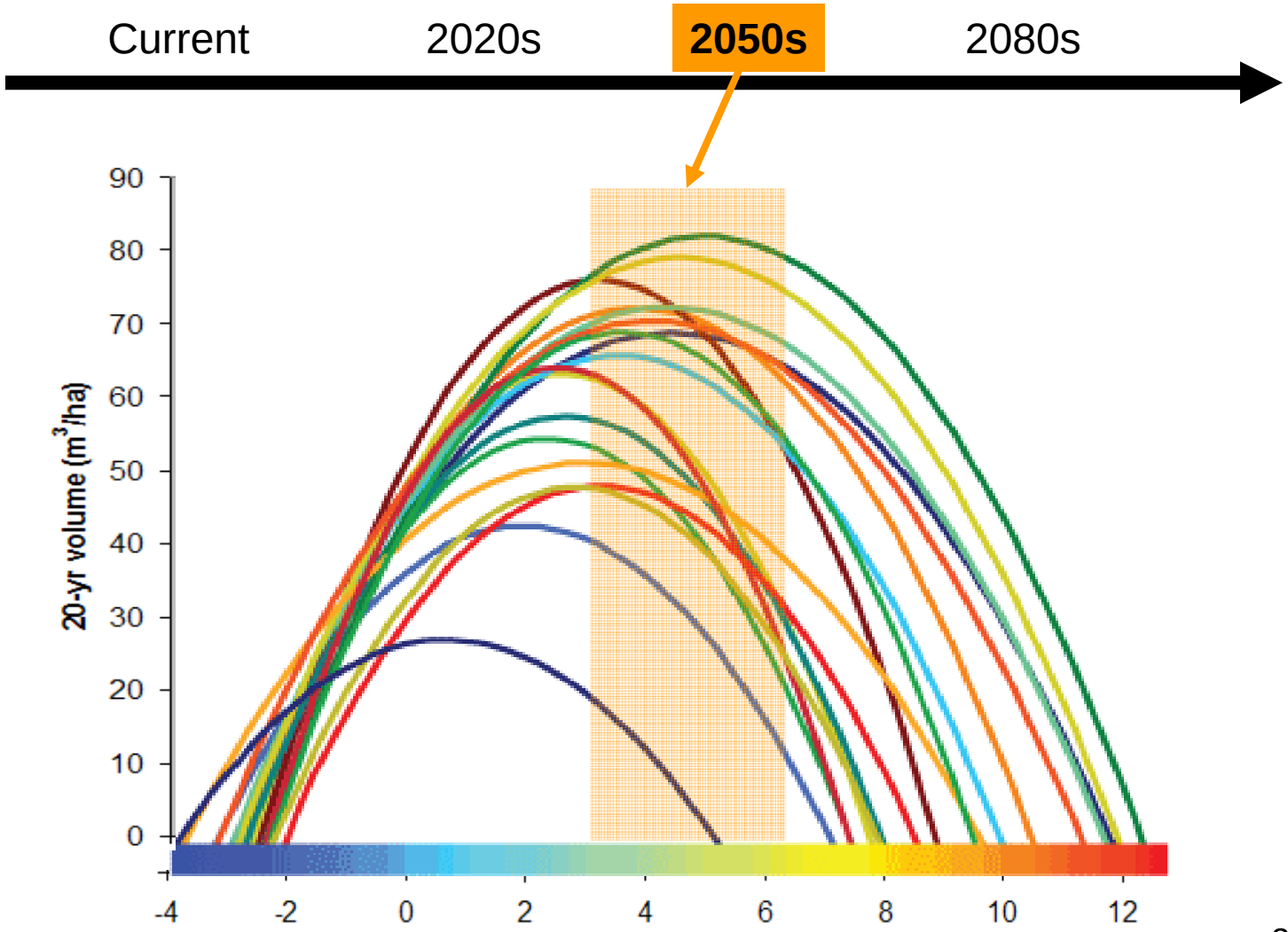


Response of lodgepole pine populations to climate change

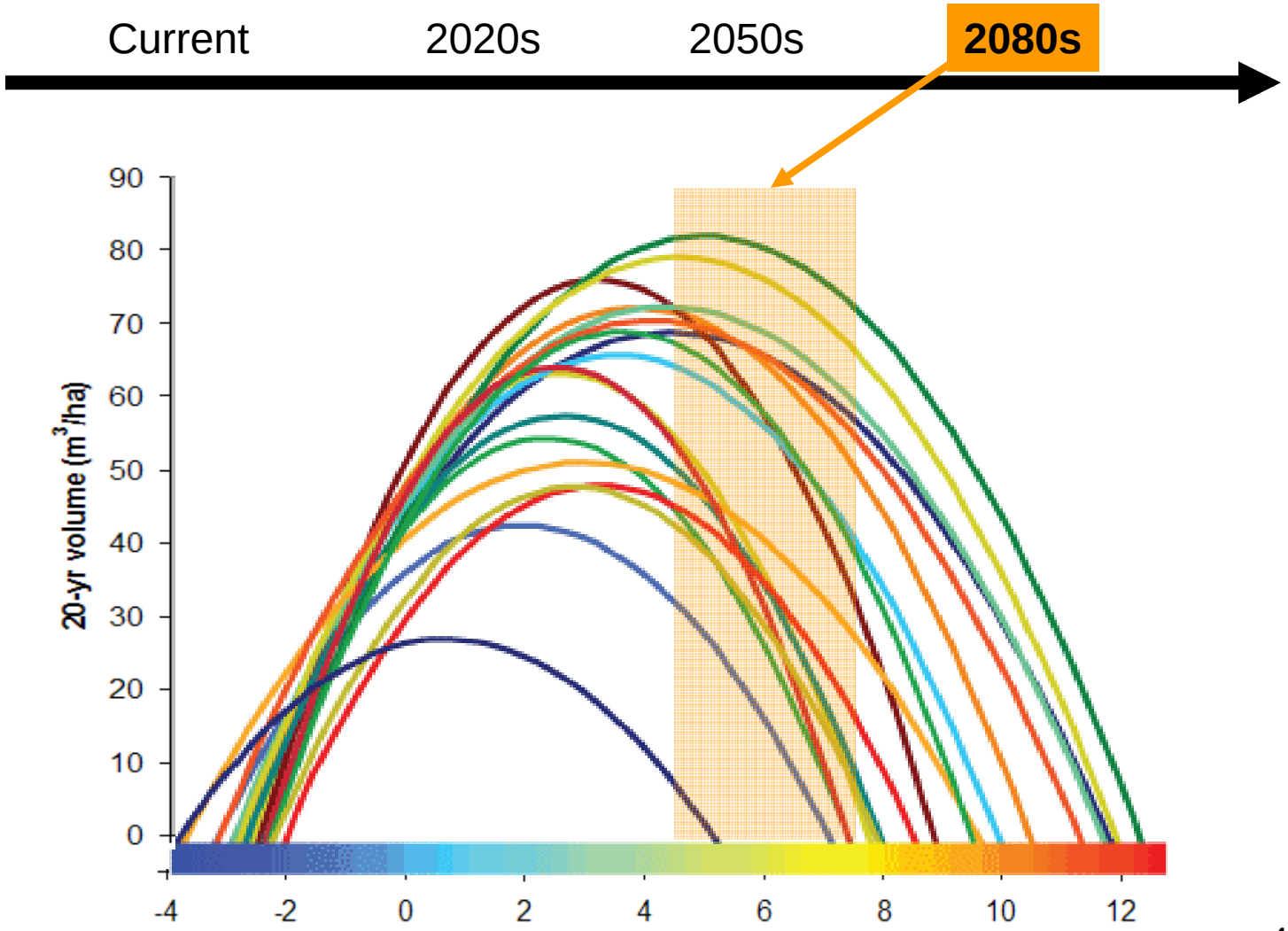


Future climates are based on CGCM2Ax2

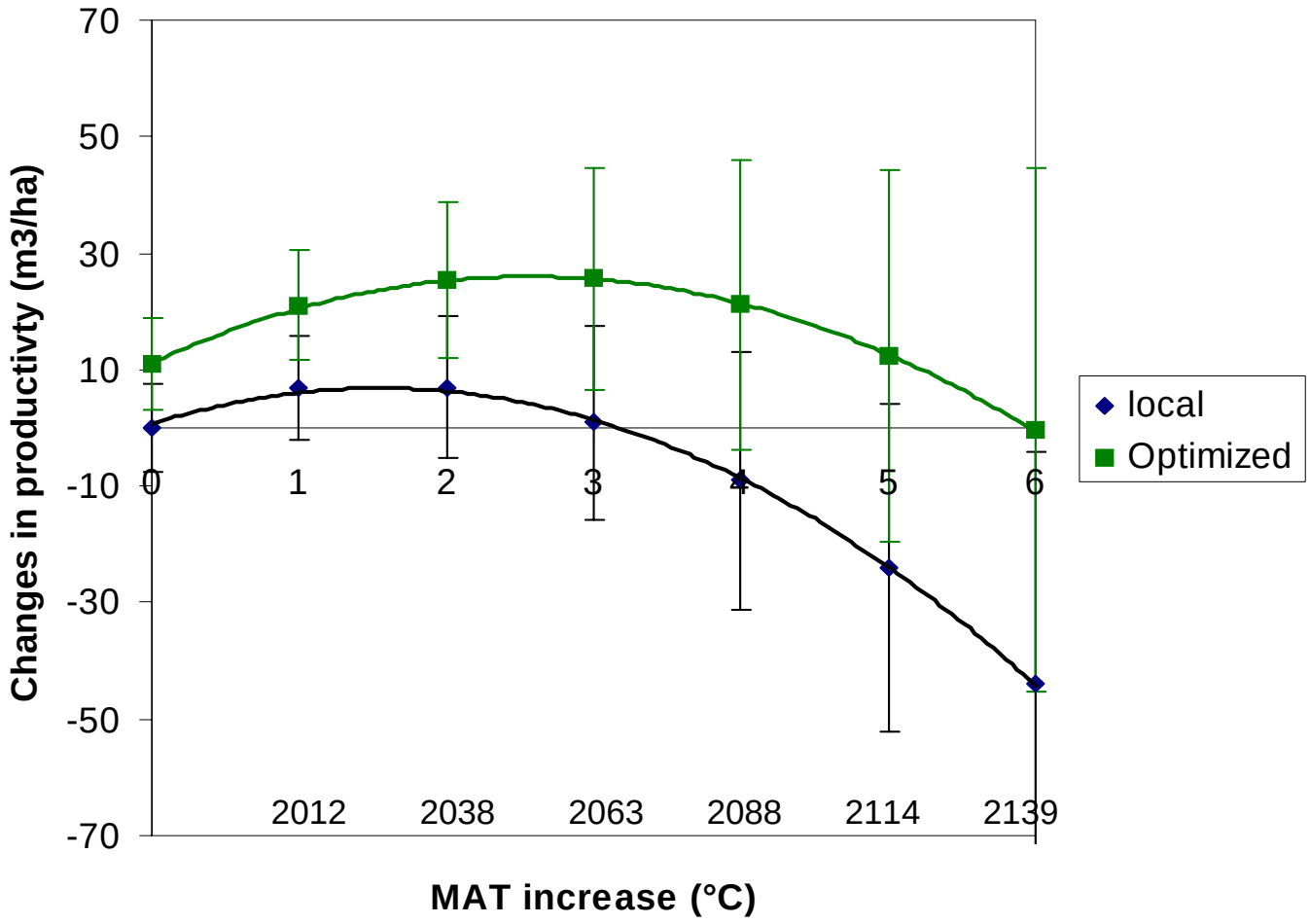
Response of lodgepole pine populations to climate change



Response of lodgepole pine populations to climate change



Optimization predicted to be effective, but uncertainty exists



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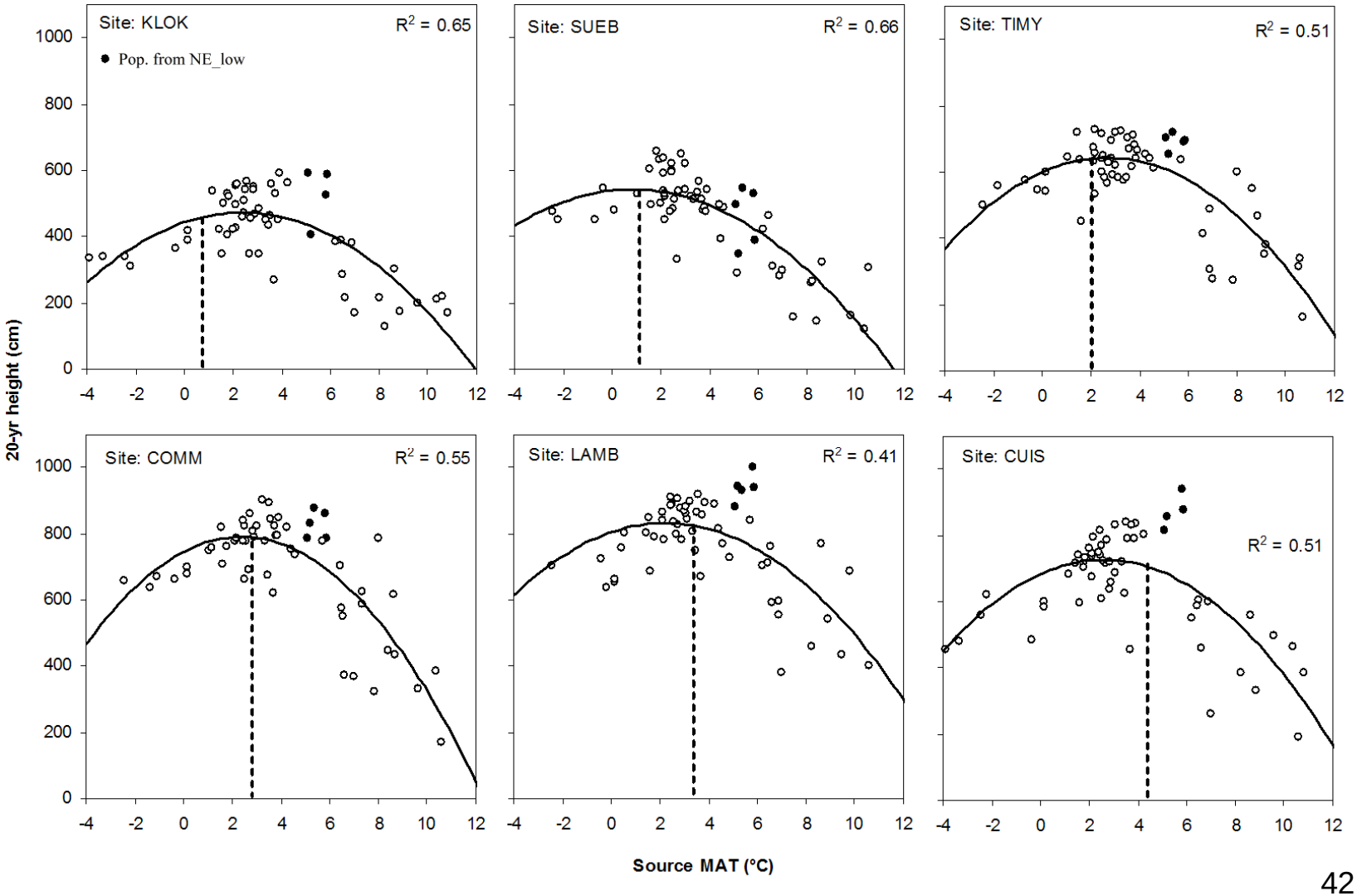
Individual transfer functions



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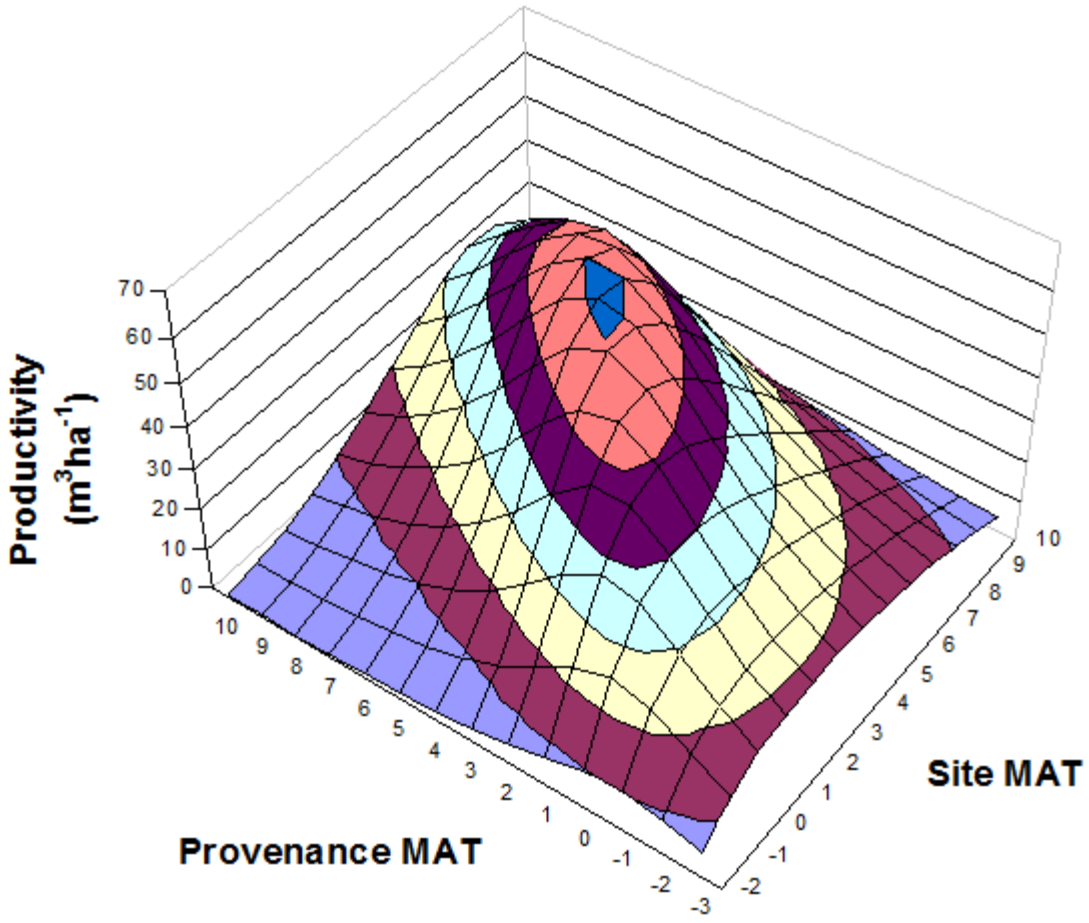
A universal transfer function

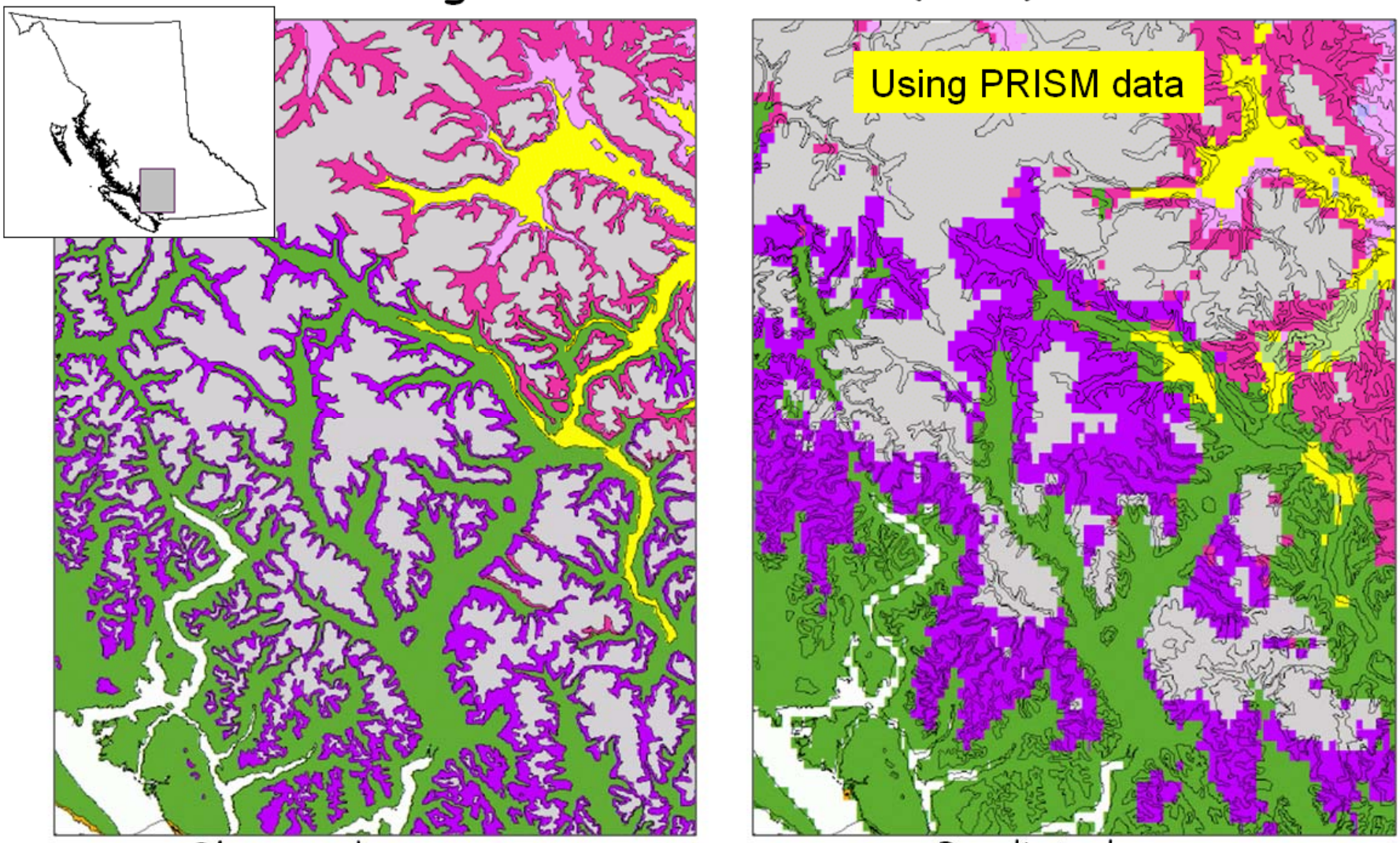


O'Neill, Hamann and Wang 2008, Journal of Applied Ecology

Objectives

- Development of high-resolution climate model
- Development of population response functions to climate
- Predict future climatic envelops for BC ecosystems and species ranges

ClimateBC is critical for climatic mapping of Biogeoclimatic Ecological Classification (BEC) zones

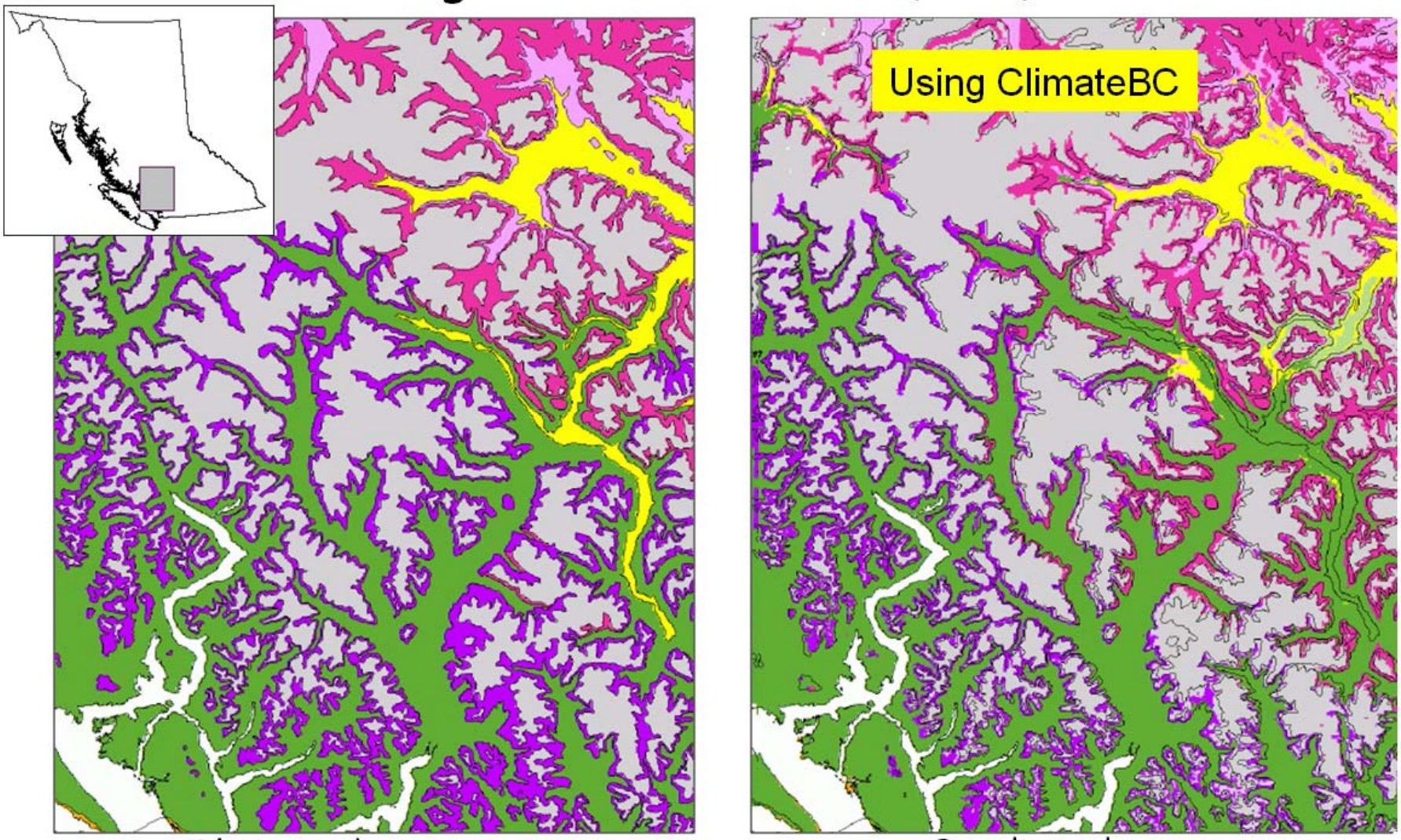


Observed

Predicted

Source: Hamann & Wang. 2005. *Agricultural and Forest Meteorology* **128**: 211-221

ClimateBC is critical for climatic mapping of Biogeoclimatic Ecological Classification (BEC) zones



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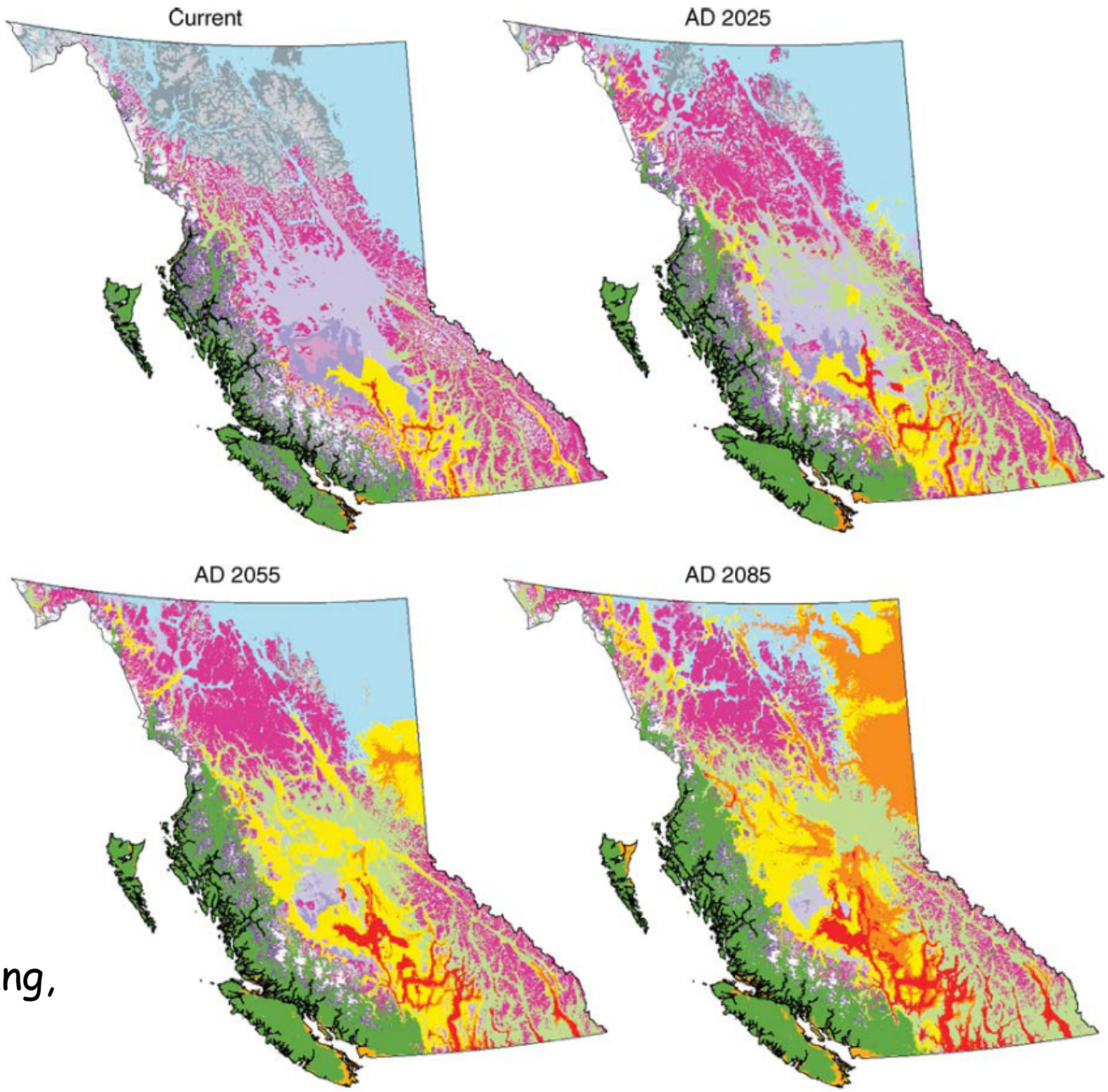
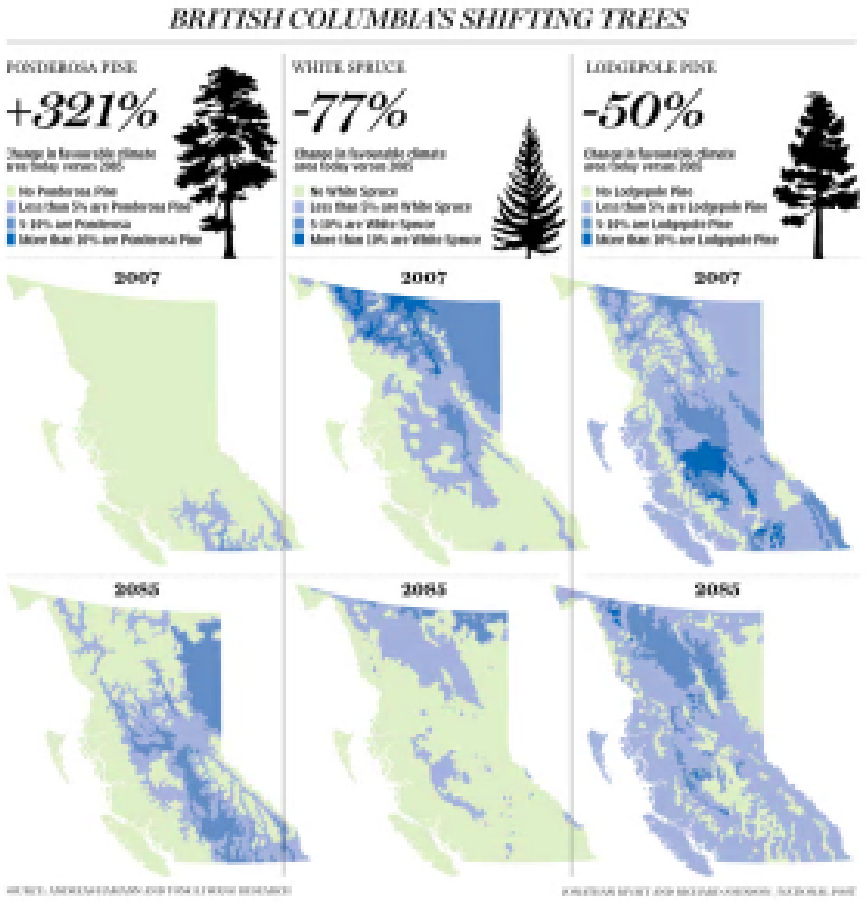


Hamann and Wang, Ecology 2006

On average, expected climate change will equal a seven-degree shift north in latitude, meaning a tree that does well today in Prince George, the heart of B.C.'s forest industry, will grow best north of the Yukon border in 80 years.

Forest for the trees



By Nathan VanderKlippe
in Vancouver

Sierra Curtis-McLane spent much of this week shimmying up whitebark pine trees, wearing a blue rain-coat, industrial-strength rubber gloves and, for a splash of something completely out of place, swim goggles and a swim cap.

Not exactly fashion's finest, but for Ms. Curtis-McLane the point was less about looking good than about trying to understand if she could use a complex new British Columbia climate model to save a species of tree.

That model, developed by the UBC Centre for Forest Gene Conservation, allows research-

it will extend into the far northeastern corner of the province; Coastal Douglas fir will see a 77% growth in its area; Western red cedar 10%.

Still, the news is not good. It's especially bad for Ms. Curtis-McLane's whitebark pine, which according to the model will see fully 86% of its area disappear.

Whitebark pine has already served as a kind of early warning system for climate change problems. In recent years, some of its B.C. populations have been cut in half. South of the U.S. border, populations have been almost completely wiped out in a scenario that could be replicated among other species in a warming climate. As the climate warms, trees lose their ability to repel attackers in ways already being seen in the whitebark, which has been

Acknowledgements

- Funding:
  - Forest Genetics Council of BC
  - BC Forest Science Program
  - Future Forest Ecosystem Initiative