

Making choices in uncertain times:

species selection &
genetic considerations

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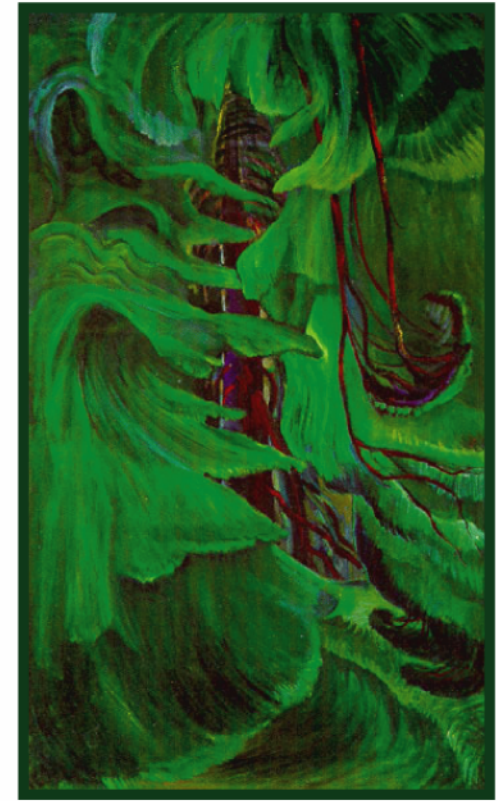
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Uncertainty



Species selection



Genetic issues

Forests:
"Perfectly ordered disorder designed
with a helter-skelter magnificence."

Emily Carr



Uncertainty



Species selection



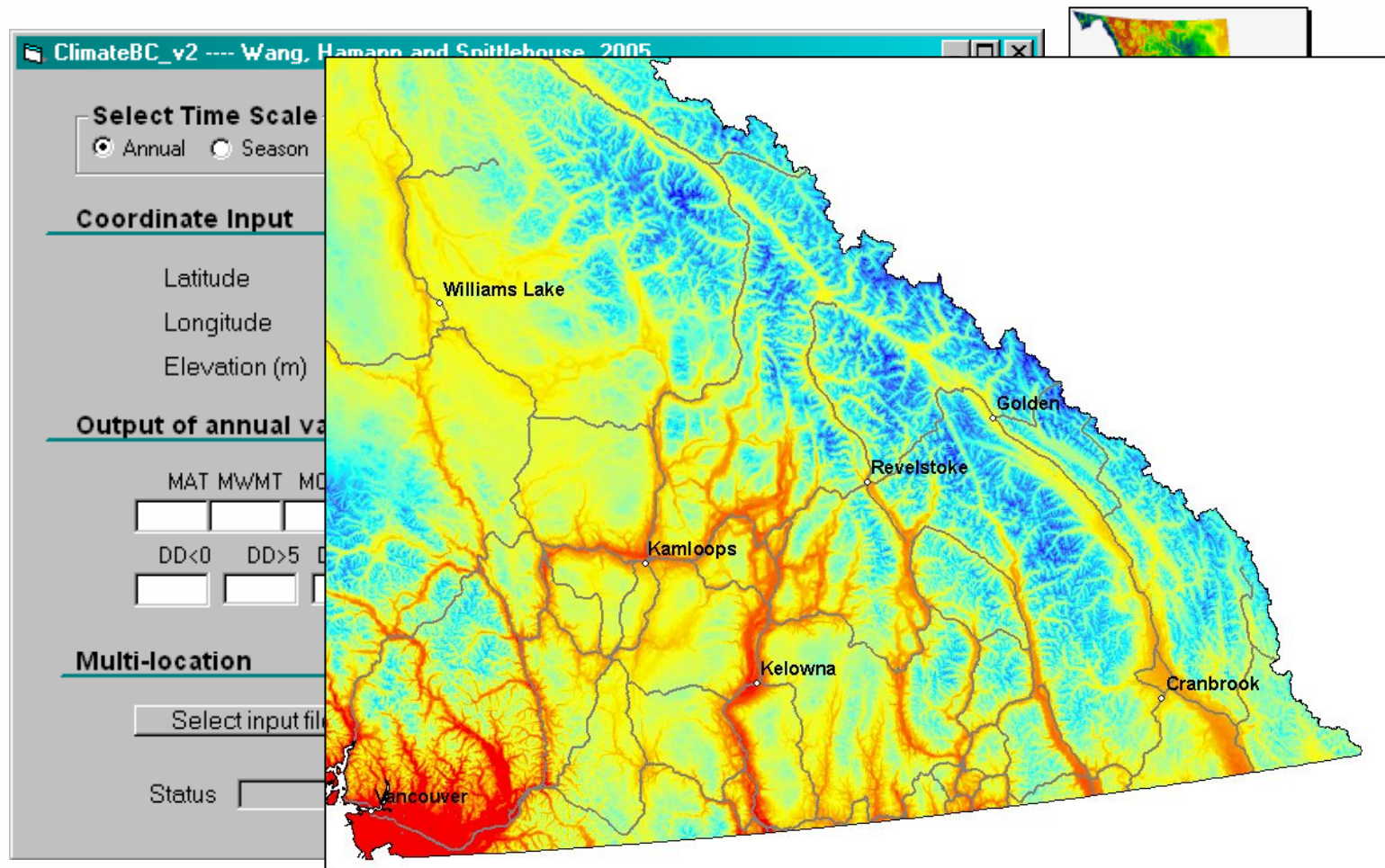
Genetic issues

Uncertainty

- Climatic uncertainty
- Biological uncertainty
- Economic and social uncertainty
- Uncertainty about when I will finish (and you will get to the bar)



ClimateBC Model allows scale-free prediction of current and future climates

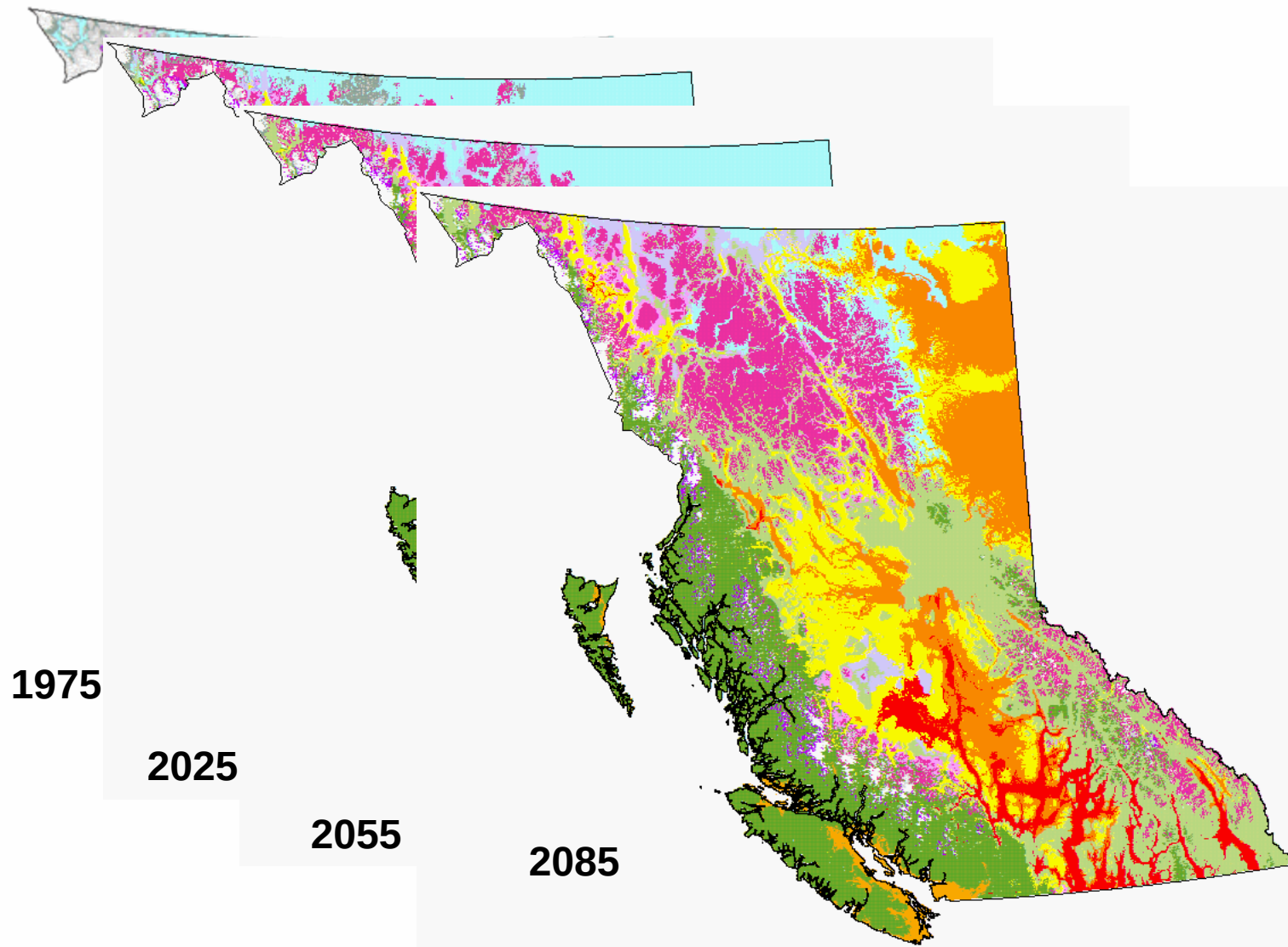
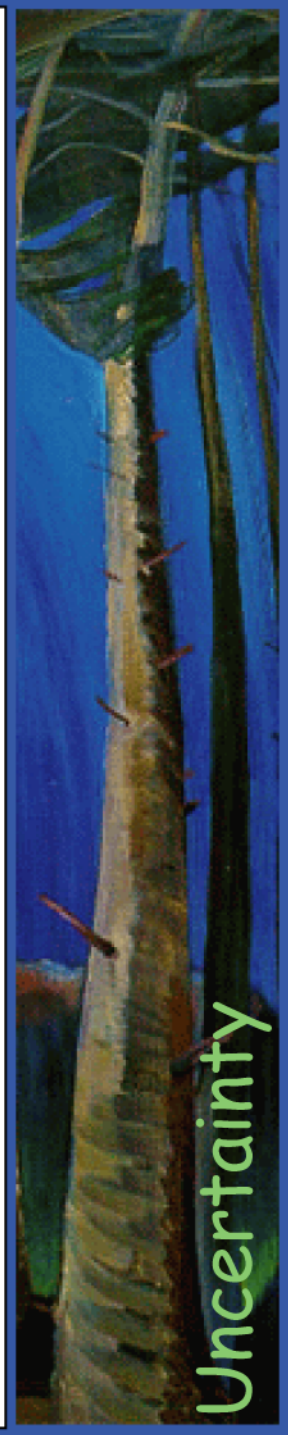


Hamann & Wang 2004 *Agr. & For. Meteor.* 126: 211-221

Wang, Hamann, Spittlehouse and Aitken. *Int. J. Climat.* In press.

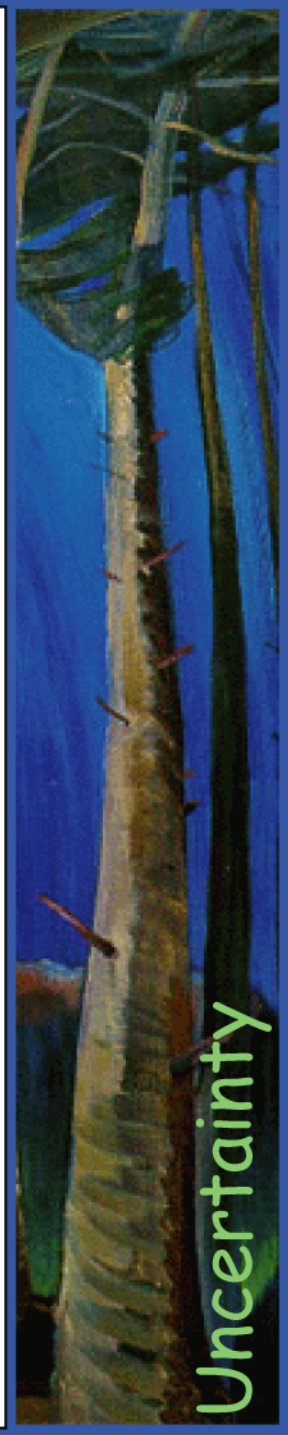


Predicted BEC zone climate envelopes 1975-2085



'There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact.'

- Mark Twain



Why won't BEC zones and species ranges 'fly' as predicted?

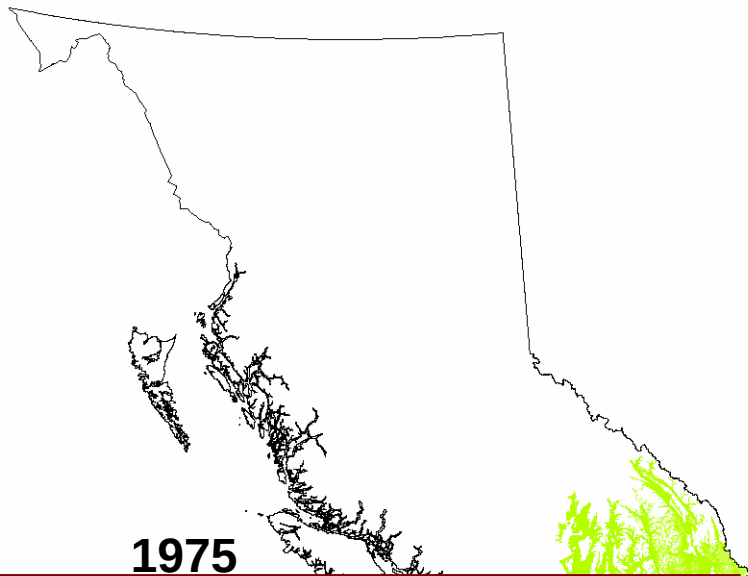
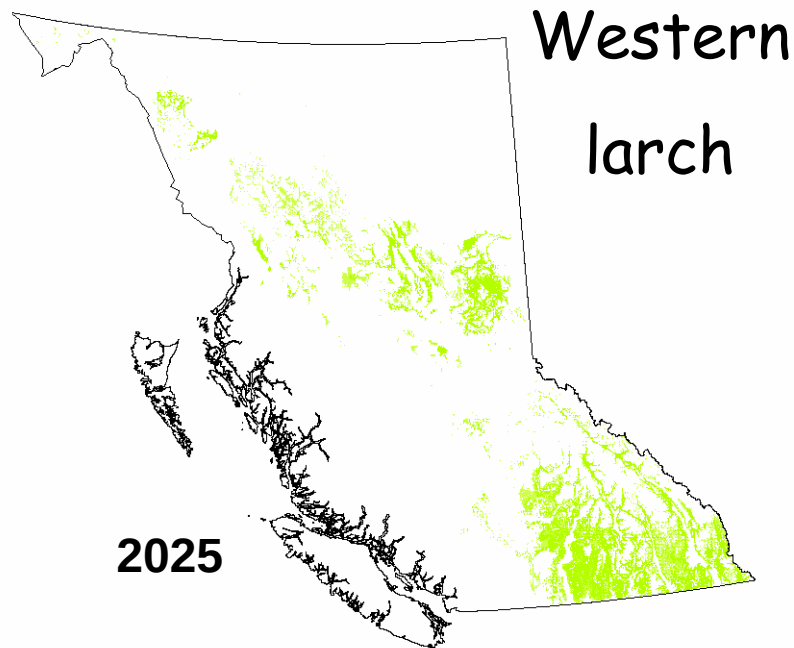
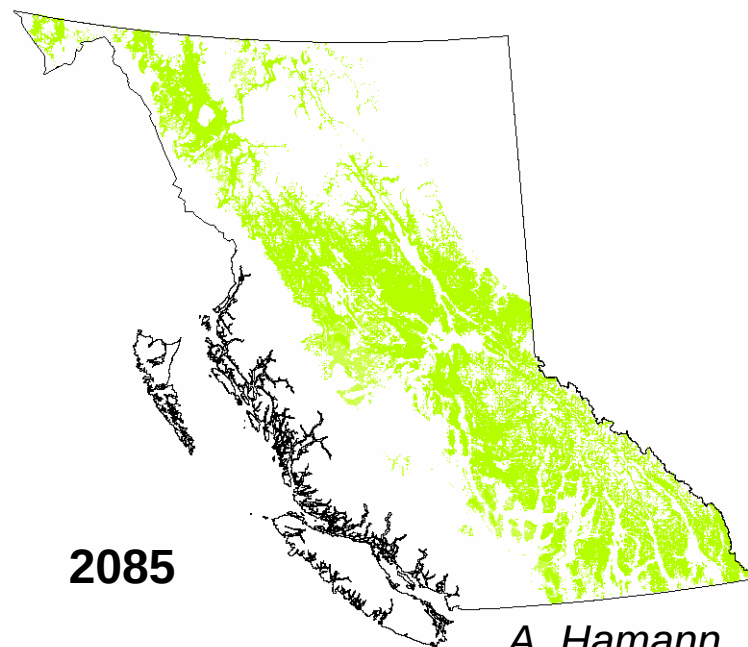
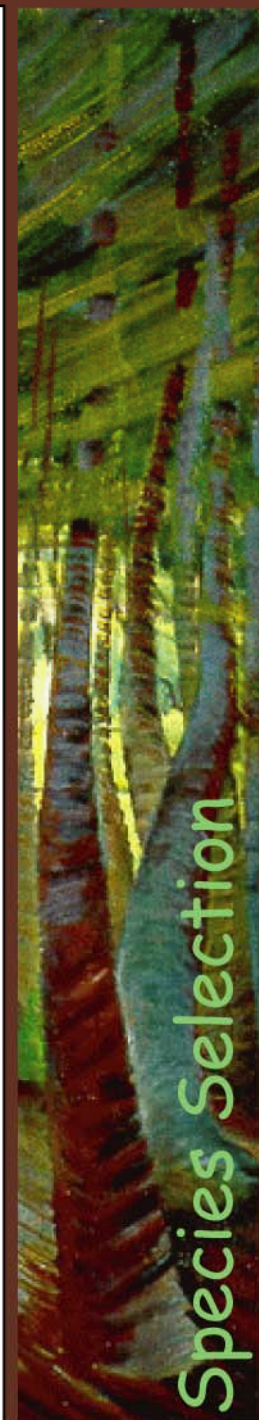
- Predictions are for multidimensional 'climatic envelopes' not actual future distributions of species and species associations
- Errors and uncertainty in predictions:
 - 1) extrapolation of BEC zone and species ranges from field plots
 - 2) Extrapolation of climate from weather stations (model error)
 - 3) Global Circulation Model assumptions and uncertainties, and errors in downscaling
 - 4) most species can't migrate as quickly as climate will (seed production, dispersal and disturbance)
 - 6) species competitive interactions may change;
 - 7) impacts of pests and pathogens (native and introduced) will likely change (e.g., MPB, *Dothistroma*)

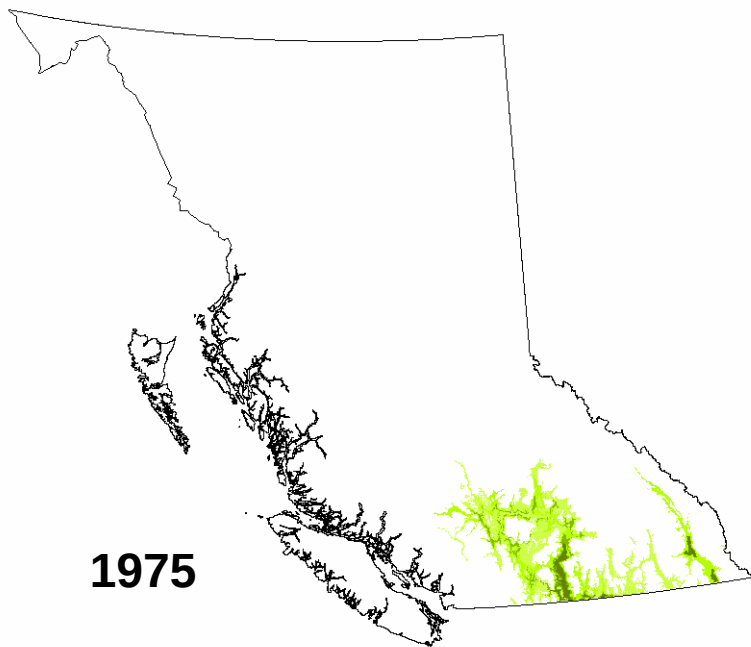
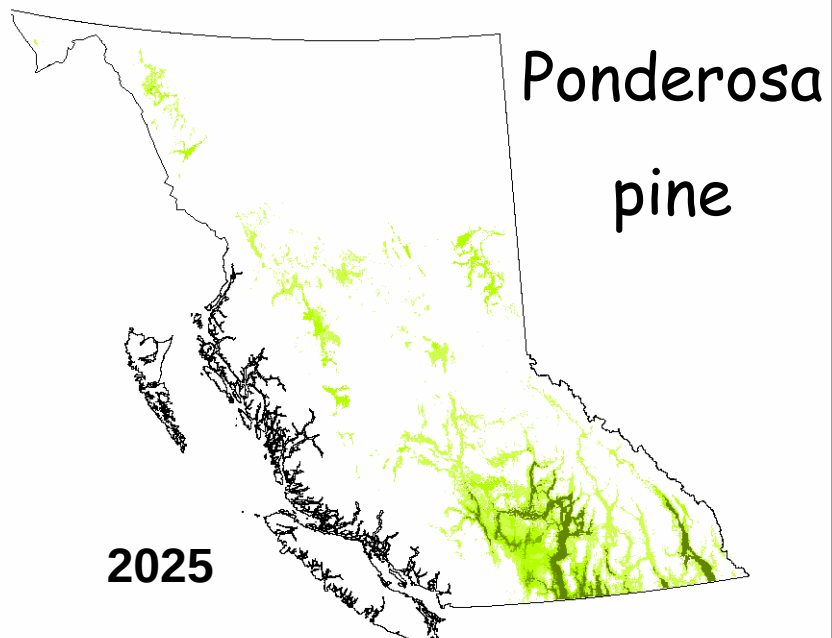
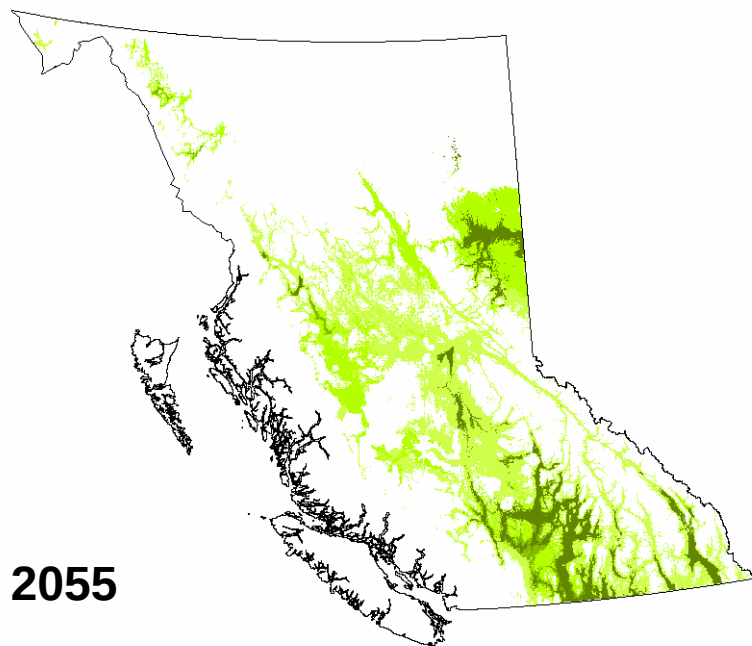
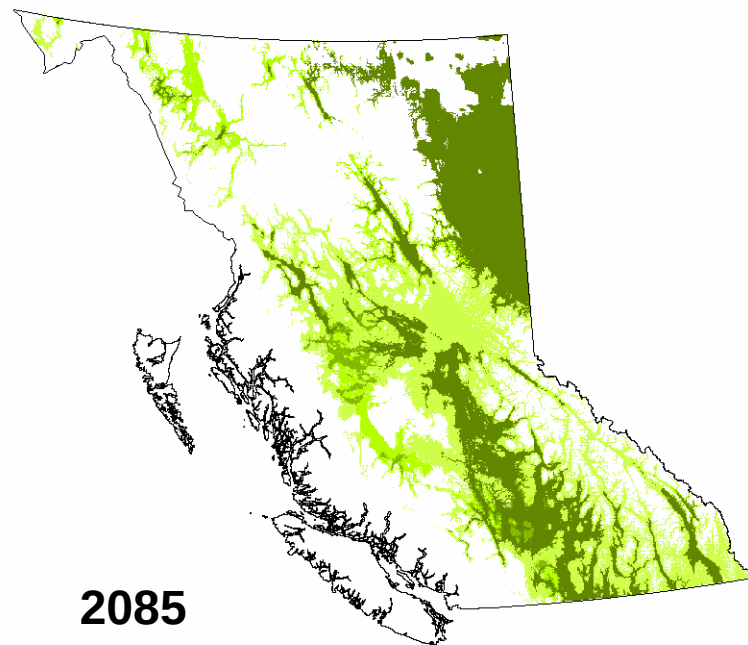


Species selection

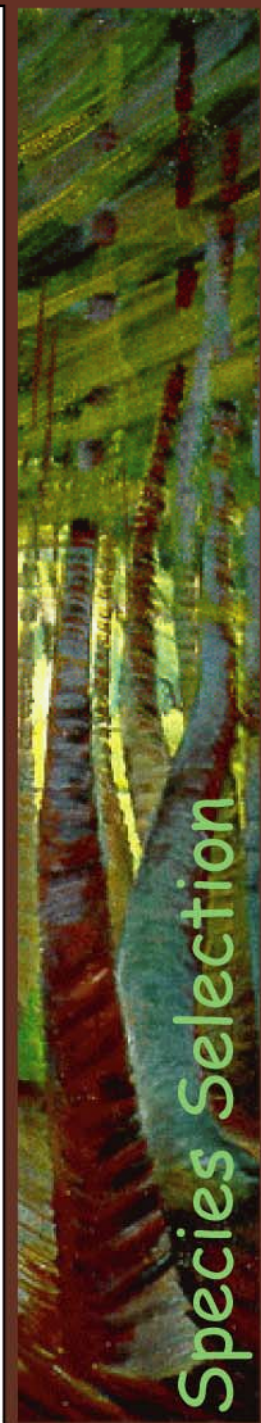
- Even if climate does not change, species choices could improve
- Given climate change predictions, greater consideration of species with a northern range limit in southern BC is needed
- Climatic response functions of all species need to be better characterized
- Species with wider climatic niches will be safer bets, but more narrowly adapted species offer landscape level diversity
- No compelling reason to use exotics at this time







A. Hamann





Clear evidence of changes in insects and diseases related to climate change, but are ranges changing yet?



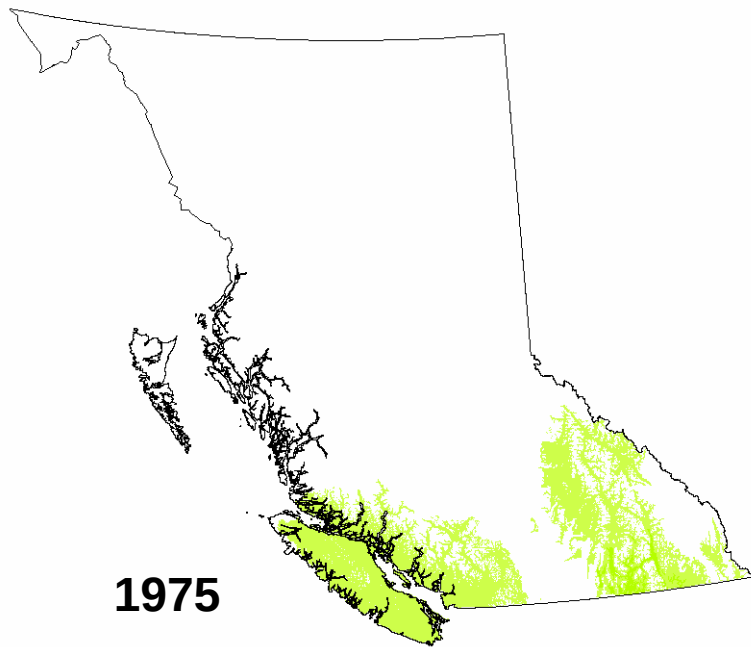
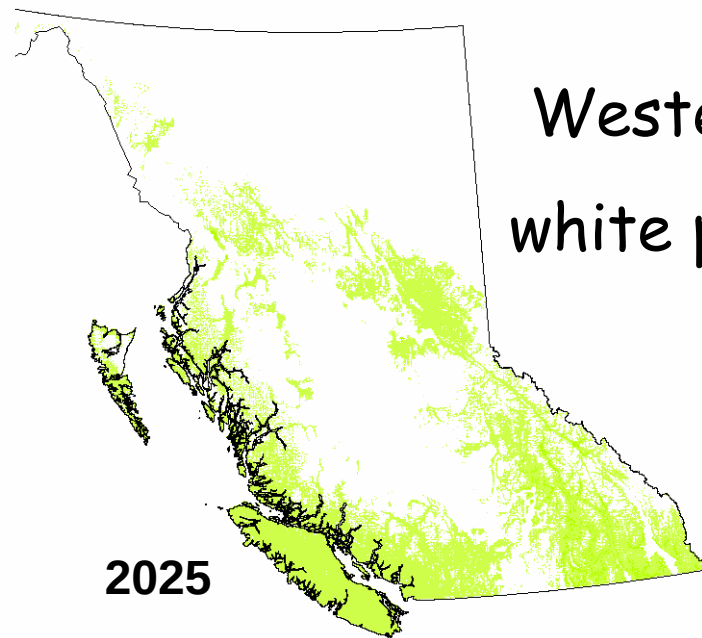
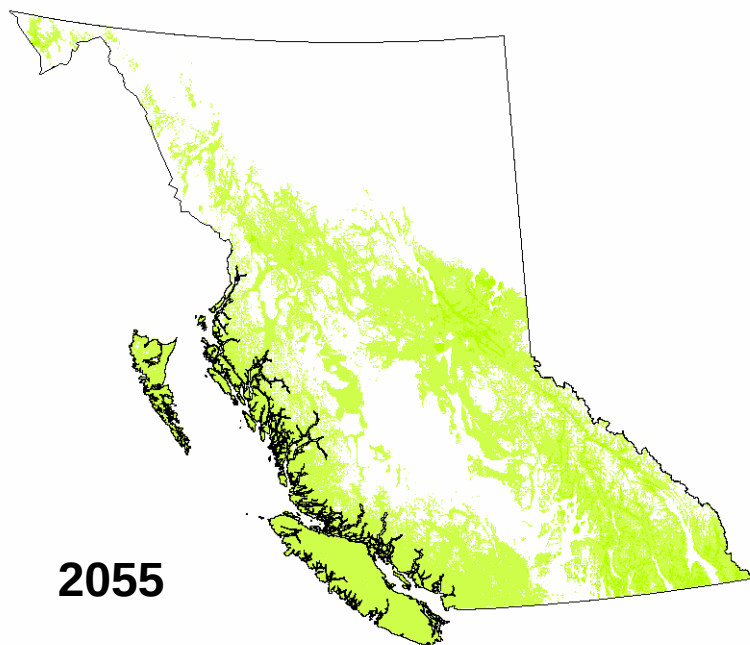
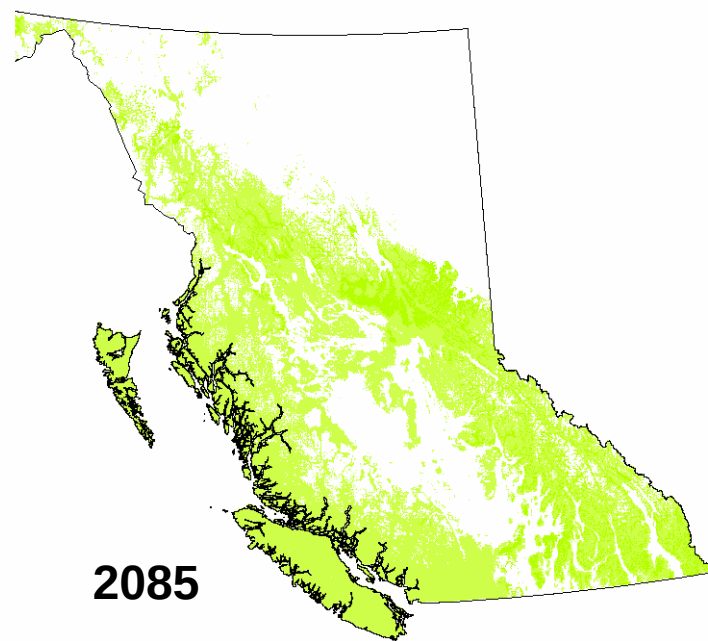
Ponderosa pine north of Clinton



Limits to Species Ranges

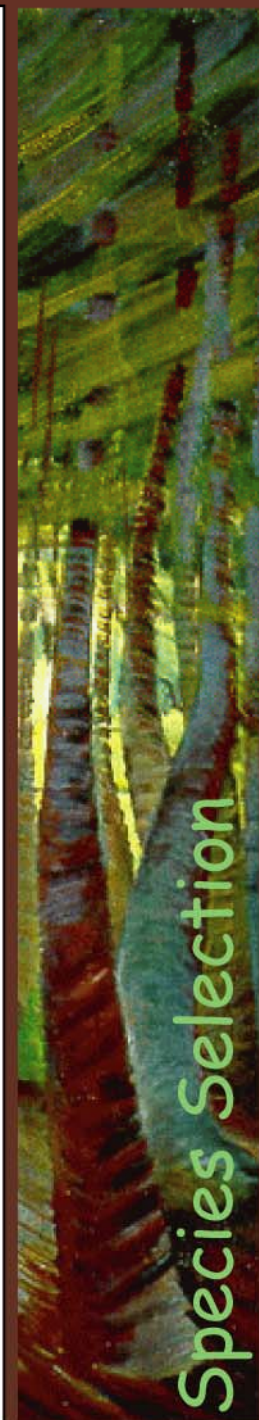
- Why don't species ranges evolve to cover a wider range of environmental conditions?
- Possible factors:
 - Abiotic factors causing damage or mortality to seedlings (e.g., frost, drought)?
 - Interspecific competition?
 - Low density resulting in low pollination success?
 - Inability to complete reproductive cycle?
 - Gene flow from other environments limiting local adaptation?

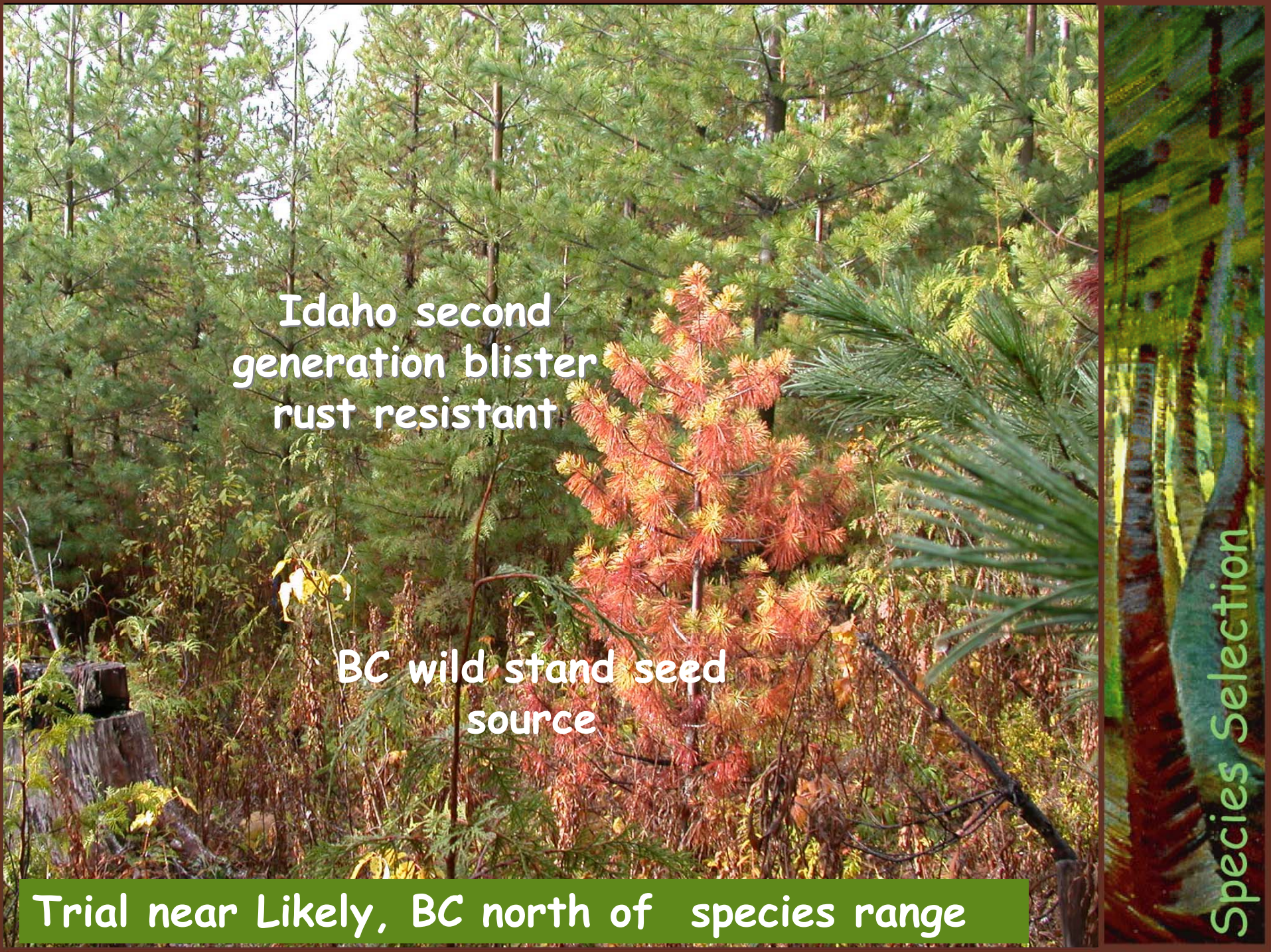




Western
white pine

A. Hamann



A photograph of a forest scene. In the center, a young tree stands out with its needles turned a vibrant orange and yellow, contrasting with the surrounding green pine trees. The background is a dense forest of tall, thin evergreen trees. The ground is covered with dry, brownish vegetation and some green ferns. A tree stump is visible on the left side.

Idaho second
generation blister
rust resistant

BC wild stand seed
source

Trial near Likely, BC north of species range

Species Selection

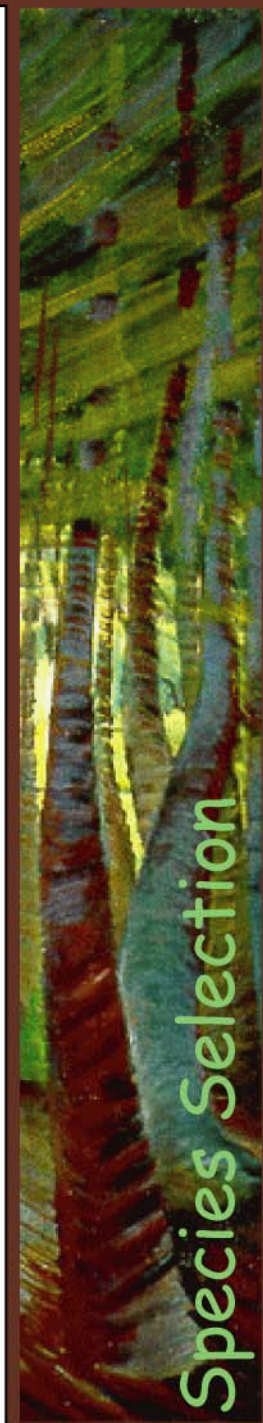
Example: Limits to northern periphery of western white pine

- Heat sum (degree days) rather than timing of frost events appears to determine northern limit
- Strong correlation between seed weight and latitude of northern species margin
- Degree days may be sufficient for vegetative growth but not complete maturation of rather large seed (I. Chuine, unpublished data)
- Ability to reproduce is not critical in plantations (nor is ability for seed to germinate and establish)
- White pine blister rust resistant genotypes should be tested over a wider range of colder environments

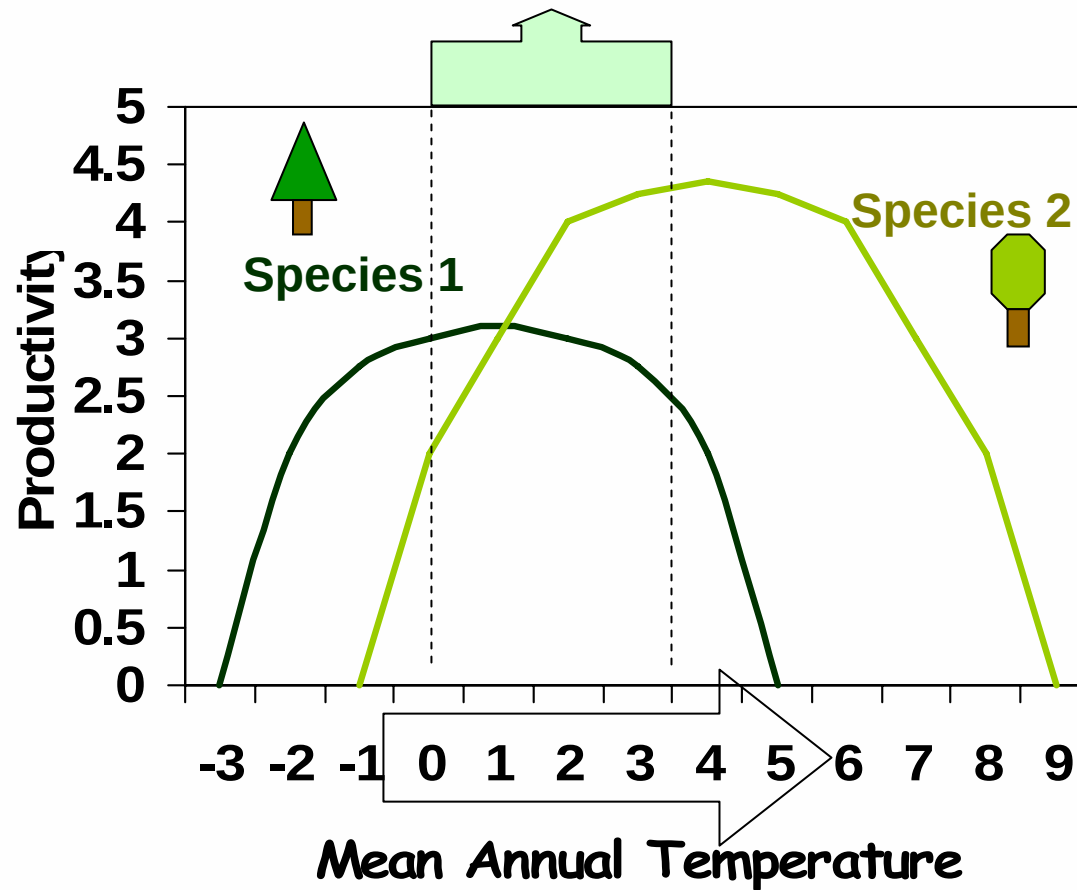


Species mixtures

- With uncertainty around environmental conditions, 'smart' species mixtures may reduce risk
- However, if planting density is high and climate changes after crown closure, species mixes may not reduce risk if one species dominates early
- Minor species components in mixed plantings may be a good way to test species beyond their current ranges
- Natural regeneration and green tree retention will contribute to diversity and resilience
- Are there opportunities to expand planting of 'minor' species for specialty wood products?

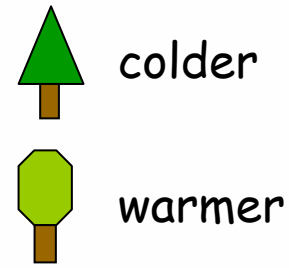
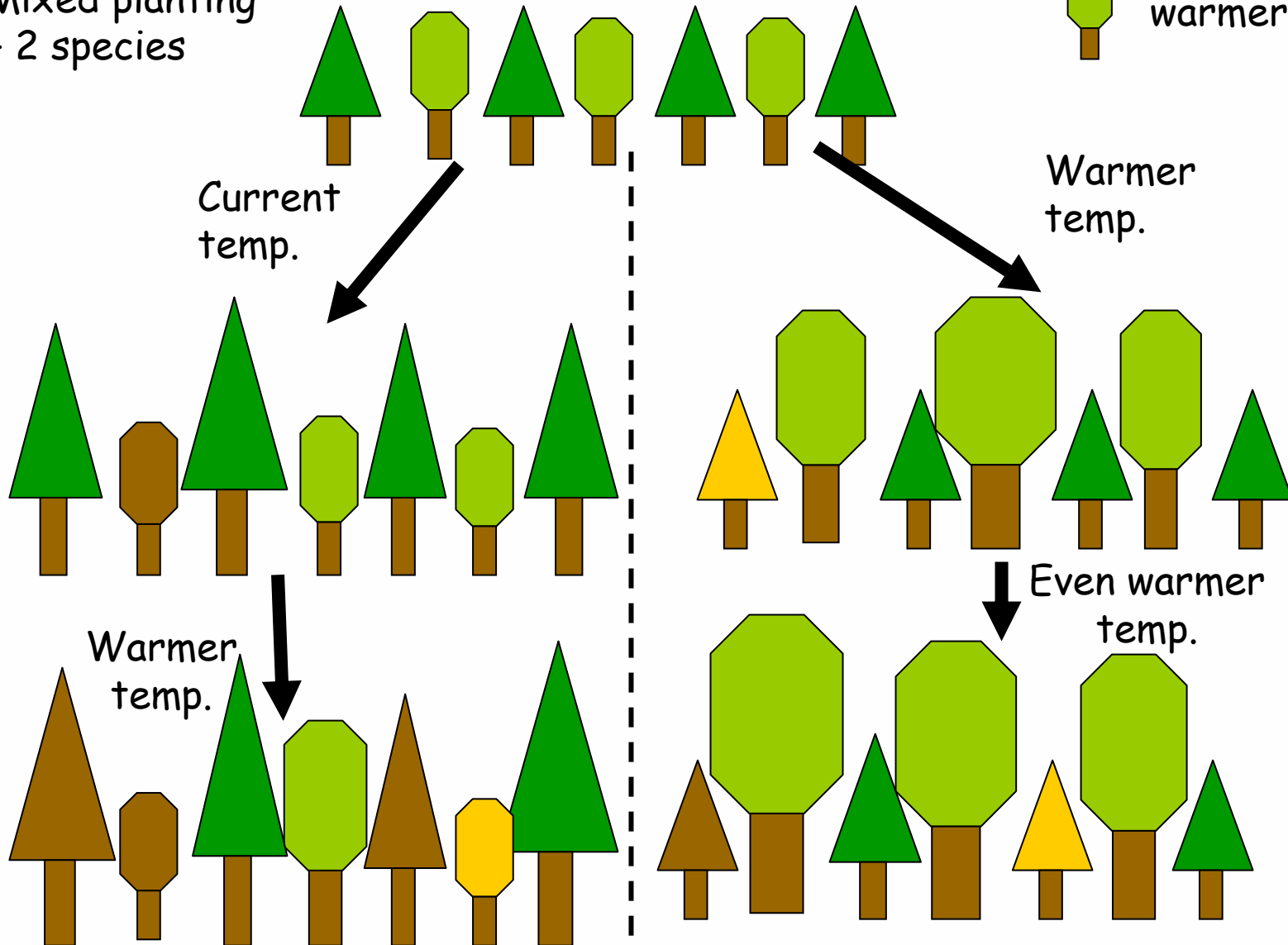
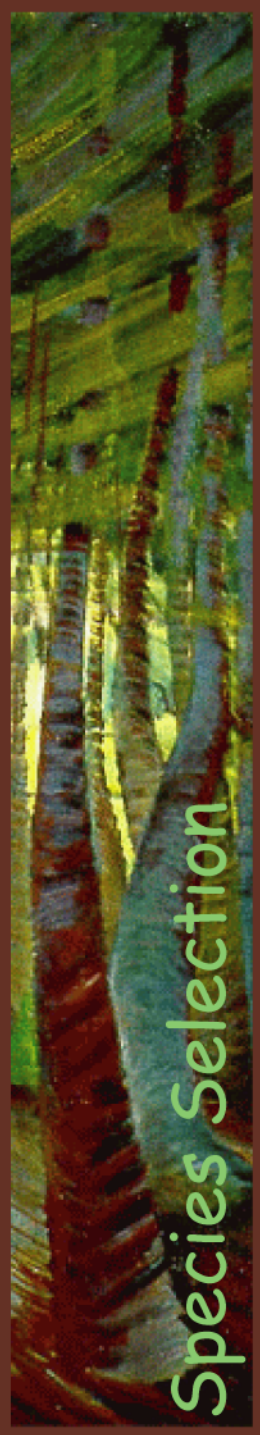


A species mix will likely only be more productive than a single species over some climatic range

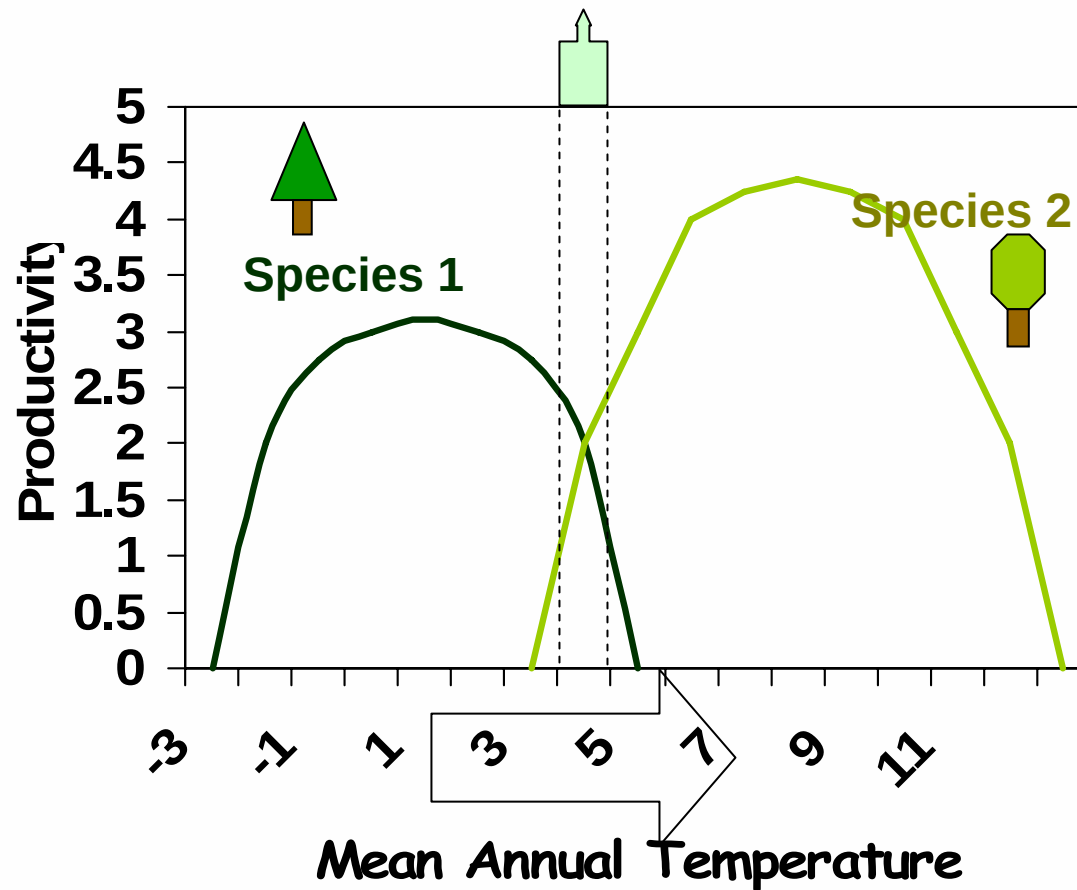


Possible outcomes of mixed species stands depend on the rate of climate change relative to stand development

Mixed planting
- 2 species



Extent to which species mixtures reduce risk will depend on breadth and overlap of species climatic envelopes



Genetic Issues

- Like species, populations vary in environmental tolerance
- Provenance selection, seed transfer and breeding are all tools for dealing with climate change
- Although some provenance trials are fairly large, test sites are lacking at climatic extremes
- Current seed transfer guidelines favour movement from warmer to colder climates, but do not optimize current or future deployment
- Seed orchards may serve new areas in future, but demands will change

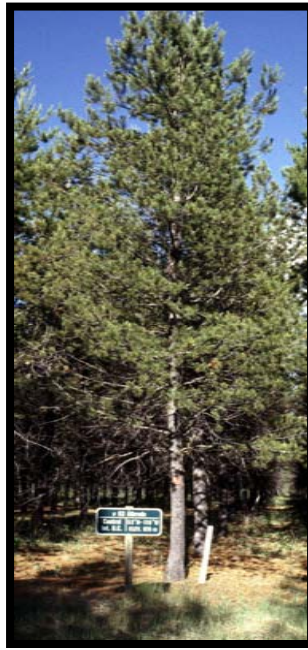


Is "local" the best seed source for reforestation in current or future climates?

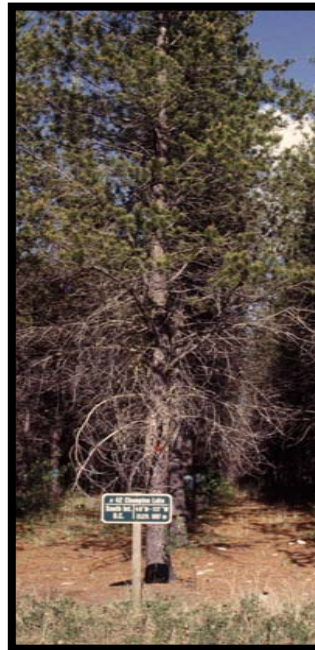
- Lodgepole pine a good model for adaptation to climate
- 20-year data from ~153 provenances of *Pinus contorta* growing on 60 test sites (Illingworth trial) used to assess optimal deployment in current and predicted future climates



Manning
49 N



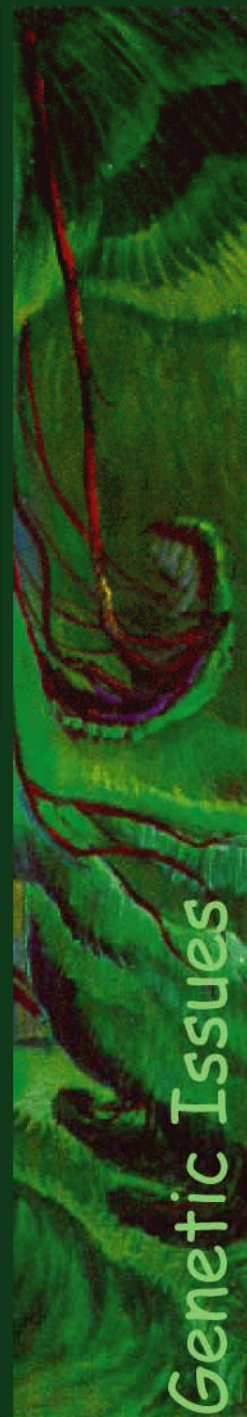
Albreda
52 N



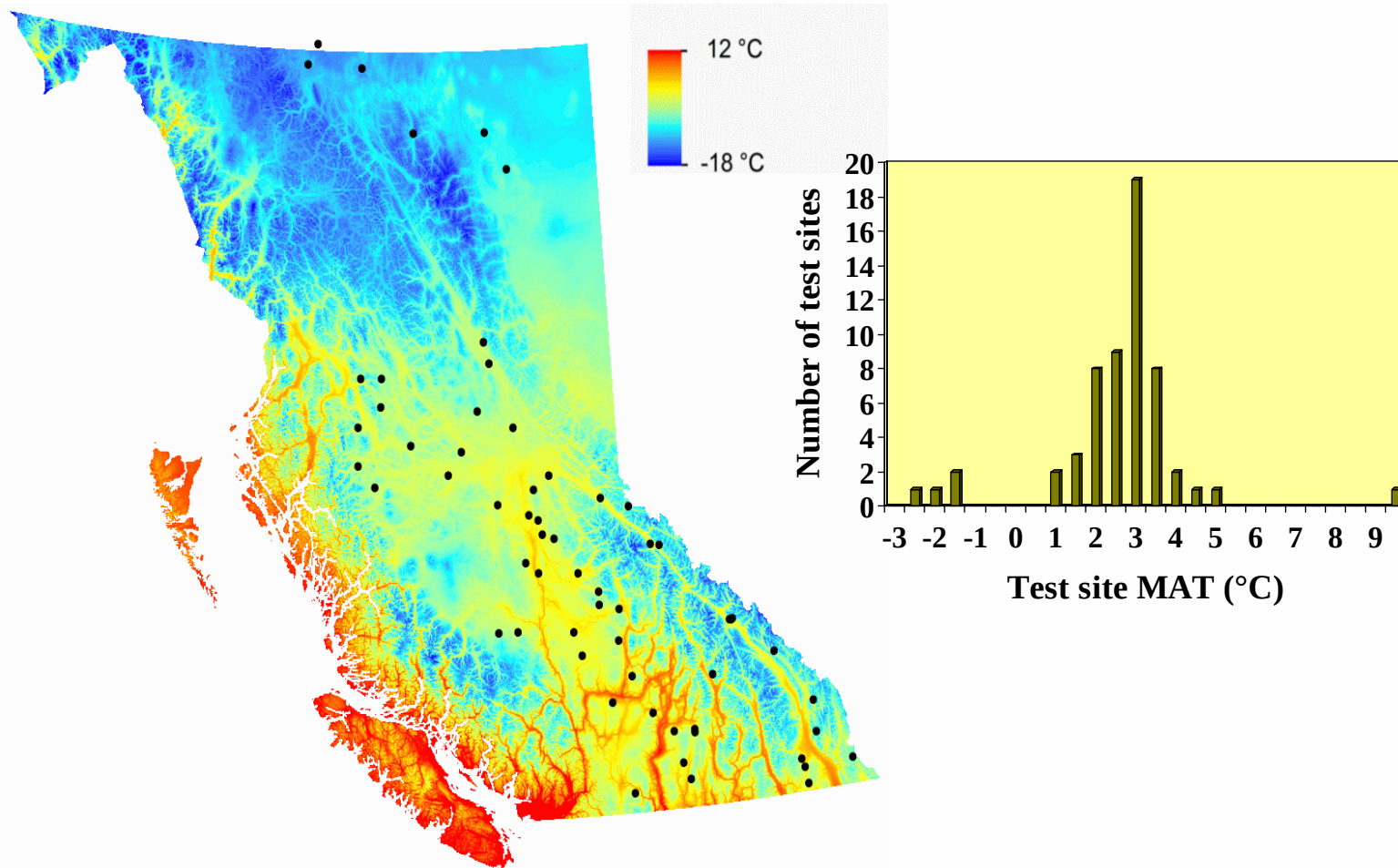
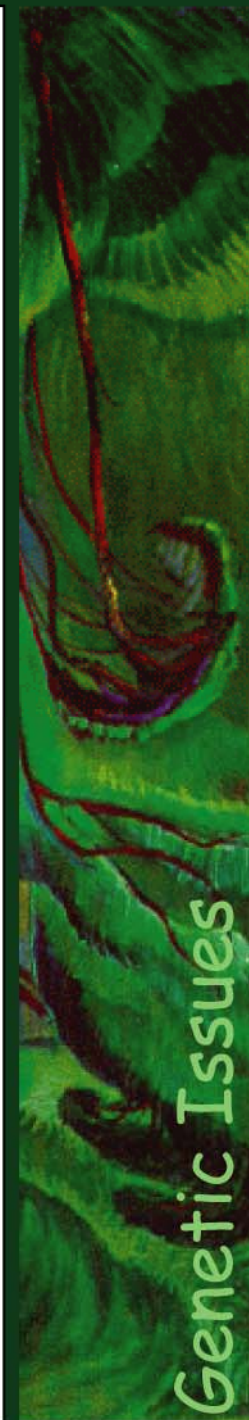
Champion
49 N



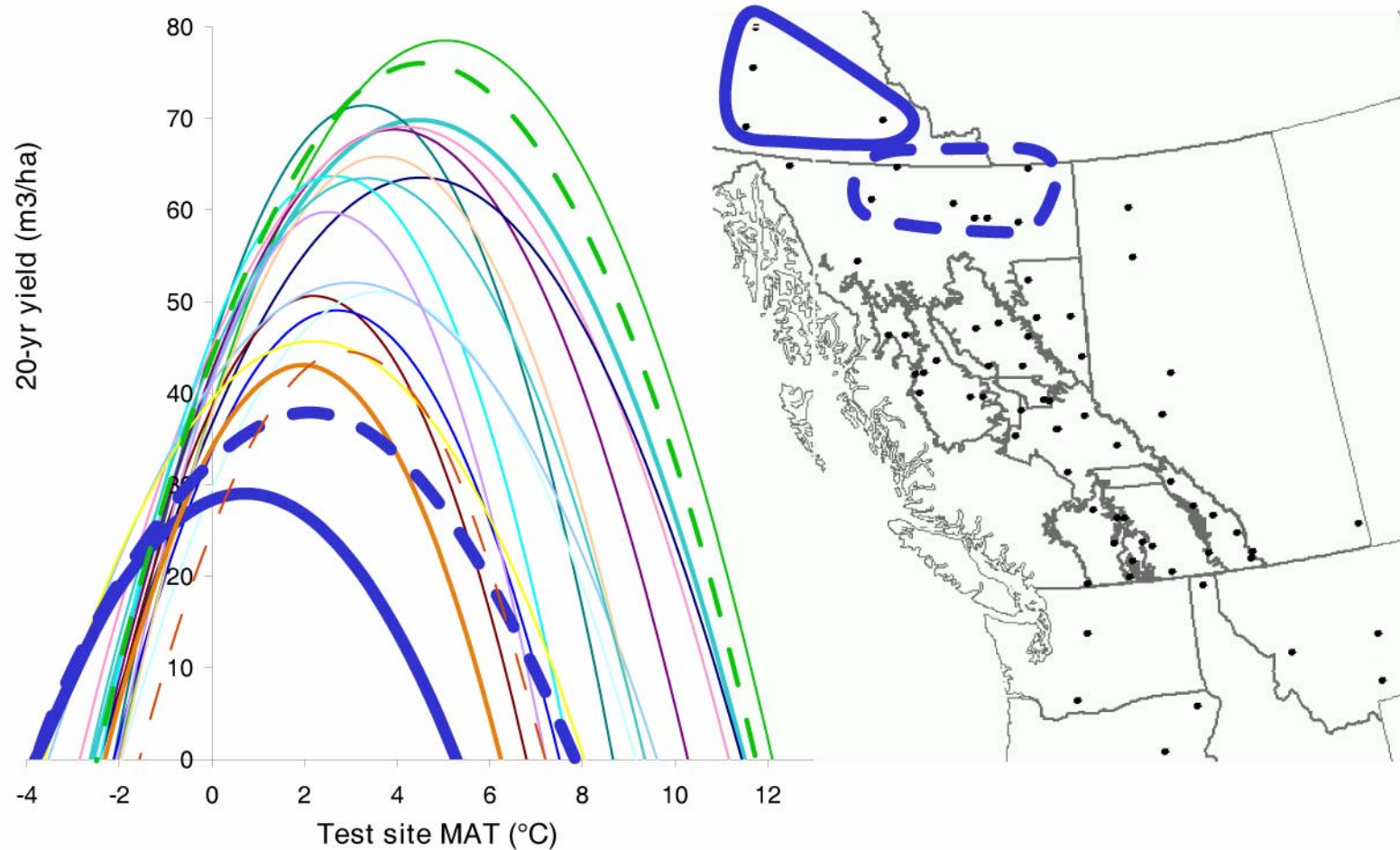
Takhini
60 N



Can we substitute spatial for temporal climatic variation using Illingworth lodgepole pine provenance trial?

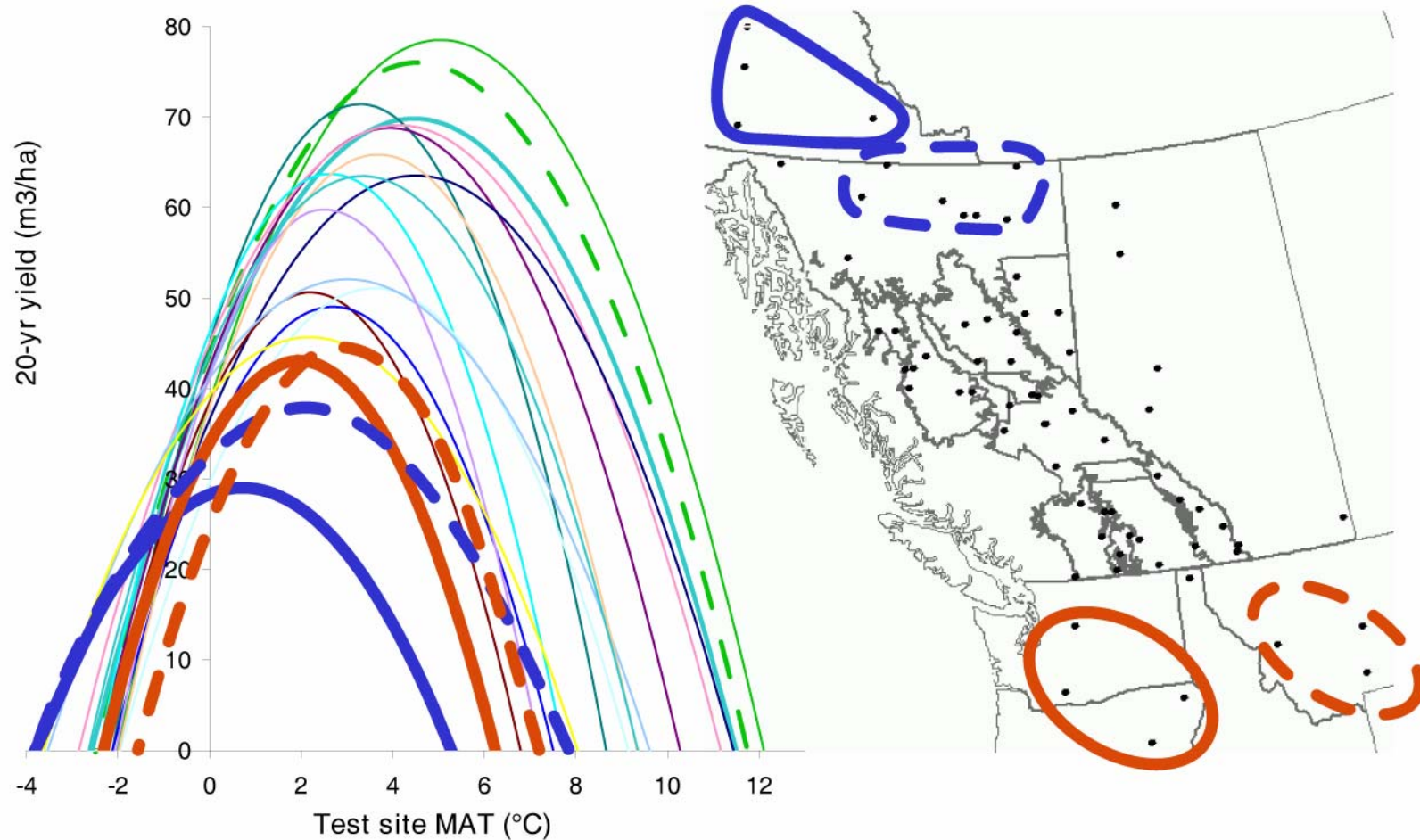


Provenances vary in response to temperature



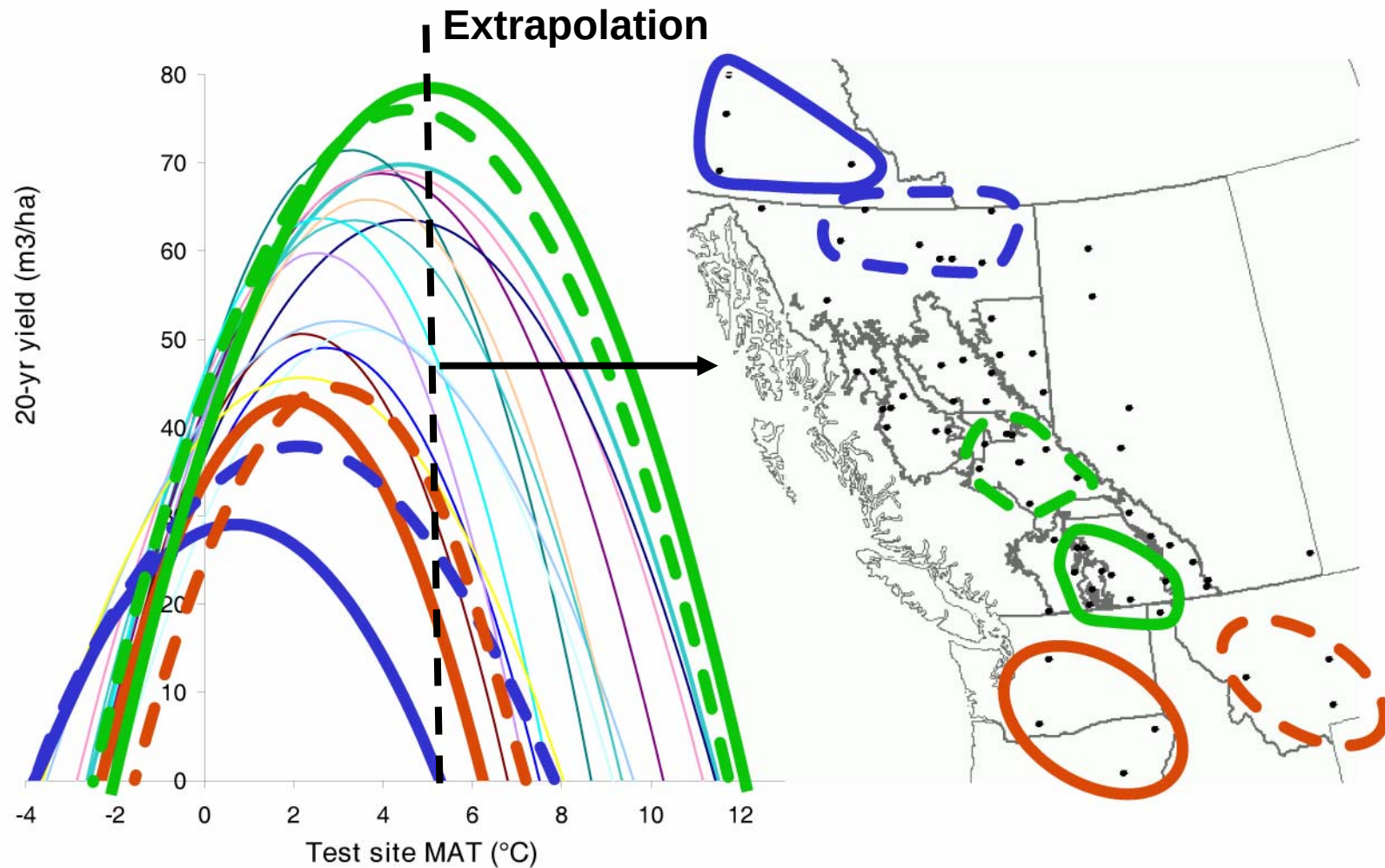
Wang et al. In prep.

Provenances vary in response to temperature



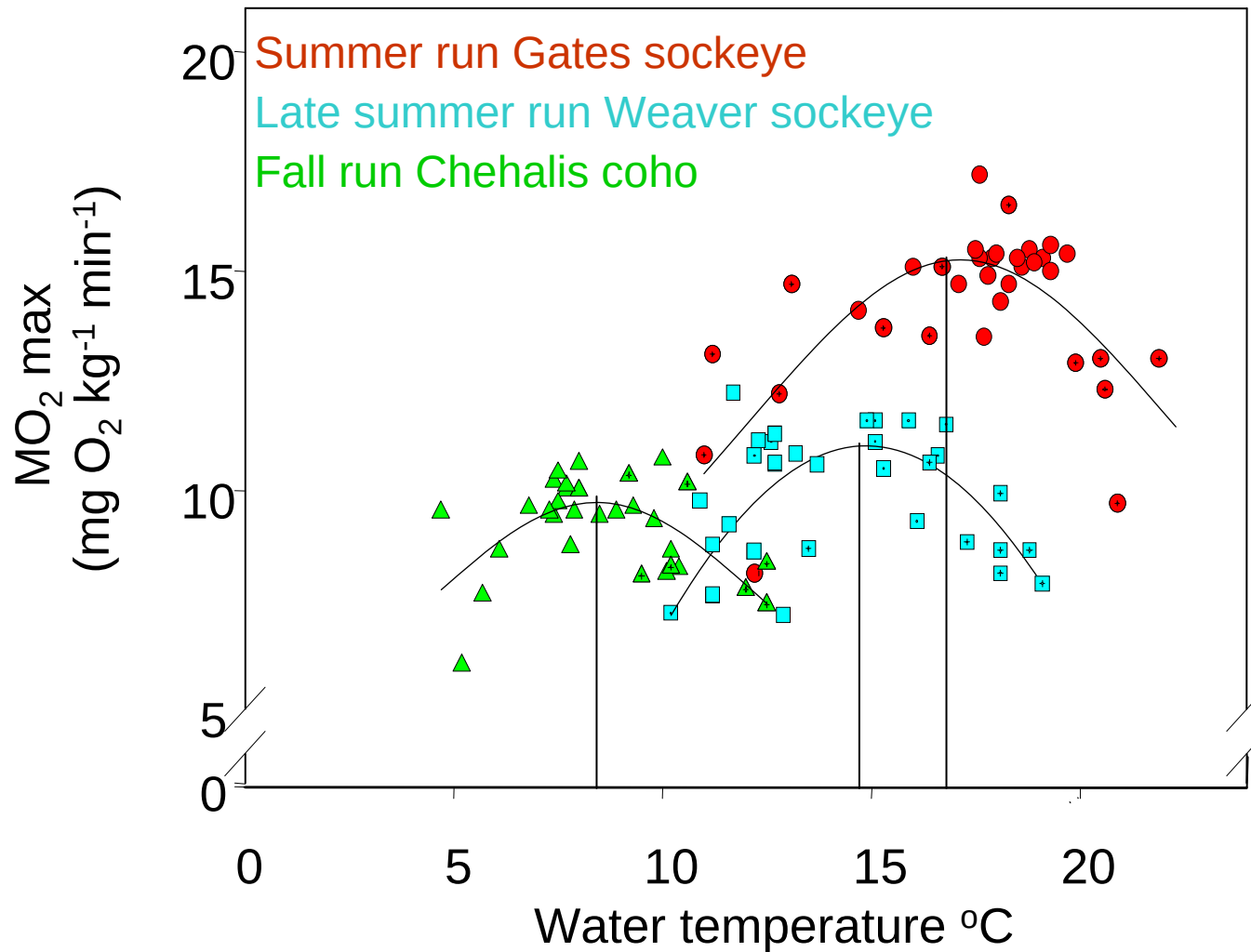
Wang et al. In prep.

Some provenances perform well over a wider range of climatic conditions than others

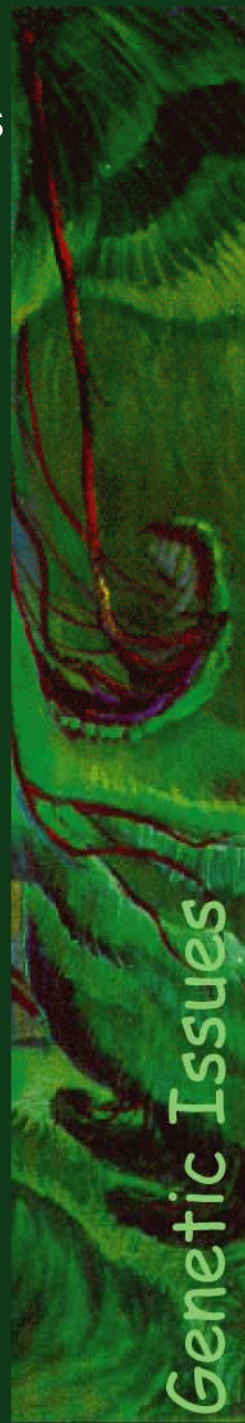


Wang et al. In prep.

"Salmon are just swimming trees..."
---Scott Hinch



Lee et al. 2003 J Exp Biol 206:3239-3251



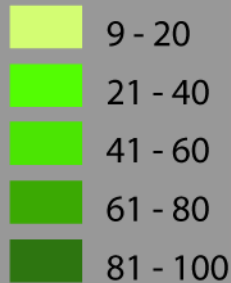
Increased productivity at +2°C can be enhanced through optimized deployment

Local

Local + 2°C

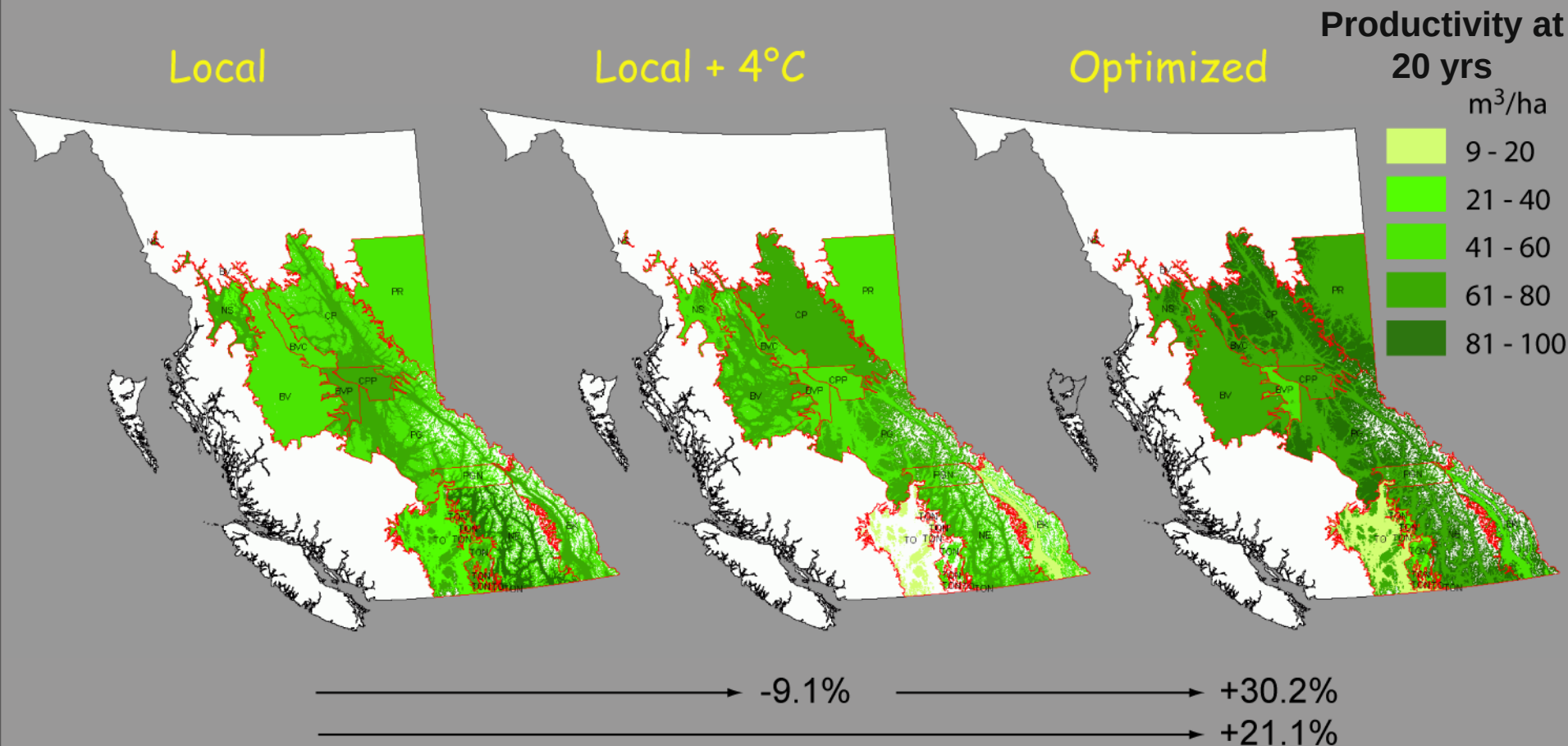
Optimized

Productivity at
20 yrs
m³/ha

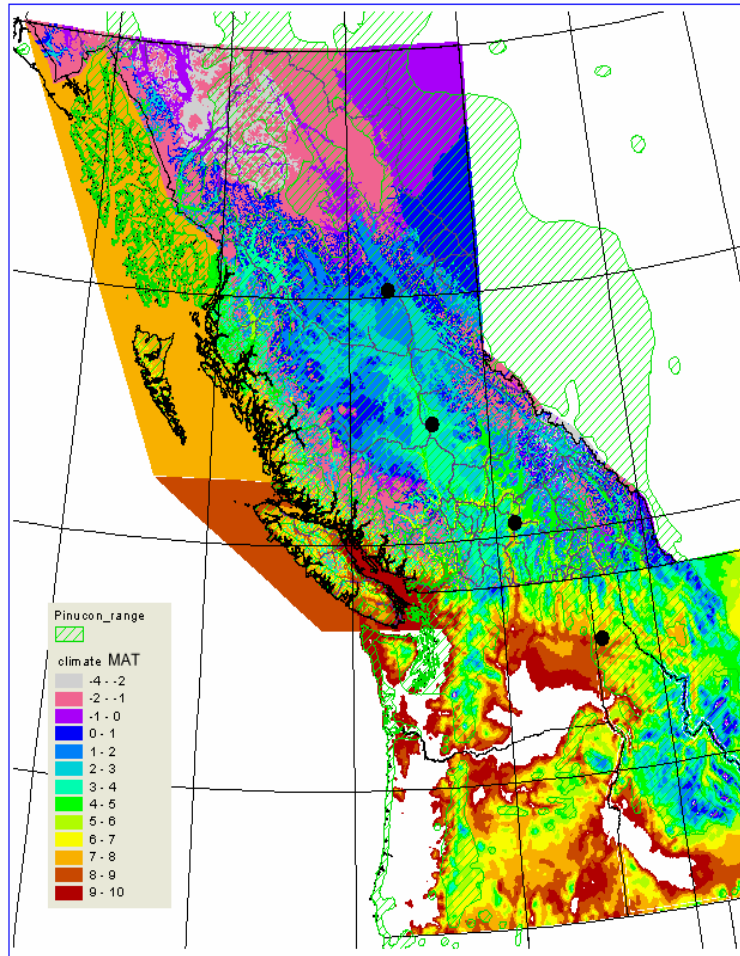
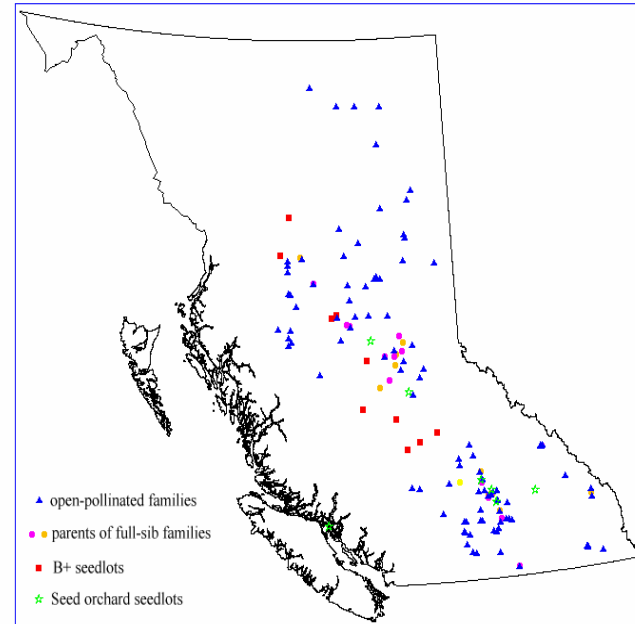


→ +6.9% → +18.4%
→ +25.3%

Productivity will decrease at +4°C but losses can be mitigated through optimized deployment

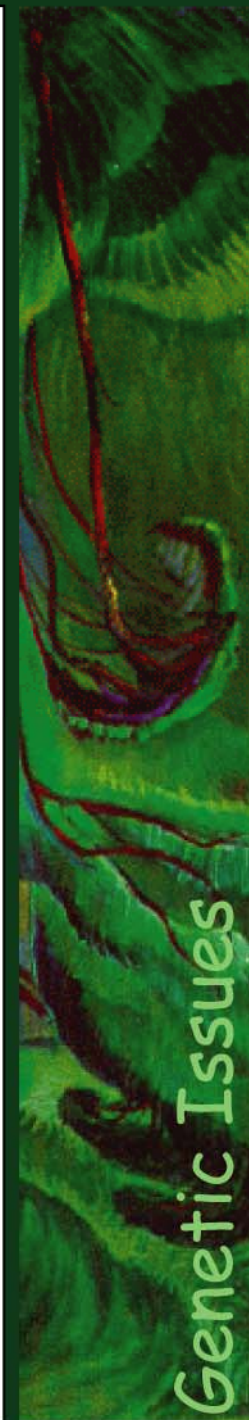


Growth chamber experiment to study provenance responses to temperature and CO₂

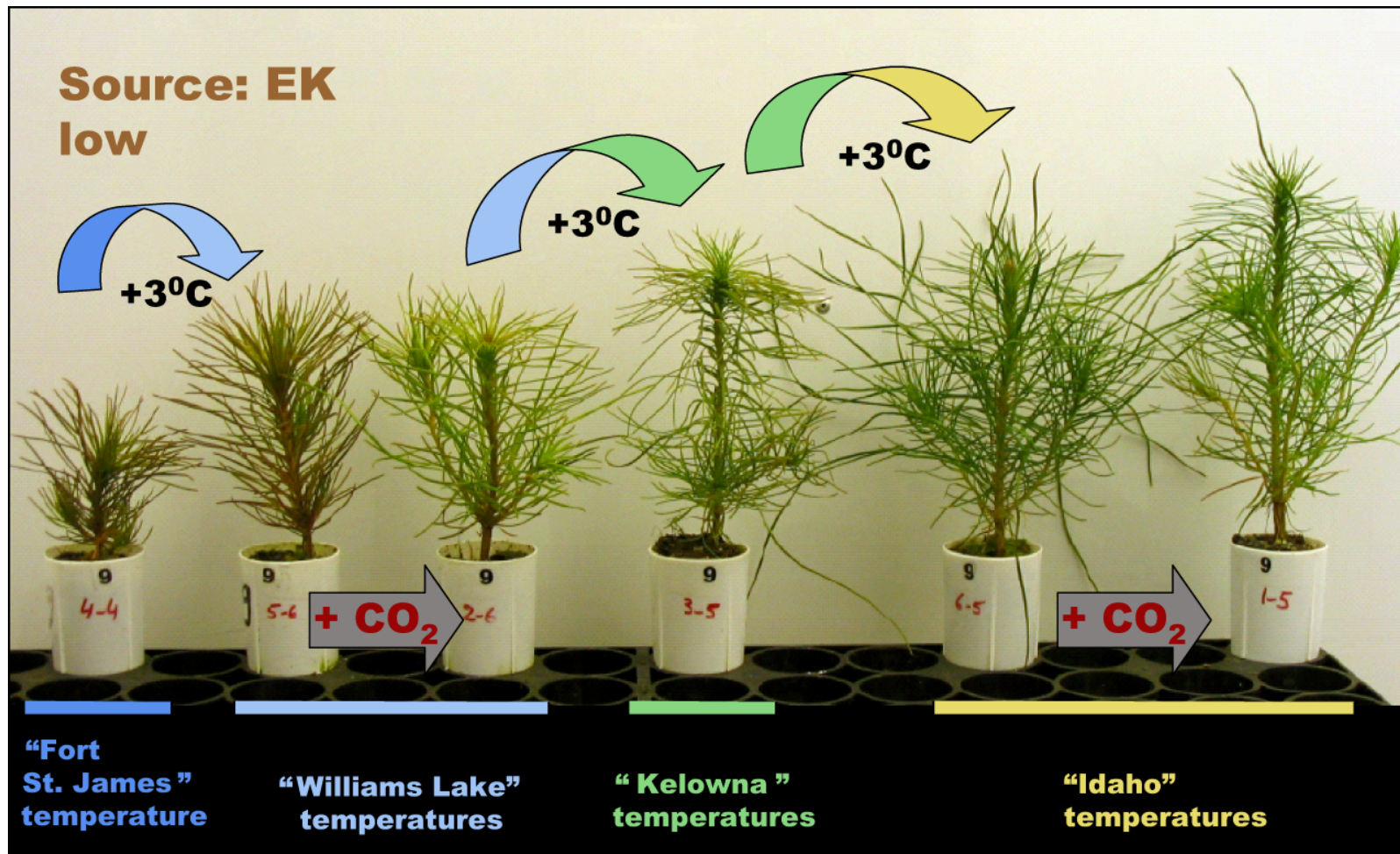
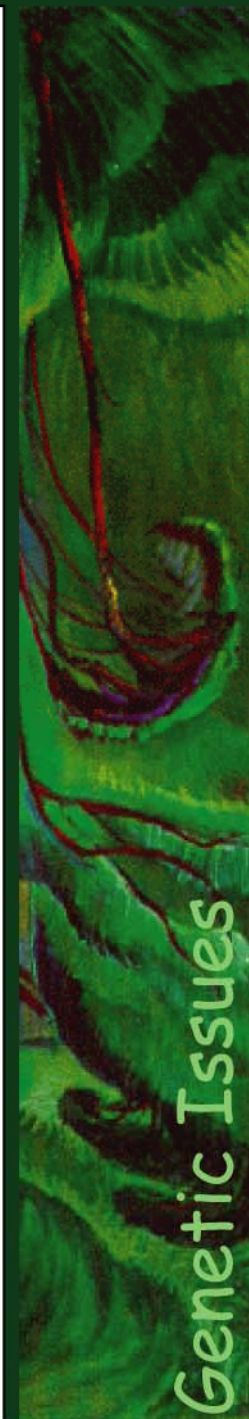


Origin of genetic materials

Simulated environments
(MAT 1,4,7, 10 and 13)

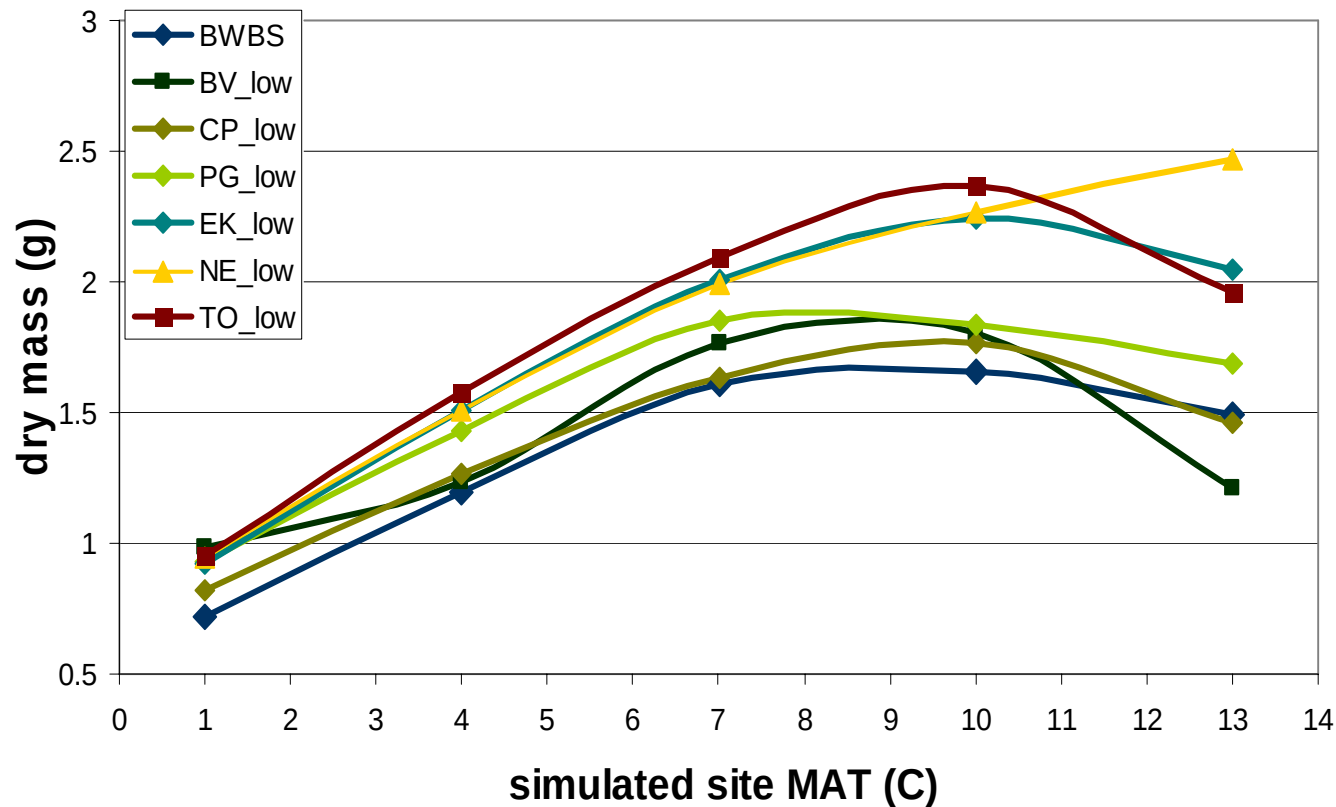


Increasing temperature and CO_2 increases growth rates

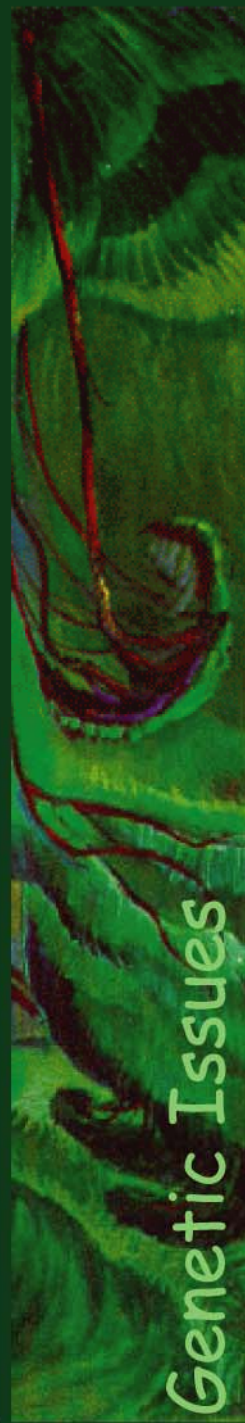


Genetic Issues

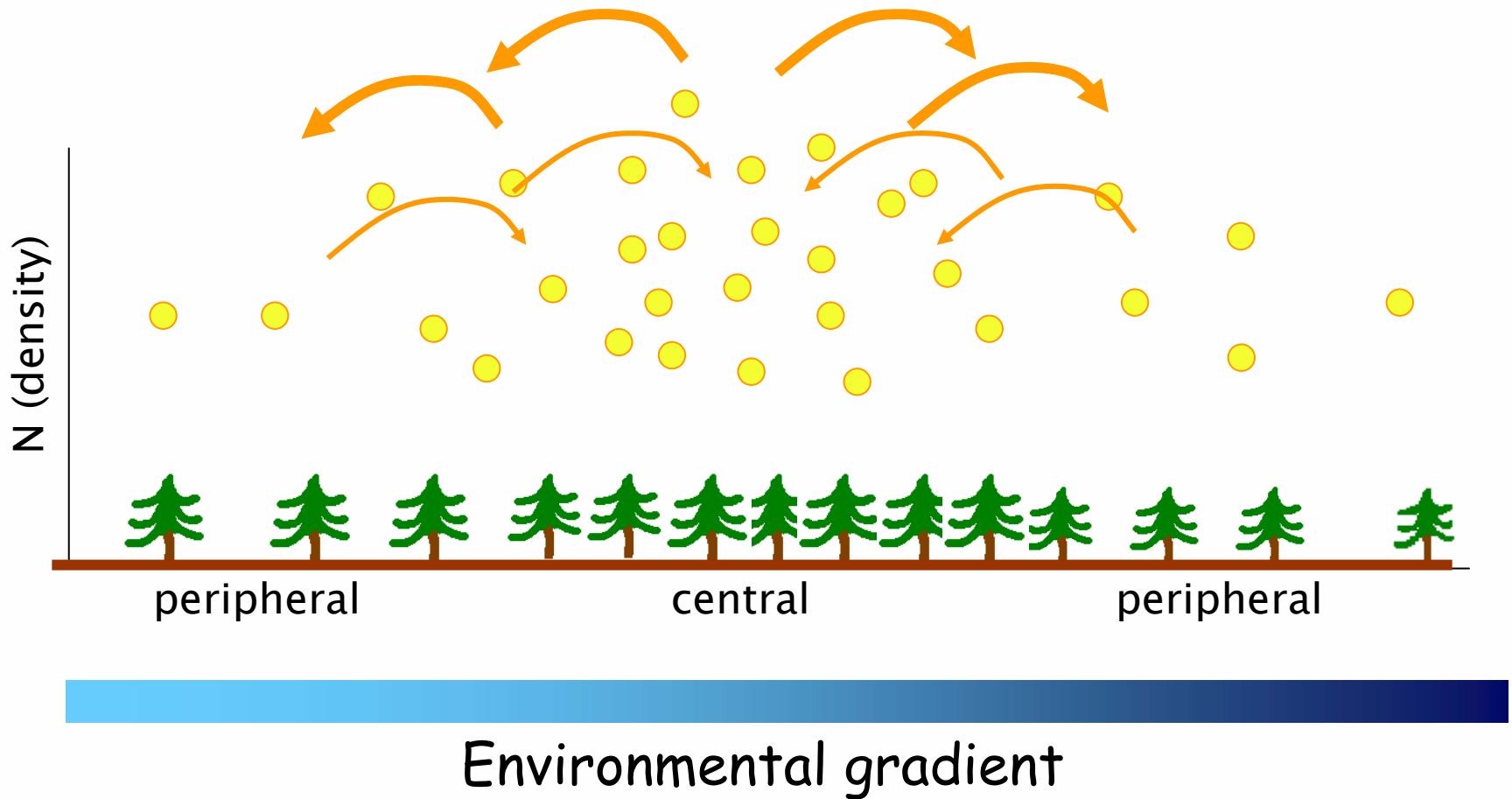
....but 13°C is too much of a good thing

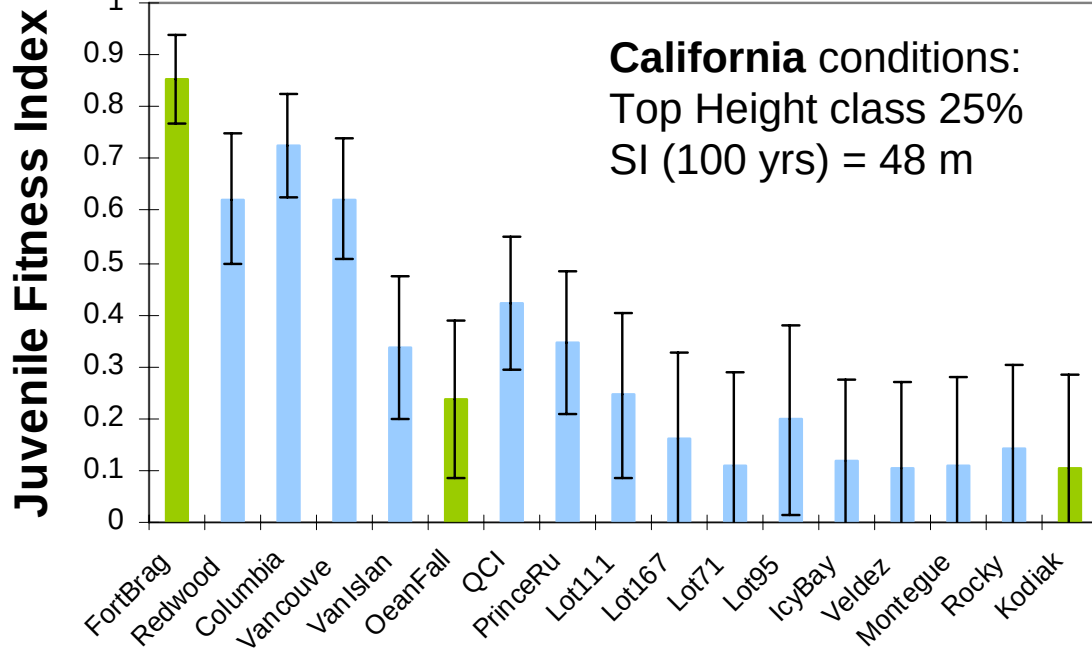
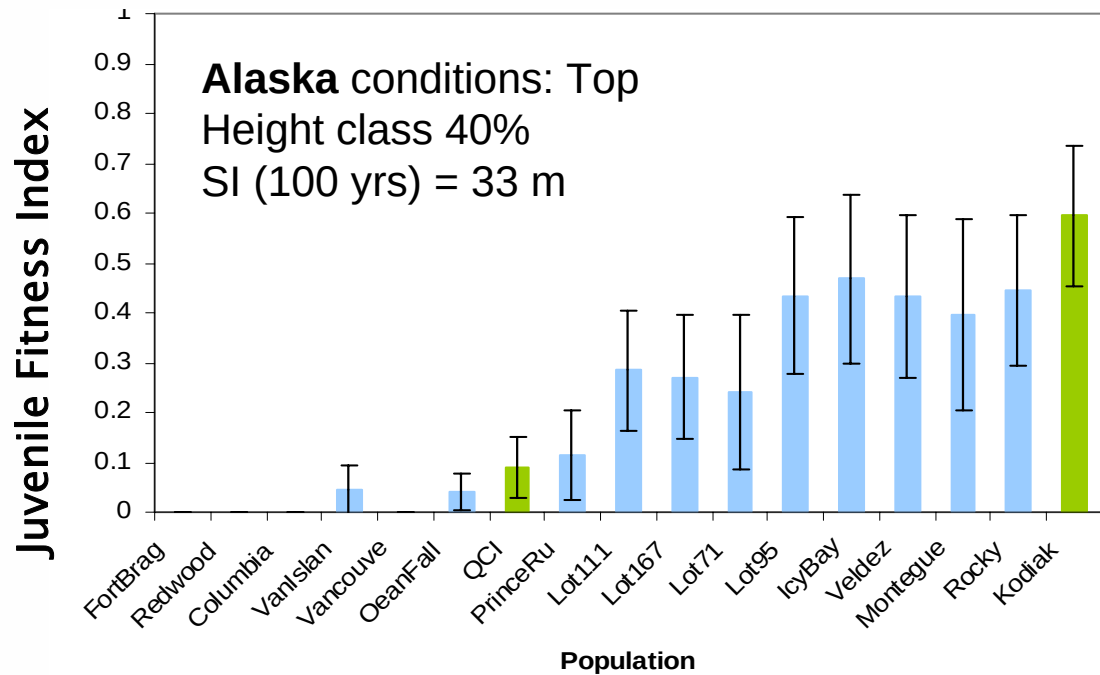


Pia Smets. Unpublished data.

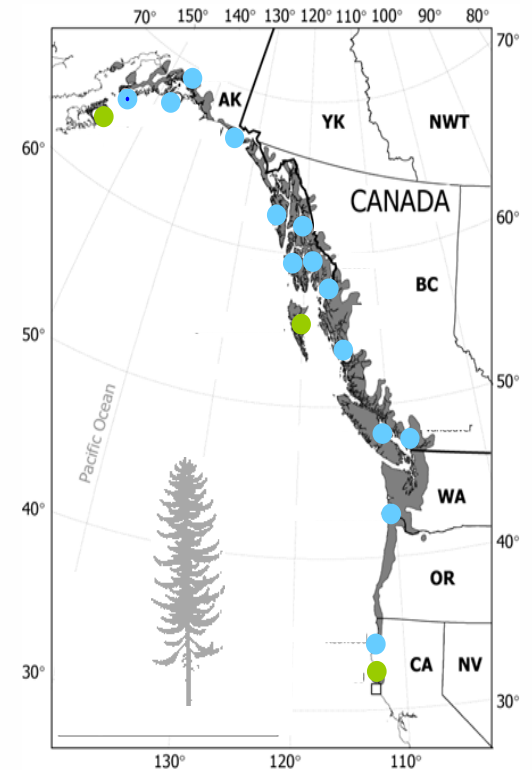


Does gene flow from central populations prevent adaptation of peripheral populations?





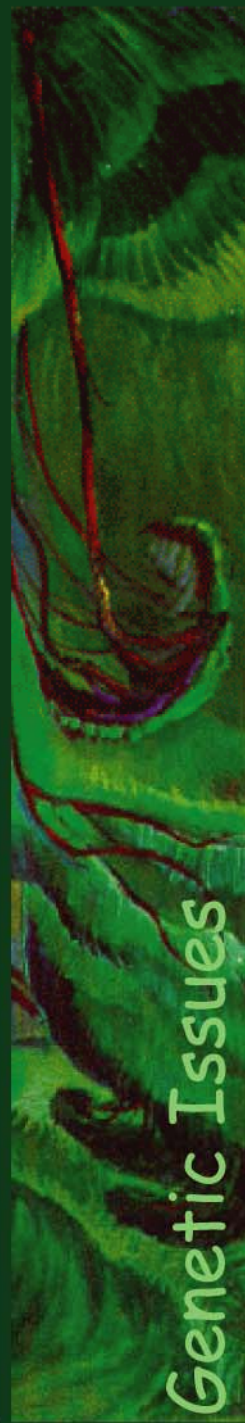
Higher fitness in isolated
than continuous
peripheral populations is
evidence of gene flow
limiting local adaptation
and possibly range
expansion



Makiko Mimura. PhD thesis.

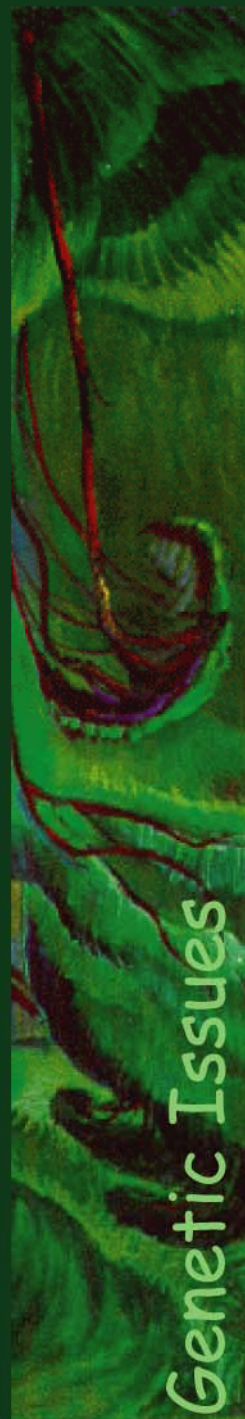
Implications of gene flow limiting species range

- The lower relative fitness of non-isolated compared to isolated peripheral populations is likely due to gene flow from central populations
- If so, phenotypes better adapted to marginal environments than those occurring in nature can be developed through selection and breeding
- Isolated populations may also be the source of novel genotypes and phenotypes for breeding for new environments



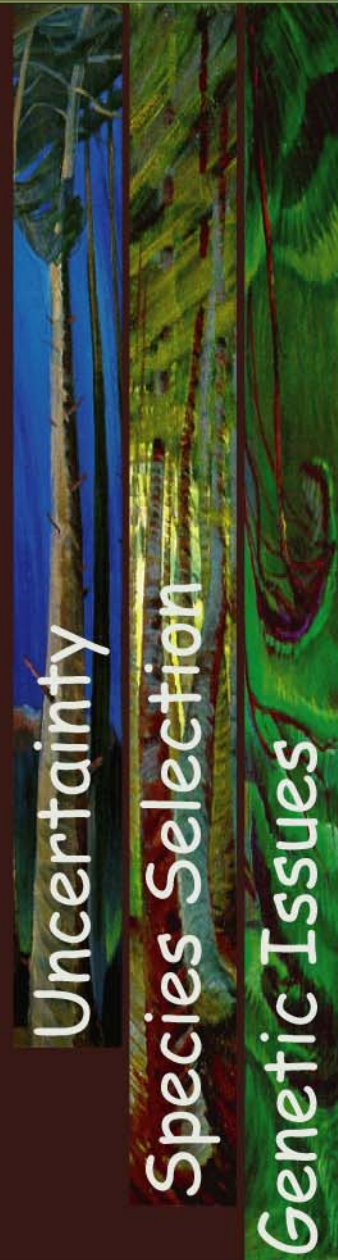
Species persistence and reproduction in protected areas

- Species and genetic composition of planted stands can be changed fairly rapidly through planting but it will take much longer in natural stands
- Mature forests may be stable for quite a long time, or succumb to epidemics or 'multiple insults'
- Degree to which species will persist in protected areas in a warming climate is unclear - depends on adaptation, migration and reproduction
- Protected areas serve as important genetic conservation areas, but only as long as species persist
- Peripheral populations may contain important genotypes for adaptation to new environmental conditions and their conservation should be high priority



Information Needs

- Need new series of field tests with multiple species over a wide range of environments to determine species and provenance climatic response norms
- Better knowledge of the genetic basis of complex traits may provide insight into capacity to adapt
- Use data in a stand model (e.g., TASS) to evaluate species and provenance mixtures under various dynamic climate scenarios
- Important to also consider role of natural regeneration (including hardwoods) and advanced regeneration in planted stands



Until we have this information,
don't do the same thing everywhere!



Uncertainty



Species selection



Genetic issues

For ClimateBC version 2 download and further information, see www.genetics.forestry.ubc.ca/cfgc

Emily Carr:
Blue Sky, 1936



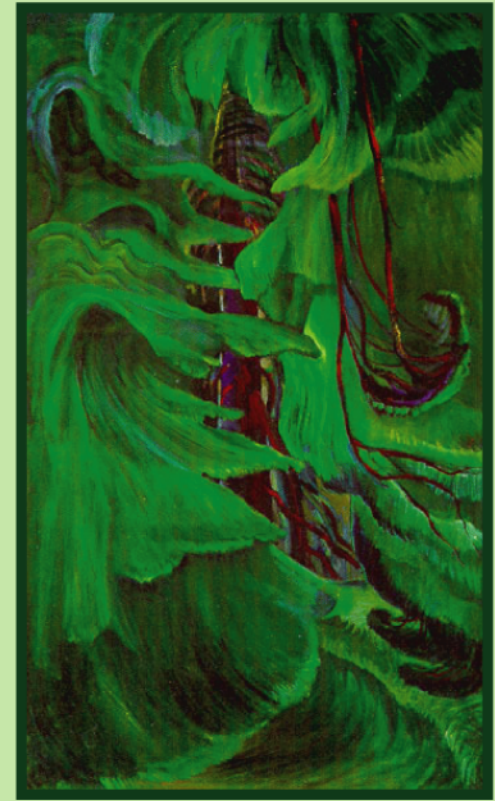
Uncertainty

Sombreness Sunlit, 1938



Species selection

Cedar, 1942



Genetic issues