Mismatch in Adaptations: Will boreal plant species genetic adaptations of spring phenology to local climates be disrupted by climate change?

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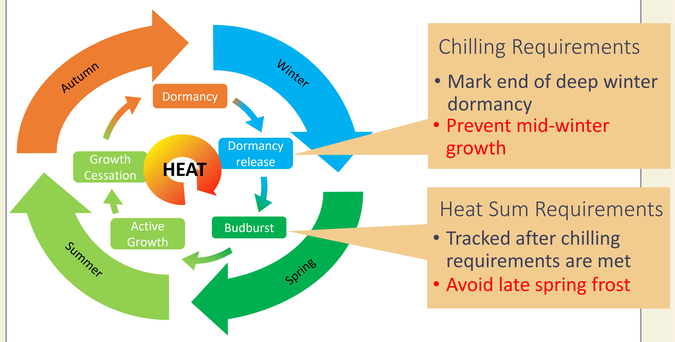
Background

- Temperate plants track spring heating to a predetermined point, referred to as heat sum requirement (HSR) to trigger bud break, optimally timed for spring growth.



- This phenology is so significant it shapes the range of species (Muffler et al. 2016).
- If populations within species have different predetermined heat sum requirements, they would be differentially affected by climate change

Objectives

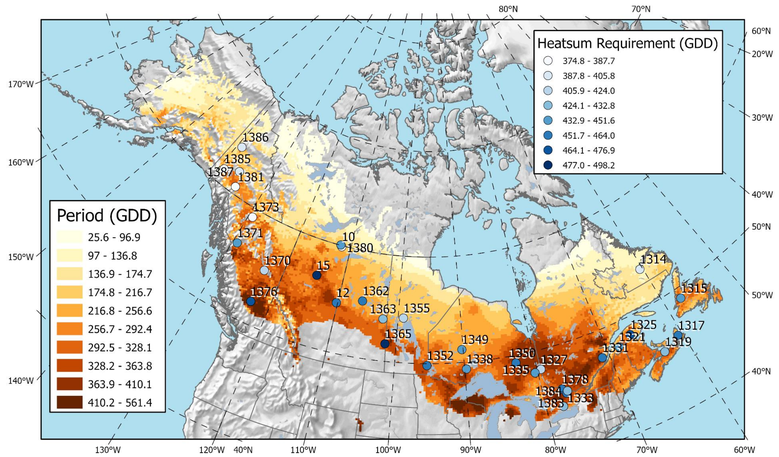
- Determine if white spruce (*Picea glauca*) populations genetically differ in their adaptation to climatic environments.
- Determine how genetic differentiation is related to the climate at the origin of the seed source to determine local adaptation.

Methods

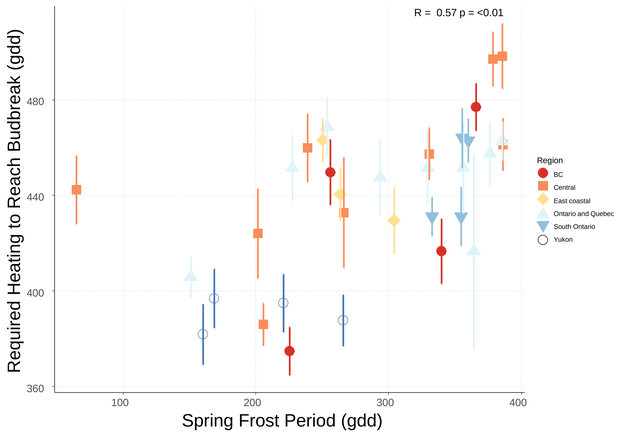
- Determine spring heating requirements of trees from genetic common garden experiment (methods: Menzel et. al 2020)
- Correlation analysis and variance partitioning to test associations of HSR and climate of origin.

Results

- Northern populations generally have lower HSR than southern populations
- No differentiation from east to west for southern populations from approximately the same latitude



Heating requirements in growing degree days above 0° C (gdd) of provenance trials in relation to new spring frost period variable (gdd) for the range of white spruce.



Plot of heating required with standerd error bars to reach bud break versus the length of the spring frost period in growing degree days above 0° C (gdd).

- The genetic differentiation is driven by the length of time in spring, where frosts may occur.
- This length of time was measured as degree days above 0° C for the period between the first day above 0° C and the last day below 0° C, referred to as Spring Frost Period (SFP)
- Strongest correlation between SFP and HS: r = 0.57, p = 0.0006)
- SFP explains variance in HS better than any other climate variable or regional delineation.

Variance Partitioning – Variance partitioning performed on model containing number of frost free days (NFFD), spring frost period, and region of origin

	Df	Adj.R.square	F	Pr(>F)
NFFD	1	-0.02248	0.025876	0.888
Spring Frost Period	1	0.182386	8.903912	0.011**
Region	5	0.090249	8.903912	0.007***

Conclusions

- We find evidence of regional adaptation – particularly in the Yukon where heating requirements are lower than more southern populations.
- At present, these low heat sum requirements in northern populations have adaptive value, because they allow trees to take full advantage of a very short growing season.
- Climate change could put northern populations at a greater risk of frost damage by late spring frosts as spring temperatures warm due to climate change.
- Due to low heat sum requirements, northern populations will break bud very early in the future.
- Our results show that white spruce populations are adapted to uses heat sum requirements to escape the local period of spring frost damage

References

- Menzel A, Yuan Y, Hamann A, Ohl U, Matiu M (2020) Chilling and Forcing From Cut Twigs—How to Simplify Phenological Experiments for Citizen Science. Frontiers in Plant Science, 11.
- Muffler L, Beierkuhnlein C, Aas G, Jentsch A, Schweiger AH, Zohner C, Kreyling J (2016) Distribution ranges and spring phenology explain late frost sensitivity in 170 woody plants from the Northern Hemisphere. Global Ecology and Biogeography, 25, 1061-1071.

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