AdapTree Assessing the adaptive portfolio of reforestation stocks for future climates

Spatial patterns of phenotypic variation in interior spruce and lodgepole pine

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Introduction

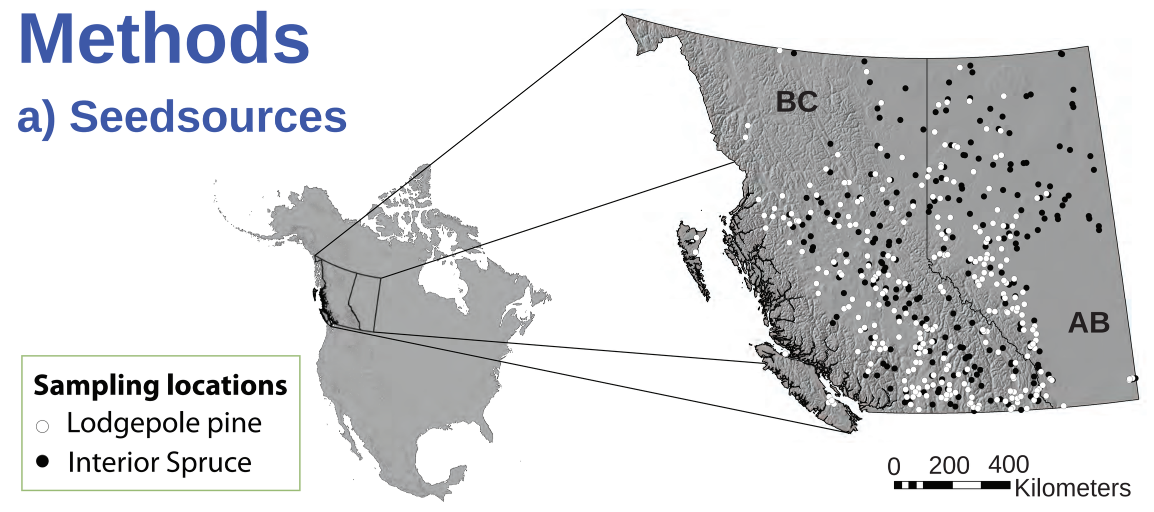
In western Canada, both interior spruce (*Picea glauca x Picea engelmanni)* and lodgepole pine (*Pinus contorta*) are highly valued timber species that provide enough resources to support a strong forest industry. Subsequently to harvest 150 million seedlings are planted in British Columbia (BC) and Alberta[1] (AB). However, changes in climate are impacting the environments to which populations are currently adapted, especially those at higher latitudes are expected to experience increases in temperature[3]. This could decrease forest productivity and threaten forest health; examples of this are already observed in large outbreaks and a spread of mountain pine beetle over the Rocky Mountains and into AB due to warmer winter temperatures[2]; the disease dothistroma needle blight causes defoliation and mortality due to warmer and wetter conditions in BC[4], whereas lower precipitation causes spruce dieback in AB.

Project objective

This research investigates phenotypic variation to examine the relation of adaptive characteristics with climatic conditions and determine the spatial distribution of populations having similar phenotypes. The results will support the development of forest management strategies to match reforestation stock with predicted future environments.

Methods

a) Seedsources

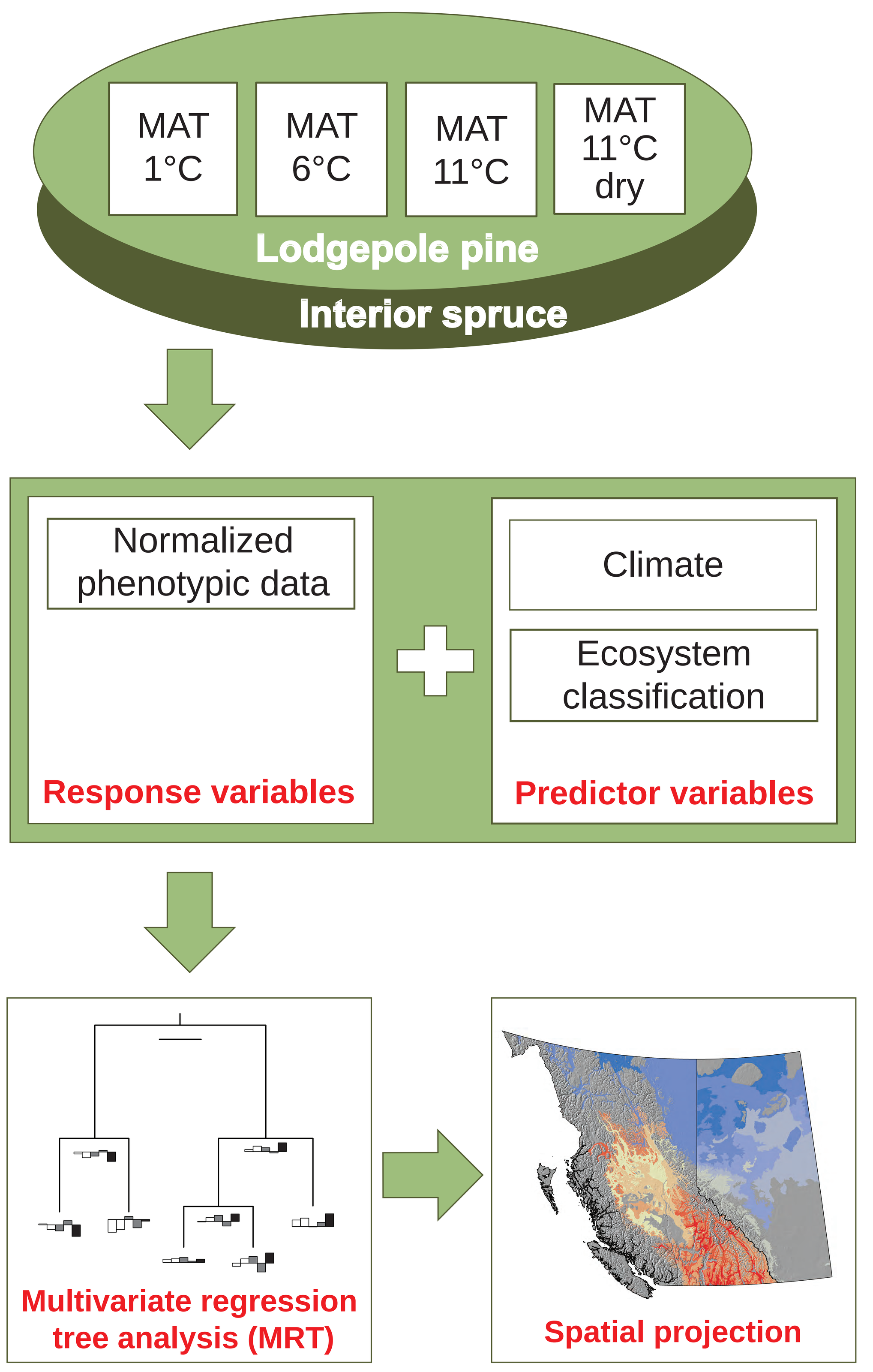


b) Common garden experiment

Seeds of both species were germinated in growth chambers controlled with four different temperature and moisture treatments. Growing conditions were simulated according to locations with mean annual temperatures (MAT) of 1ºC, 6ºC, 11ºC. The last chamber was divided in two sets: one with sufficient water supply and one with dry conditions. Throughout the second growing season phenotypic expression was examined measuring:

1. Growth performance - height & diameter
2. Bud phenology - budbreak & budset
3. Cold hardiness - frost injury

Analysis



Preliminary results

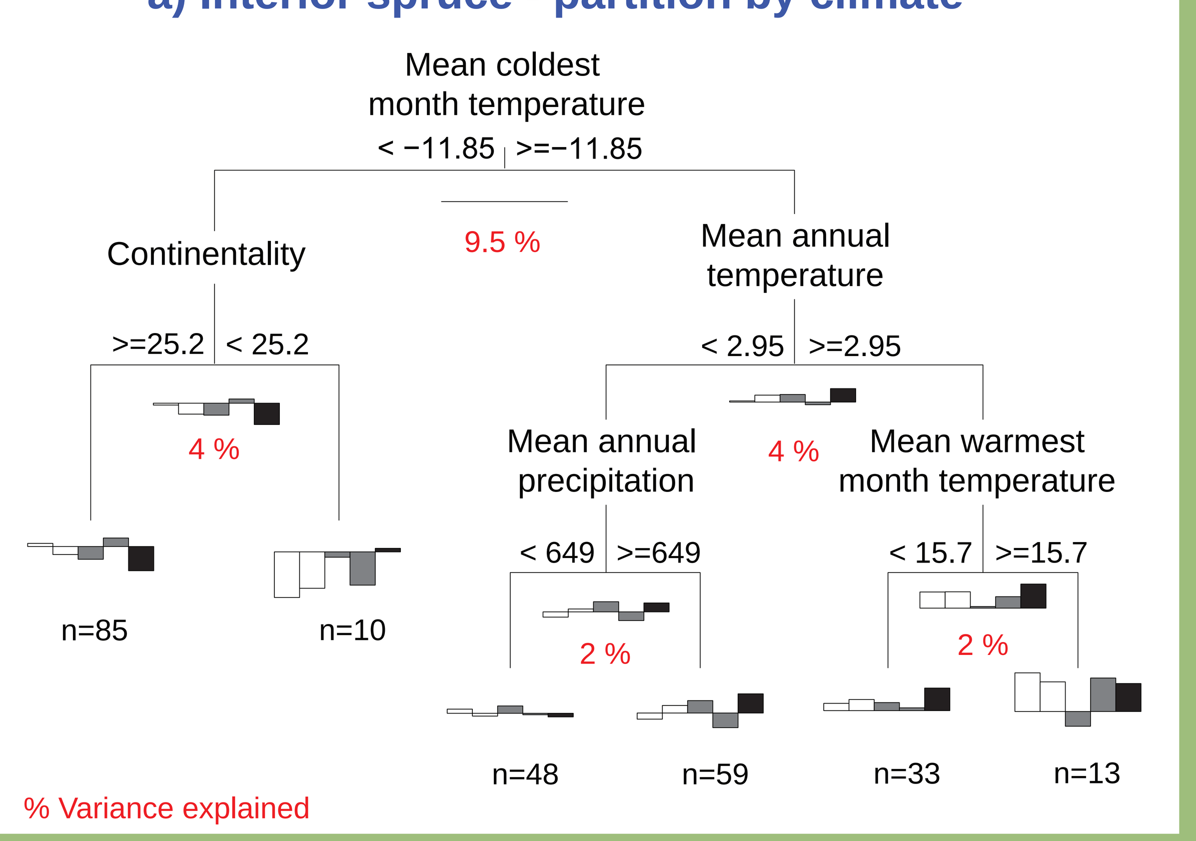
The MRT with continuous climate variables, exemplary shown for interior spruce (**a**), partitions the whole dataset into six groups. They can be identified from left to right as boreal plains with the lowest cold injury and therefore highest cold hardiness; montane AB; two groups including sub-boreal ecosystems and AB's foothills; and finally the interior mountains and the interior valleys with best growth.

Using categorical ecovariants as predictor, interior spruce populations (**b**) split in 11 groups of similar phenotypic expression. The Rocky Mountains separate cold hardy populations (low injury) in the east from frost susceptible ones (high injury) in the west. Best growth was observed in the interior valleys. Montane areas (5,8,9) generally show a shorter growing season which leads to poor growth. Sub-boreal populations in BC show intermediate characteristics.

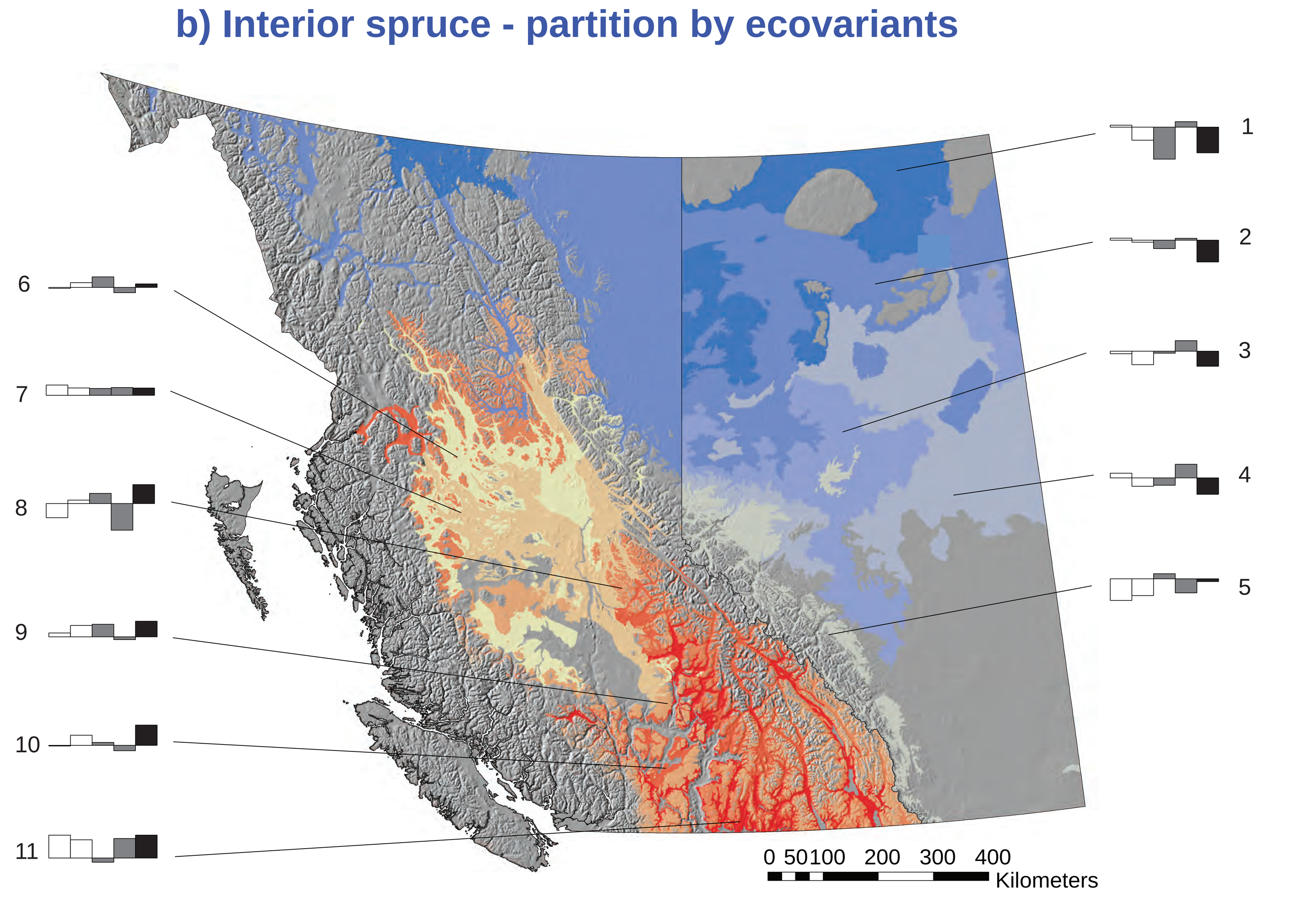
Lodgepole pine (**c**) mostly follows a similar trend in its phenotypic expression, however there is an unexpected variation with a group of extremly frost hardy and simultaneously good growing populations in Alberta's dry mixed wood region. The small group of shore pine populations in coastal BC breaks buds really late, the entire growing season is shortened and starting much later.

Phenotypic traits
- Height
- Diameter
- Budbreak
- Budset
- Cold injury

a) Interior spruce - partition by climate



b) Interior spruce - partition by ecovariants

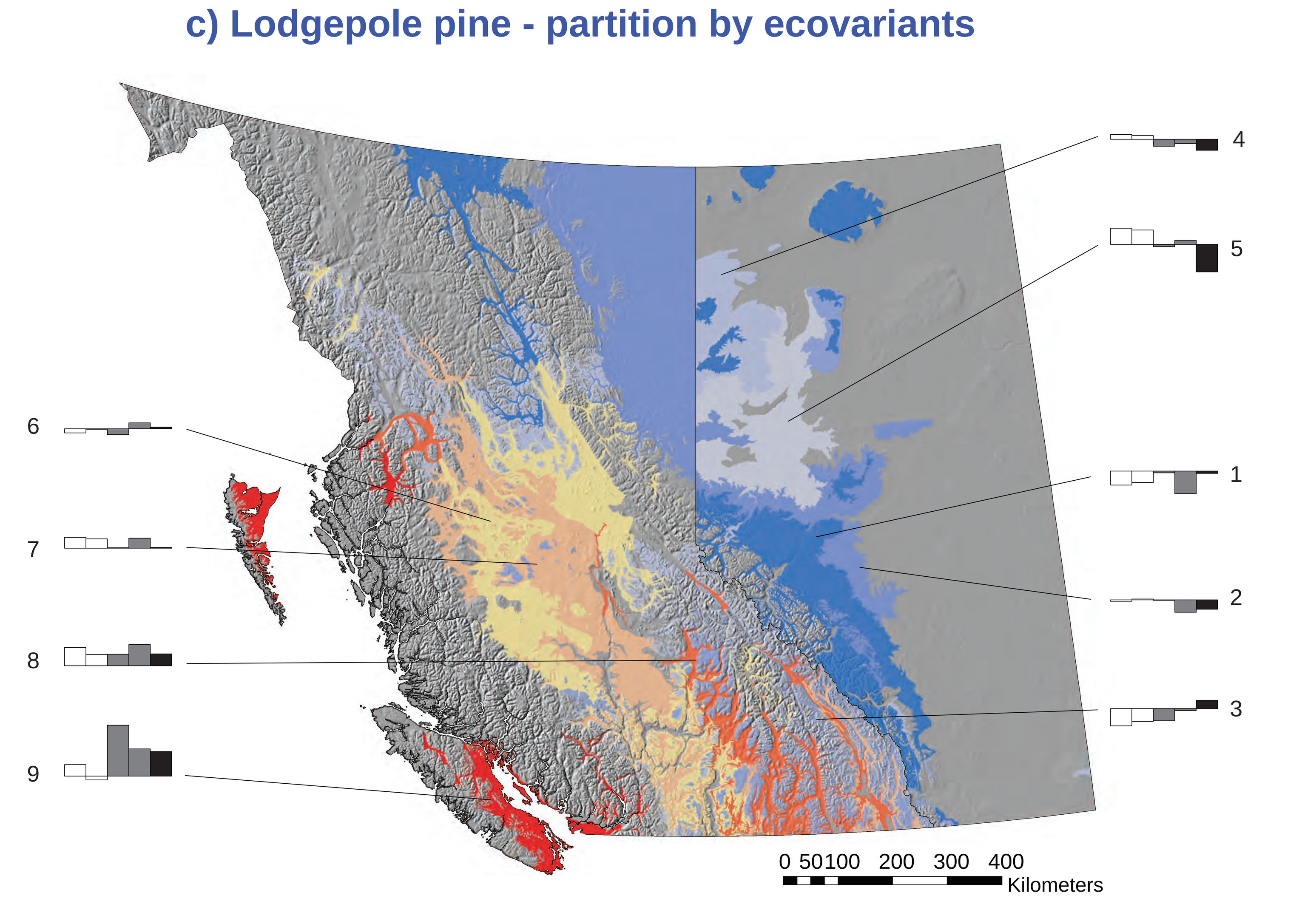


Locally adapted populations

b) Interior spruce
1. Boreal Forest N
2. Boreal Forest central
3. Lower Foothills
4. Boreal Forest S
5. Montane,Upper Foothills
6. Sub-boreal
7. Sub-boreal
8. Interior Mountains N
9. Interior Mountains S
10. Interior Valleys SW
11. Interior Valleys S

c) Lodgepole pine
1. Montane AB
2. Lower Foothills; NE of BC
3. Montane BC
4. Lower Boreal Highlands AB
5. Dry Mixed Wood AB
6. Sub-boreal
7. Sub-boreal
8. Interior Valleys
9. Coastal BC

c) Lodgepole pine - partition by ecovariants



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