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Genetic variation in aspen spring phenology

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Phenology is the timing of recurring phases of plant development. The timing of de-hardening and budbreak in spring is an important adaptive trait. Too early, and plants risk damage from late spring frosts – too late, and the growing season is not fully utilized. Populations of wide-ranging species are usually optimally adapted to local risk environments. This geographic differentiation in adaptive traits is of practical relevance to guide the movement of planting stock for reforestation and to select genotypes in tree improvement programs.

Methods: The timing of budbreak is one of the most sensitive and direct biological responses to temperature, measured as thermal time or heatsum: the average daily temperature values above a certain threshold are added until a phenological event occurs. Genetic differences in heatsum requirements are typically detected by growing seed collections in a common test environment. But in addition to this classical approach, we observe budbreak of natural populations in western Canada through remote sensing, using data from NASA's Terra satellite. To calculate the corresponding heatsum requirements of populations, we use interpolated daily climate data from weather stations.

Results: When planted in a common garden experiment, seed sources from western Canada showed a 24–day difference in the timing of budbreak, with corresponding heatsum requirements of 145 to 325 degree days (symbols in Figure). Similar, but more comprehensive results were obtained through remote sensing (the figure inset shows 500m resolution satellite data interpolated to a coarse grid for better visualization of patterns of genetic variation in aspen populations).

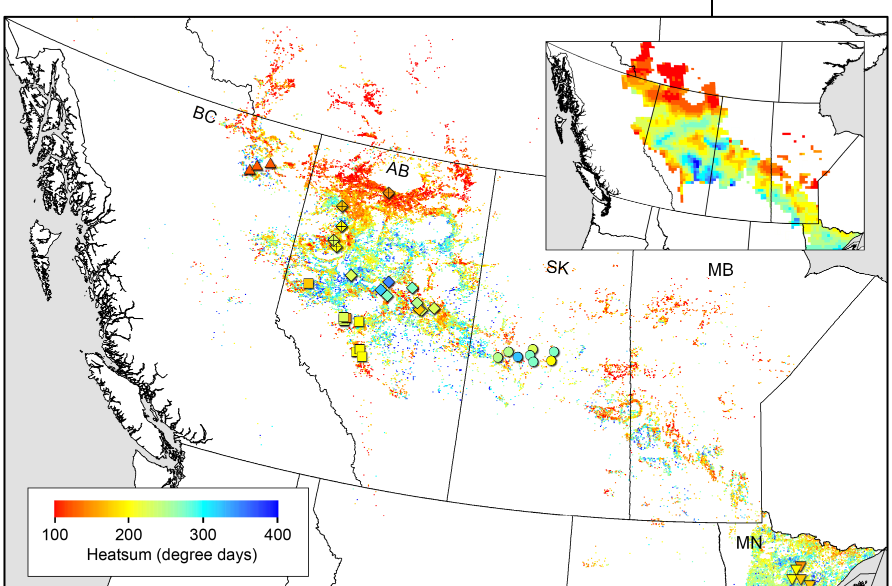
1) Northern and higher elevation populations usually flush earlier for a given heatsum (red), because utilizing the growing season takes relative precedence over survival adaptation under a restricted growing season.

2) In the driest environments, such as aspen parklands and dry mixed wood ecosystems, both spring drought conditions and risk of late spring frost damage select for high heatsum requirements and late budbreak (blue).

Implications: Results from previous transplant experiments suggest that movement of seed sources north and to higher elevation planting sites results in substantial increases in growth, with Minnesota sources performing exceptionally well in Alberta compared to local sources. Does this increase in productivity come at the expense of increased exposure to late spring frost events or other adaptive disadvantages?

1) Our results suggest that movement of seed from central Alberta sources northward and to higher elevations does not expose planting material to late spring frosts.

2) However, we caution against long-distance seed transfer of Minnesota provenances to dry environments in Alberta and Saskatchewan. Although results from short-term trials are promising, these sources could be at risk from exceptional frosts and drought events in early spring, while local sources are still protected through dormancy.



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