Preregistration

Differential photosynthetic capacity and carbon allocation strategies in yellow birch in Quebec

Lukas Van Riel[1], Francois Girard[2], Marie-Hélène Brice[1], Mathieu Bouchard[3]

[1] Département de sciences Biologiques, Université de Montréal, Montréal, Québec, Canada

[2] Département de Géographie, Université de Montréal, Montréal, Québec, Canada

[3] Département des sciences du Bois et de la Foret, Université Laval, Québec City, Canada

26. September 2023

Data collection No data have been collected for this study yet.

Hypothesis

- Photosynthetic capacity decreases with latitude but never reaches zero since other factors besides climate impact the current northern limit of yellow birch.
- With increasing latitude, yellow birch individuals allocate relatively higher fractions of their producedcarbohydrates for growth, leaving less for other functions such as reproduction because the environmental conditions become gradually less suited for photosynthesis when moving northward.

Data collection procedures

At each plot, photosynthetic gas exchange measurements will be carried out for 5 different yellow birch saplings and adults (dbh = 1-9 cm), using the LI-6800 Portable Photosynthesis System (Li-Cor Inc., Lincoln, NE, USA) with the RACiR method (Stinziano et al., 2017). Measurements will be carried out in a closed chamber to control for weather conditions such as temperature (aiming for 25 °C, Dally-Bélanger & Girard, 2022) and air moisture content.To complement the RACiR measurements and make comparisons between leaves easier (e.g. through NDVI), a field spectroradiometer (PSR-3500 Spectral Evolution Inc.) will be used to measure the spectral properties of each sampled leaf. Next, the diameter at breast height of each sampled tree will be measured and a core sample taken to determine the radial growth rate. All trees in the plot will be mapped and the plot canopy openness measured using a LAI-2200C Plant Canopy Analyzer (Li-Cor Inc., Lincoln, NE, USA). A soil sample will be taken that will be analysed in the lab to consider any soil variability.

Every site will be visited throughout the summer of 2024. All Vc,max and Jmax measurements will be taken in a short period of time at the end of summer to ensure leaf maturity. Weather conditions will be controlled for as much as possible, aiming for clear skies 5 days before and during measurements.

Analyses

The obtained A-Ci curves will be corrected by the plot's baseline curves (based on measurements in an empty chamber, Stinziano et al., 2017). Next, all individual, corrected, curves will be fit in order to extract the values for Vc,max and Jmax (Dally-Bélanger & Girard, 2022). This is straightforward when using the plantecophys package (Duursma, 2015), 16 developed for the R environment (R Core Team, 2022). The other relevant parameters to estimate CO2 assimilation rates (mesophyll conductance gm, dark respiration Rd and photorespiratory compensation point Γ*) typically show little phenotypic variation and can be derived from literature (Farquhar et al., 1980). Tree ring width will be prepared and measured using standard methods (Swetnam et al., 1985) and subsequently converted to basal area increments using the tree diameter.

In case of data normality, a multi-way ANOVA test (and possibly Tukey tests, Abdi & Williams, 2010) will be carried out to assess the significance of latitude on Vc,max and Jmax. Contrasting ratios of Vc,max (or Jmax) and basal area increments with

latitude will allow to determine the different carbon allocation strategies of yellow birch over its range in Quebec. Lastly, the derived Jmax and Vc,max values will be used to model photosynthesis capacity for sampled individuals under future climatic conditions (e.g. temperature, VPD, atmospheric CO2), to corroborate the projections in my third study using the Photosyn function of the plantecophys package.

Outliers and exclusions

Individuals that yield Vcmax and/or Jmax values that lie outside the reported values in literature by more than 2σ will be discarded.

Subjects missing data will be included until they miss so much the fitting is no longer acceptable

---

Sample size

75 adult and 75 juvenile individuals (5 sites x 3 plots/site x 5 individuals/plot).

This design allowed to maximise the sample size with the available time and funds.

Study type

Field Survey

References

Abdi, H., & Williams, L. J. (2010). *Newman-Keuls Test and Tukey Test.*

Dally-Bélanger, C., & Girard, F. (2022). Comparative Ecophysiology of Black Spruce between Lichen Woodlands and Feathermoss Stands in Eastern Canada. *Forests*, *13*(4), 491. https://doi.org/10.3390/f13040491

Duursma, R. A. (2015). Plantecophys - An R Package for Analysing and Modelling Leaf Gas Exchange Data. *PLOS ONE*, *10*(11), e0143346. https://doi.org/10.1371/journal.pone.0143346

Farquhar, G. D., Caemmerer, S. von, & Berry, J. A. (1980). A biochemical model of photosynthetic CO2 assimilation in leaves of C3 species. *Planta*, *149*(1), 78–90. https://doi.org/10.1007/BF00386231

R Core Team. (2022). *R: The r project for statistical computing.* https://www.r-project.org/

Stinziano, J. R., Morgan, P. B., Lynch, D. J., Saathoff, A. J., McDermitt, D. K., & Hanson, D. T. (2017). The rapid A-Ci response: photosynthesis in the phenomic era. *Plant, Cell & Environment*, *40*(8), 1256–1262. https://doi.org/10.1111/pce.12911

Swetnam, T. W., Thompson, M. A., & Sutherland, E. K. (1985). Using dendrochronology to measure radial growth of defoliated trees. *Agric. Handbook No. 639. Washington, D.C.: U.S. Department of Agriculture, Forest Service, Cooperative State Research Service. 39 p.* https://www.fs.usda.gov/research/treesearch/40898