# Drought Responses of Tree Populations Using Isotopes & Genetic Provenance Trials

Miriam Isaac-Renton*[1,3], David Montwé[2], Andreas Hamann[1], Heinrich Spiecker[2], Paolo Cherubini[3], Kerstin Treydte[3]

* isaacren@ualberta.ca; [1]University of Alberta; [2]University of Freiburg; [3]Swiss Federal Institute for Forest, Snow & Landscape Research

## Objective & Significance

To inform the reforestation strategy of lodgepole pine (*Pinus contorta* Dougl. ex Loud.) for a changing climate by evaluating population drought response. As western Canada's most common tree, millions of seedlings are planted annually: results could therefore be immediately implemented and potentially yield long-term benefits.

## Background: Provenance Trials & Isotopes

Choosing drought-tolerant populations for planting can help adapt forests to climate change. One strategy involves moving seeds from drier environments northward [1]. These assisted migration prescriptions can be evaluated with provenance trials, which test multiple seed sources at several planting sites. These sites act as a climate change laboratory because southward seed transfer represents a climate regime shift [2,3]. Physiological stress due to such simulated climate change scenarios can be reconstructed from tree-rings using stable isotope analysis. Under optimal conditions, plants discriminate against carbon 13 relative to the more common carbon 12, while oxygen 18 becomes enriched compared to oxygen 16 [4,5]. These processes change under drought stress, altering isotope ratios in the wood created in that year.

## Experimental Design & Approach

We work at 9 experimental sites in British Columbia that were affected by a drought in 2002. We measured annual height increments and cut stem disks from over 1200 trees representing 23 populations sourced from a 4000 km range (Fig 1). To evaluate population drought responses, we analyse growth, wood anatomy and isotope ratios.

## Pilot: Cellulose & Ring Suitable For Analysis

Cellulose is often used for isotope ratio analysis because it is stable, but extraction is time-consuming, so whole-wood is preferred when there is a consistent offset. Cellulose and whole-wood are highly correlated ($r$=0.91), but are significantly different ($p$<0.001) in our samples (Fig 2a). We also compare latewood to the entire ring, in case earlywood cells were formed with stored photosynthate. Latewood and entire ring were correlated ($r$=0.86) and significantly different ($p$=0.030), but latewood shows higher variability (Fig 2b), likely introduced when separating the latewood, causing inconsistent bias. Whole-wood from the entire ring is therefore most suitable for our samples.

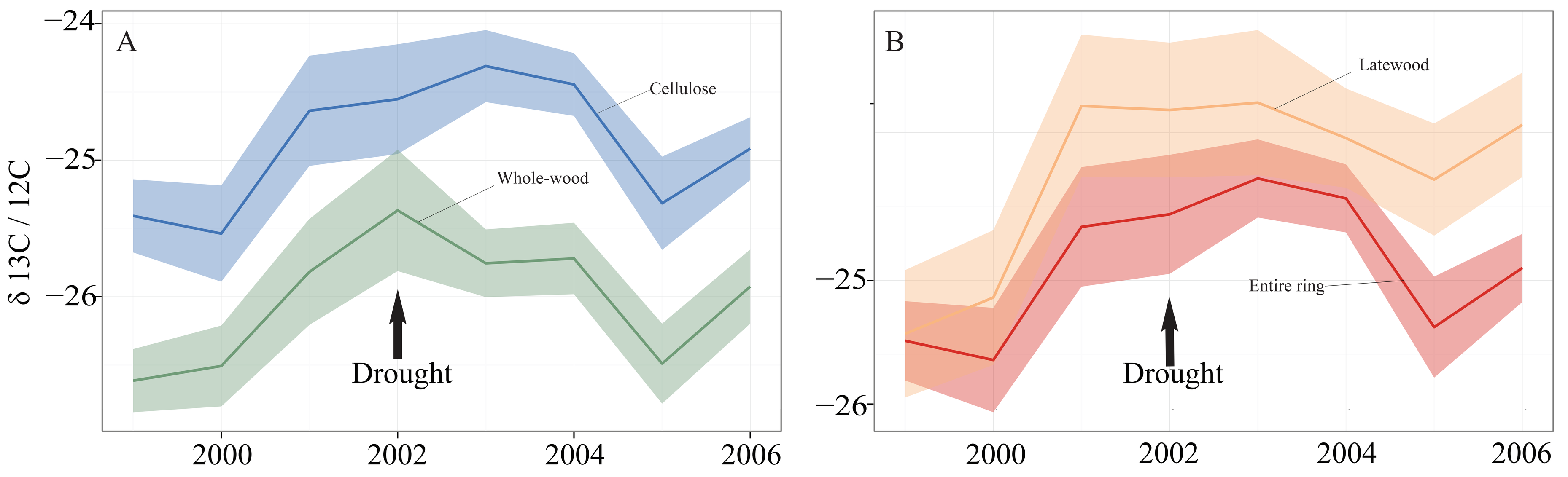


**Fig 2.** Ratio of Carbon 13 to Carbon 12 (deviations from Vienna Pee Dee Belemnite) by year. Cellulose (blue) and whole-wood (green) are compared on the left; latewood (orange) is compared to the entire ring (red) on the right.

## Pilot: Highly Correlated to Moisture

High correlations exist with several temperature, precipitation and moisture-heat variables (Fig 3). Correlations were strongest for whole-wood and entire-ring, reaffirming that these materials are most suitable for further analysis.

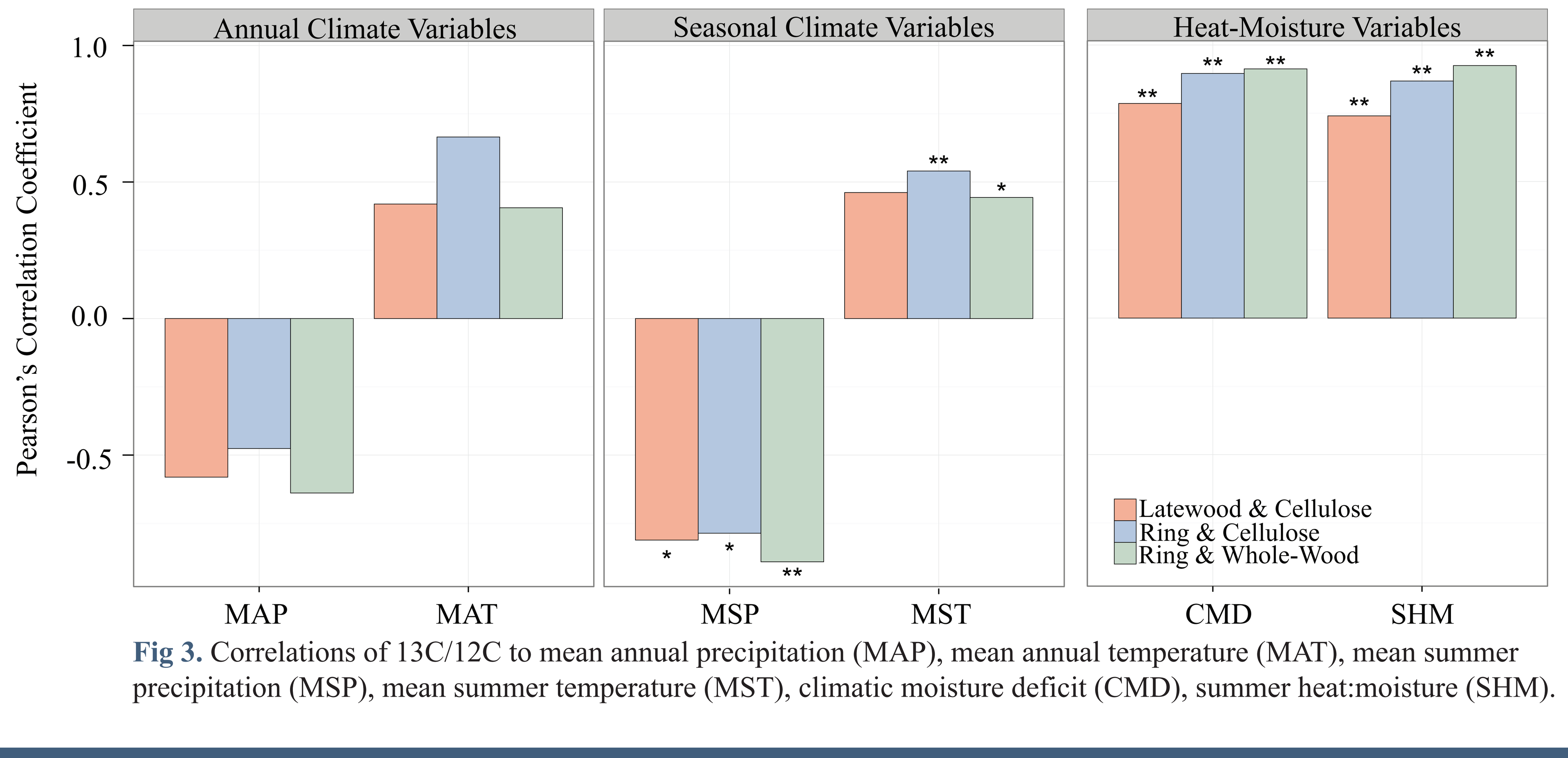


**Fig 3.** Correlations of 13C/12C to mean annual precipitation (MAP), mean annual temperature (MAT), mean summer precipitation (MSP), mean summer temperature (MST), climatic moisture deficit (CMD), summer heat:moisture (SHM).

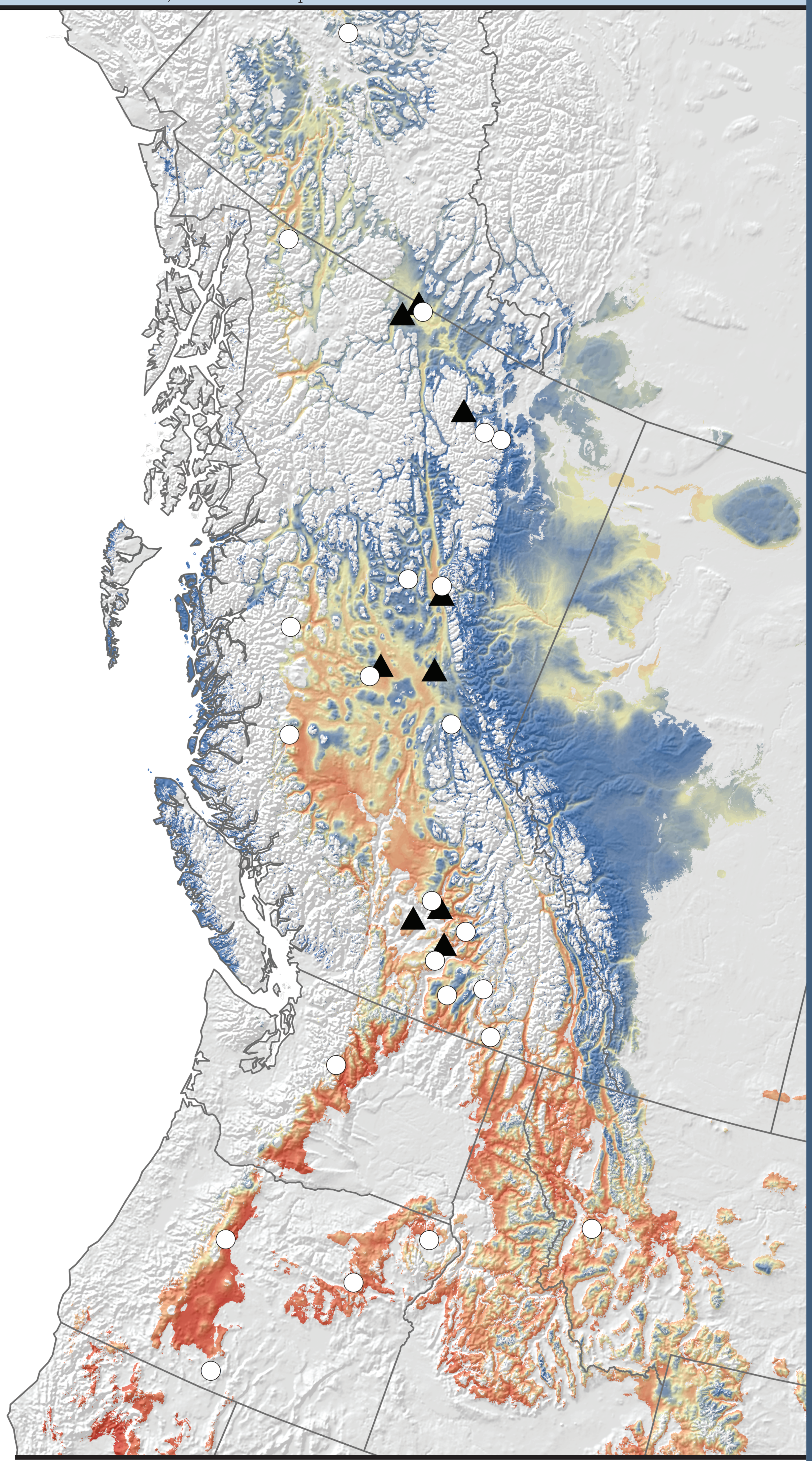

**Fig 1.** Lodgepole pine (*Pinus contorta*) species range in western North America coloured by Hargreaves Climatic Moisture Deficit (mm, 1961-1990). Circles indicate seed sources; triangles represent planting sites.

## Up Next: Population Drought Response

We will test inter-provenance variability in another pilot: If variability is high, we will increase sample size at fewer sites, but ideally variability will be low, allowing us to expand our isotope analysis across space to the full extent afforded by our genetic provenance trial. We will then test up to 900 samples over the eight year period covering a drought in order to find populations for planting that represent suitable compromises between productivity and drought tolerance.

**References:** [1] O'Neill G, *et al*. 2008. Assisted migration to address climate change in British Columbia: recommendations for interim seed transfer standards. B.C. Min. For. Range, Victoria, B.C. [2] Matyas C. 1994. Modeling climate-change effects with provenance test data. Tree Physiology. 14:797-804. [3] Schmidtling RC. 1994. Use of provenance tests to predict response to climatic change: loblolly pine and Norway spruce. Tree Physiology 14, 805-817. [4] Farquhar GD, et al. 1989. Carbon isotope discrimination and photosynthesis. Annu. Rev. Plant Physiol. Plant Mol. Biol. 40:503-37. [5] Scheidegger Y, et al. 2000. Linking stable oxygen and carbon isotopes with stomatal conductance and photosynthetic capacity: a conceptual model. Oecologia. 125:350-357.

**Acknowledgements:** Thank you to our field and laboratory assistants: J. Braun-Wimmer, A. Bueno, S. Giese, J. Grossman, M. Harrhy, E. Körtels, J. Rabenschlag, A. Vorländer, and A. Wiegelmann. This work was funded by an NSERC Strategic Project Grant (STPGP-430183) and a DFG grant SP 437/18-1. DM is supported by a scholarship from the State Graduate Funding Program of Baden-Württemberg. MIR is supported by an NSERC Alexander Graham Bell Canada Graduate Scholarship D and an Alberta Innovates Technology Futures Graduate Student Scholarship.