Apr 20th, 5:00 PM - 6:30 PM

Why do slow trees grow old? Exploring the mechanisms that link slow growth and longevity in ponderosa pine

Beth Roskilly
The University Of Montana, beth.roskilly@umontana.edu

Why do slow trees grow old?
Exploring the mechanisms that link slow growth and longevity in ponderosa pine

Beth Roskilly[1], Eric Keeling[2], Sharon Hood[3] and Anna Sala[1]
[1]Division of Biological Sciences, University of Montana, Missoula, MT, [2]Biology, SUNY New Paltz, New Paltz, NY,
[3]Fire, Fuel, and Smoke Science Program, USDA Forest Service, Missoula, MT

Introduction

Evidence has shown that slow-growing trees live longer.

The mechanisms underlying this pattern are not resolved but may relate to specific wood traits that lead to critical functional tradeoffs (Figure 1).

To explore this hypothesis, we compared growth rates and wood anatomical traits in old and young ponderosa pine trees from a two mixed-age stands in Idaho.

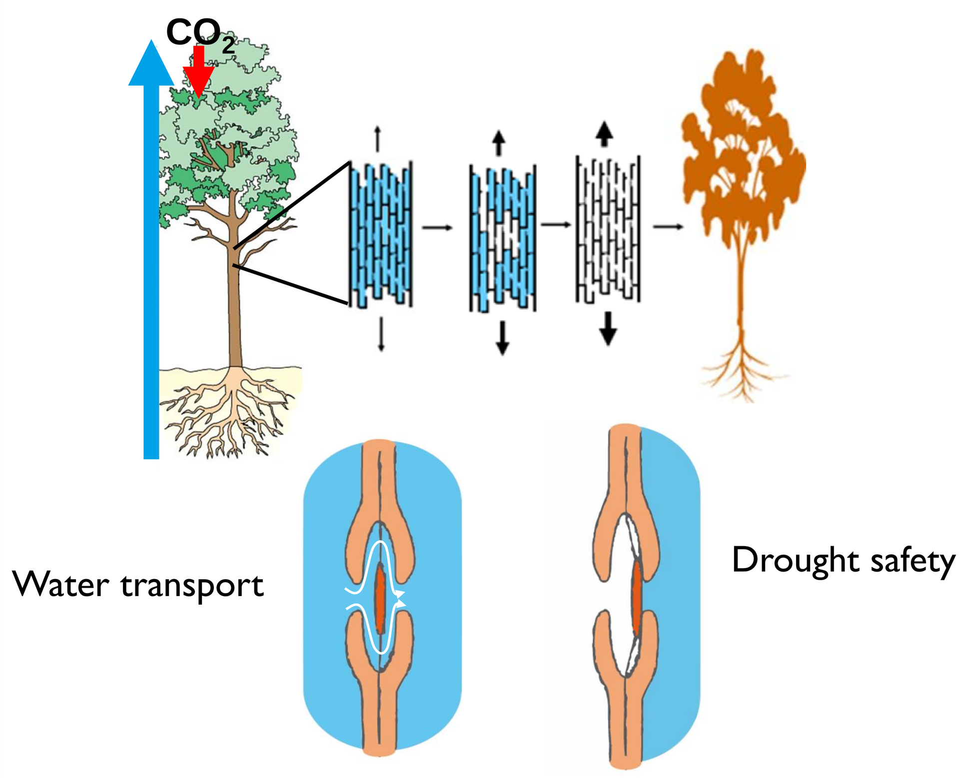
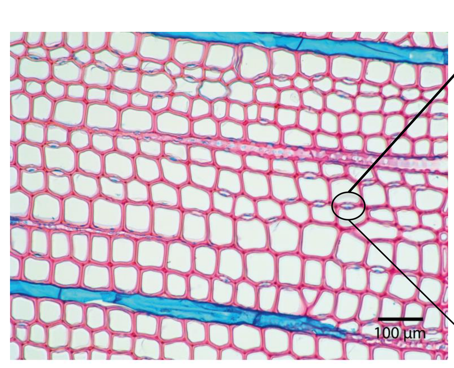


Figure 1. Functional tradeoff between water transport efficiency and drought safety in wood.

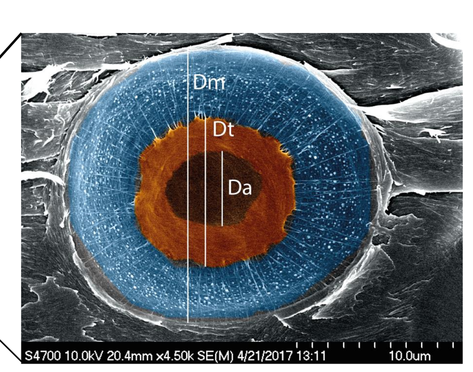
Methods

We collected wood core samples from trees using an increment borer. We measured growth rates based on annual growth rings.

We measured wood density, tracheid diameter and pit structure through the lifespan of each tree.



Tracheid diameters
Light microscope image of transverse xylem section (pit openings are visible between tracheid cells).



Pit structure
Scanning electron microscope image (colored with Adobe Photoshop® software) showing dimensional measurements.

Results

Old trees have the slowest lifetime growth. Among young trees, there are both fast and slow-growing individuals (Figure 2).

Pit structure, but not wood density or tracheid diameter, has a strong relationship with growth rates.

Torus overlap, a measure of the degree of overlap between the inner valve-like structure and the opening within a pit membrane (Figure 3), was higher in the slow-growing trees (both old and young) relative to young fast trees ($p = 0.03$; Figure 4).

The effect of growth rate on torus overlap was not confounded by tree size through ontogeny (Figure 4).

Tracheid diameters increase with tree size through its lifespan ($p < 0.001$; Figure 5).

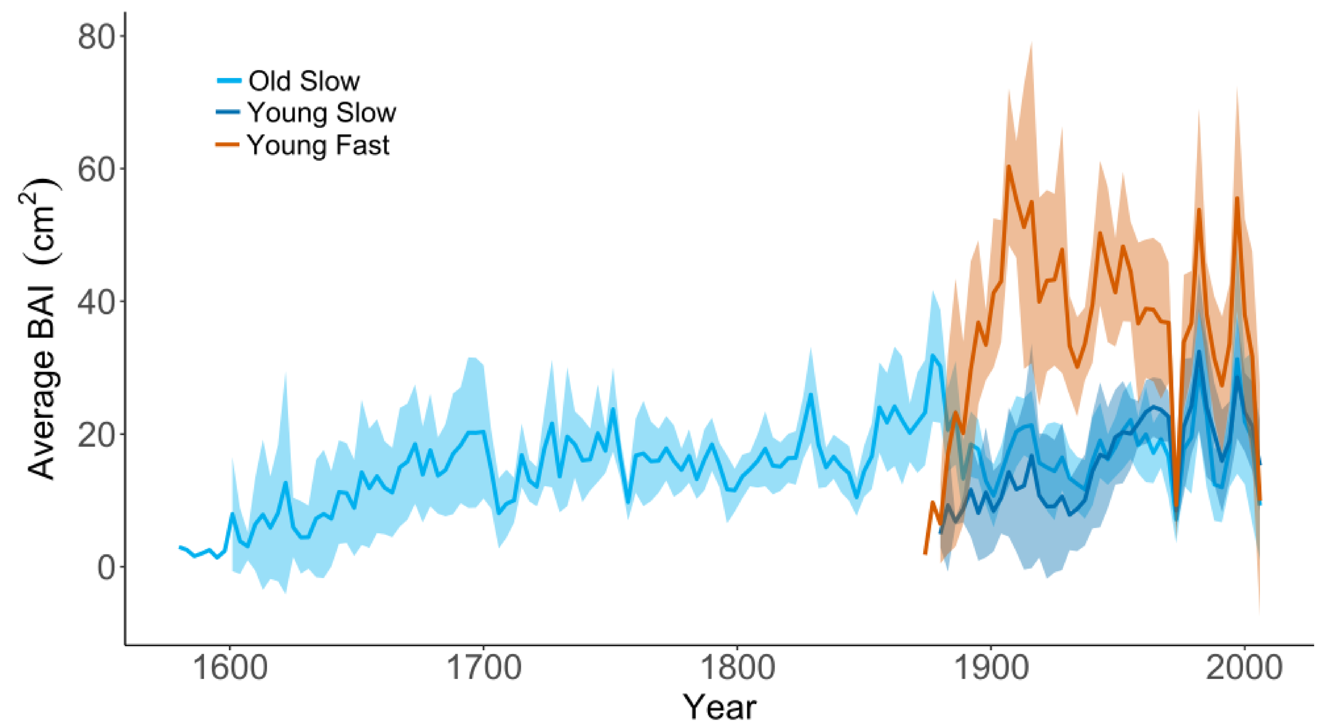


Figure 2. Annual growth rate (basal area increment, BAI) over time for each class:

Class	Age	Lifetime BAI	n
Young Fast	131	39.32	7
Young Slow	114	17.43	7
Old Slow	410	16.67	7

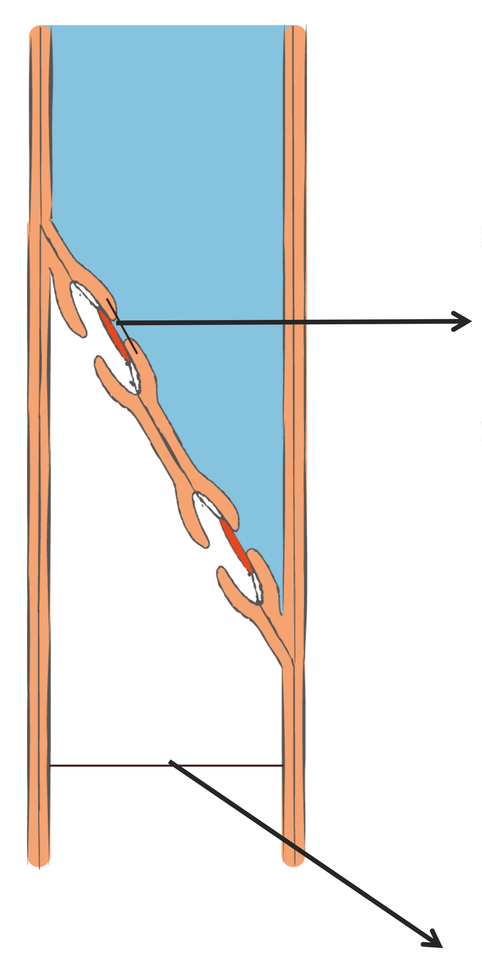


Figure 3. Two adjacent tracheid cells as viewed from the side. The lower tracheid is depicted as embolized (filled with air) while the upper tracheid retains water.

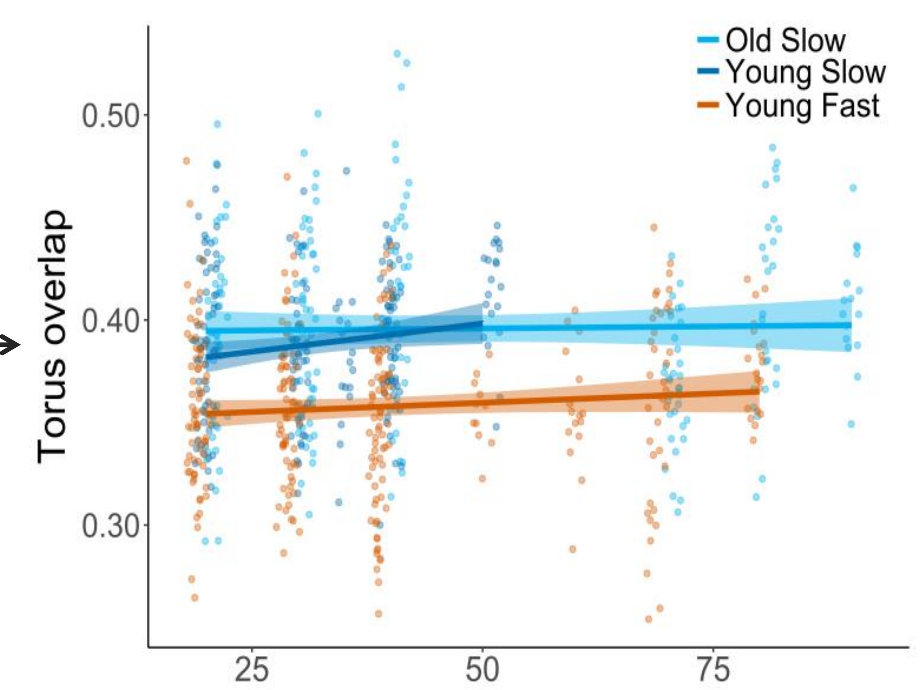


Figure 4. The relationship between torus overlap and trunk diameter for each class. Points represent individual pits (n = 708). Torus overlap was calculated as:
O = (Dt-Da)/(Dm-Da)[1]

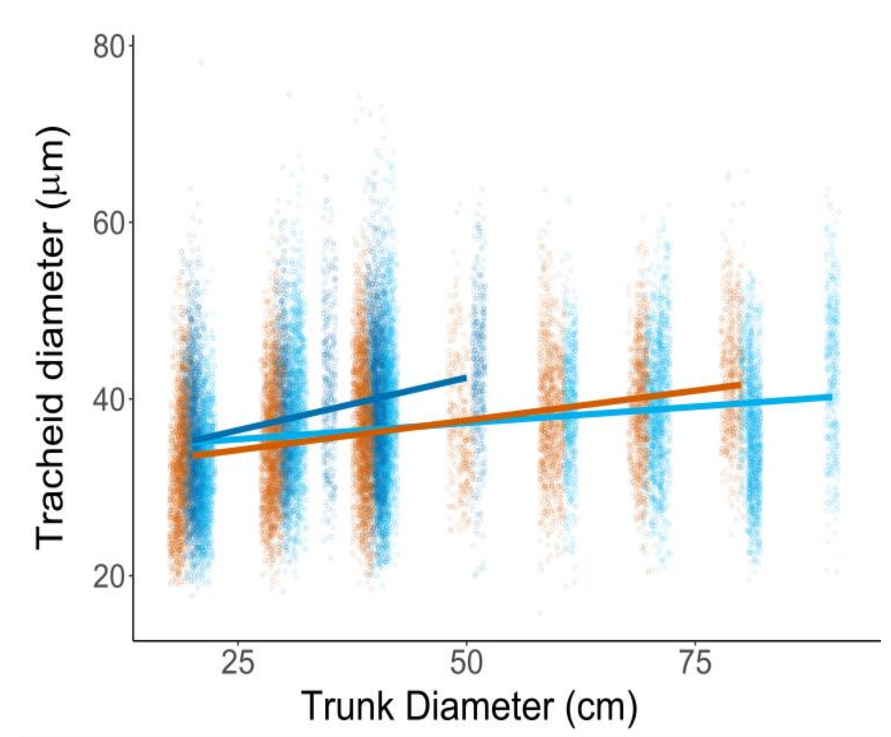


Figure 5. The relationship between tracheid diameter and tree size for each class. Points represent individual tracheids (total n = 24,989).

Conclusions

Our work shows that slow-growing trees live longer because they have a pit structure that increases drought tolerance (larger torus overlap)[2].

However, larger torus overlap may constrain water transport and thereby growth rates (Figure 5).

Our results highlight that pit structure contributes to functional conflicts underlying tree life history tradeoffs.

Implications for forests under climate change: trees with fast growth may have compromised drought tolerance and longevity, reducing carbon storage.

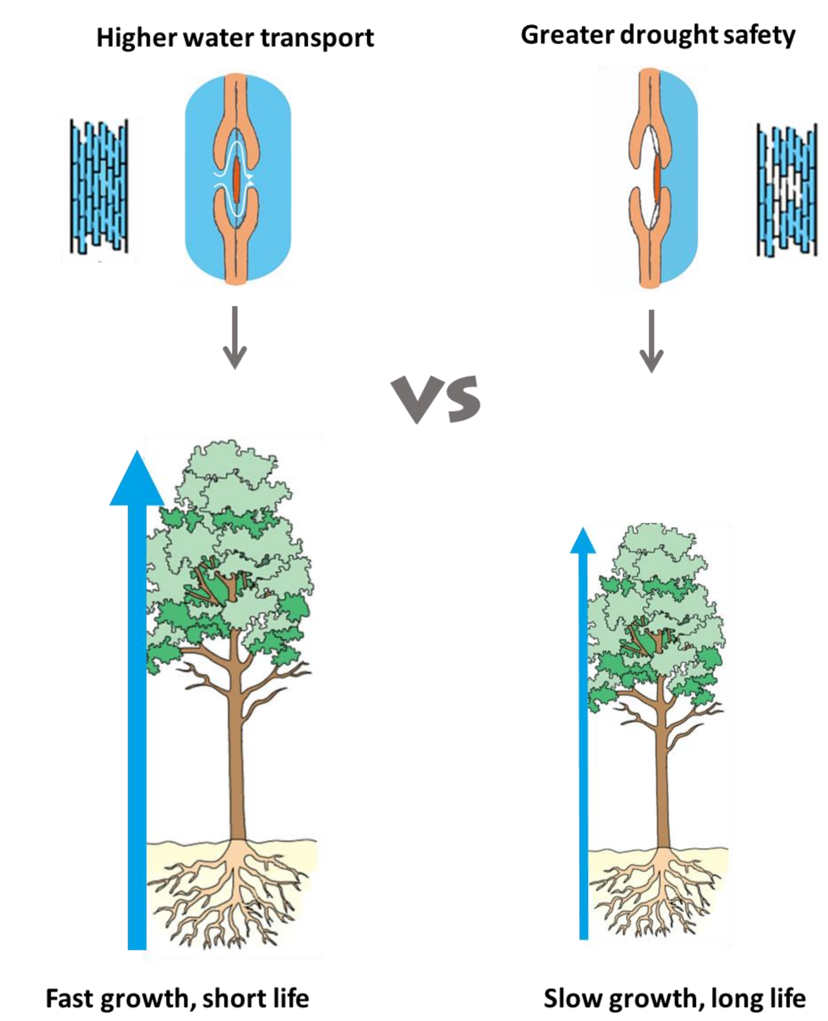


Figure 5. Functional trade-off in stem wood is due to pit structure, which explains the patterns of growth and survival in trees.

Literature cited

1. Hacke, U. et al. 2004. Analysis of circular bordered pit function II. Gymnosperm tracheids with torus-margo pit membranes. American Journal of Botany. 91:386-400.
2. Bouche, P. et al. 2014. A broad survey of hydraulic and mechanical safety in the xylem of conifers. Journal of Experimental Botany. 65: 4419-4431

Acknowledgments

Funding was provided by the NSF GRFP and the University of Montana. We thank Jim Driver for training on the electron microscope, Laura Thorton for assisting in image analysis, and Gerard Sapés for help beautifying images.

GRFP NSF UNIVERSITY OF MONTANA