Let's answer when/how/why growing season length and growth relate!

Team Grephon

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Contents

1 What to do next or some day ...

1. Review our old notes and outlines
2. Fill out table Janneke is making ... what do we want out of it?
3. How to review the papers (pick them) for Janneke's table
4. Measurement comparisons: growth estimated from tree rings (climatology), tree rings (ecology), tree rings in experiments or such?
5. Why is the Parent et al. 2012 curve different than Alan's curves for A_{net}?

2 Outline

Translator:

1. GSL: growing season length
2. RL: resource limitation

1. Introduction (what's happened in the past and where this paper goes)
   (a) Unexpected controversy over GSL and tree growth — needs organizing
      i. Basics: GDD model of growth suggests GSL x growth (with some base temperature for GDD)
      ii. Back when: Ecosystem scale growth (NPP?) increases with warming

iii. New studies: Tree rings don't show GSL x growth (ring width)

iv. But ... Tree ring old studies do show GSL x growth (ring width)

Do they? Need refs

(b) What's going on?! (Briefly)

i. Measurement issues

ii. Biophysical constraints

iii. Resource limitations

(c) Here, we. ...

i. Our premise is that some hypotheses for what's going may be tractably already answered by combining data across fields/methods

ii. Is our premise also that constraint issues are not well included in current hypotheses?

iii. And, you could go far by cross-field tweaking of what each field is doing

(d) This is important!

fit this into intro

i. Carbon storage and climate change

ii. Fundamental to physiology, species assembly

2. Section: Review three reasons for not growing (Our opinion on now)

(a) Overview paragraph of three reasons

i. measurement – see box (include measurement only here, maybe)

ii. Resource limitation

iii. Constraints

(b) Resource limitation, evidence for an against

we need to go back to literature to work on this

i. Nutrients

ii. Water

iii. Is this more species-specific?

(c) Constraints, evidence for an against

we need to go back to literature to work on this

i. Leaf life span

ii. Budset stuff ... (Zohner, Sool.)

iii. Evidence across species? Or which is species-specific

3. What do do next (The future! Is there a framework to our future directions? It would be nice if we found one)

(a) Tree ring people should ... get better phenology data and a better sampling design ... and figure out the transfer f(x)

i. core trials with phenology data

ii. PEP725 x ITRB plot – sampling overlap; sample more places/species withe phenology data

iii. Take more fine-scale measurements

(b) Permanent plot data (provenance/forestry plots) need some temporal resolution and need more allometry data
    i. Do they have GSL?
    ii. They calculate growth every 5 years, they need annual data!
    iii. Allometry here is big opportunity: measuring at different heights (more fine-scale data)
(c) Greenhouse/chamber experiments
    i. Our experiment (which needs a name)!
    ii. VPD x temperature curves – figure those out, include more xylogenesis here
(d) Big experiments
    i. You could do one for this topic
    ii. Measure GSL and tree rings in other ones: FACE, Phynwald, Rainout things, SPRUCE
(e) Constraint experiments (yes, messy topic ... not sure where all this goes ...)
    i. Give plants everything they want and show they still shut down growth at the same time (this goes with some full factorial experiments with drought etc. so we could estimate when the constrain matters ... we could say 'of course there is a constraint but we need to better understand when it would matter with climate change)
    ii. How do people show contraints?
        A. You sort of need the mechanism ... molecular, experiment on proximate cues etc.
        B. Show variation across latitude often for this

Feelings & thoughts coming up

1. If you want to resolve this debate, you need comparable estimates – you have to report similar models (you
2. Some of the fields (tree rings, where we found so far studies do not look consistently at growing season length x growth, they are more interested in spring temperatures x growth) do not care as much about the mechanism... but it really matters
3. Very difficult to compare studies as terms are defined differently (e.g., growing season length) ... could compare what the terms mean across fields
4. Two major ways to measure growing season length: phenological and growth data (xylogenesis)

Wait, WTF is a constraint? Or is there a gradient of constraint to RL ...

1. Lifespan determination growth mush
    (a) Seasonal growth stops: Budset, Zohner equinox paper

(b) Does high temperature fit here? (Definitely on a different timescale)

2. High temperature limitation – enzymatically it's over
3. Low temperature limitation – sort of like energy limitation
4. Things we feel sure are resource limitation
   (a) Nutrients
   (b) Water
5. Terms we could use. ...
   (a) Phenomenological without a real mechanism (plants stop growing at the same time every year)
   (b) External versus internal
   (c) Abiotic versus biotic
6. Kavya adds: I was thinking a little more about the whole constraints vs. limitation thing and this is a thought I had: Is the distinction between resource limit and constraint that resource limitation occurs across a spectrum while constraints have more rigid boundaries (even for the same organism)? In this case (and following Alana's cool figure), temp could be both — at the two ends of the spectrum it's a constraint (cannot photosynthesize below or above a threshold (enzymatic limits)) but in the middle, it's a resource limitation? Or maybe up till Topt it a resource limit and beyond that it becomes a constraint? Also I think it would be good for us to distinguish between net C uptake and allocation to growth? As in trees might still be photosynthesizing but not growing, or not growing in the ways we think they would. Or maybe this just goes into the measurement box with the idea that we aren't measuring the correct/all of the facets of growth.
7. Janneke then added: problem is that temperature influences the rate of everything to do with growth and resource uptake (e.g., water and nitrogen) and is also damaging agent (e.g., frost, denaturing)

Things that need a home

1. Patterns of GSL x growth across elevation/latitude
2. What is growing season length? (Actually when growth starts? Or something else?)
3. Measurement issues
   (a) Maybe they are growing and you measured the wrong thing
   (b) What scale of effect can we detect (and do we expect)?
   (c) Maybe we are measuring the wrong species ...
4. Conifers (tree ring data) versus deciduous (phenology data)

5. Conifers: Does leafout matter in conifers or would it be much more related to when they start photosynthesizing with old leaves?

6. Species diversity in tree ring studies ... maybe make table on whether the studies with tree rings and growth have looked at dominant canopy species

7. Maybe ... which species have budset constraints been shown in?

add to Janneke's table?

3 Figure ideas

1. Ruben's figure

2. Alana's rate x temperature (x limitations) figure: maybe add in agriculture

3. ISI cross-pollination currently across fields

   (a) tree rings in climatology

   (b) tree rings in ecology

   (c) constraint folks

   (d) forestry plots (provenance trials)

   (e) experiments ...

4. PEP725 x ITRB plot

5. Figure for future part?

6. Table/figure on advantages/limitations for each approach? Key places where interdisciplinary opportunities (leverage)