Notes from fall 2022 reading group

Week 8: See grephonideas files

Week 7: Are growing season length and tree growth related?

Many notes are in 2022Dec5 folder on repo

1. Cat reviewed: Understanding relationship between BB and assimilation, some very cool stuff on photoperiod, she also checked her work and found plants that leafed out earlier (under higher chill) also produced more belowground biomass (also saved in 2022Dec5 folder on repo)

2. Alana reviewed heartwood and phenology as well as more generally – where does sugars go if not into radial growth? See 'heartwood and phenology.' Cool points about how you should measure widths every 10 m otherwise it could be really hard to see anything (and small amounts of width at the lower height could mean MASSIVE growth), root exudates, selfish branches and more!

3. Warming experiments and more team

   (a) See warmingexperimentsandmore for info on HF soil warming experiment

   (b) General takehome that experiments are messy with no clearly agreeing results.

   (c) Other papers ... One by Etzold, "Peak growth happens always before the summer solstice. From the potential growing season growth occurred only on 29-77 days (30 - 80% of the GS)."

   (d) Other papers ... Lizzie read a bunch of flux tower x MODIS ones: 2014 says we're all good and land-surface models underestimate carbon sink (because of respiration in autumn) but then 2022 papers say models land-surface models overestimate

   (e) Other papers ... Also a plants grow at night paper was cool, but dependent on turgor model that Alana thinks is fine

   (f) Other papers ... Lizzie needs to track down paper that said findings vary by method.

4. Kavya found two similar garden papers to others and also some cool molecular stuff on photoperiod. You can read more in gardensphotoperiodetc

5. Elevation/latitude

   (a) Ailene wrote, "I found a lot of papers published on this relationship, nearly all of which find an decreasing relationship between tree growth and elevation (as elevation goes up, tree growth declines); however this relationship is sometimes nonlinear and abrupt. I added 2 example papers on this to the spreadsheet I started to summarize Zohner last week." See more info here.

(b) Takehome was that lots of papers find elevational gradients with phenology or with growth, but fewer put the two together ... less evidence across latitude (but maybe because it is obvious?) ... I (Lizzie) liked one paper mentioned that reported things along a 'a more benign conditions' gradient (if I understood correctly)

6. Experiments with growing season and productivity – Rubén found lots of correlation papers with flux towers and other long-term data, but also two cool papers one An earlier start of the thermal growing season enhances tree growth in cold humid areas but not in dry areas (also correlational but with path analysis) and a cool review paper by Piao et al.

   (a) Longer growing seasons lead to less carbon sequestration by a subalpine forest

   (b) ediflux tower , 9 years data. Growing season lenght actually negatively correlated with carbon. Subalpine forest. Cause: carbon uptake dependent on snow melting water, which decreases in warmer years.

   (c) Evidence Of Increased Net Ecosystem Productivity Associated With A Longer Vegetated Season In A Deciduous Forest In South-Central Indiana, Usa – Also american ediflux tower, 10 yeras data, showed increase in net ecosystem productivity associated with longer season. Unsure how that links to the forest component and individual trees, though.

   (d) Changes in growing season duration and productivity of northern vegetation inferred from long-term remote sensing data – Using remote sensing data, calculating growing season and effects on productivity. Boreal biomes. 33yr of data. Productivity is measured vai NDVI. Sotrong increase in forests of all tpyes (mxed 6

   (e) Increased growing-season productivity drives earlier autumn leaf senescence in temperate trees – Zani et al. – ok, that's now insane. Increase growing season productivity is now driving leaf senescence?

   (f) Phenological response to climate variation in a northern red oak plantation: Links to survival and productivity – 58 year common garden, red oak from all eastern US. Consistent phenological response, no increase in productivity consistently. Earlier leafout also associated to higher mortality

Miscellaneous summary thoughts this week

1. Maybe you see these trends in elevation because fewer things other than growing season length change (you measure the same year, same general drought etc.) ... basically, you remove many of the other growth-limiting factors. So maybe this makes latitudinal trends within the same species messier than we expect and thus they are published less?

2. Could we look for latitudinal growth trends with ITRB?

3. What is 'growing season'? It really seems to vary ...

Week 6: What are we doing?

Tasks before meeting were ... What do we wish we knew?

1. Useful exercise: What papers we wish exist? Where are the gaps.
2. To get to this Lizzie will assign us each a paper we already read and we need to answer – What did they measure? What did they find? What is their theory/mechanisms? What are the gaps you see? Are any of those gaps filled by other papers or data you know of that would be easy to get?

At meeting ...

1. What question are we asking (or what is our goal)?
   (a) Goal: To crystallize gaps across fields in different phenological indicators
   (b) Question: How do shifts in phenology relate to growth and carbon uptake?
   (c) Question: Why/how (does) climate-change driven shifts in phenology affect tree growth ... and thus, carbon (somehow)?
   (d) Question: What are common responses across species?
   (e) Question: How do uncertainties propagate across chains?
2. We have some complexities
   (a) Are we interested in growth (and, if so, above or belowground)? Or we interested in carbon?
   (b) If we're interested in carbon, are we interested in uptake, storage, residency ...?
   (c) Is how question a why/how or just 'does this happen'?
   (d) Oh no, what if other things limit plant growth? Such as
      i. Drought
      ii. Nutrients
      iii. Competition/herbivory
      iv. Temperature, in other ways
3. We may need to know:
   (a) For each species, when growth changes with climate (projections etc.), where does that growth go?
   (b) For each species, when growth changes, what does it mean for fitness (fruit or such)?
   (c) When BB is earlier how does photosynthesis/growing season/net C gain change?
   (d) What evidence do we have that growth and growing season length are related?
   (e) What is a growing season? Is it ...
      i. BB to budset? Or some time of season defined by phenological events?
      ii. When photosynthesis is possible?
      iii. When growth is happening?
4. More on ... What evidence do we have that growth and growing season length are related?

(a) Latitudinal/elevational patterns (mentioned in Dow) ... do those papers ever mention interannual patterns in tree rings?

(b) Maybe from field warming experiments?

(c) What about from controlled greenhouse or such experiments?

(d) Common gardens?

5. Gaps and good stuff in papers we've read

   (a) Dow/Tumajer papers:

      i. No ring width by season length

      ii. No link to carbon uptake (tree rings are incomplete measure)

      iii. Dow drops a lot of data

      iv. But! Do show that early BB leads to earlier growth (Dow)

      v. But! Do look at other climate metrics (Tumajer)

      vi. But! They could look at more, especially Dow

   (b) Soolananayakanahally

      i. Unclear how growing season relates to growth (not good enough mechanisms)

      ii. But! Do show that higher temperatures (in Vancouver) lead to earlier BB, budset and leafdrop

   (c) Zohner

      i. No growth

      ii. Lots of phenology metrics (good), but we're not sure how we feel about MODIS data

End of week 6 musings on paper we could write ...

1. Could we say what each field needs to measure to answer this question? (AKA what does each field ignore at its own peril?)

2. Could we design the ideal experiment?

   (a) Measure growth (Dow has this)

   (b) Measure photosynthesis (Zohner)

   (c) Phenology

3. Other cool ideas we have had (from below)

   (a) What about autocorrelations in climate?

   (b) Simulate data to see how much data Dow would need to see effect sizes that are reasonable (perhaps across latitude or such)?

   (c) Hypothesis from Alana: EOS_{10} is just a measure of herbivory ... so maybe this paper just means that earlier springs means earlier onset of 10% herbivory

(d) We (says Kavya) need a daylength experiment to make the Zohner solstice argument convincing

(e) Does growth change with longer seasons? Depends on whether you're talking about ind. species versus communities? Communities should get longer, but we're not sure on species ... but most of the authors seem to be assuming all species act the same.

(f) Diffuse vs. ring porous spp.

Weeks before week 6

1. Week 1: Dow *et al. 2022* and skim Gantois 2022

   (a) Curious about standardizing ... why they did it what way? Do results hold up with other methods?

   (b) What about autocorrelations in climate?

   (c) Heartwood! Roots!

   (d) What about VPDI? They should do analyses with that

   (e) They did not have much data in the end ... especially given they don't define how big an effect they expect to find or how big an effect they could detect (simulate data people!)

   (f) Why did Gantois exclude March from the spring?

   (g) Lots of good citations in Dow on other hypotheses/latitudinal variation to review!

2. Week 2: Zohner *et al. 2022* solstice pre-print

   (a) Paper diverges from Keenan work cited where longer seasons mean more carbon storage

   (b) Things that could explain the shift over time that looks to go with solstice and that earlier means you stop growing sooner (if you are tree)

      i. Drought correlates with earlier springs

      ii. NEW **cool** hypothesis from Alana: EOS_{10} is just a measure of herbivory ... so maybe this paper just means that earlier springs means earlier onset of 10% herbivory

      iii. Running out of nutrients?

      iv. Limited leaf lifespan

      v. Specific to some species?

      vi. Something about radiation

   (c) Kavya suggests they needed a daylength experiment to make the solstice argument convincing

   (d) No changes over latitude seem weird

   (e) Thermal optimum of leaf tissue can change up to 10C on the SAME tree each year, says Alana.

(f) See also the to do list below

(g) Misc.

i. Some of the error reported is ODDLY small, suggesting the models are wrong somehow.

ii. Needs better measures of senescence says Fredi – check A_{max} and other measurements and see how they correlate with MODIS

iii. We're not sure that MODIS is not just measuring radiation also ... in which case part of the paper is circular but that does not explain the ground observational data

iv. Radiation? ... constructing leaf tissue, increase productivity (not sure what I meant here says Lizzie looking at her notes later)

3. Week 3: Schofield *et al. 2016* tree rings

(a) This paper compares tree ring methods in a joint Bayesian models and shows that when you model altogether you get WILDLY different temperatures.

(b) Cat and Lizzie loved the math and paper, others found it dense and frustrating ... and we all agreed the figures are bad.

(c) Ruben found discussions of uncertainty in the step-wise approach and in cross-dating important and cool.

(d) Who has cited this paper?

(e) Lizzie really enjoyed how they used the models to show support for classic approach and less support for RCS and how much a slightly more realistic biology sucked up variation and climate stuff.

(f) New paper idea from JHRL: Write an ecological paper with a joint model and show that you get something NEW out of it

4. Week 4: Tumajer *et al. 2020* the VS lite model, which gives your start of wood growth and end of wood growth from annual tree ring data via a process-based model ... See Fig. 1 in the supp for how well the model fits to real xylogenesis data

(a) About the paper

i. No one is sure about the model – what's with all the tuning (what does tuning mean)? Did they tune to sites or not? We need to understand the validation stuff better, and it would be cool to know how their model works if you run white noise through it versus a model where you generate data from the VS model and then add noise or such.

ii. Ruben asked – is this model possible? Do we believe you could build it? Alana says if these things do work, then where in the tree you measure this would matter...

(b) Other things we discussed ...

i. Does growth change with longer seasons? Depends on whether you're talking about ind. species versus communities? Communities should get longer, but we're not sure on species ... but most of the authors seem to be assuming all species act the same.

ii. Earlier leaf phenology does not mean more wood, because leaves go into sugar not obviously wood... says Alana.

iii. Physic-focused vs. observational/statistical groups of physiologists ... and who works on tree rings? (The latter.)

iv. What do we know about xylogenesis? Does winter temperature matter? It could says Alana, esp. with winter embolusism but she's not sure of anyone working on this.

5. Week 5: Soolananayakanahally *et al.* 2013 (notes include week 5 discussion and discussion from

   (a) Vocab: LS - leaf senescence, HGC – height growth cessation, and (lammas is a bud you make after you've made your other buds and (I think...?) see wiki

   (b) Summarise: BB is sensitive to warming as we know, but HGC also responds in opposite direction (earlier with earlier springs) – they have bud flush versus bud-set and leaf senenscence... HGC variation was higher in Vancouver (and lots of variation)

   (c) HGC ... happens before LS. HGC – their evidence that it reversed?

   (d) Is this whole photoperiod thing a good idea?

      i. Why is photoperiod so adaptive? It seems tough to use as a cue for budset (aka mostly stopping growing)?

      ii. Is lammas growth a way to get in some more growth despite the photoperiod/budset cues.

      iii. Why do plants use photoperiod to stop growth?

   (e) Design issues ... Is this potentially maladaptive because the common garden was so far south (and one out of range)? Do they have any up higher?

   (f) More physiology info please! How much leaf area did lammas make up? Is lammas common across years for this species? Ray storage – did they measure that?

   (g) Is it really latitude? Did they look at other metrics to predict variation instead of latitude? MAT or climate variability?

   (h) (From Cat): They mention that length of night is what matters (so maybe wavelength during the day doesn't matter so much).

   (i) If someone had a lot of time they could play around with stop and starting growth in trees in one season (in a greenhouse or such) and then measure tree rings the next year. They could look across species also to see how they vary. Ruben had a cool common garden study in Vancouver where they measured tree rings ...

   (j) Is this species diffuse or ring porous? ... Lizzie's old database (`https://www.wood-database.com/hardwoods/`) may not have it but the USDA (`https://plants.usda.gov/DocumentLibrary/plantguide/pdf/pg_pobat.pdf` says ... diffuse!

(k) Should we do more tree ring measurements in common gardens (possibly related 'Cold adaptation recorded in tree rings highlights risks associated with climate change and assisted migration' see `https://www.nature.com/articles/s41467-018-04039-5`)

(l) What is the minimum amount of physiology that Alana wants? NSC weekly would be useful (and something else I missed)

What do we want to do next?

There are sort of two big possible ways to go – think broadly about what could drive trends (or lack thereof) between season length and growth (and ideally jot down a concept paper) *or* or dive in on some data and related analyses we want to do. These sort of overlap ... if we start with the latter we likely need to return to the former.

1. Where is this all going and how do we get there?
   (a) Are we talking about community or species-level trends?
   (b) If you had all the data, and all the models are correct; what is most urgent? What is most important to know?
   (c) If we can link phenology to cambial growth; could we understand how this shifts with climate change and thus carbon sequestration? [Relating to above, can we make that link?]
   (d) Scroll to last page maybe – see 'Lizzie's earlier notes'
2. Can we link leaf phenology to tree ring growth? ... with some data...
   (a) Maybe through common garden data? (Aitken lab etc.) ... Do we have tree ring, bud-set, start of season data? Someone must have done dendro?
   (b) Can we get good high-resolution satellite data to look at EOS by species (we asked Kavya)? Some cool 'cubesat' stuff ... Cat added: GEDI is now 30m x 30m resolution

Paper ideas
Interesting papers to read:

1. `https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2745.13464` (Some of Jucker last papers, super interesting approach, used something similar to the RCS but then use those to calculate the over/under production. Is not phenology, but shows I think a bit better how to use dendro in a better way)
2. VS-lite models: this is a way to build physiological constrains (very similar to what they did in Schofield paper with the thresholds) to decompose tree ring into intra-annual patterns and then model it forward. It's really interesting and loads of paper but it really feels like it shouldn't work. I would be curious to dig in and get people's feedback, specially of those most experience in these. Definitively has more links to phenology if we consider it robust:

(a) "Original" paper: Tolwinski-Ward: https://link.springer.com/article/10.1007/s00382-010-0945-5

(b) Example of application: https://onlinelibrary.wiley.com/doi/full/10.1111/geb.13377

3. Aloni R (2022) How the Three Organ-Produced Signals: Auxin, Cytokinin and Gibberellin, Induce and Regulate Wood Formation and Adaptation. In: Auxins, Cytokinins and Gibberellins Signaling in Plants. T Aftab (Ed), Springer Nature, Cham, Switzerland.

4. Decoupled leaf-wood phenology in two pine species from contrasting climates: Longer growing seasons do not mean more radial growth

5. A photoperiod-budset paper

6. Papers on VPDI and heartwood? (sink limitation)

7. Any other papers on phenology and tree growth??!!

From Ruben:
Groups/people doing 'modern ecology' with tree-rings to keep an eye on:

1. Margaret Evans. Arizona. https://scholar.google.com/citations?hl=en&user=IGG0ZKQAAAAJ&view_op=list_works&sortby=pubdate

2. Charlotte Grossiord. Lausanne. https://scholar.google.com/citations?hl=en&user=RsHW0OsAAAAJ&view_op=list_works&sortby=pubdate

3. Tommasso Jucker. Bristol. https://scholar.google.com/citations?hl=en&user=s0x7E5wAAAAJ&view_op=list_works&sortby=pubdate

4. Valerie Trouet. Belgium. https://scholar.google.com/citations?hl=en&user=-hF1HN8AAAAJ&view_op=list_works&sortby=pubdate

5. Loic D'Orangeville. New Brumswick. https://scholar.google.com/citations?hl=en&user=CwBKApgAAAAJ&view_op=list_works&sortby=pubdate

6. Dario Martin-Benito. Madrid. https://scholar.google.com/citations?hl=en&user=Qiooe3EAAAAJ&view_op=list_works&sortby=pubdate

Zhao et al. 2018 is the paper where we commented about this project together with Shoudong of characterizing the bias of the ITRDB and where we proposed some ideas on how to tackle it. It is the base for the ERC proposal but not much else went with it afterwards (and the database went again back to get filled with problems, but well... we tried)

To do items ... maybe?

1. Email Keenan to see his perspectives on Zohner preprint; also ask Norby? ... Keenan, T. F. et al. Net carbon uptake has increased through warming-induced changes in temperate forest phenology. Nat. Clim. Chang. 4, 598–604 (2014). Do they also use MODIS GPP?

2. Check refs of earlier spring = later EOS in Zohner preprint and COMPARE the papers

3. For the Zohner preprint: Check if budbset is earlier in years with early springs (from common gardens with multiple years of data)

4. Review refs in Pederson for latitude and other things ... here's all the ones Lizzie highlighted (last 3 are latitude).

   (a) Ahlstrom, A., Schurgers, G., Arneth, A. & Smith, B. Robustness and uncertainty in terrestrial ecosystem carbon response to CMIP5 climate change projections. Environ. Res. Lett. 7, 044008 (2012).

   (b) Zweifel, R. et al. Why trees grow at night. New Phytol. 231, 2174–2185 (2021).

   (c) Tumajer, J., Scharnweber, T., Smiljanic, M. & Wilmking, M. Limitation by vapour pressure deficit shapes different intra-annual growth patterns of diffuse- and ring-porous temperate broadleaves. New Phytol. 233, 2429–2441 (2022).

   (d) Cabon, A. et al. Cross-biome synthesis of source versus sink limits to tree growth. Science 376, 758–761 (2022).

   (e) D'Orangeville, L. et al. Drought timing and local climate determine the sensitivity of eastern temperate forests to drought. Glob. Chang. Biol. 24, 2339–2351 (2018).

   (f) Helcoski, R. et al. Growing season moisture drives interannual variation in woody productivity of a temperate deciduous forest. New Phytol. 223, 1204–1216 (2019).

   (g) Anderson-Teixeira, K. J. et al. Joint effects of climate, tree size, and year on annual tree growth derived from tree-ring records of ten globally distributed forests. Glob. Chang. Biol. 28, 245–266 (2022).

   (h) Banbury Morgan, R. et al. Global patterns of forest autotrophic carbon fluxes. Glob. Chang. Biol. 27, 2840–2855 (2021).

   (i) Churkina, G., Schimel, D., Braswell, B. H. & Xiao, X. Spatial analysis of growing season length control over net ecosystem exchange. Glob. Chang. Biol. 11, 1777–1787 (2005).

5. Check who has cited Schofield et al. 2016 since it was published!

6. VS lite model: How to know what the null trends or findings are (Tumajer paper discussion notes above: would be cool to know how their model works if you run white noise through it versus a model where you generate data from the VS model and then add noise or such).

Lizzie's earlier notes below

Background: As springs shift growing seasons lengthen and plants are expected to grow longer. Especially trees, but tree rings suggest growth may not be increasing with earlier seasons in temperate zones.

Hypotheses:

1. Statistical – Non-stationarity in temperature (climate) data may make accurately estimating phenological change and tree growth change accurately difficult. Check this early and often.

2. Climate correlations – warmer springs may be associated with factors that reduce plant growth such as drought (and/or did someone write something about winter chilling?). Relates to climate hazards work.

3. Ecology – shifting competitive landscapes (or something else?)

4. Evolution – It may not be a long-term stable strategy to try to adjust growth dramatically year-to-year, so should we really expect this correlation? If this is true, you predict:

    (a) Latitudinal variation in length of growing season and tree growth. (May connect back to Ailene's Putnam – predicts species from warmer provenances would better exploit longer growing seasons?) ... also these papers cited in Dow 2022: 44. Anderson-Teixeira, K. J. et al. Joint effects of climate, tree size, and year on annual tree growth derived from tree-ring records of ten globally distributed forests. Glob. Chang. Biol. 28, 245–266 (2022). 45. Banbury Morgan, R. et al. Global patterns of forest autotrophic carbon fluxes. Glob. Chang. Biol. 27, 2840–2855 (2021). 46. Churkina, G., Schimel, D., Braswell, B. H. & Xiao, X. Spatial analysis of growing season length control over net ecosystem exchange. Glob. Chang. Biol. 11, 1777–1787 (2005).

    (b) Species diversity: species should vary in how much they try to take advantage of interannual variation in climate (likely early-active species show the highest correlation? Again, Ailene's Putnam focused on this.)