Put your organizing schemes over here!

Species-Level: 1) species-specific cue responses with climate change, 2) variation in storage mechanisms across species (??)

Spatial: 1) latitudinal variation in cues, 2) elevational variation, 3) continental - with different oscillations (e.g., NAO, ENSO)

Why are trees not growing more :(
Release vs. Carbon limiting factor:
•Q: Is the limiting factor changing due to climate change? Is it changing in the "good direction" due to climate change?
A: If temp in early part of growing season was limiting, now it is not then this should lead to earlier phenology, which we see and thus earlier start of plant processes so growth should increase BUT
•If this limiting factor is no longer limiting, then what is the new limiting factor? And how does it (if at all) change with climate change? e.g.
•More competition for limited nutrients/nutrient supply ending early in the growing season
•drought/heat when trees hit peak growth period
•mass balance — more photosynthate is created, but more is also used to deal with things like pests, competition, repair, etc

We're not measuring all the things/the right things:
•Maybe tree girth growth isn't the best measure of increased growth
•Maybe other things like:
•Root mass increased – partially to also find more soil nutrients and water?
•increase in canopy branches that would not be captured by tree cores
•Not growth but still good things:
•Increased fitness? Maybe more photosynthate means more baby trees!
•Increased ability to defend or repair?

Scale dependence – temporal
•Short term vs long term – is there a threshold beyond which earlier phenology leads to quantifiable/measurable growth? In other words,
Scale dependence – organismal/spatial
•Leaf level and Individual plant level (physiological release and constraints due to climate change; phenological cues for leaf out etc, physiological constraints due to water related things (turgor, vpd))
•Species level (local vs range wide)
•Local
•Rangewide: differences across latitude
•Community level:
•Differences amongst species within a community
•Differences as community composition changes (also ecosystem changes)

Biological scale:
1. Individual
2. Population
3. Species
4. Community

Temporal/Spatial scale:
•Across years
•One year across elevation (or otherwise small-scale space)
•Across years x small-scale space
•Across latitude

Then cross them to make predictions (I only show one prediction so far) ...
•Individual across years (cannot cross individual with anything other than across years)
•Population across years — should grow more due to more time/energy etc UNLESS longer seasons mean more intra-specific competition
•Populations spanning elevational gradient
•Populations spanning latitudes
•Species across years ...

This lead me maybe what we really want is: temporal/spatial scale x predictions from physiological (i.e., energy, etc.) versus community theory (i.e., competition).

Hierarchy / level	Why should an earlier (and perhaps longer) growing season length lead to greater tree growth / productivity?	Why might an earlier (and perhaps longer) growing season length NOT (visibly) lead to greater tree growth / productivity?
Individual tree	• Assuming earlier leads to longer growing seasons (i.e. more growing degree days), this means more growing degree days, which means more photosynthesis. This could occur because temperatures are on average warmer or because temperatures are above an important threshold for longer.	• If earlier / longer growing seasons cause trees to indeed grow more, but to allocated growth to something that we don't typically measure (e.g. carbon storage, belowground growth), there may be no effect on common metrics of annual tree productivity (ring width, dbh). • Earlier growing seasons from a temperature point of view may not necessarily mean a longer growing season from the trees point of view, if this is paired with increased frost damage early in the growing season or drought stress late in the growing season. • Individual trees may be preprogrammed (developmentally) to only allocate so much to growth, so that an earlier / longer growing season may not necessarily lead to more growth (this argument may be similar to the first). This argument I think presupposes that there is some phenotypic / evolutionary control over this, so that for wide ranging species, this developmental control varies across elevation / latitude.
Forest community (ecosystem)	• All individual trees grow more (see above) • Trees of different species avoid some level of competition (suppression of growth) because their times of optimal growth are more spread out, thus, the forest as a whole is more productive (even if individual growing seasons are the same length).	• No individual tree grows more (see above).

Why should plants grow more with longer growing seasons? Or – did we mean – what will happen to plant growth with climate change as growing seasons lengthen?? ... Maybe we focus on **longer via earlier** (and are they the same as longer however or longer via later?)

More time to grow = more total growth (elevational/latitudinal patterns correspond to this reality) because plants should maximize using up resources.

Longer growing season could allow more partitioning of resources and thus more growth (community ecology theory, sort of like BEF work I saw recently by Xavier Morin)

More temperature and more carbon means you should grow more (assuming other resources are not limiting)...

Earlier growing season means you have access to resources at a better (less stressful?) timing when you can actually use them.

Earlier means you're ready to go when the peak season comes – get out early, get leaves ready and you win! Should work for individual trees? But not too early as then you get hit by frost/herbivory.

Assumptions ...

Something is limiting and it is (or relates directly) to growing season length.

This is actually about growing season length, and not just something else that is changing with climate change (temperature, increased carbon).

Why not? (Or why not immediately?)

Maybe plants don't have a truly longer time to grow because the period of time with suitable conditions to grow has not happened yet.

On that note, why not? Drought. Or maybe high temperatures (higher limits to GDD). Or frost events are increasing. ...

It's spatially variable – so plants in variable climates might be selected to track growing season length, while those in constant climates would not ....

Only some species actually have a strong relationship between growth and season ...

Constraints. Wood! Maybe leaf lifespan is limited at each latitude. Or turgor can always constrain stuff. Some other resource is limiting, like nitrogen or protein (spelling?). This includes risk ... so early is a way to lose tissue. Also herbivory ...

Related to this ... maybe early is bad because temperatures are low and you don't grow much (so the effect might be real, but super small)

Depends on what you measure ... tree rings might not be the bomb.

Longer term patterns – especially given that plants have the option to grow or store carbon or such.

But species composition change with elevation/latitude presumably adapted to its corresponding GS length. -> vs. same species composition than suddenly is exposed to longer GS