Growth & Allocation

March 19, 2019

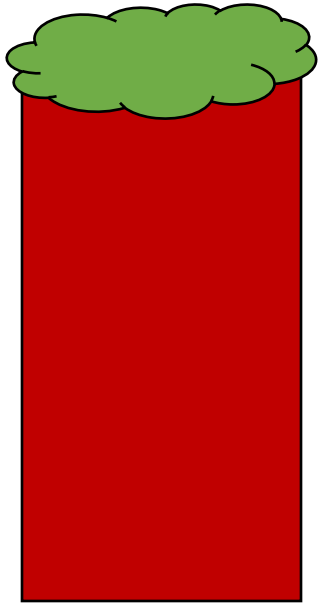
Spicoli question of the day: Why do plants grow?

Allocation

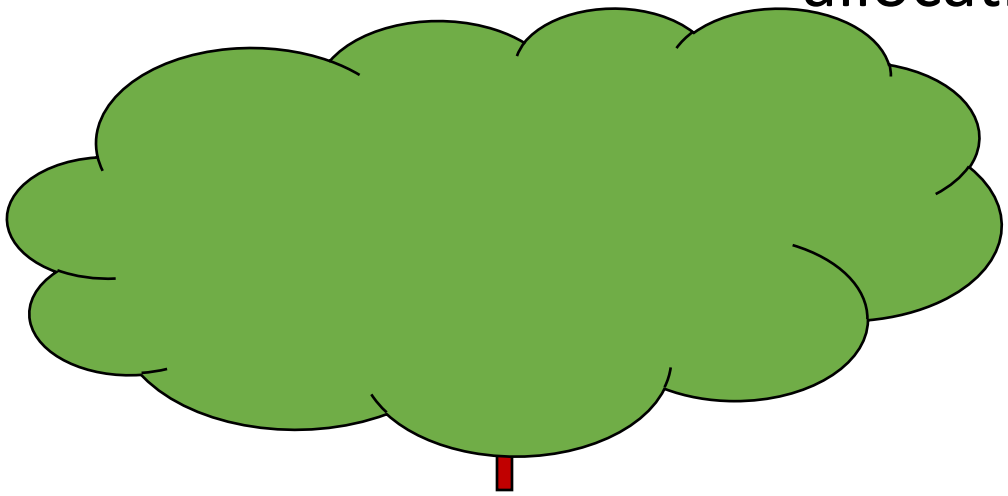
Allocation

- The distribution of growth to different organs
- Allometry: the relative size of different organs

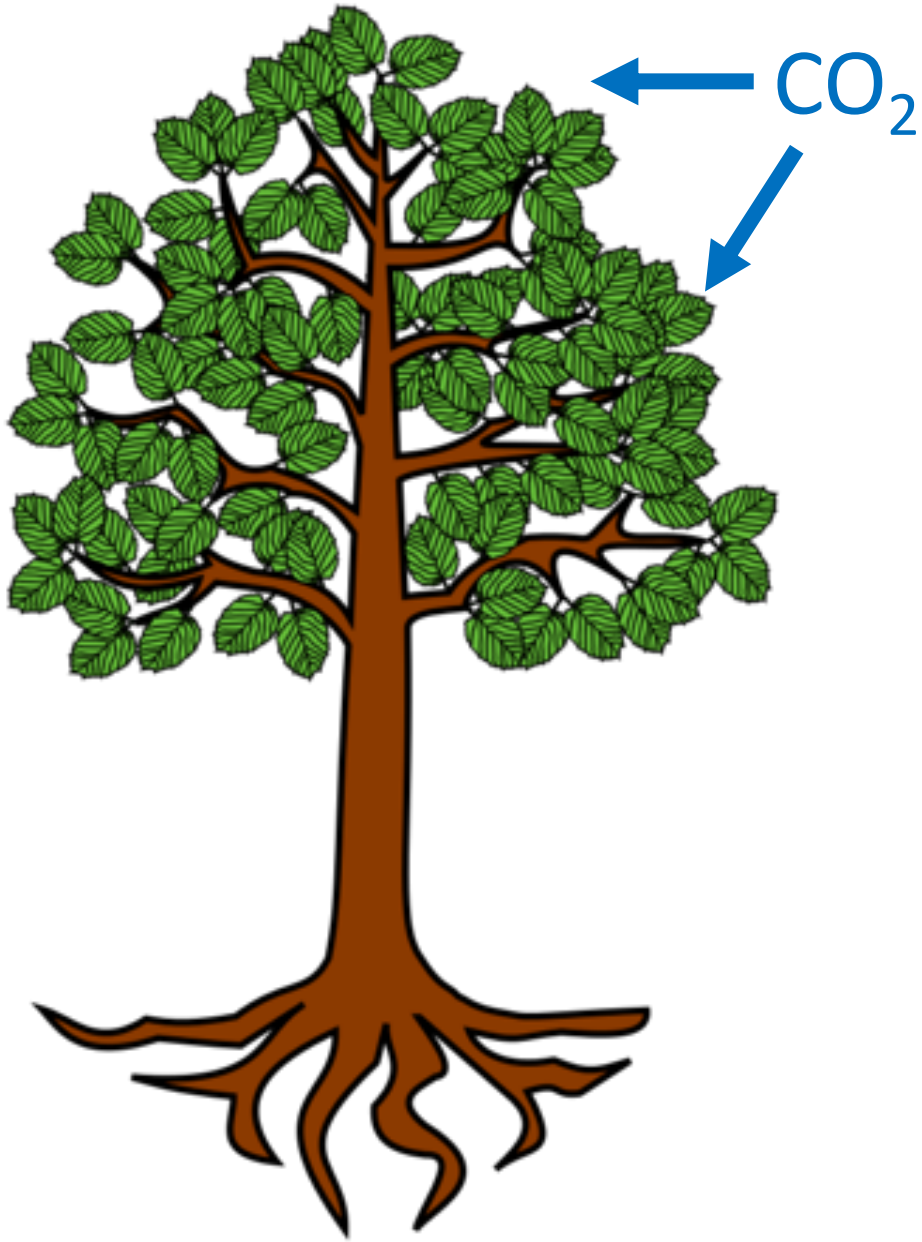
High stem allocation



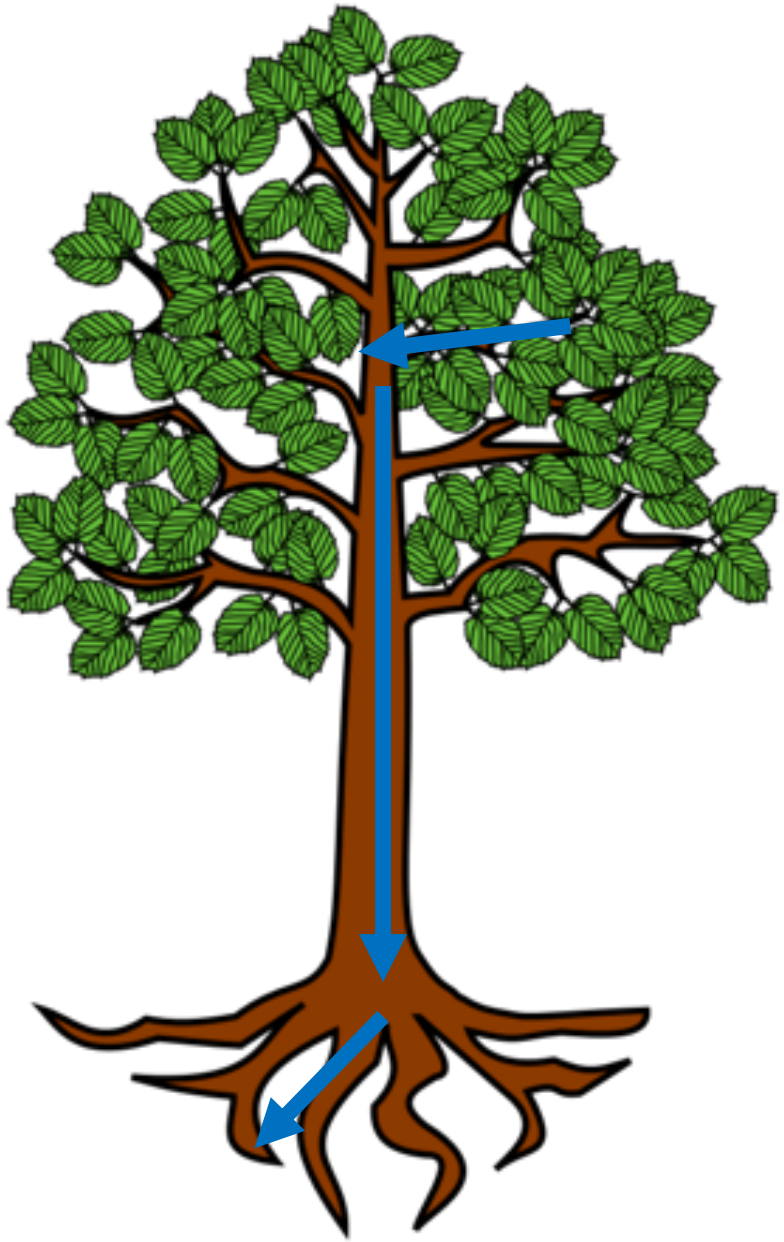
High leaf allocation



Following the carbon

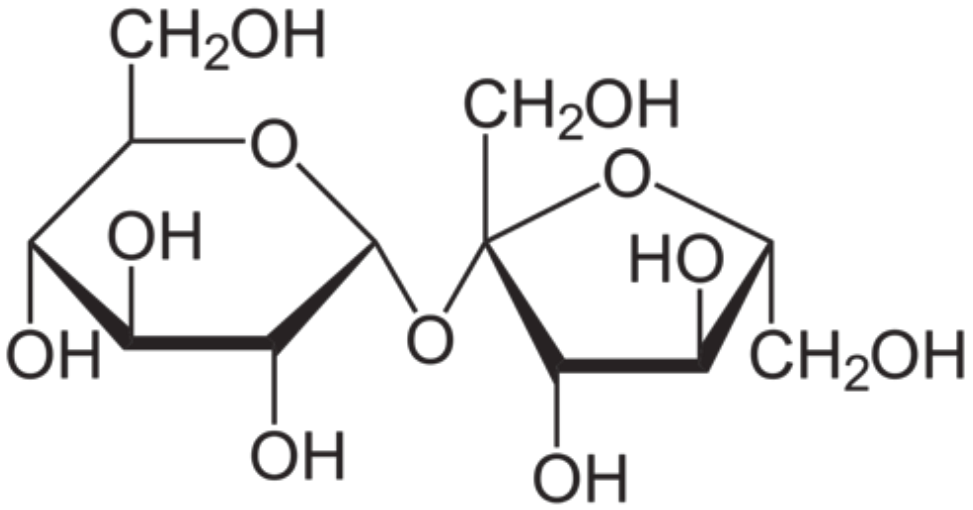


Carbon is first taken up by photosynthesis (source)

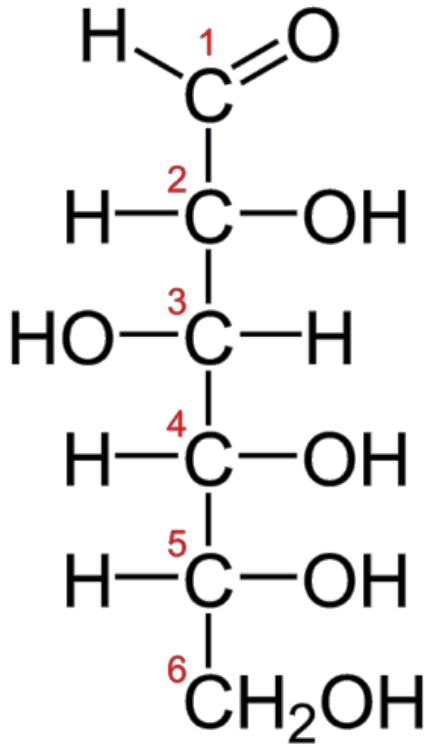


The sugars are then transported throughout the plant (sinks)

Sucrose, not glucose, is the primary transport sugar…huh?



Sucrose



Glucose

Translocation

- Movement of food substances through the plant (via water)

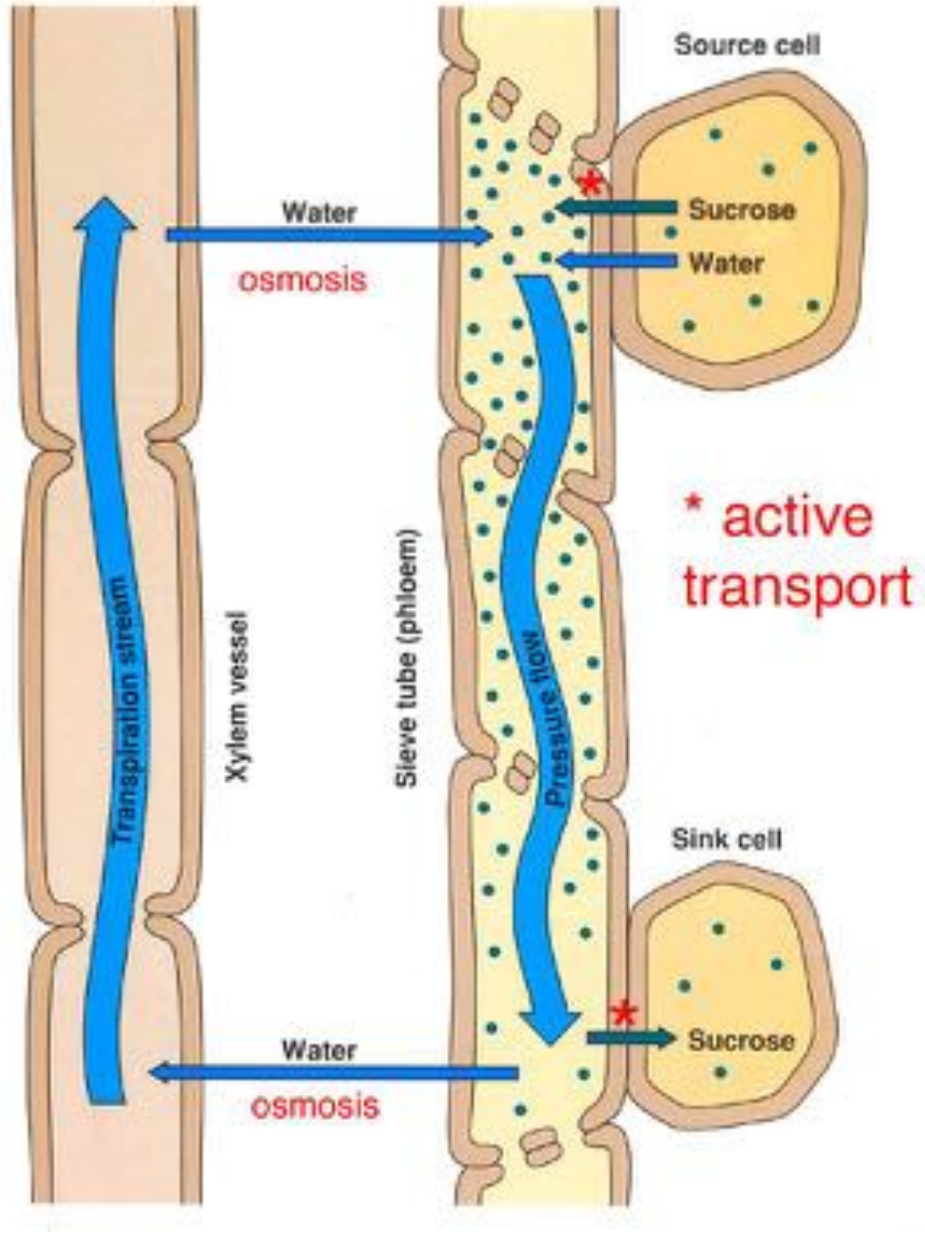
(a)

From Martin H. Zimmerman, "Movements of Organic Substances in trees" Science 133:73-79, 1961, American Association for the Advancement of Science

Translocation happens fast!
(Can't be accounted for by diffusion alone)

Pressure-flow hypothesis

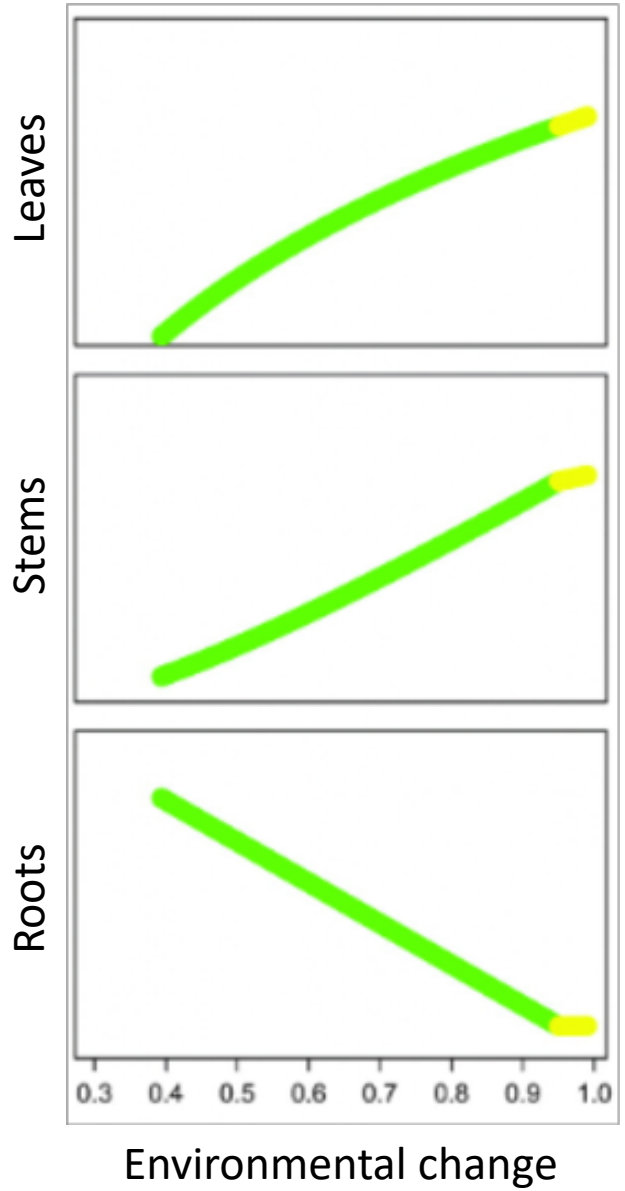
- Food is actively loaded into phloem from “source”
- Water enters phloem from xylem via osmosis
- Pressure gradient drives food to “sink”
- Food is actively removed from sink



What do the sugars from photosynthesis get used for?

(What are the sinks?)

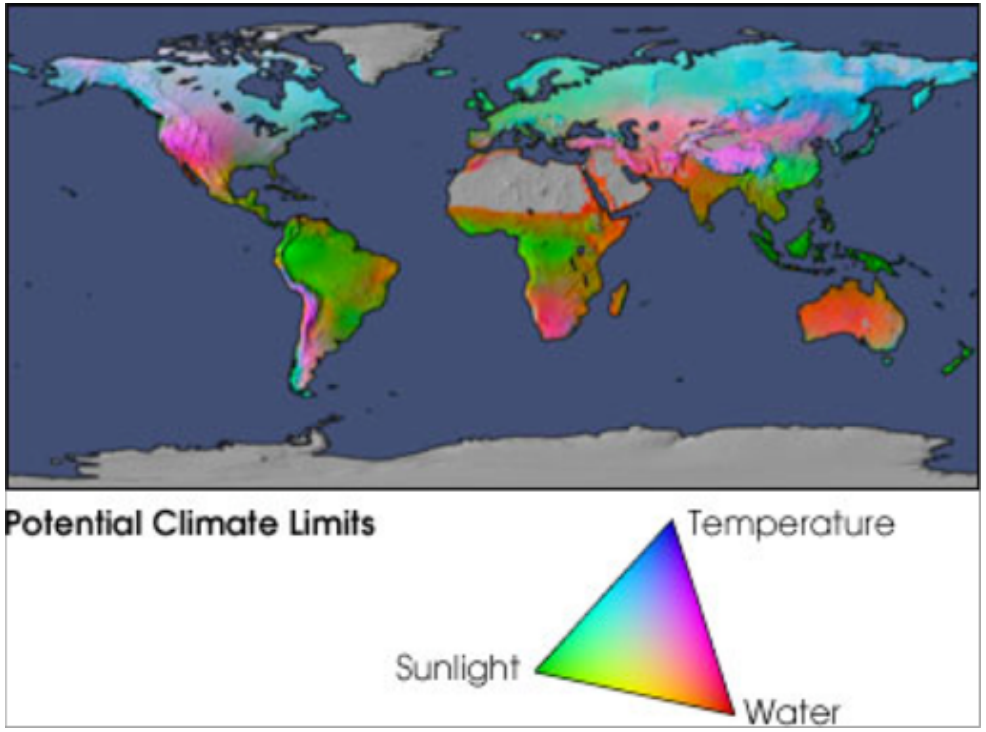
Allocation is a dynamic process that is dependent on the environment



Farrior et al. (2013)

In isolation, how would abiotic conditions influence allocation?

1. Light
2. Temperature
3. Water
4. CO_2
5. Nutrients



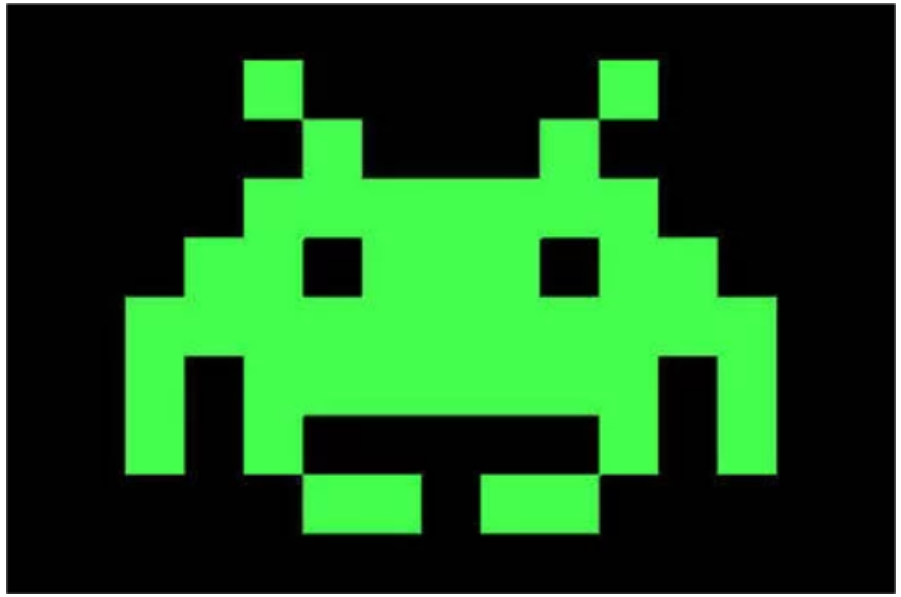
NASA

In isolation, how would life history traits influence allocation?

1. Lifespan
2. Ontogeny
3. Photosynthetic pathway
4. Microbial symbiosis

Class activity: the Invader

1. Pretend you are a species of plant
2. Dr. Smith will give you a place to invade
3. What growth and reproductive strategy will you adopt?
4. What would your allocation pattern be like?



Things to think about:

- What is the environment like?
- Natural enemies?
- Competitors?
- What kind of flowers/seeds?

Joshua Tree NP (CA)

Big Bend NP (TX)

Congaree NP (SC)

Everglades NP (FL)

Smokey Mtns NP (TN)

Badlands NP (SD)

Rocky Mountain NP (CO)

Sequoia NP (CA)

Acadia NP (ME)

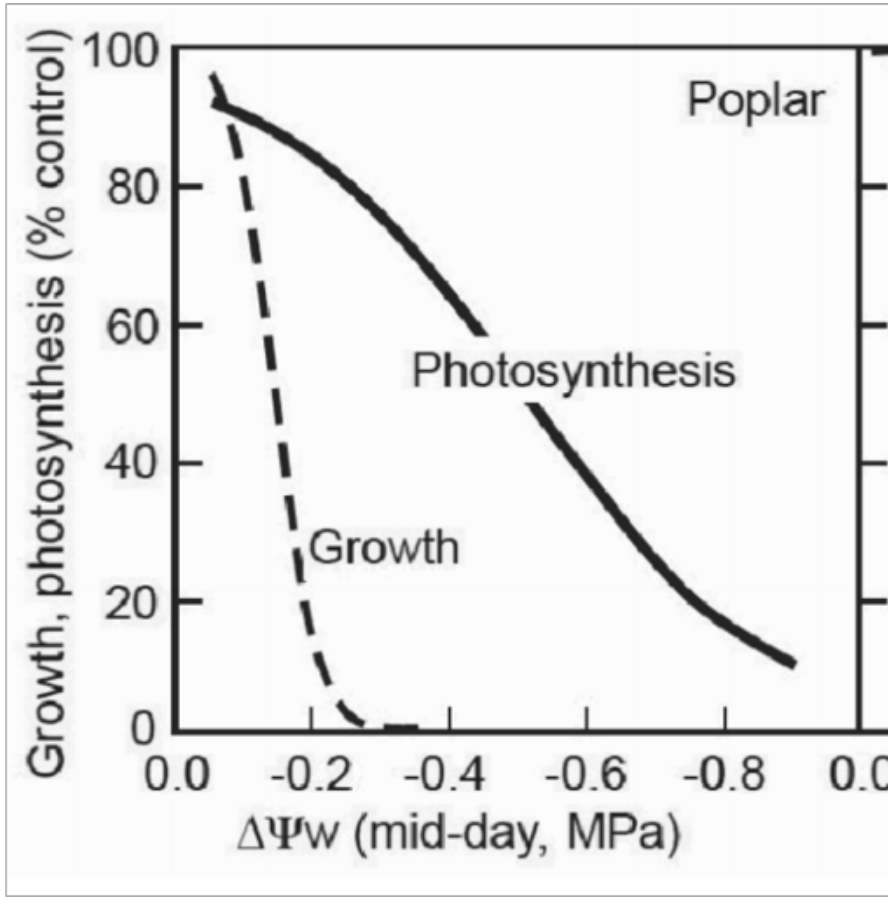
Source/sink controversy

Nova Acta Leopoldina NF *114*, Nr. 391, 273–283 (2013)

Growth Controls Photosynthesis – Mostly

Christian KÖRNER ML (Basel)

Water availability constrains growth more than photosynthesis



Körner (2003)

Low temperature constrains growth more than photosynthesis

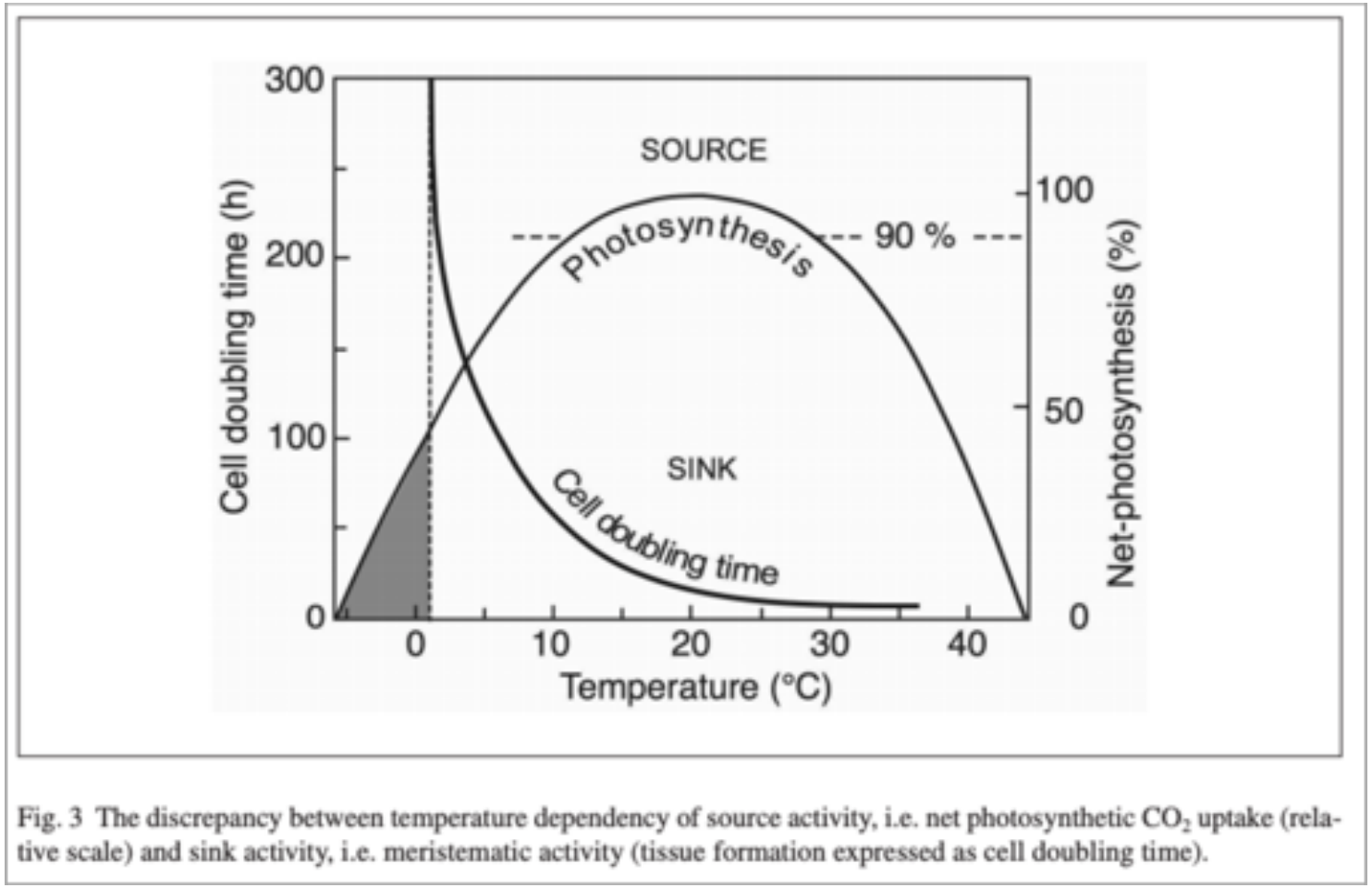


Fig. 3 The discrepancy between temperature dependency of source activity, i.e. net photosynthetic CO_2 uptake (relative scale) and sink activity, i.e. meristematic activity (tissue formation expressed as cell doubling time).

Körner (2003)

So under low resource availability, we might expect low growth to result in reduced photosynthesis, as more photosynthesis would be wasteful

Overarching thesis – photosynthesis matches sink strength

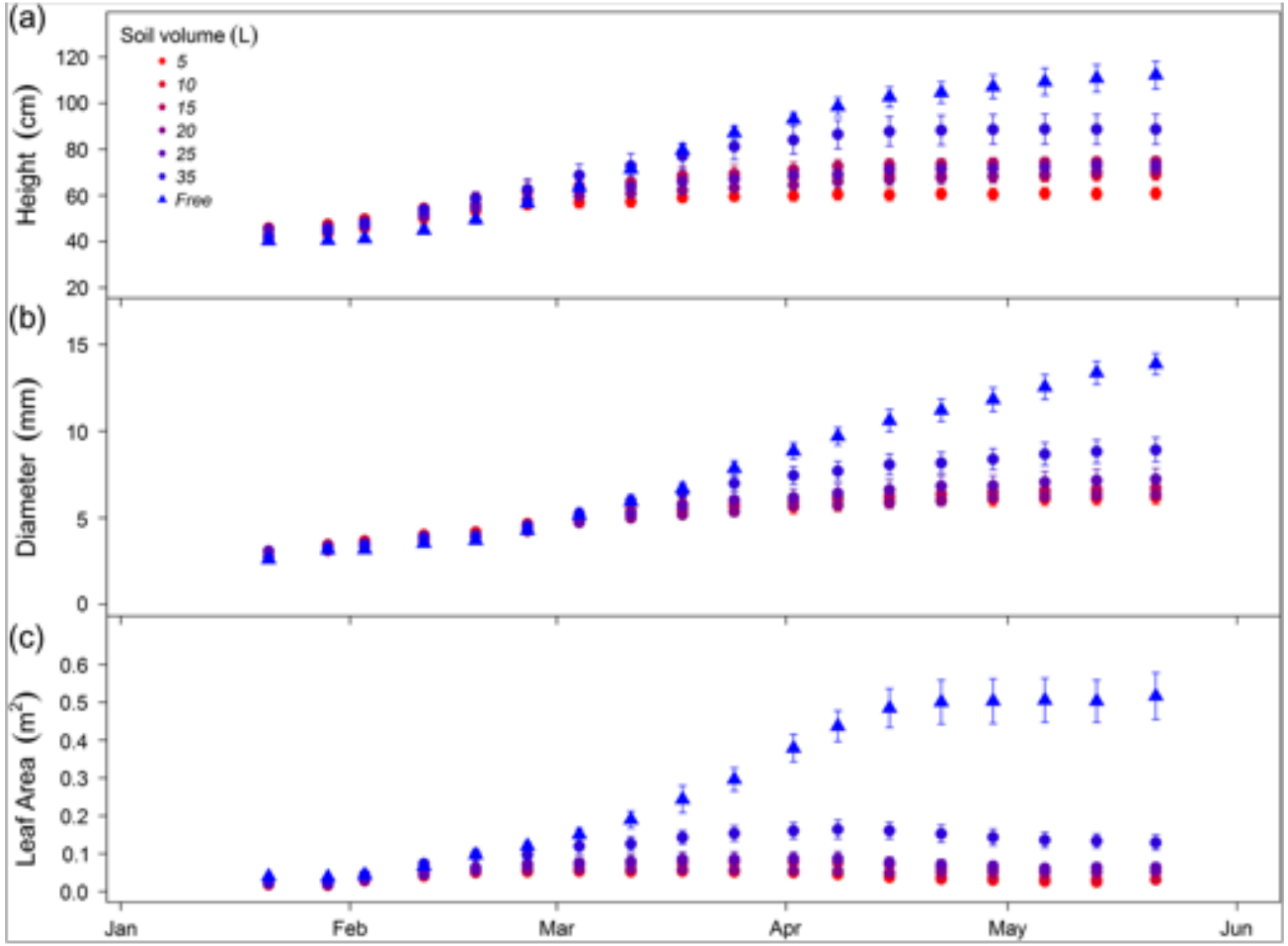
Overarching thesis – photosynthesis matches sink strength

How could you test this??

Reduced growth due to belowground sink limitation is not fully explained by reduced photosynthesis

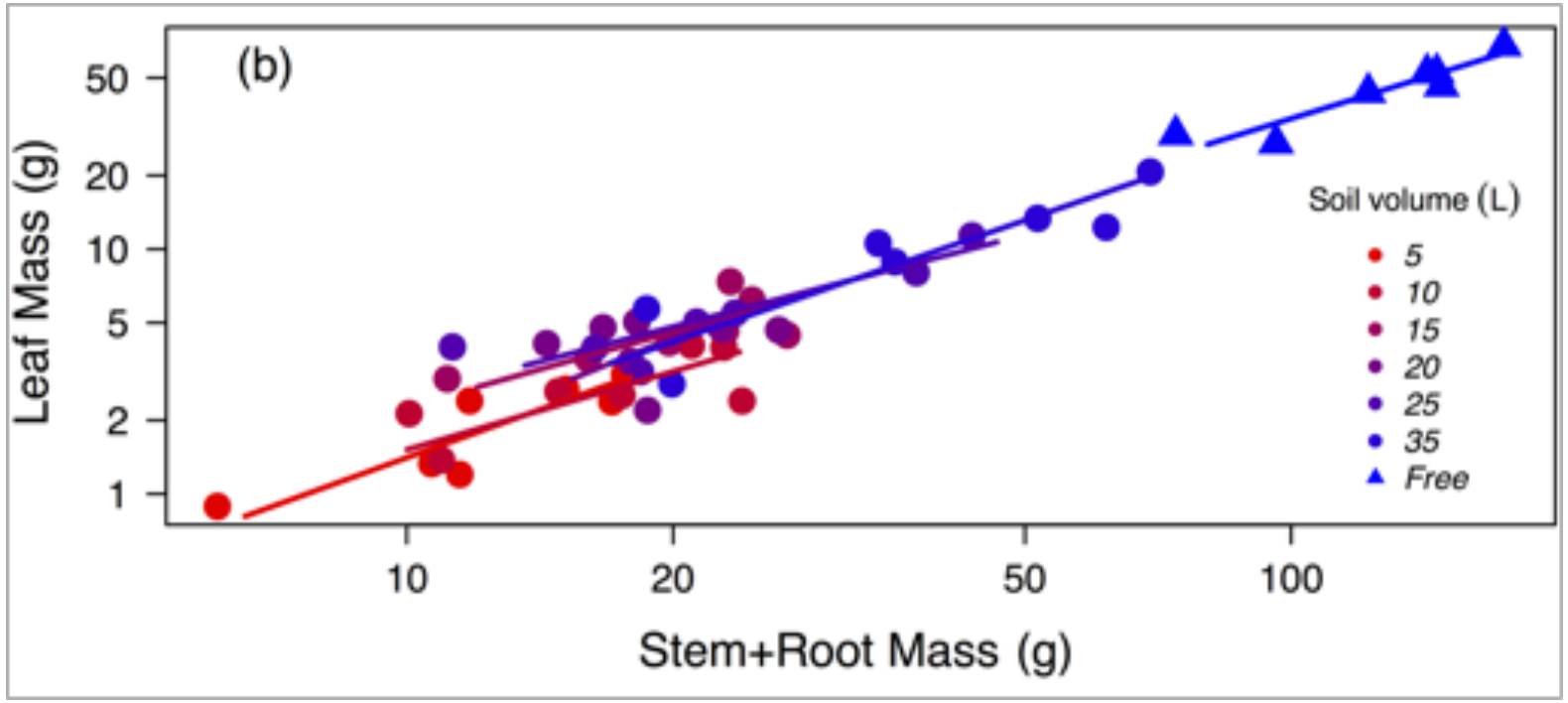
Courtney E. Campany ✉, Belinda E. Medlyn, Remko A. Duursma

Tree Physiology, Volume 37, Issue 8, 1 August 2017, Pages 1042–1054,
https://doi.org/10.1093/treephys/tpx038
Published: 04 April 2017 **Article history** ▾



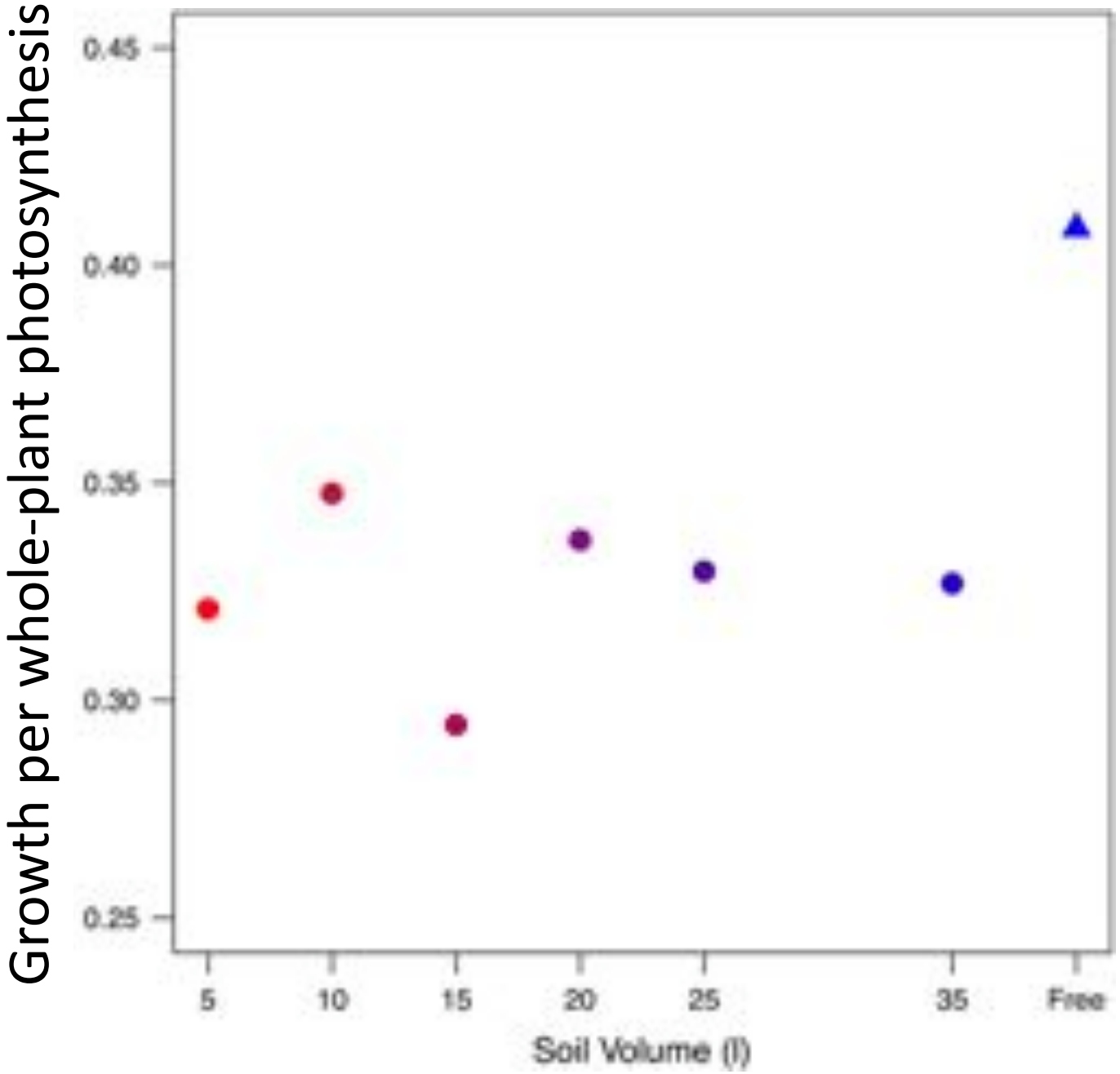
Plant growth decreased by 84%

Campany et al. (2017)



Allocation was similar

Campany et al. (2017)



Photosynthesis only decreased by 26%, but there was a big change in carbon use efficiency

Campany et al. (2017)

Conclusion: sink strength does influence photosynthesis, but this does not fully explain sink-limited growth reductions

Some things that need considered

- Photosynthetic acclimation
- Whole-plant- versus leaf-level photosynthesis
- Within-leaf and whole-plant allocation of nutrients