Shaded trees save their carbon

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Background

Non-structural carbohydrates (NSC, i.e. free sugars and starch) are freely available **carbon (C)** reserves in plants. They are important to mitigate environmental stress, and are often used to estimate a plant's C supply status, assuming that NSC are controlled by the net-balance between photo-assimilation and C-usage (respiration, growth and other sinks). We shaded young trees for two years to test the possibility of C-reserve formation against pronounced sink demands through light deprivation.

Hypothesis

NSC concentrations in shade follow seasonal dynamics, but do not deplete completely and are kept at a species-specific minimum level in trade-off with growth and respiration.

Fig. 1 Outside and inside the shading tent in Witterswil, Switzerland.

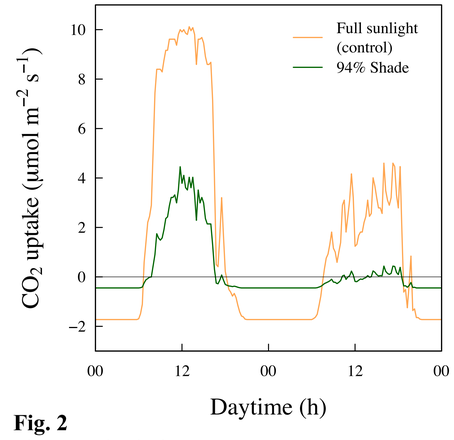


Fig. 2 Photosynthesis in *Prunus avium* on a sunny (left) and a clouded (right) day in May 2016.

Results & Discussion

- Leaves in broad-leaved species significantly adapted to shade by tripling the specific leaf area.
- The net leaf C assimilation per area was reduced by around 75% (Fig. 2).
- Growth and root respiration were strongly impaired during the second growing season in shade.
- Most species showed a "C-saving" response as explained in Fig. 3.
- Due to severe slug herbivory, *Fagus sylvatica* performed surprisingly poorly in the shade (Fig. 4, 5).

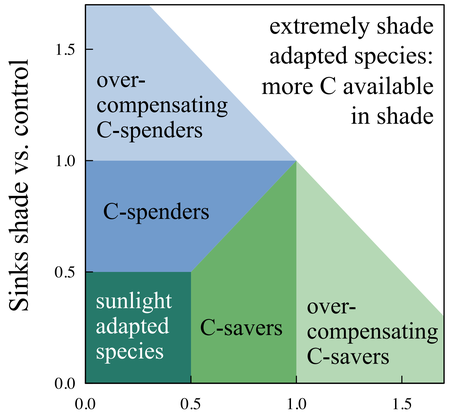


Fig. 3 (above) Do trees favor storage over sinks under shade? A comparison[2] of the fraction of stored C (x-axis) and used C (y-axis) between shaded and unshaded individuals.

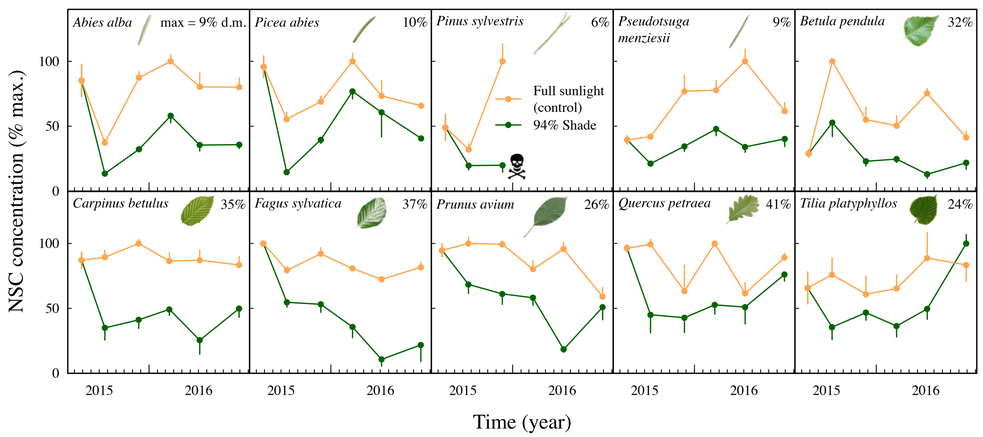
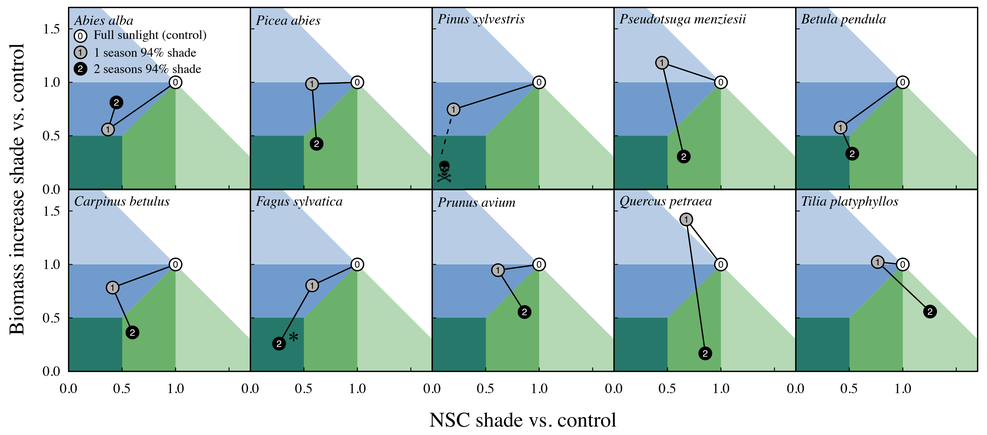


Fig. 4 Non-structural carbohydrates (± SE) weighted among tissues and standardized by the maximum NSC concentration of each species (indicated top right; n=6).

Fig. 5 (right) The fraction of end-of-season NSC concentrations between shaded saplings and controls (x-axis) after one and two seasons in shade, and the percentage of biomass increase during each season, displayed as a fraction between shaded saplings and controls (y-axis, n=6). *Slug herbivory.



Conclusions

- NSC reserves deplete strongly at 94% shade, but tend to stabilize at half of the tissue concentrations of unshaded trees.
- Most tree species favor carbon (C) storage under shade and follow a "wait-and-see" strategy, rather than investing the limited amount of available C into growth.
- These findings challenge the usage of NSC to indicate a tree's C supply status under severe C-limitation, since NSC seem to be up-regulated even under low C supply.

Methods

- 1000 two-year-old saplings of 10 temperate tree species planted in natural soil in March 2015
- Half of the saplings exposed to 94% shading; start: June 2015, end: August 2017
- Harvest of 6 individuals per species and treatment in March, July and November of each year
- Analyses of growth, root respiration, CO_2-gas exchange (LiCOR 6400*xt*), and NSC[1,3] in leaves, stem and roots.
- HOBO® light logger data were used to model the amount of assimilated C per season (Fig. 2).

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[2] Wiley et al. (2016). Journ. Ecol.
[3] Wong SC (1990) Photo. Res. 23:171–180.

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