OLM 8.3. Relationship of protoplasm/cell wall ratio and photosynthetic capacity

The two extreme ends of the leaf economy spectrum (Table 8.1, p. 148) are occupied by metabolically very efficient plants which are poorly defended against herbivores and mechanical damage on the one hand, and well defended but very inefficient ones on the other. The defence is often mechanical, in which case the trade-off between growth and defence is due to the constraint that cytoplasm and cell wall can increase only at each other's expense within a certain volume. Below we show (following Shipley et al. 2006) that increasing cell wall proportion while keeping all other parameters constant, photosynthetic capacity (i.e., the quantity of assimilates produced by a unit biomass of leaves) decreases.

Denote then volume of the leave by *V*, and its mass by *M*. We discriminate two components of leaves: the living cells and the cell walls. The corresponding volumes and masses of these components are labelled by the indices *c* and *w*. Suppose that the only parameter in which the species differ is the V_c/V_w ratio, they are identical otherwise. The assimilates produced by a unit biomass per unit time is the rate of photosynthesis (p_{mass}):

$$p_{\mathrm{mass}} = \frac{A}{M_c+M_w} = \frac{aV_c}{M_c+M_w} \qquad (8.3.1)$$

where *A* is the total mass of assimilates produced by the leave and *a* is that corresponding to a unit of living cell mass (i.e., to a unit of chloroplasts).

If the cell does not contain large quantities of non-structural carbohydrates, then the cell wall is much heavier than the living cell, so that $M_w \gg M_c$.

Then

$$p_{\mathrm{mass}} \approx \frac{aV_c}{M_w} = \frac{aV_c}{dV_w} \qquad (8.3.2)$$

where *d* is the density of the cell wall. This means that the quantity of assimilates produced by the protoplasm per unit time is approximately proportional to the ratio of the volumes of the protoplasm and the cell wall. Q.E.D.

References

Shipley, B., Vile, D. and Garnier, É. (2006). From Plant Traits to Plant Communities: A Statistical Mechanistic Approach to Biodiversity. *Science*, 314(5800): 812-14.