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On the relative magnitudes of photosynthesis, respiration, growth and carbon storage in vegetation

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• Background and Aims. The carbon balance of vegetation is dominated by the two large fluxes of photosynthesis (P) and respiration (R). Mechanistic models have attempted to simulate the two fluxes separately, each with their own set of internal and external controls. This has led to model predictions where environmental change causes R to exceed P, with consequent dieback of vegetation. However, empirical evidence suggests that the R:P ratio is constrained to a narrow range of about 0.4-0.5. Physiological explanations for the narrow range are not conclusive. We aim to introduce a novel perspective by theoretical study of the quantitative relationship between the four carbon fluxes of P, R, growth and storage (or its inverse, remobilisation).
• Methods. Starting from the law of conservation of mass – in this case carbon – we derive equations for the relative magnitudes of all carbon fluxes which depend on only two parameters: the R:P ratio and the relative rate of storage of carbon into remobilisable reserves. The equations are used to explain observed flux ratios and to analyse incomplete data sets of carbon fluxes.
• Key Results. Storage rate is shown to be a freely varying parameter, whereas R:P is narrowly constrained. This explains the constancy of the ratio reported in the literature. With the information thus gained, a data set of R and P in grassland was analysed, and flux estimates could be derived for the periods after cuts in which plant growth is dominated by remobilisation before photosynthesis takes over.
• Conclusions. We conclude that the relative magnitudes of photosynthesis, respiration, growth and substrate storage are indeed tightly constrained, but because of mass conservation rather than for physiological reasons. This facilitates analysis of incomplete data sets. Mechanistic models, as the embodiment of physiological mechanisms, need to show consistency with the constraints.
• Reference. Van Oijen, M., Schapendonk, A. & Höglind, M. (2010). On the relative magnitudes of photosynthesis, respiration, growth and carbon storage in vegetation. Annals of Botany 105: 793-797.