Carbon allocation changes: an adaptive response to variations in atmospheric CO$_2$

Sandy Harrison (1), Guangqi Li (2), and Iain Colin Prentice (3)
(1) School of Archaeology, Geography and Environmental Sciences (SAGES), University of Reading, Whiteknights, Reading, RG6 6AH, UK (s.p.harrison@reading.ac.uk), (2) School of Archaeology, Geography and Environmental Sciences (SAGES), University of Reading, Whiteknights, Reading, RG6 6AH, UK (g.li2@reading.ac.uk), (3) AXA Chair, Programme in Climate and Biosphere Impacts, Grand Challenges in Ecosystems and the Environment and Grantham Institute – Climate Change and the Environment, Department of Life Sciences, Silwood Park Campus, Imperial College, Ascot, UK (iain.colin.prentice@gmail.com)

Given the ubiquity of nutrient constraints on primary production, an optimal carbon allocation strategy is expected to increase total below-ground allocation (fine root production and turnover, allocation to mycorrhizal and carbon exudation to the rhizosphere) as atmospheric CO$_2$ concentration increases. Conversely, below-ground allocation should be reduced when atmospheric CO$_2$ concentrations were low, as occurred during glacial times. Using a coupled generic primary production and tree-growth model, we quantify the changes in carbon allocation that are required to explain the apparent homoeostasis of tree radial growth during recent decades and between glacial and interglacial conditions. These results suggest a resolution of the apparent paradox of continuing terrestrial CO$_2$ uptake (a consequence of CO$_2$ fertilization) and the widespread lack of observed enhancement of stem growth in trees. Adaptive shifts in carbon allocation are thus a key feature that should be accounted for in models to predict tree growth and future timber harvests, as well as in large-scale ecosystem and carbon cycle models.