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Plants in a low CO_2 world: validation of botanical proxies for the Pleistocene

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While a number of studies have documented the growth response of plants to high CO_2 environments, few have investigated the response of plants to the low atmospheric CO_2 ($<$220 ppmv) levels which were present throughout most of the Pleistocene. The last 400,000 years, for example, were characterised by low atmospheric CO_2 with levels ranging between 200 to 300 ppmv and below during glacial stages. Growth experiment studies have demonstrated that C_3 plants grown at ambient CO_2 levels (380 ppmv) had greater weight, leaf area, and total carbon compared to plants grown at pre-Industrial CO_2 levels (280 ppmv). At high levels of CO_2 other physiological parameters including pollen productivity and stomatal frequency have also been shown to increase. It is not well know whether these relationships will hold for low CO_2 conditions, or how these relationships will change as CO_2 levels decrease below pre-Industrial levels and approach the suggested limit for natural growing conditions at around 160 ppmv. Terrestrial palaeoclimate reconstructions based on botanical proxies (pollen and seed productivity, stomatal frequency) do not account for plant physiological response to low atmospheric CO_2 levels. It is therefore important to examine aspects of plant growth and function at sub-ambient CO_2 levels in order to refine our understanding of the relationship between plant function and low CO_2 conditions. Low atmospheric CO_2 levels may limit growth and water use efficiency in plants. Photosynthetic performance in C_3 plants may decrease significantly as photorespiration rates increase below c. 300 ppmv, limiting energy production and carbon allocation to plant processes. Growth chamber experiments will be conducted at sub-ambient CO_2 levels to evaluate plant physiological response to low CO_2 environments. In order to validate growth-chamber CO_2-starvation experiments, Pleistocene fossil plant material will be examined. Ultimately it may be necessary to refine quantitative terrestrial palaeoclimate reconstructions for the Pleistocene based on the possible bias of pollen and seed abundance in the fossil record. Full-glacial temperature estimates could be improved with pollen-inferred biomass estimates if a clear relationship between low CO_2 and pollen productivity can be experimentally determined. Here we present the results of the initial growth chamber experiments with *Arabidopsis thaliana* and *Phaseolus vulgaris*, as well as preliminary results from the examination of Pleistocene fossil plant material.