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The variability and environmental drivers of soil respiration in a deciduous forest: A cyclic sampling analysis.

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Forests play a critical role in the global carbon (C) cycle as they are an important C sink. Current predictions of the sequestration of carbon within this sink have large uncertainties, mainly due to a poor understanding of the individual soil CO_2 efflux components and their environmental responses. Soil respiration (R_s), measured as soil CO_2 efflux, is a combination of both autotrophic and heterotrophic respiration. R_s is often modeled as a single flux influenced by environmental variables, mainly temperature and moisture, similarly across all time scales. Recent studies have however shown a tight coupling between above-ground C assimilation and below-ground respiration from roots and mycorrhizas. Analysis of the co-variation between R_s, environmental variables and plant productivity at a high spatial frequency is therefore needed to understand which processes and environmental factors control its component fluxes. This information can then be incorporated into ecosystem C models to test and improve model formulations of soil C turnover. We investigated if and when R_s is predominantly controlled by plant productivity *versus* environmental drivers, with a study carried out in a mature oak forest in southern England during 2009-2010.

Three 21m x 21 m cyclic sampling plots consisting of 64 permanent sample points, separated by 1 m, 2 m and 4 m distances were established in the forest. Within each plot, the location of each woody plant >5 cm DBH was surveyed and the herbaceous understory vegetation fully characterised. At each point, measurements of R_s, soil temperature, soil moisture, leaf litter depth and leaf area index were made at three-monthly intervals over one year. At the end of the survey, dry mass of coarse and fine roots in the top 5 cm soil layer was measured for each point. Temporal patterns of rooting density were measured using rhizotrons and ingrowth cores adjacent to the plots. As a control, R_s flux measurements were compared with those taken at the same time by automatic mesh collar chambers, which separated autotrophic from heterotrophic fluxes.

Forest R_s fluxes were highest during summer months when rooting density was greatest. Larger R_s fluxes were noted in areas of greater litter depth and furrow areas with a deep organic layer. The average R_s flux measurements taken manually but infrequently over a dense network were consistently higher than those taken with the automated chambers with much fewer samples in space, but many more in time; but this could reflect a measurement artefact due to higher soil disturbance. Multivariate statistics have been used to assess which of the measured factors best explained soil R_s and semivariograms assess the statistical difference between data points according to their separation distance. This dataset provides a novel insight into the control of R_s by environmental drivers and plant productivity at different spatial scales, over the course of a season.