

## **Water use efficiency of temperate semi-natural grassland has increased since 1857: an analysis of the carbon isotope composition of herbage from the Park Grass Experiment**

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A 150 years-long record of intrinsic water use efficiency ( $W_i$ ) was derived from community-level carbon isotope discrimination ( $^{13}\Delta$ ) in the herbage of the unfertilized, unlimed control treatment (plot 3) of the Park Grass Experiment at Rothamsted (England) between 1857 and 2007.  $^{13}\Delta$  during spring growth has not shown a long-term trend ( $P = 0.5$ ) since 1857.  $^{13}\Delta$  of summer / autumn growth increased between 1875 and 2007.  $W_i$  during spring growth has therefore increased by 33% since the beginning of the experiment, and  $W_i$  of summer / autumn growth has increased by 18%. The variation in  $^{13}\Delta$  was mainly related to weather conditions. Plant available soil water explained 51% and 39% of the variation in spring growth  $^{13}\Delta$  and summer / autumn growth  $^{13}\Delta$ , respectively. In the 1857-2007 period yields have not increased, suggesting that community-level photosynthesis has not increased either. Therefore, the increased  $W_i$  probably resulted from a decreased stomatal conductance. Vapour pressure deficit (VPD) during spring growth has not changed since 1915, meaning that instantaneous water use efficiency ( $W_i$ ) in spring time has increased and transpiration has probably decreased. Conversely, VPD in the months between the first and second cut has increased since 1915, offsetting the effect of increased  $W_i$  on  $W_i$  during summer and early autumn. Our results suggest that vegetation has adjusted physiologically to elevated  $\text{CO}_2$  by decreasing stomatal conductance in this nutrient limited grassland.