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Ecohydrological controls over water budgets in floodplain meadows

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Floodplain meadows are important ecosystems, characterised by high plant species richness including rare species. Fine-scale partitioning along soil hydrological gradients allows many species to co-exist. Concerns exist that even modest changes to soil hydrological regime as a result of changes in management or climate may endanger floodplain meadows communities. As such, understanding the interaction between biological and physical controls over floodplain meadow water budgets is important to understanding their likely vulnerability or resilience. Floodplain meadow plant communities are highly heterogeneous, leading to patchy landscapes with distinct vegetation. However, it is unclear whether this patchiness in plant distribution is likely to translate into heterogeneous soil-vegetation-atmosphere transfer (SVAT) rates of water and heat, or whether floodplain meadows can reasonably be treated as internally homogeneous in physical terms despite this patchy vegetation. We used a SVAT model, the Soil-Water-Atmosphere-Plants (SWAP) model by J.C. van Dam and co-workers, to explore the controls over the partitioning of water budgets in floodplain meadows. We conducted our research at Yarnton Mead on the River Thames in Oxfordshire, one of the UK's best remaining examples of a floodplain meadow, and which is still managed and farmed in a low-intensity mixed-use manner.

We used soil and plant data from our site to parameterise SWAP; we drove the model using in-situ half-hourly meteorological data. We analysed the model's sensitivity to a range of soil and plant parameters – informed by our measurements – in order to assess the effects of different plant communities on SVAT fluxes. We used a novel method to simulate water-table dynamics at the site; the simulated water tables provide a lower boundary condition for SWAP's hydrological submodel. We adjusted the water-table model's parameters so as to represent areas of the mead with contrasting topography, and so different heights above the river level and different moisture and drainage regimes.

The model was most sensitive to changes in the parameters that define the water-table model. Plant above-ground parameters, such as leaf area index and canopy height also had strong influences on simulated fluxes. The model exhibited low sensitivity to plant root parameters; this was particularly true during wet periods when the simulated plant communities were oxygen stressed. Changes in soil texture profile exhibited an intermediate level of control over SVAT fluxes.

Our findings indicate that unlike in environments with deep water tables, such as drylands and headwater basins, high-quality water-table data with decimetre or even centimetre accuracy are important to accurate simulation of SVAT fluxes. Future studies that seek to simulate SVAT fluxes in shallow groundwater systems should either use high frequency, high-quality water-table observations as part of the driving data set, or should ensure that water-table dynamics and their interactions with surface processes can be simulated in a robust and physically meaningful manner. The low sensitivity of our model to plant root parameters reflects the proximity of the water table to the ground surface and the fact that the simulated plant community is rarely water-stressed, and again contrasts with findings from existing SVAT model research in environments with deep water tables.