**Deep vadose zone respiration contributions to $CO_2$ fluxes from a semi-arid floodplain**

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**Abstract**
Although $CO_2$ fluxes from soils are often assumed to originate within shallow soil horizons (< 1 m depth), relatively little is known about respiration rates at greater depths. As part of the Berkeley Laboratory's Subsurface Biogeochemistry Genomes-to-Watersheds SFA effort, we compared measured and calculated $CO_2$ fluxes at the Rifle floodplain along the Colorado River, and measured $CO_2$ production rates of floodplain sediments in order to determine the relative importance of deeper vadose zone respiration. Measurements of soil surface $CO_2$ fluxes and depth profiles of vadose zone $CO_2$ concentrations were obtained at five monitoring sites on the floodplain. Calculations based on measured $CO_2$ gradients and estimated effective diffusion coefficients yielded fluxes that are generally consistent with measurements obtained at the soil surface (330 g C $m^{-2}$ $yr^{-1}$). $CO_2$ production from the 2.0 to 3.5 m depth interval was calculated to contribute 17% of the total floodplain respiration, with rates that were larger than some parts of the shallower vadose zone and underlying aquifer. Respiration rates determined from laboratory incubations of sediments, and from 2.0 m deep non-isothermal sediment columns are consistent with the field-based measurements. The deeper unsaturated zone typically maintains intermediate water and air saturations, lacks extreme temperatures and salinities, and is annually resupplied with organic carbon from snowmelt-driven recharge and by water table decline. These conditions support deeper unsaturated zone respiration throughout the year, and influence vadose zone-aquifer interactions.