Riparian zone control on catchment hydrology and biogeochemistry across European ecoregions

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The importance of riparian zones in shaping the hydrology and biogeochemistry of forest headwater catchments has been well-established in the last couple of decades. However, most studies rely on single catchment approaches or focus on a single ecoregion. Here, we present a multiple-site approach using data from four catchments located in four European ecoregions and encompassing a wide range of hydrological and biogeochemical conditions: the boreal Krycklan, the temperate Rappbode, the sub-humid Mediterranean Font del Regàs, and the semi-arid Mediterranean Fuirosos.

At long temporal scales, both climate and topography interrelate to determine the dominant source layer (DSL), i.e. the riparian zone depth stratum that contributes the most to water and solute fluxes to streams. Generally, shallower DSLs are found in wetter climates characterized by higher ratios of annual precipitation to potential evapotranspiration (e.g. boreal), but locally can occur in the flatter contributing areas defined by higher topographic wetness indexes. Riparian soils show large differences in carbon and nutrient content across ecoregions. Mediterranean riparian soils are characterized by lower organic matter content and small dissolved organic carbon (DOC) exports from deeper, mineral layers, resulting in overall lower stream DOC concentrations compared with the temperate and, especially, the boreal sites. On the other hand, the denitrification potential of the Mediterranean riparian zones, especially at the semi-arid site, is limited due to drier conditions that oxygenate the riparian soils and may even promote nitrification, resulting in higher stream nitrate (NO$_3^-$) concentrations compared to the boreal site. The denitrification potential of the temperate site is counterbalanced by a significantly higher nitrogen deposition compared to the other sites.

At the event scale, antecedent soil moisture conditions and associated hydrological connectivity within the catchments becomes an important factor defining solute export from riparian profiles and hysteresis patterns between riparian groundwater tables and stream discharge. Generally, the wetter conditions in the boreal site generate anticlockwise patterns between groundwater tables and discharge, indicating high catchment hydrological connectivity. Clockwise patterns are characteristic of the Mediterranean sites and imply low hydrological connectivity, except during
very wet antecedent conditions. The temperate site is characterized by linear patterns and intermediate conditions. Solutes displaying relatively high concentrations in the riparian profile are generally transport limited, especially during events preceded by dry conditions, whereas source limitation occurs during events preceded by wet conditions, especially for solutes displaying relatively low concentrations.

We highlight that multiple-site approaches can help identifying common patterns and differences in riparian hydrological and biogeochemical functions across ecoregions, as well as the factors driving these patterns and the resulting dynamics of stream water chemistry.