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Comparison of rainfall and stemflow peak intensities and infiltration patterns for a mature coastal forest in British Columbia, Canada

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Most studies on stemflow have focused on the amount of stemflow in different forests or for different rainfall events. So far, few studies have looked at how stemflow intensity varies during rainfall events and how peak stemflow intensities compare to peak rainfall intensities. High stemflow intensities at the base of the tree, where roots and other preferential flow pathways are prevalent, may lead to faster and deeper infiltration of stemflow than rainfall and thus affect soil moisture dynamics and potentially also subsurface stormflow generation.
We measured stemflow intensities for three Western hemlock, two Western red cedar, two Douglas-fir and one Birch tree in a mature coniferous forest in coastal British Columbia to determine how stemflow intensities were related to rainfall intensity. We sprayed a blue dye tracer on two Western hemlock trees (29 and 52 cm diameter at breast height (DBH)) to determine how stemflow water flows through the soil and to what depth it infiltrates. We also applied the blue dye tracer to an area between the trees to compare infiltration of stemflow with rainfall. Stemflow increased linearly with event total precipitation for all trees. The larger trees almost exclusively had funneling ratios (i.e. the volume of stemflow per unit basal area divided by the rainfall) smaller than one, regardless of species and event size. The funneling ratios for the small trees were generally larger for larger events (up to a funneling ratio of 20) but there was considerable scatter in this relation. Trees with a DBH <35 cm, which represent 24% of the total basal area of the study site, contributed 72% of the estimated total stemflow amount. Stemflow intensities (volume of stemflow per unit basal area per hour) often increased in a stepwise manner. When there were two precipitation bursts, stemflow intensity was usually highest during the second precipitation burst. However, when there were several hours of very low rainfall intensity between consecutive precipitation bursts, stemflow intensity was lower during the first burst after the break in rainfall. Peak stemflow intensities were higher than the maximum precipitation intensity. The blue dye that was applied to the tree stems was found more frequently at depth than near the soil surface. Stemflow flowed primarily through the 10 cm organic rich upper layer of the soil around the tree before flowing between or along live and dead roots, inside dead roots, around rocks and boulders deeper into the soil. Lateral flow was observed above a dense clay layer but where roots were able to penetrate the clay layer, the infiltrating water flowed deeper into the soil and (almost) reached the soil-bedrock interface. Stemflow appeared to infiltrate deeper (122 cm) than rainfall (85 cm) but this difference was in part due to variations in maximum soil depth. These results suggest that even though stemflow is only a minor component of the water balance, the double funnelling of stemflow may significantly affect soil moisture, recharge and runoff generation.