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Scaling of increased dissolved organic carbon inputs by forest clear-cutting - What arrives downstream?

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Forest clear-cutting has been found to significantly increase concentrations of dissolved organic carbon (DOC) in boreal first-order streams. Here, we address the questions of 1) how the additional inputs of DOC by upstream forest harvesting affect downstream locations within a stream network and 2) what catchment area has to be harvested to cause a significant downstream increase in DOC concentration. We combined the use of primary data from a paired-catchment experiment, clear-cut history of a nested stream network derived from satellite images with a mixing-model approach in order to quantify the importance of upstream clear-cuts on two downstream sites with different catchment sizes. Modeled [DOC] agreed well with the measured concentrations in the smaller, 8.7 km^2 catchment located above a larger wetland area, but discrepancies occurred for the larger 22.9 km^2 catchment located downstream of the wetland. Estimates of the critical area ($A_{critical}$) needed to be harvested to cause a significant impact on downstream DOC concentrations was quantified to be 11% for $p<0.05$ and 23-25% for $p<0.001$. Our results suggests that (i) increased DOC concentrations induced by forest harvesting affect downstream sites and (ii) additional DOC inputs by harvests have a significant impact on stream water quality, if harvests exceed $A_{critical}$. We suggest that the estimates of $A_{critical}$ could be used in sensitive river networks to provide harvesting-thresholds. The latter could be implemented into forest planning that includes considerations of the negative impact of clear-cutting on water quality.