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Combining hydrology, carbon and nutrient cycles for better peatland management

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Economic, climate and water protection targets need to be balanced in acceptable peatland management. This is not a simple task as the targets are not necessarily synergetic, and hydrology, carbon (C) and nutrient cycles are tightly connected forming a complex network of feedbacks and interactions. Thus, planning of peatland management calls for holistic simulation models. Recently, we have developed Peatland simulator SUSI (Lauren et al. 2021) as a platform for a combined modelling of hydrology, biogeochemistry, and tree stand growth under different water table (WT) management (drainage) regimes. SUSI simulates WT, organic matter decomposition, nutrient release and tree growth between two parallel ditch drains in daily time step, and allows us to change meteorological input data, stand and peat characteristics, ditch depth and the distance between the ditches. Here, we extended SUSI to account for forest thinning and ash fertilization as management practises. To allow simulation of logging residue decomposition, we substituted the earlier empirical decomposition model with a simple compartmental process model describing separately the decomposition of tree stand litter and peat. Effect of ash fertilization was modelled so that the leaf biomass was adjusted according to the prevailing nutrient supply and the stand nutrient demand. Improving nutrient supply allows a higher leaf mass and elevated light and water use efficiency. The new modifications allow unraveling the feedback loop extending from improved nutrient availability -> increased leaf mass, light and water use efficiency -> lowering WT -> increased nutrient release from peat -> improved stand growth -> increased litterfall -> changed C and nutrient balance -> further lowering WT. The new model also includes lateral C fluxes. Release of dissolved organic carbon (DOC) in labile and recalcitrant form was calculated using computed WT, soil temperature, peat bulk density, and literature-derived release rates. The DOC release and the biodegradation of DOC to CO_2 were connected as a source term to a 2-dimensional advection equation describing water movement and the equation was solved using a finite volume method. The model conceptualization, structure and the significance of the feedback mechanisms are analyzed and discussed. The new model enables, for the first time, internally coherent balancing among the economic, climate and water protection targets in management of boreal and tropical peatlands.