



Mitigating freshwater ecosystem browning calls for a systemic change in peatland forestry

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Several mechanisms behind browning

- Browning of surface waters mainly results from increased concentrations of organic carbon (OC) and iron
 - No single mechanisms can explain browning
- **Climate change**
 - Increasing temperature, changes in precipitation and runoff, duration of frost-free periods
- **Decreased sulfur deposition**
 - Increased leaching of OC from the soil
 - Impact of deposition on OC leaching decreasing, while climate change increasing
- **Changes in land use** have gained increasing attention
 - Drainage, afforestation, conifer dominance
- OC production in peatland dominated catchments sensitive to climate change
 - [SysteemiHiili-project](#): can we mitigate surface water browning in peatland forestry?



Boreal and temperate regions characterized by peatlands

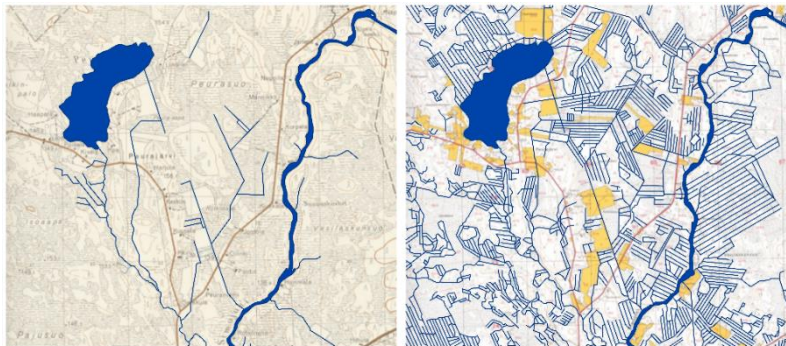
- Mires accumulate biomass in terms of peat and are significant, natural sources of OC to surface waters
 - 10 Mha of peatlands drained for forestry in Fennoscandia and Russia with nearly half of them in Finland
 - Initial ditching has ceased, ditch network maintenance (DNM) predominant since 1990s
- First-time ditching generally decreases the water table depth (WTD), and results in flashier runoff
 - Effects of DNM on WTD and runoff lower
- Impacts of drainage operations on discharge OC concentrations ambiguous, at times even "positive"



...HOWEVER

Drainage for forestry promotes excess leaching of OC to surface waters

- Drainage has increased peat decomposition and soil microbial activity with implications for OC, Fe and CO₂ release
 - Peat decomposition continues, possible legacy effect for loading
- Drainage has multiplied the size of the stream network
 - Routes for OC export, diminished retention time in the receiving lakes
 - Density of artificial ditches in the catchment well explain water color in aquatic ecosystems
- At the same time, all water protection structures inefficient or at best ambiguous in retaining OC



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background maps from <https://vanhatkartat.fi/#11.74/66.0277/26.2373>

Forest biomass, dominant tree cover and even-aged management also matter

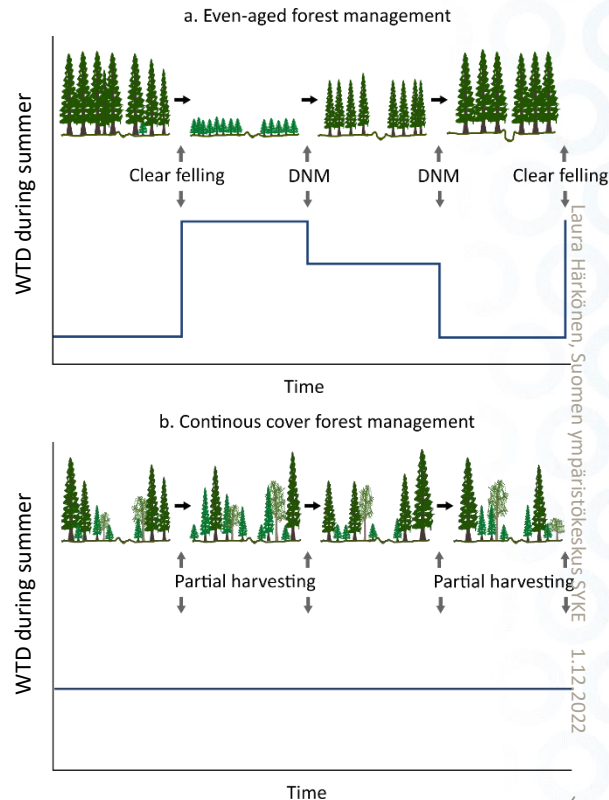
- While increased forest biomass accumulates OC, it also
 - Increases evapotranspiration and peat oxidation
 - Increases litter input and OC accumulation into the soil
 - Increases the share of labile OC thus driving browning
- Conifer abundance correlates with OC export, and with lake OC and Fe concentrations
- Even-aged management, i.e., clear-cutting of peatland forests increases OC loading by
 - Decreasing WTD,
 - Increasing surface soil temperature
 - Increasing runoff
- Site preparation and logging residues further amplify the impacts
- Because of decreased WTD, also DNM often needed

→ VICIOUS CIRCLE!



Developing forestry practices that diminish peat decomposition is a necessity for water protection

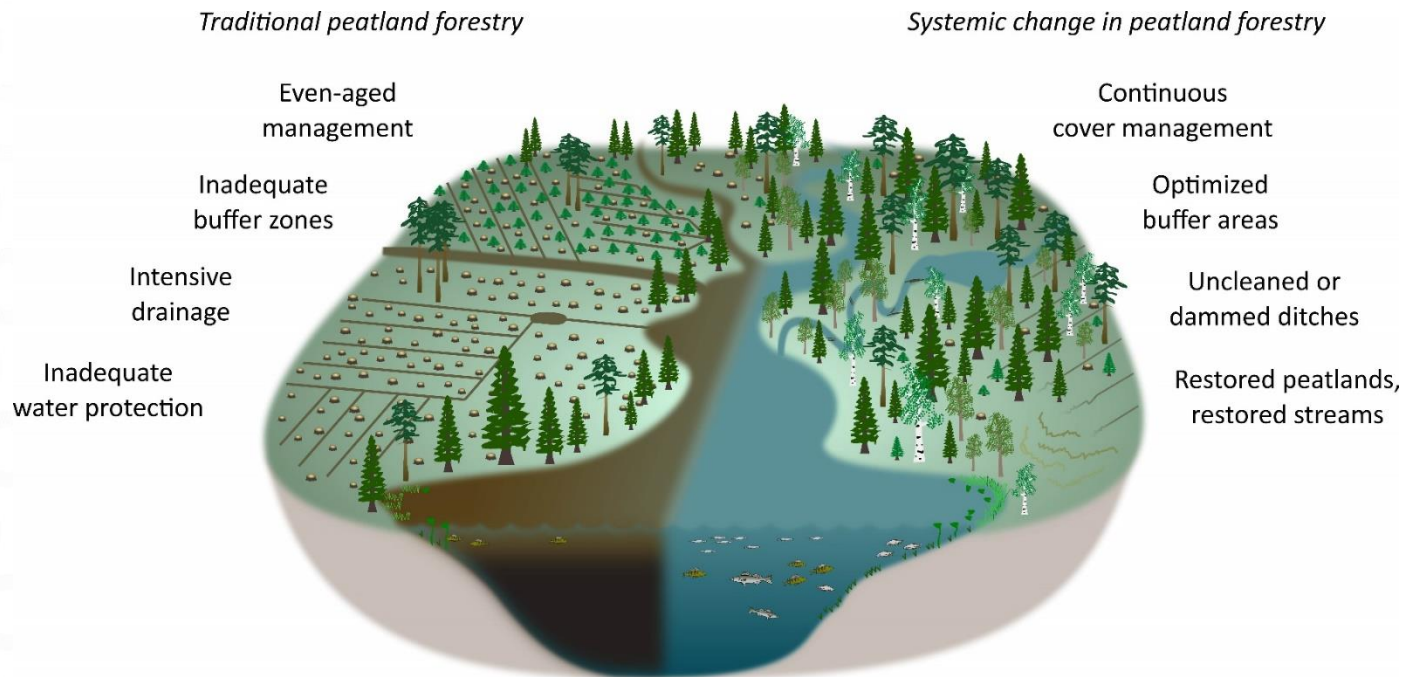
- Continuous cover forestry (CCF) could
 - Reduce the need for DNM
 - Decrease the WTD fluctuation and subsequent peat decomposition, decrease OC loading
- Could favoring mixed forests reduce the accumulation of soil OC and subsequent leaching?
- Reducing hydrological connectivity, decreasing ditch depths (if DNM needed) could reduce the routes for OC rich runoff
 - CCF could allow for damming ditches in economic forests too
 - Restoration of peatlands may increase the loading in short-term, impacts equalize with time
 - In the long-term, restoring peatlands and returning them closer to a natural state could diminish loading



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Mitigating browning requires a systemic change in peatland forestry – acknowledgement needed in future policies and recommendations



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Thank you!

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