Toward Continuous Cover Forestry on Boreal Lowlands – Hydrological Responses to Partial Harvesting

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Abstract

Interest towards continuous cover forestry (CCF) has grown in recent years as it is considered more favorable from environmental perspectives than even-aged management. CCF could be particularly feasible on peatlands and other lowland soils as continuously maintaining a tree cover with significant evapotranspiration capacity could decrease the need for artificial drainage. Clear cutting, site preparation, and regular cleaning of drainage ditches increase greenhouse gas emissions and affect water quality by releasing sediment, nutrients and carbon to water bodies. Whereas even-aged management on peatlands relies on these intensive and environmentally adverse practices, regeneration in CCF forests would occur naturally and evapotranspiration of the tree stand would play a key role in maintaining drainage conditions. Partial harvest is an essential component of CCF and our study focuses on understanding its impacts on hydrology. The study site comprises a fertile drained peatland forest in Southern Finland, where three parallel sites were established in March 2016: (i) clear-cut with site preparation and seedling planting, (ii) partial harvest removing 75% of tree biomass, and (iii) control left untouched as reference. Data on ecosystem fluxes (Eddy covariance) and ground water depth were available from each site after the harvest and for a pre-treatment period of 6 years. In our attempt to understand the mechanisms behind observed changes after clear-cut and partial harvest, we applied a one-dimensional multi-layer multi-species soil-vegetation-atmosphere transfer model in conjunction with data analysis. The hydrology of each parallel site was simulated to explore the role of the amount and diversity of vegetation. Results suggested that on the partial harvest site the undergrowth of birch and spruce had the potential to partly compensate for the transpiration of the harvested pine, which dominated the stand before the treatment and limited the light received by the undergrowth trees. Such changes in vegetation-driven water balance components revealed by mechanistic modeling form the basis for understanding vegetation controls on growing season ground water depth, which is a key factor for the successful implementation of CCF in peatland forests.

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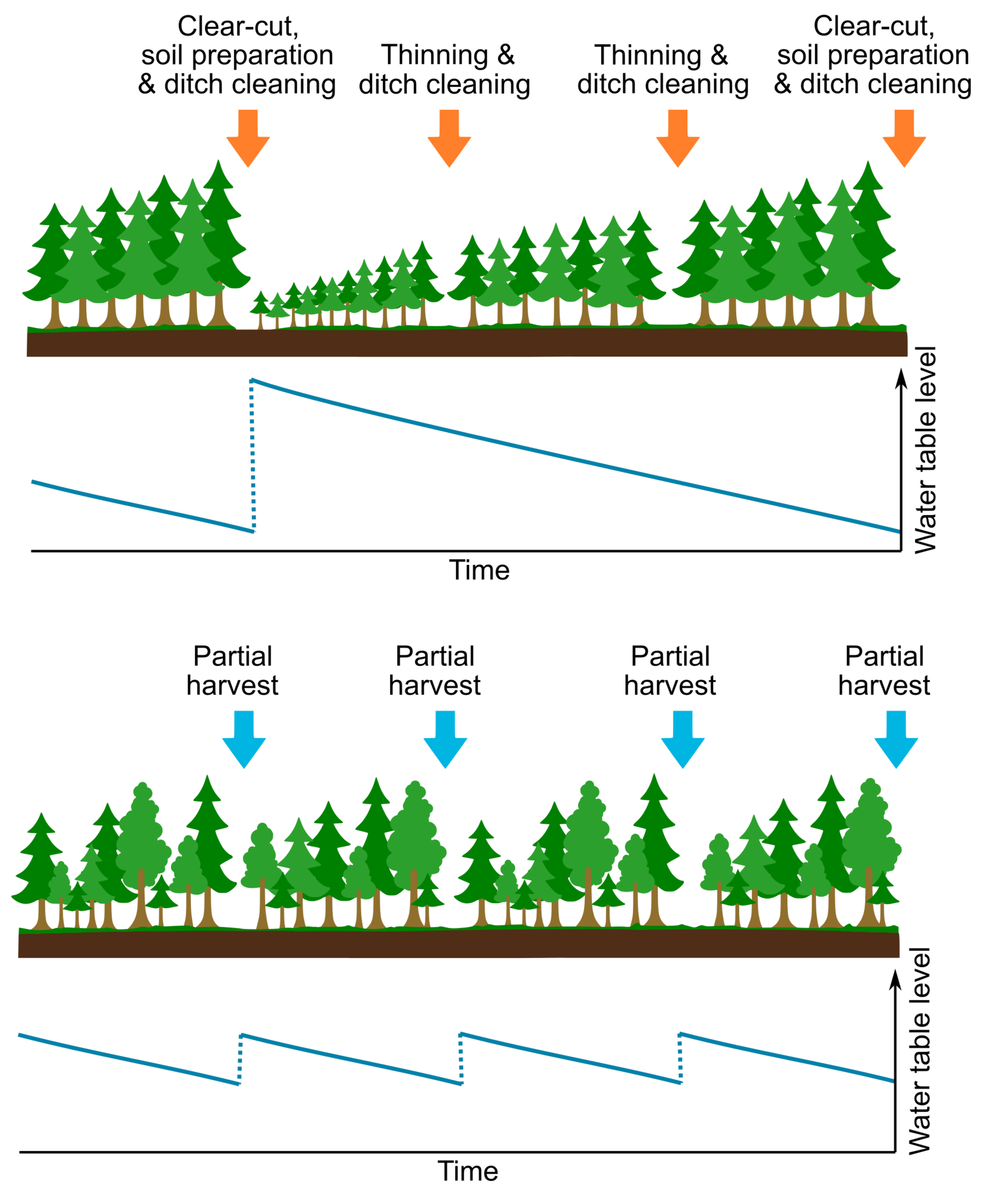
1 Motivation

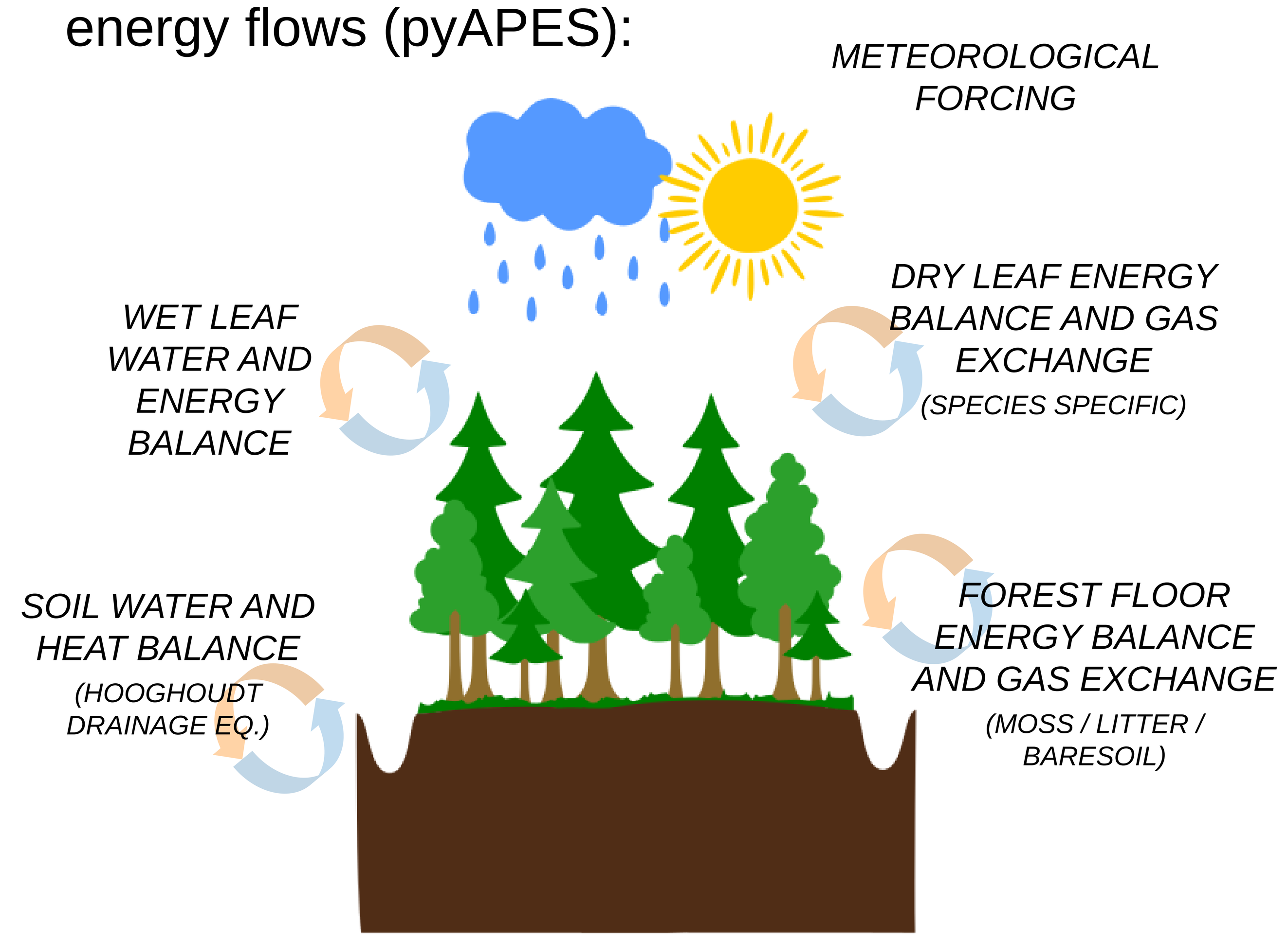
Continuous cover forestry is considered environmentally more favorable than the prevailing **even-aged management**. On lowland soils the feasibility of **continuous cover forestry** depends on whether the tree stand can sustain sufficient drainage after partial harvests.

Combining data analysis and mechanistic modeling we studied the hydrological responses to partial harvesting.



2.2 Model description

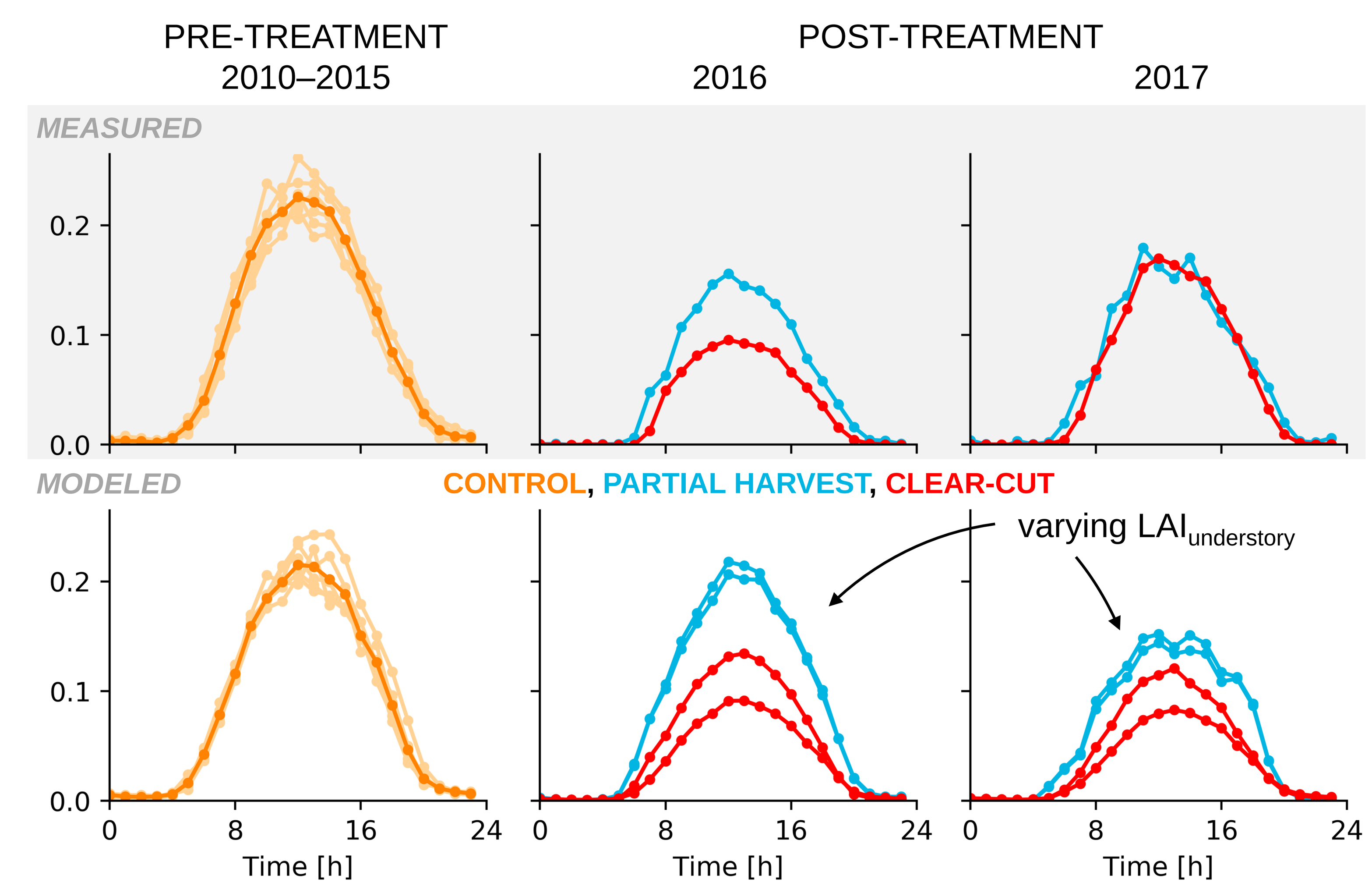
A 1D multi-layer multi-species soil-vegetation-atmosphere model describing H_2O, CO_2 and energy flows (pyAPES):



(based on Launiainen et al. 2015, Ecol. Model.)

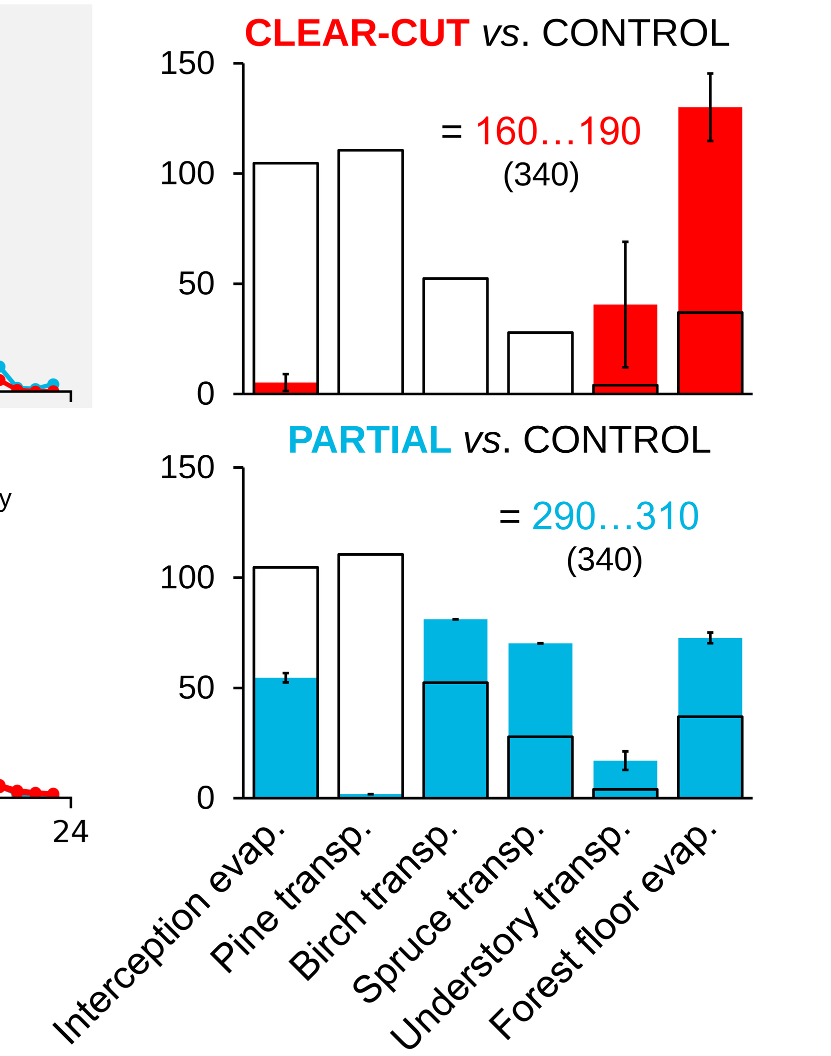
3.1 Results on evapotranspiration (ET)

Diurnal evapotranspiration (mm/h)*



* Includes data from times with no precipitation in May-September (not gap-filled)

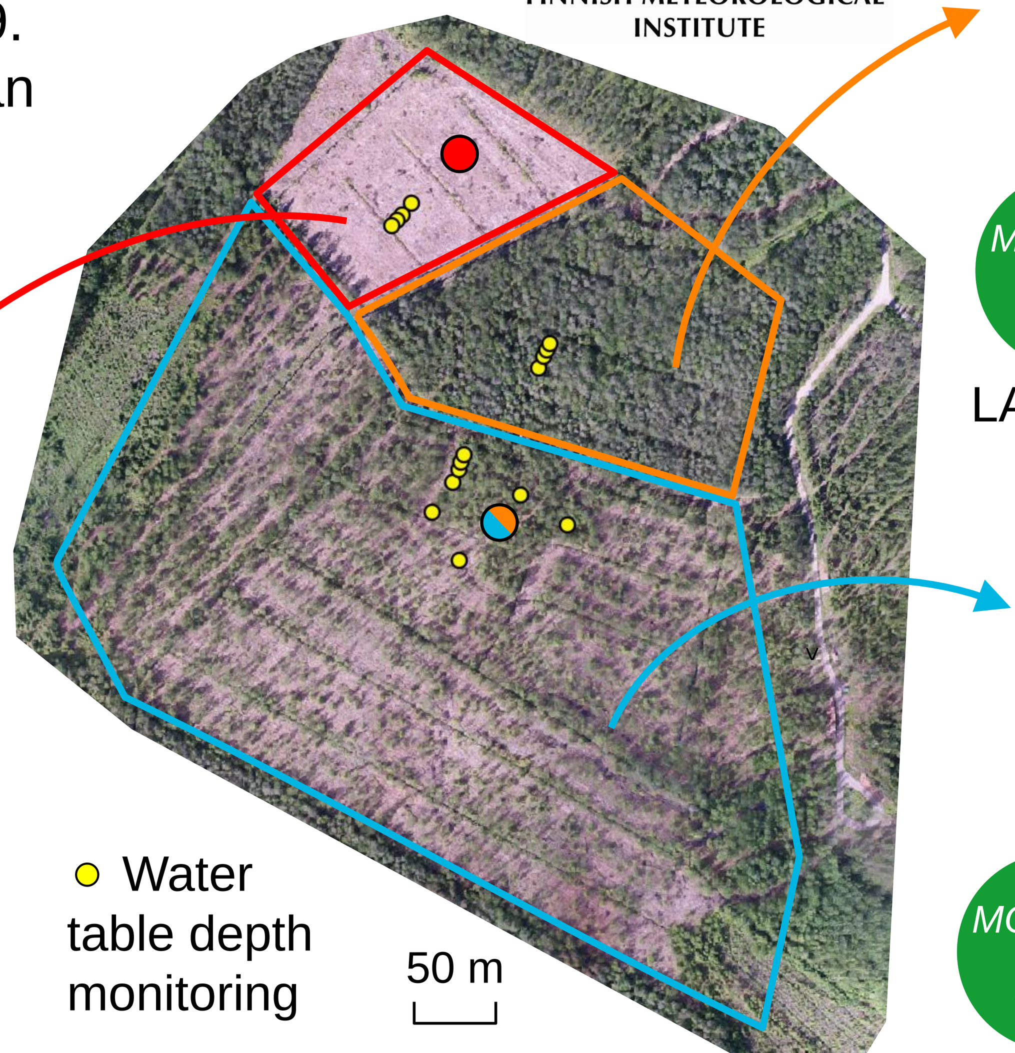
Evapotranspiration components (mm/y)



2.1 Experimental site: Lettosuo

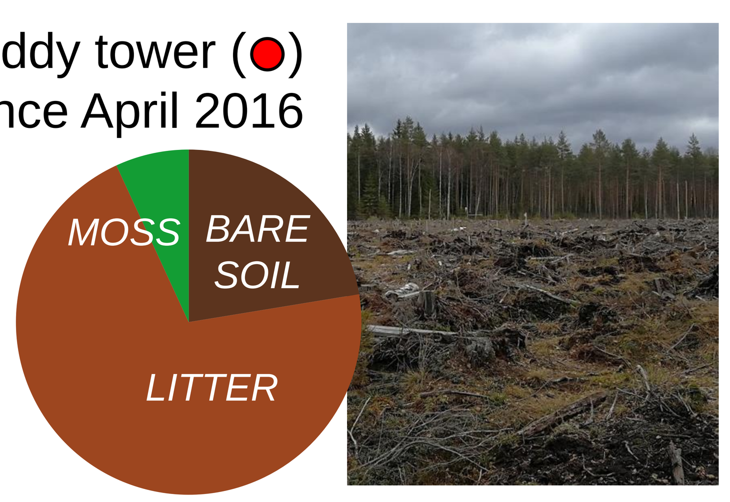
A peatland forest in Southern Finland (60°38'N, 23°57'E) drained in 1969. Monitoring started in 2010, when an Eddy flux tower (●) was installed.

In March 2016, two harvesting experiments were carried out, creating tree parallel sites:



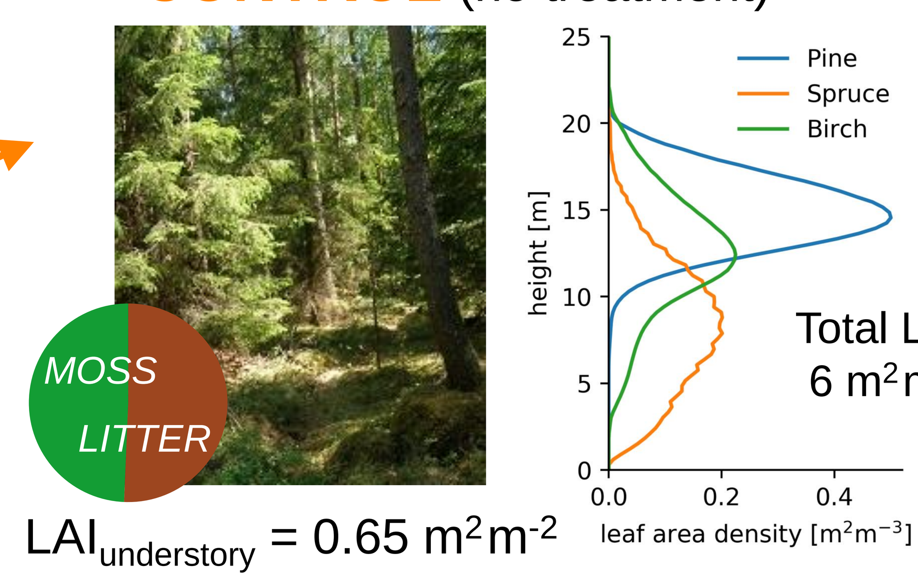
CLEAR-CUT

Eddy tower (●) since April 2016



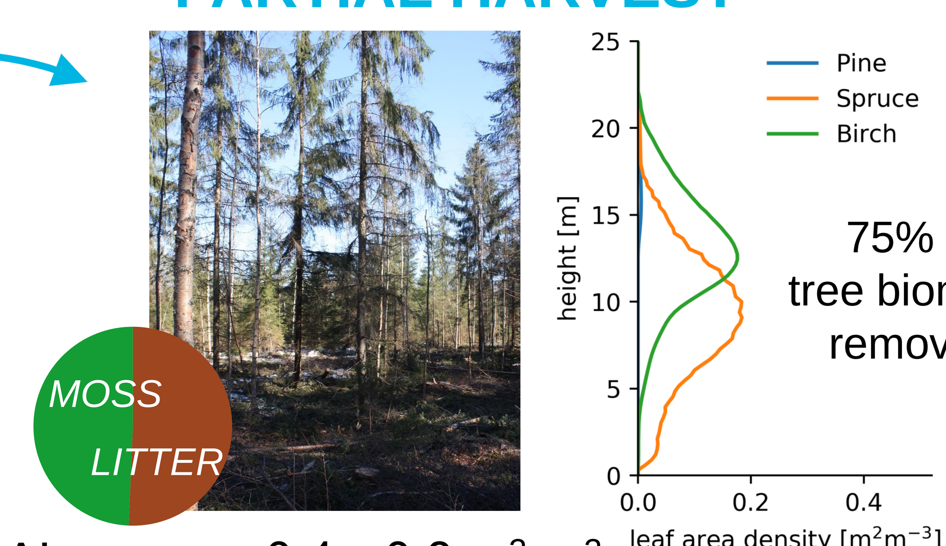
$LAI_{understory}$ = 0.1…0.8 m^2m^{-2}

CONTROL (no treatment)



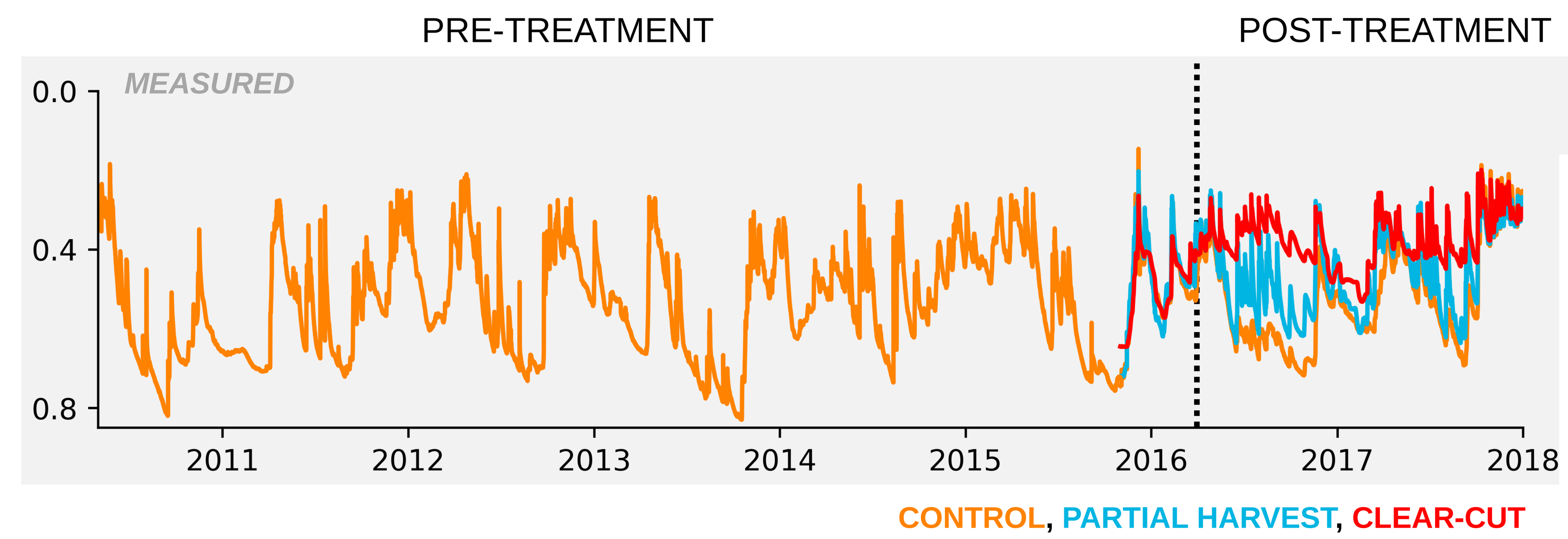
$LAI_{understory}$ = 0.65 m^2m^{-2}

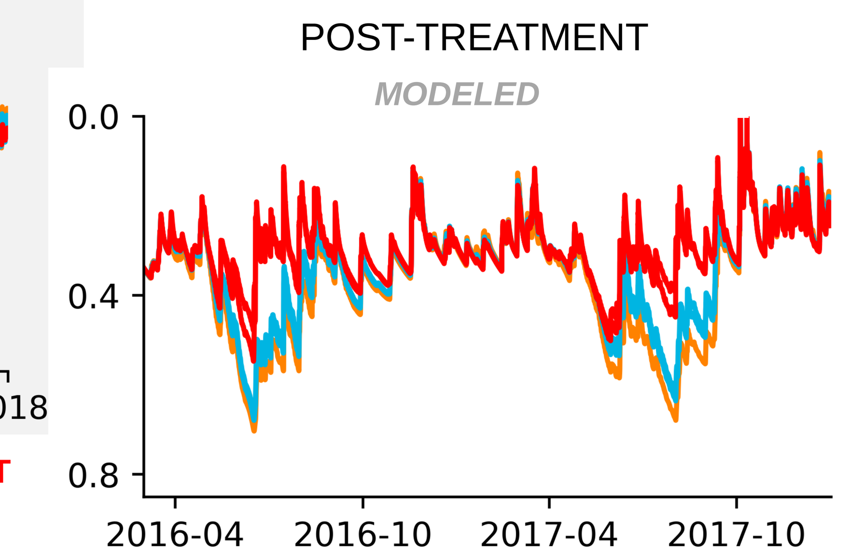
PARTIAL HARVEST



$LAI_{understory}$ = 0.4…0.8 m^2m^{-2}

3.2 Results on water table depth (WTD)





4 Conclusions

- At clear-cut site, **changes in vegetation** explained the significantly increased ET during 2nd year
- Differences between modeled and observed ET and WTD during first post-treatment year at partial harvest site indicate **trees were under stress**
- At partial harvest, transpiration of the harvested pine was **almost fully compensated for** by the remaining stand and understory, whereas interception evaporation was clearly reduced
- High ET capacity at partial harvest supports the **feasibility of continuous cover forestry**

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