OBSERVATIONS OF CLIMATE IMPACTS OF CUTOVER PEATLAND AFFORESTATION AND PEATLAND FOREST RESTORATION, IN FINLAND

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Introduction

The European Union has an ambitious goal to be carbon neutral in 2050. To achieve the ambitious goals for carbon neutrality, countries ought to, not only reduce the greenhouse gas (GHG) emissions of the energy, industry, and traffic sectors, but also enhance the carbon sinks of the Land Use, Land Use Change, and Forestry sector (LULUCF). In fig 1. is presented greenhouse gas emissions and carbon dioxide sinks of the LULUCF sector of the EU total. National inventories are performed under the Kyoto Protocol of the United Nations Framework Convention on Climate Change. In Finland, for the first time in 2021, the LULUCF sector seems to have turned from a net sink to a net source of greenhouse gases (Fig. 2).

Peatlands are remarkable source of green house gas emissions. There are approximately 4.84 Mha of drained peatlands for forestry, 0.250 Mha of drained peatlands for agriculture, and 0.100 Mha of areas for industrial peat extraction purposes, in Finland. Yearly emissions from the forestry-drained peatlands are 6.0 Mt CO2-eq and from the wetlands, peat extraction areas included, 2.2 Mt CO2-eq.

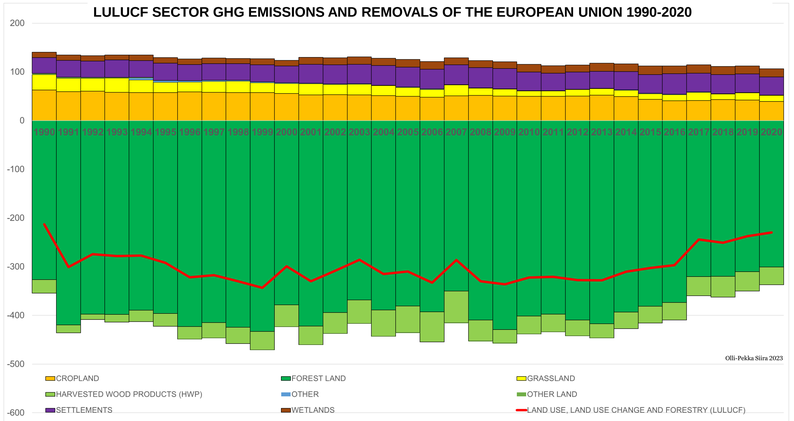

Fig. 1. Land use, Land Use Change, and Forestry (LULUCF) sector greenhouse gas (GHG) emissions and removals (sinks)of the member countries of the European Union in total (data from: European Environmental Agency 2023).

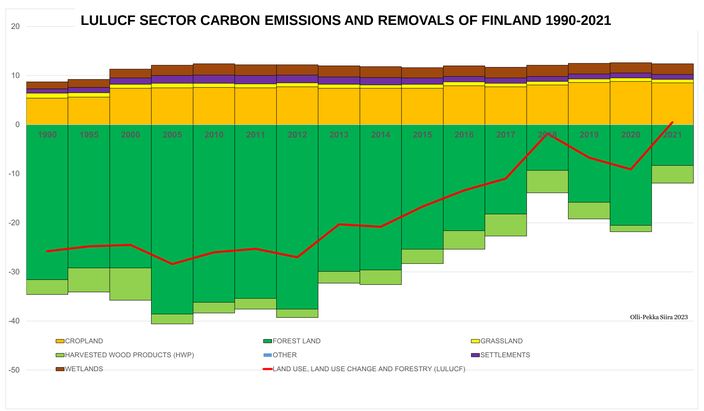

Fig. 2. Land use, Land Use Change, and Forestry (LULUCF) sector greenhouse gas (GHG) emissions and removals (sinks)of Finland (data from: Statistics Finland 2023).

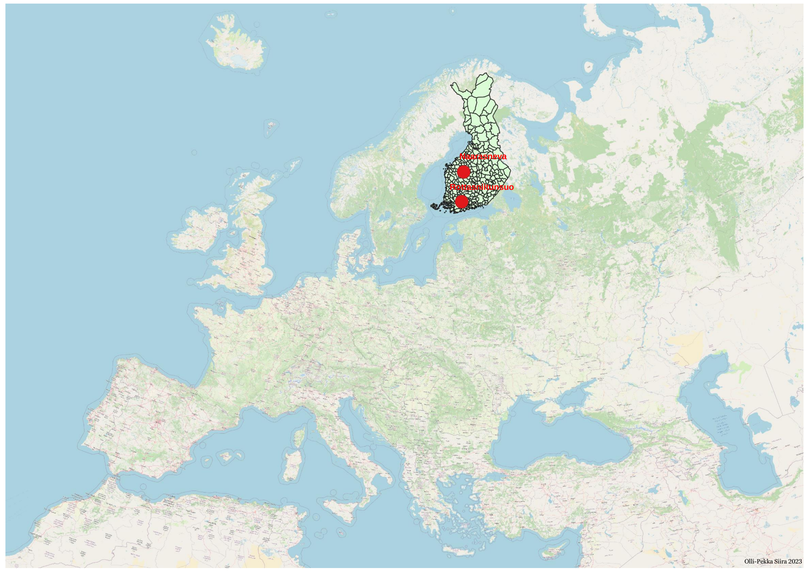

Fig. 3. Location of the example observation stations in Finland, marked with red circles. (GIS: Open Street Map).

The Academy of Finland and The Ministry of Agriculture of Forestry of Finland support research activities which are tackling the problems of peatland emissions. The TURNEE project investigates the climate impacts of afforestation of cutover peatlands and restoration of fertile peatland forests (Nappaa hiilestä kiinni program). The RESPEAT project, funded by the Academy of Finland, focuses on quantifying the potential of boreal peatland rewetting for climate change mitigation including changes in local microclimates through biophysical impacts. Quantification of the total climate impacts of the LULUCF sector, accounting for GHG balances, albedo, aerosol-cloud-climate and water cycle effects, and feedback to ecosystems, is also one of the scientific objectives of the Academy of Finland Flagship: Atmosphere and Climate Competence Center (ACCC).

Material and Methods

To study the net ecosystem exchange (NEE), we have established two new observation stations: 1. Naarasneva (2021), in central Finland on a cutover peatland; 2. Rottasniitunsuo (2022), in southern Finland on a peatland forest, which will be rewetted in 2024 (Fig. 3).

The functional idea is based on the SMEAR concept (Hari and Kulmala 2005). At both sites, carbon dioxide as well as sensible and latent heat fluxes, are measured using the Eddy Covariance (EC) technique. Methane fluxes are measured utilizing in-situ chamber technique, and with EC method at the rewetted peatland. Biogenic particle formation is measured with Neutral Cluster and Air Ion Spectrometer (NAIS). Supporting measurements include upward and downward radiation, soil temperatures, soil heat flux, relative humidity, and air temperature. Geochemical properties and hydrological changes are monitored by extensive field sampling. The vegetation growth is monitored by fieldwork with the assistance of unmanned aerial RGB photographing. Long-term climate impacts of peatland afforestation and peatland forest restoration are scaled and modeled using the LDNDC (Smith et al. 2001) and JSBACH-HIMMELI (Reick et al. 2013, Raivoinen et al. 2017) land surface process models.

Preliminary results

The ongoing research projects deliver in-situ data on peatland greenhouse gas fluxes, biogenic particle formation, and surface energy balance providing information on climate impacts of different land use measures of managed peatlands. We present CO2 flux (Fig. 4), and meteorological (Fig.5) observations of the Naarasneva site; and simulations of Net Ecosystem Exchange (NEE) development (Fig.6, Fig.7). In Fig.8 we present CO2 flux observations of the Rottasniitunsuo site.

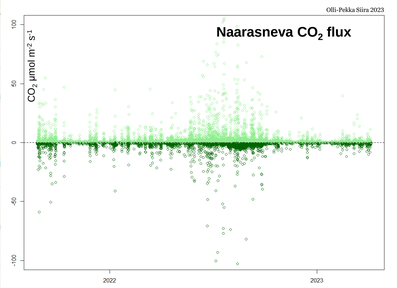

Fig. 4. Naarasneva site CO2 flux observations 26.8.2021-6.4.2023.

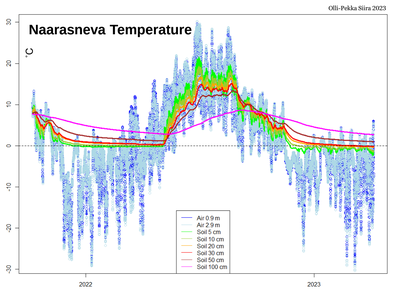

Fig. 5. Naarasneva site air and soil temperature observations 26.8.2021-6.4.2023.

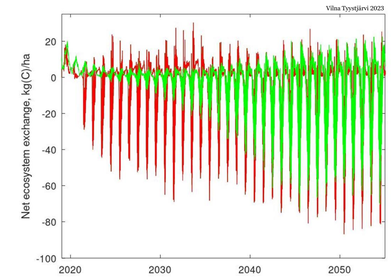

Fig. 6. Simulations 2020-2050 of the Net ecosystem exchange development of CO2 as kg (C) / ha at Naarasneva according to JSBACH (green) and LDNDC (red) models. The climate drivers for the model runs were obtained from CORDEX database (CanESM model).

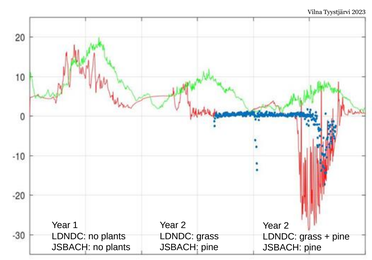

Fig. 7. Simulations of the JSBACH (green) and LDNDC (red) models, and eddy covariance flux measurements (blue dots that correspond to daily mean flux values).

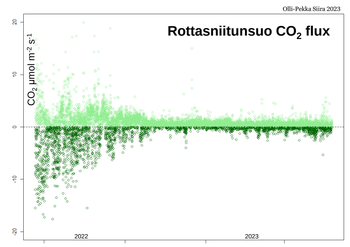

Fig. 8. CO2 flux observations (µmol CO_2 m^{-2} s^{-1}, EC-measurement) during the research period 25.8.2022-6.4.2023 at the Rottasniitunsuo site.

Acknowledgements

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