CO_2 exchange in restored milled peatlands in Estonia — importance of vegetation, water table and weather conditions

Anna-Helena Purre, Raimo Pajula, and Mati Ilomets

Institute of Ecology, Tallinn University, Tallinn, Estonia (annahele@tlu.ee)

Introduction

Peat is an important land resource in Northern Europe:
- mainly used for horticulture and energy
- In Estonia about 10 000 ha of abandoned milled peatlands, from which, only less than 200 ha have been restored. At least 2 000 ha will be restored by 2023 with European Union co-funding.

Carbon is bind in the mires, so the peat is accumulating.
- in drained and excavated peatlands, vegetation has been removed or altered, peat layer is decomposing and large quantities of carbon are released into atmosphere.
- Peatland restoration aims to mitigate these negative effects and turn milled peatland from CO_2 sources back to CO_2 sinks.

The main aim of this study is to analyse the correlations between vegetation, NDVI and carbon dioxide fluxes on restored milled peatlands and determine, if these areas are CO_2 sinks or sources during the growing seasons.

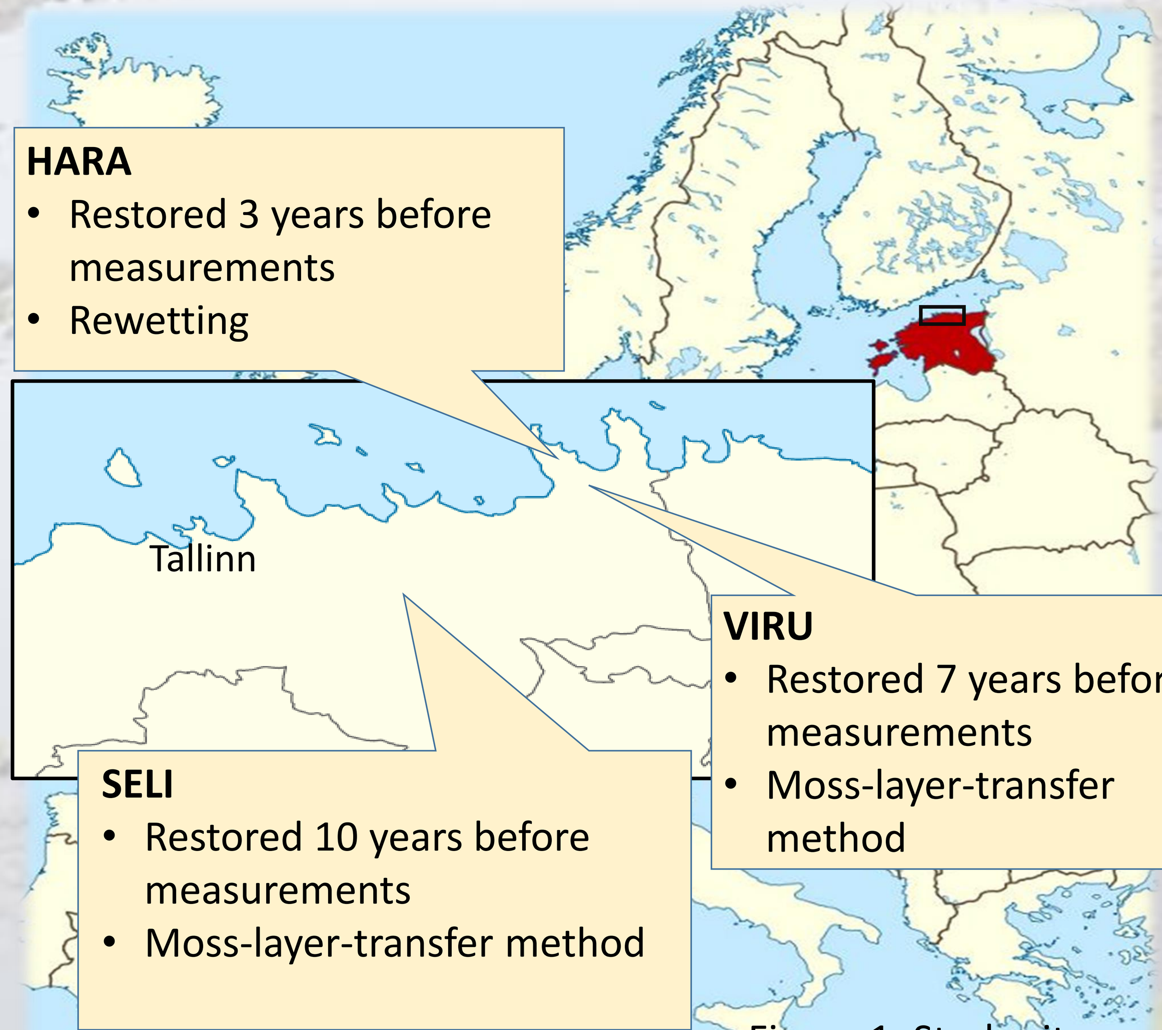

Figure 1. Study sites

Methods

In three recovering milled peatlands (Fig. 1) CO_2 fluxes (net ecosystem exchange (NEE) and respiration (R_{ECO})) were measured with chambers and infra-red gas analyser Li-6400 in growing seasons of 2015 and 2016 (Fig. 2). The photosynthesis (P_g), respiration, and NEE (NEE=R_{ECO}-P_g) were modelled for those growing seasons (May-September).

In both years plant cover and Leaf Area Index (LAI) was determined, plant biomass was measured in 2016. Normalized Difference Vegetation Index (NDVI) was measured in September 2017 with eBee SQ drone with Parrot Sequoia multispectral sensor. Results were considered statistically significant if p<0,05.

Figure 2. Chamber measurements of NEE (a), respiration (b) (T. Penttilä), destructive sampling of biomass (c), and drone flight for NDVI measurement (A-H. Purre).

Results and discussion

Vegetation

Above-ground shrub biomass and cover were significantly higher in Seli, while forb cover and biomass were higher in Hara (Fig. 3). Shrubs like *Calluna vulgaris* benefit from lower water tables in Seli, in reverse forbs like *Eriophorum vaginatum* can grow also in inundated conditions in Hara, where shrubs were absent.

There were no significant differences in plant cover and LAI between the years.

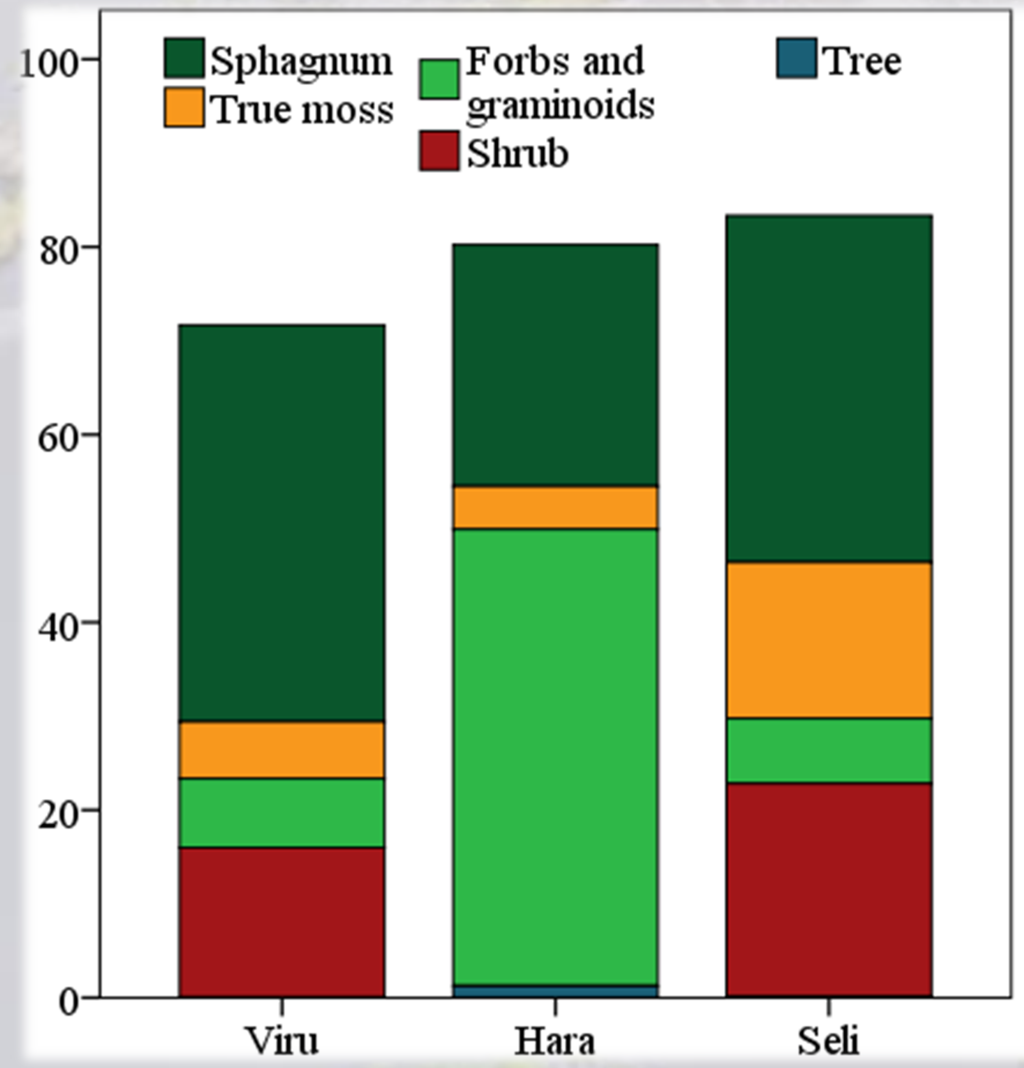

Figure 3. Plant cover (%) in study sites.

CO_2 fluxes

In drier and warmer year (2015), all sites were CO_2 sources in average (Fig. 4), whereas two sites were CO_2 sinks in wetter year (2016). Cumulative percipitation and average temperature of both study years are brought in Table 1. Average $R_{ECO}$was highest in site with lowest water level (Seli) whereas differences in P_g between sites were insignificant.

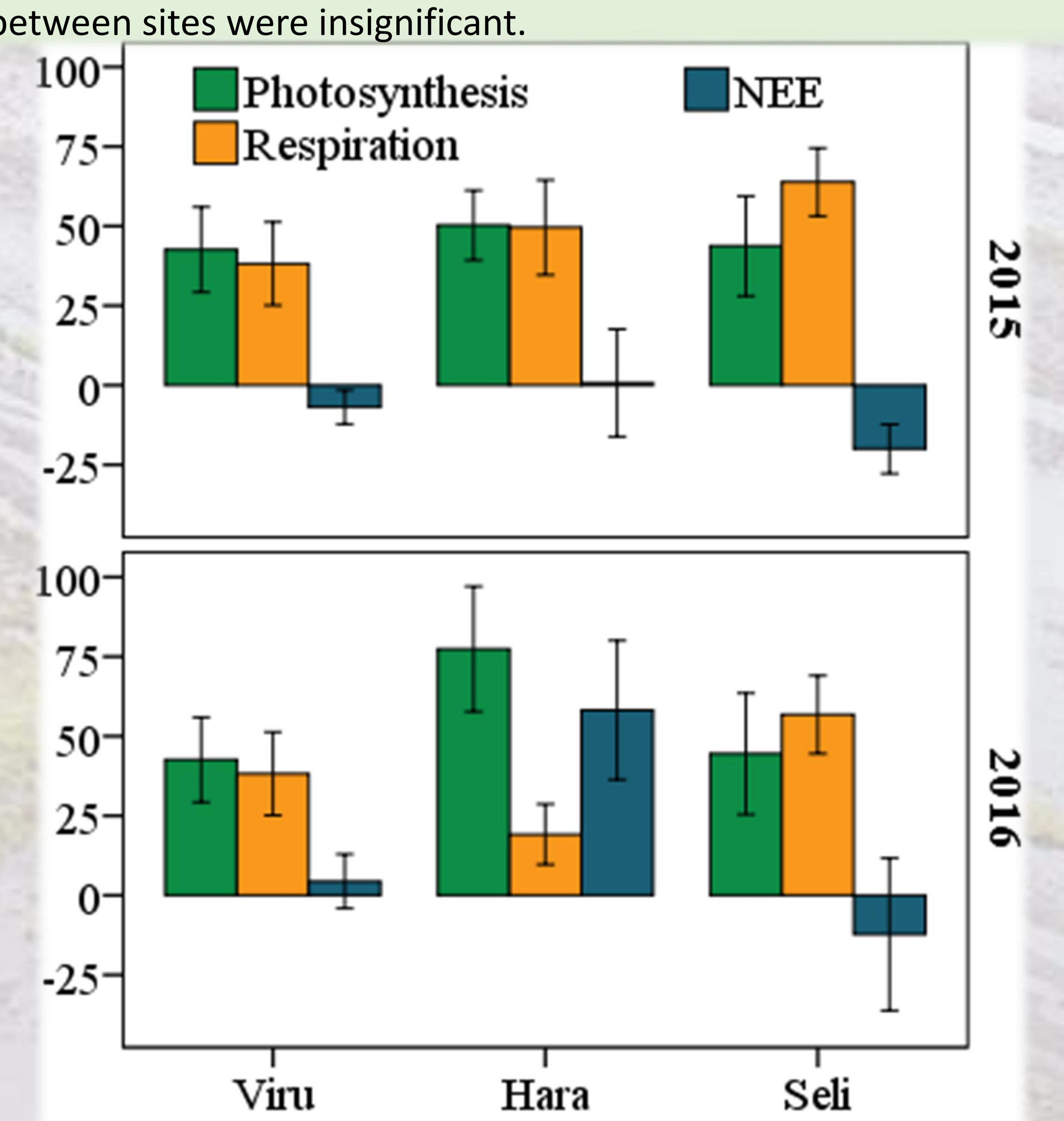

Figure 4. Average growing season CO_2 fluxes (mg CO_2 m^{-2} h^{-1}) in study sites.

Table 1. Percipitation and temperatures in 2015, 2016 and long-term (1981-2010) average (Estonian Environment Agency).

	Percipitation (mm/year)	Temperature (^{0}C)
2015	562	7.5
2016	803	6.6
Long-term	703	5.7

CO_2 uptake increased with higher plant coverage and LAI, NDVI, graminoid and forb (mainly *E. vaginatum*) cover and biomass and *Sphagnum* cover (Fig. 5). Plots with bare peat remained to be CO_2 sources in both growing seasons (–62 ± 25 mg CO_2 m^{-2} h^{-1}). R_{ECO} was higher with higher coverage of dwarf-shrubs (mainly *C. vulgaris*).

NDVI, which quantifies photosynthetic capacity of plant cover explained about 25% of variation in NEE (Fig. 6). To our knowledge NDVI has not been related to CO_2 on restored milled peatlands before.

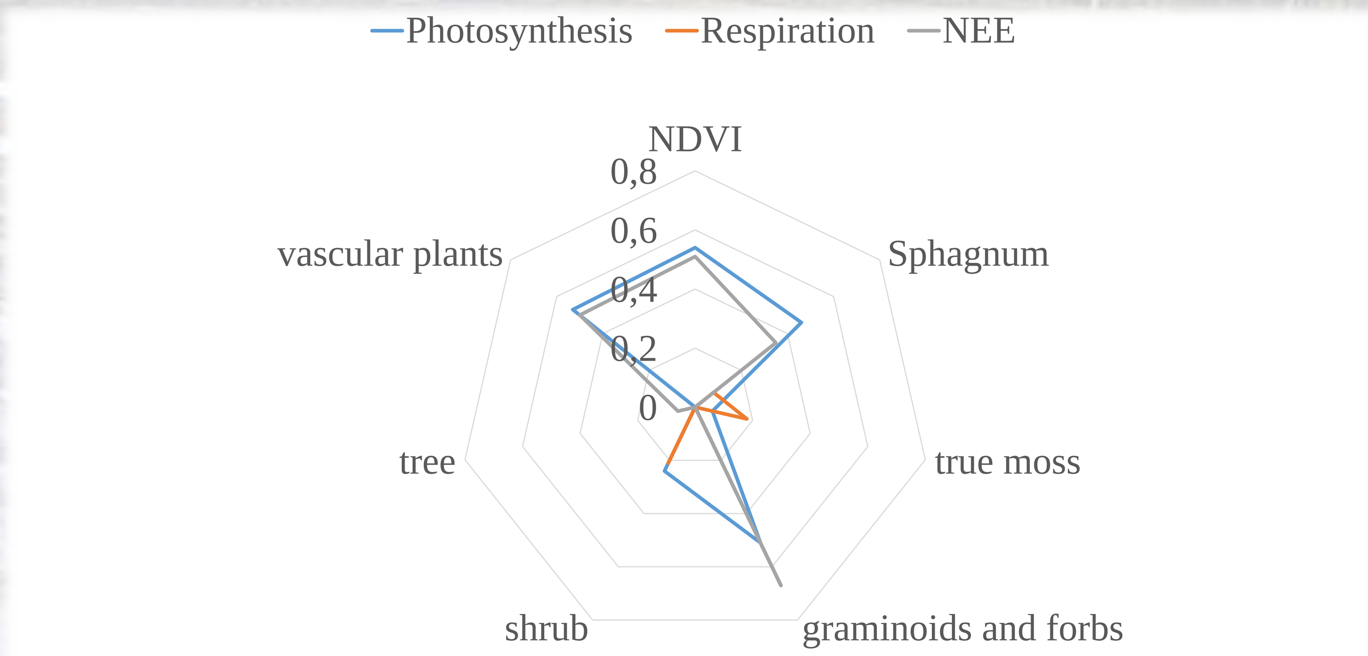

Figure 5. Correlations between CO_2 flux components and vegetation (NDVI and plant cover). Correlations are statistically significant if r > 0.30).

Conclusions

- Multi-annual CO2 flux measurements are needed, as one year measurements could be influenced by extreme weather conditions like droughts
- Spatial distribution of NDVI values obtained with drone equipped with multispectral camera may give us valuable information about vegetation, weather and water table condition temporal changes in photosynthetic capacity on recovering peatlands

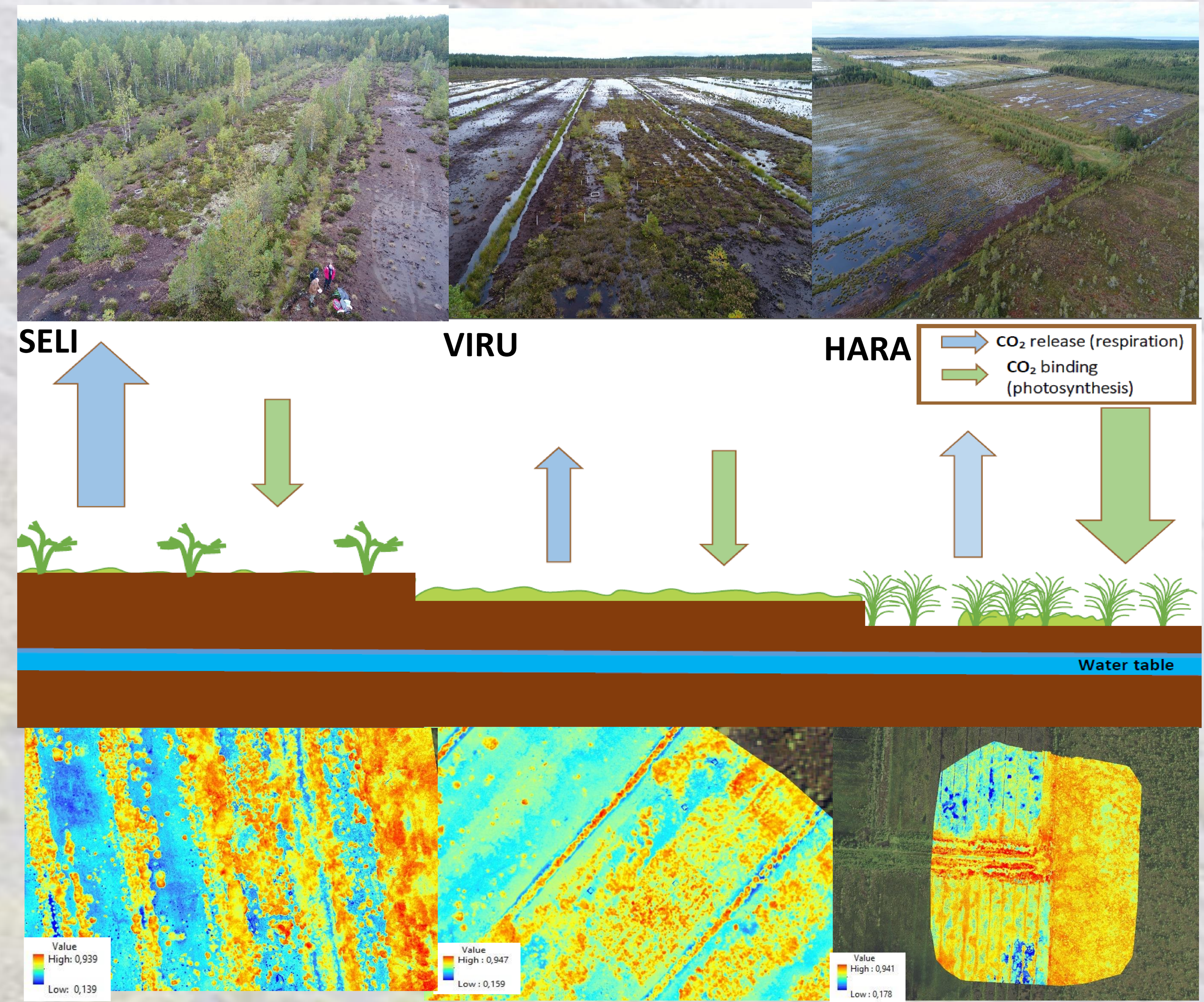

Figure 6. Aerophotos, scheme of water table, vegetation and CO_2 fluxes, and NDVI map of sites .Warmer colours indicate higher NDVI, while colder colours show lower NDVI.

Acknowledgements

Authors thank Aleksandra Krijer for her help in biomass sampling and measurements. Estonia Weather Service provided the weather data for modelling and State Forest Management Centre granted the water table data. Tallinn University Centre of Excellence of Natural Sciences and Sustainable Development, and scholarship of Jaan-Mati Punning financed the study.