Afforestation as a type of peatland recultivation and assessment of its affecting factors in the reduction of GHG emissions

Emīls Mārtiņš UPENIEKS, Agnese RUDUSĀNE

Latvian State Forest Research Institute «Silava», Rigas iela 111, Salaspils, LV-2169

Introduction

During 20th century the global average air temperature has been significantly rising at a rapid, unusual pace (Ji et al., 2014). The main reason for this is increasing concentration of greenhouse gases (GHG) in the atmosphere, which is caused by human activity (Ring et al., 2012). Three main human-caused GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (NRDC, 2019). To reduce the impact of these gases on global climate change, it is important to plan human actions in such a way as to minimize the emissions of these gases, as well as to reduce their amount in the atmosphere. One way to reduce GHG emissions in the atmosphere is sustainable land management. This means rehabilitating the areas where resource extraction has been concluded so GHGs can be sequestrated into biomass and emissions reduced. This paper will focus on afforestation as one of the most effective ways of recultivating degraded peatlands in Latvia.

One of the biggest carbon sinks in the terrestrial biosphere are peatlands. Although peatlands cover only about 3% (4,000,000 km^2) of the world's total land area, they store at least 550 Gt of carbon in their peat soils, or 30% of all land-based carbon in the world (Parish et al., 2008). This high carbon concentration in peatlands is ensured by the wet conditions (Joosten, Couwenberg, 2009). Before peat extraction the peatland area is drained (Haghighi et al., 2018). As a result, the constant moisture conditions in the upper layer are disturbed and the CO_2 balance becomes negative. In order to restore CO_2 sequestration, after the completion of peat extraction, it is necessary to recultivate the area.

In LIFE REstore project it was concluded that afforestation is one of the most effective ways of peatland recultivation in Latvia to keep the GHG emissions low. In fact, CO_2 emissions are even smaller than in the areas, where recultivation is done by restoring bog ecosystem (renaturalization). It was observed that renaturalized areas emit more CH_4 than the afforested areas and CO_2 emissions remain high during summer months, when groundwater level decreases. There was even a sink effect where Scots pine (*Pinus sylvestris* L.) was used for afforestation (Lazdiņš, Lupiķis, 2019).

The first studies about GHG emissions from peatlands have been started only in the last decades of 20th century however since the beginning of 21st century the amount of research has been rising. The demand for these studies is dictated by the European Green Deal, which proposes climate neutrality in the EU by 2050 (Krīgere, 2020). In Latvia comprehensive research related to GHG fluxes has been started within the scope of the "LIFE REstore" project carried out by the Nature Conservation Agency and its partners although a big portion of the collected data has not yet to be analyzed.

The aim of the study is to describe afforesting as a type of peatland recultivation and to evaluate its efficiency in GHG mitigation.

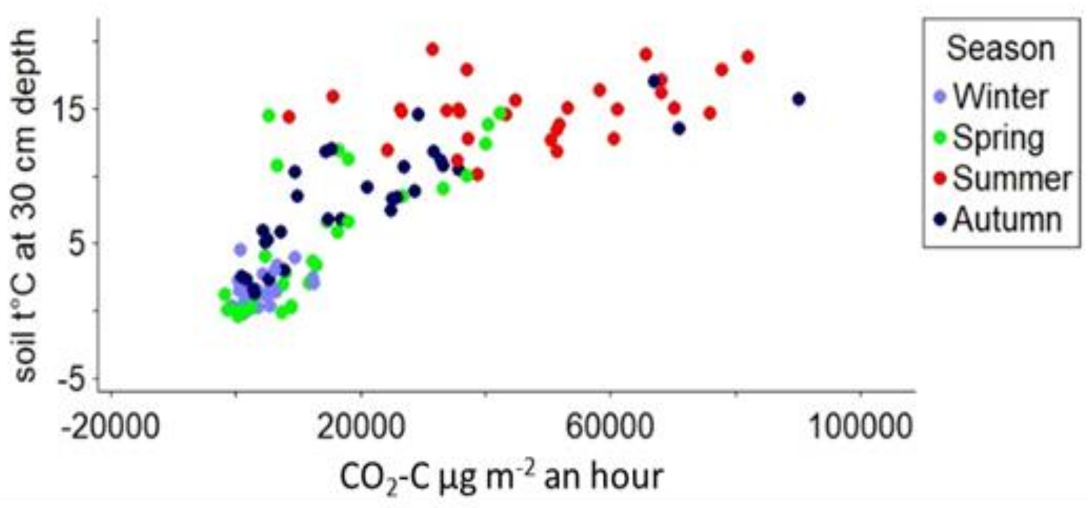

Fig. 6. Correlation between soil temperature (°C) at 30 cm depth and CO_2 emissions (CO_2-C µg m^{-2} an hour)

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Methodology

Fig. 1. Location of Kaigu and Silgulda mires

Fig. 2. Measurements with closed chambers

Secondary data obtained within the LIFE REstore project was used to perform the work. The data required for the research were obtained from December 2016 to November 2018 in Kaigu and Silgulda mires (Figure 1). The data contains measurements of the three main GHGs (CO_2, CH_4 and N_2O) as well as various factors that affect them (air and soil temperatures at depths of 5, 10, 15 and 30 cm, water table depth, weather conditions at the time of the measurements, area of both the peatland and the part of it that is degraded, thickness of the remaining peat layer, degree of decomposition of the upper peat layer). For GHG measurements closed chamber method was used (Figure 2). The data was further processed in Microsoft Excel, IBM SPCC Statistics 22, and PC-ORD 5.

Results

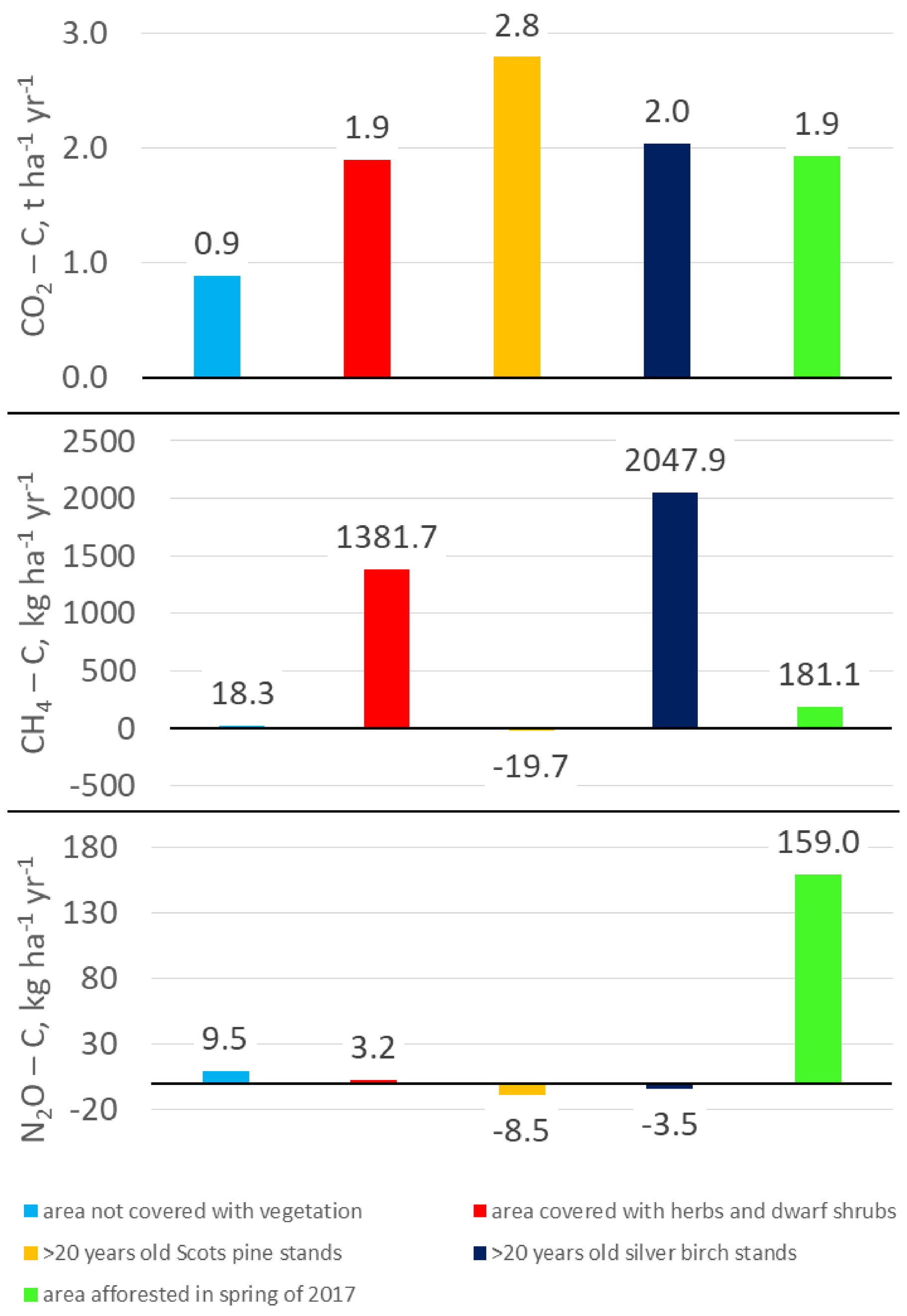

Fig. 3. Net CO_2, CH_4 and N_2O emissions, recalculated to CO_2 equivalents

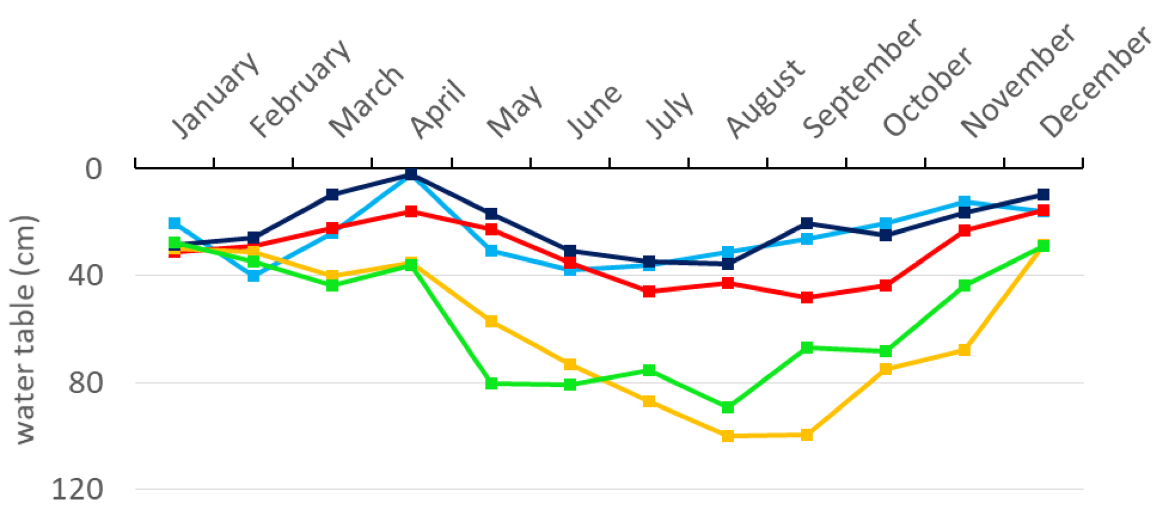

Fig. 4. Two year average water table (cm) in different land uses

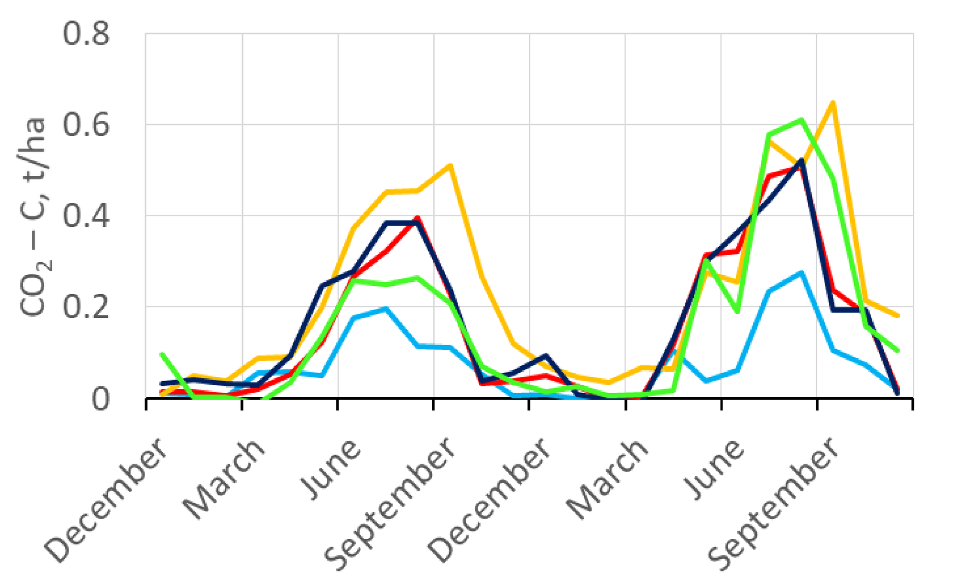

Fig. 5. Monthly net CO_2 emissions from December 2016 to November 2018 in different land uses

After analyzing the data on GHG from all the study sites and comparing them in CO_2 equivalents it was concluded that the most significant amount of emissions is made up by CO_2 (Figure 3). These emissions in afforested areas are similar to the territory where herbaceous and shrub vegetation is growing but differ significantly from the area without any vegetation cover. CH_4 emissions are high in the areas where water table is near the ground surface (Figure 3 and 4) with an exception in the area without any vegetation cover (shallow water table and low CH_4 emissions) which could likely be explained by reduced microbial activity due to less organic matter available for decomposition.

CO_2 are the only emissions that show a seasonal trend (Figure 5). This is due to their strong correlation with air and soil temperatures. The strongest correlation was found between CO_2 emissions and soil temperatures in 30 cm depth. CO_2 emissions are most homogenous during winter when vegetation period has ended (Figure 6). During summer and autumn CO_2 emissions show the least homogeneity.

Main conclusions

1. The strongest correlation with CO_2 emissions was found for soil temperature – the higher the temperature the higher the amount of emitted CO_2.
2. As the depth of soil increases the correlation between soil temperatures and CO_2 emissions becomes stronger.
3. Significant seasonal differences in CO_2 emissions were found in the study. During summer the highest GHG fluxes are observed, but during winter – the smallest. This can be explained by seasonal changes in soil temperature and this also points out that measurements of GHG fluxes during winter period are not necessary. However, significant increase of N_2O emissions is observed in early spring, therefore should be measured more often than once per month or continuously.