Afforested cutover peatland can be a net CO_2 sink after two years

In Finland, most areas released from peat extraction are afforested after peat extraction has ceased. Unlike in Canada or Germany, the landowner has no obligation to restore the areas to wetlands. Instead, the landowner can freely choose the after-use method (see, e.g., Laasasenaho et al. 2023). According to the Bioenergy Association of Finland (2022), approximately 75% of the areas are afforested and only 5% have been restored to wetlands.

This has raised concerns that afforested cutover peatlands will become a long-term net carbon dioxide (CO_2) source, when the drainage maintains the low water table and the residual peat continues to decompose and forms greenhouse gases.

Figure 1: Naarasneva measurement station. Photo: Kari Laasasenaho

In the case of afforestation, the direction of emission development is not straightforward. After afforestation, leftover peat (which can be up to 1 m thick) continues to decompose while, at the same time, the growing ground vegetation and trees start to sequester carbon and produce litter.

The few previous studies on the topic have separately quantified the different carbon cycle components to provide an estimate of the carbon balance on cutover peatlands (Jauhiainen et al. 2023).

However, measurement of the net ecosystem CO_2 exchange (NEE) is usually conducted via a method that disturbs the soil and vegetation. One method that does not present such disturbance is the eddy covariance method.

In the present work, we provide a preliminary snapshot of results of the initial phase of afforestation obtained in a project called “Forests on peatlands - solutions for reducing emissions and increasing of carbon sinks (TURNEE)”, funded by the Finnish Ministry of Agriculture and Forestry.

Future carbon sinks?

In the TURNEE project, a station measuring the overall climate effects of afforestation of a cutover peatland was established in Naarasneva, South

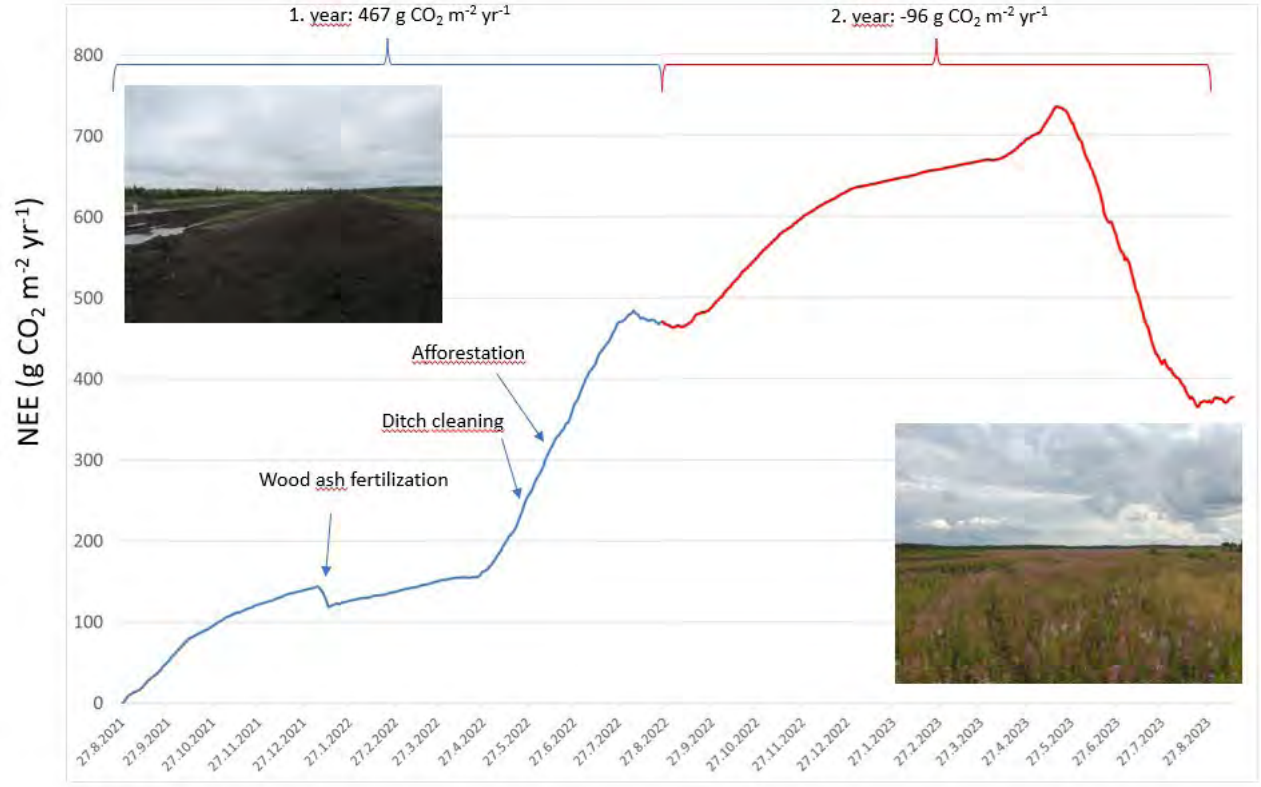

Figure 2. Daily cumulative net ecosystem CO_2 exchange (NEE) between an afforested cutover peatland and the atmosphere. Positive numbers indicate a source from the peatland into the atmosphere, negative indicate a sink. The slope of the curve illustrates the speed of net CO_2 emission or sink. During the first two years, the site has lost almost 400 g CO_2 m^{-2} into the atmosphere. Illustration: Annalea Lohila

Ostrobothnia, in 2021 (Laasasenaho et al. 2022). The peat extraction at Naarasneva ceased in 2020 and the area was fertilized with wood ash, maintained with ditch cleaning, and afforested with pine seedlings in 2022. NEE of carbon dioxide has been measured in the area for more than two years using the eddy covariance technique (Figure 1).

According to preliminary results, the area was a net source of CO_2 during the first measurement year, i.e., more CO_2 was released from the soil than was sequestrated by the vegetation (Figure 2). During the first summer, some weeds appeared at the site around late July and caused a small, short-lasting sink of CO_2, indicated by a decreasing cumulative NEE in August 2022.

However, the rapid growth of weeds such as the willowherb and downy birch that appeared in early summer 2023 (Figure 3) meant that the carbon sink strengthened in such a way that in the second year of measurement, the cumulative carbon balance became negative, i.e., more CO_2 was sequestrated to plants than was released into the atmosphere. In the first year, the area was a source of CO_2 at an approximate rate of 470 g CO_2 m^{-2}, while in the second year, the site acted as a CO_2 sink at a rate of almost 100 g CO_2 m^{-2}. These very preliminary results suggest that afforestation and its related management measures, such as fertilization, can relatively quickly create a new carbon sink on cutover peatland. Ash fertilization is crucial for producing vegetation cover quickly.

It is not yet clear how the NEE and the carbon sink will develop in the upcoming years and how the decomposition of vegetation and the litter production will evolve. These preliminary results indicate that it is possible to create rapid carbon sinks on cutover peatlands through afforestation, even though the area of restored cutover peatlands could remain small in Finland in the future.

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Figure 3. Naarasneva afforested cutover peatland in summer 2023. Vegetation cover has developed fast after wood ash fertilization. Photo: Kari Laasasenaho

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Kari Laasasenaho & Risto Lauhanen

Seinäjoki University of Applied Sciences
kari.laasasenaho@seamk.fi

Annalea Lohila

University of Helsinki and Finnish Meteorological Institute

Kari Minkkinen & Paavo Ojanen

University of Helsinki

Tuula Aalto

Finnish Meteorological Institute

Hannu Marttila

University of Oulu

Markku Kulmala

Institute for Atmospheric and Earth System Research, INAR, University of Helsinki

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