Client report Istutapuita
26.3.2020

Effect of reforestation of former peat production area on organic carbon fluxes in soil and trees

Antti Wall
Natural Resources Institute Finland

Methods

The methods used to calculate changes in the carbon stock are based on the methods used in Finland's greenhouse gas inventory (Greenhouse gas emissions 2019) and to the forecasted development of trees, produced by the Motti software (http://www.metla.fi/metinfo/motti/). The changes in carbon stock were calculated for soil and tree biomass in southern Finland for a period of 100 years.

Soil

The changes in the soil carbon stock of the reforested areas were evaluated by applying emission factors from the greenhouse gas inventory, using the emission factors of the area that transformed from peat production area to woodland for the first 20 years after reforestation and the emission factors of woodland after that. The changes in the soil carbon stock were calculated based on gaseous CO_2 emission measurement results and underground litter input. The former peat production area to be reforested was presumably a type of forest poor in nutrients and ash-fertilized.

Tree biomass

The development of the trees is based on the corresponding forest type woodland's development, according to the MOTTI software's pine growth forecast models.

To forecast the development of the trees, thinning models of swamp forests up to 100 years of age were used in accordance with good forest management practices. In this case, a thinning was carried out to the stand of trees at 44 and 74 years of age. The annual biomass yield (including the part of tree above ground, the stump and the root system) was calculated from the growth of the trees produced by the growth models using biomass equations (Repola 2008, 2009). The tree

biomass was converted to carbon with a factor of 0.5 (50% of carbon). A planting density of 2,000 pcs/ha was used in the calculations.

Carbon compensation

The carbon compensation caused by reforestation was calculated as follows: we subtracted the change in the carbon stock after reforestation from the change in the carbon stock caused

by the previous land use (former peat production area) annually over a period of 100 years. The growth of the trees was calculated according to the average growth of the rotation period. The unit we used for carbon stocks was t carbon (C)/ha.

Results

In the early years of reforestation, the soil is a source of carbon until the litter produced by growing trees and the growth of biomass cause the soil to become a carbon sink 27 years after reforestation (Figure 1). In a forested area, with a 100-year rotation period, the total accumulation of the soil carbon stock is negative, but the carbon absorbed by the tree biomass offsets the carbon emission caused by the soil. This way, at the end of the rotation period the net carbon stock is 63 t C/ha. At the end of the rotation period, the carbon emission of the former peat production area would be 260 t/ha without afforestation. The carbon compensation accomplished by reforestation, calculated on the basis of the average growth of the tree, is 323.6 t C/ha (Table 1).

The calculation is based on a 100-year tree growing period, during which an area of 1 ha of a former peatlands reforested for pine absorbs a total of 323.6 tons of carbon compared to previous land use (former peat production area, nutrient content like the woodland). As the planting density is 2,000 seedlings/hectare, the share of one planted seedling is 161.8 kg of compensated carbon over 100 years.

The absorbed carbon is converted into carbon dioxide by a factor of 3.67 (the molecular ratio of carbon dioxide and carbon is 44/12=3.67), whereupon the amount of carbon dioxide absorbed is 594 kg per tree over 100 years. If the annual carbon footprint of one person is 10,000 kg of carbon dioxide, it contains 2,725 kg of carbon (the molecular ratio of carbon dioxide and carbon is 44/12=3.67). Thus, 2,725 kg/161.5 kg = 17 seedlings is needed to compensate such an amount of carbon. In other words, 17 trees that grow for 100 years, absorb the carbon caused by one person in one year.

To compensate for the carbon footprint caused by one person over 100 years, the amount of seedlings needed can be found out using the formula: 2,725 kg*100 years=272,500 kg of carbon /161.50 kg = 1,687.30 seedlings.

Figure 1. Evolution of the total organic carbon stock of soil and trees in a former peat production area reforested for pine.

	Reforested	Former peat production area	Carbon compensation, t/C/ha
Soil	-12	-260	248
Trees	75		75
in total	63	-260	323

Table 1. Accumulation of organic carbon (C) in soil and trees in reforested former peat production area and without reforestation 100 years after reforestation and carbon compensation achieved by reforestation (reforestation-peat production area). A negative number indicates carbon emissions and a positive one the accumulation.
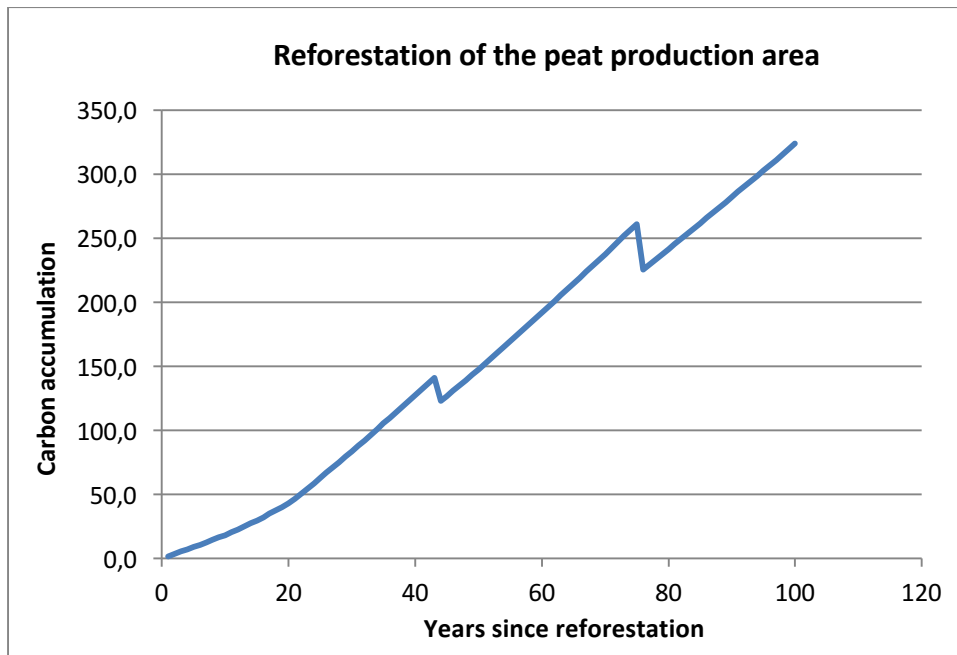
Reforestation of the peat production area

Figure 2. Total carbon compensation of reforestation of the peat production area.

References

Greenhouse gas emissions in Finland 1990 to 2017. National Inventory Report under the UNFCCC and the Kyoto Protocol. Submission to the European Union. Statistics Finland. 2019.

Repola J. 2008. Biomass equations birch in Finland. Silva Fennica vol. 42 no. 4.

Repola J. 2009. Biomass equations for Scots pine and Norway spruce in Finland. Silva Fennica vol. 43 no. 4.