

# Carbon balance of forest land in Finland as affected by different levels of wood use and climate change

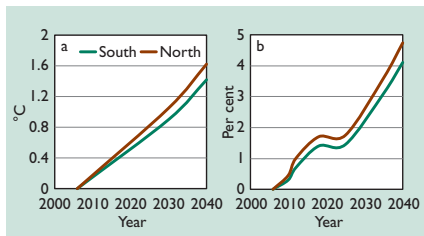
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## Introduction

The Finnish forests are providing (on about 80 per cent of its total area 26.1 million ha) wood for industrial and other use, about 60 million m<sup>3</sup>/year in the last decade. It is projected that the industrial use of wood will decline in the future. The use of wood for bioenergy is rapidly increasing, and there are governmental plans to raise it to a considerable level during this decade. Climate change (CC) will increase forest growth but on the other hand also the decomposition rate of organic matter. This may affect carbon balance of forest soils considerably.

## Scenarios

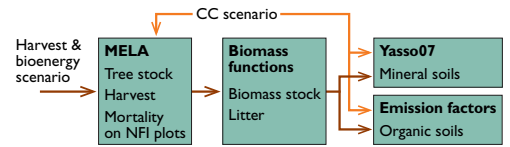
We present estimates of carbon balance of forest land for the next 30 years with varying levels of industrial and bioenergy wood use (Figs 3 and 4) and assess the effect of CC (Fig. 3) with one scenario: IPCC SRES A1B (Fig. 2). The scenarios of the industrial and bioenergy wood consumption (Table 1) are potential paths of development (LOW, MED, BIO+, BIO-). We also consider the maximum sustainable harvesting level (POT), which is not likely to be achieved.



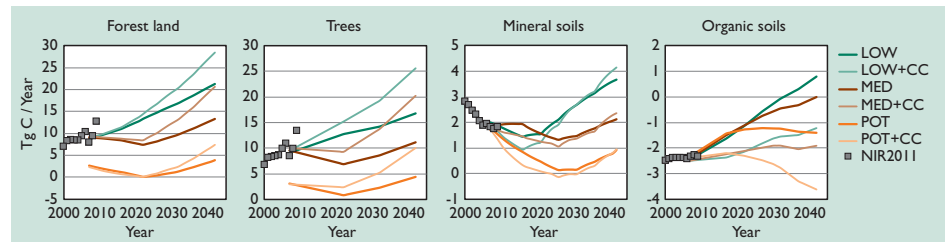
**Figure 2.** Projected changes in annual mean temperature (a) and precipitation (b) relative to year 2006 in Southern and Northern Finland based on the A1B scenario (Jylhä *et al.* 2009). Temperature changes are expressed in absolute and precipitation changes in per cent terms. The climatological annual mean temperatures and precipitations in 2006 for Southern and Northern Finland are 3.1 °C, -0.3 °C, 515 mm and 438 mm, respectively. These values were used in simulations ignoring CC.

## Models

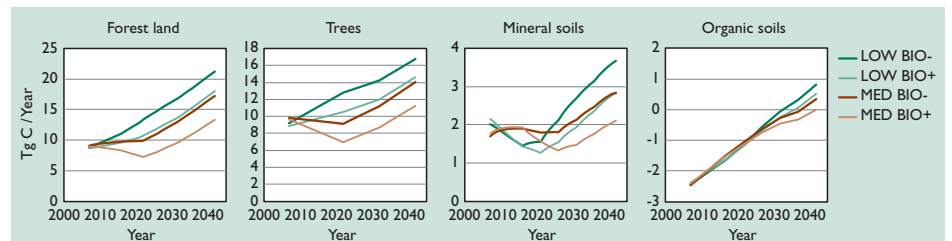
We used the large-scale forestry model MELA (Redsven *et al.* 2011) to predict development of growing stock (Fig. 1). The soil carbon model Yasso07 (Tuomi *et al.* 2011) was used for mineral soils. Peatland forests comprise ca. 30% of forest land, and for the carbon balance of their soils we used a method based on emission factors and litter input. These methods are similar to those in the Finnish greenhouse gas inventory (Greenhouse ... 2012).



**Figure 1.** Connecting models for the carbon balance of trees, mineral and organic soils in the scenario analyses. MELA (Redsven *et al.* 2011) uses information of NFI (National forest Inventory) plots.



**Figure 3.** The effect of wood utilization scenarios LOW, MED and POT (Table 1) on carbon balance of Forest land (=sum of changes in all pools), Trees, Mineral and Organic soils in the three. Dark color lines display simulations without CC and light color ones with CC. Shown are also corresponding values by the national greenhouse gas inventory to the UNFCCC in 2011 (grey squares, NIR2011). Positive values represent sink and negative source.



**Figure 4.** The effect of bioenergy wood utilization levels on carbon balances (Forest land, Trees, Mineral and Organic soils). Levels are (Table 1): low (dark color; BIO-) and high (light color; BIO+). Orange color: commercial harvesting according to MED scenario, blue color: commercial harvesting according to LOW scenario. Positive values represent sink and negative source.

**Table 1.** The Commercial harvest and Bioenergy wood use levels in different scenarios (Figs. 3 and 4).

Scenario	Commercial harvests in 2020 (million m <sup>3</sup> )	Bioenergy wood use in 2020 (million m <sup>3</sup> ) <sup>a</sup>
LOW / LOW BIO-	43.9	18.0
MED / MED BIO+	56.6	25.5
POT	70.6	24.0
LOW BIO+	43.9	25.5
MED BIO-	56.6	18.0

<sup>a</sup>Includes also fuelwood for small scale housing 5.5 million m<sup>3</sup>

## References

Greenhouse gas emissions in Finland 1990–2010. National inventory report to the UNFCCC and the Kyoto Protocol, 13 April 2012. [Web document]. Statistics Finland. Available at: [http://www.stat.fi/tup/khkinv/unfccc\\_nir\\_2012.pdf](http://www.stat.fi/tup/khkinv/unfccc_nir_2012.pdf). [referenced 26.4.2012].

Jylhä, K., Ruosteenoja, K., Räisänen, J., Venäläinen, A., Tuomenvirta, H., Ruokolainen, L., Saku, S. & Seitola, T. 2009. Arvioita Suomen muuttuvasta ilmastosta sopeutumistutkimuksia varten. ACCLIM-hankkeen loppuraportti. Finnish Meteorological Institute, Reports 2009:4 (In Finnish with an English summary).

Redsven, V., Hirvelä, H., Härkönen, K., Salminen, O., Siitonen, M. 2011. MELA2009 Reference Manual (2nd edition). The Finnish Forest Research Institute. 664 p. ISBN 978-951-40-2283-3

Tuomi, M., Rasinmäki, J., Repo, A., Vanhala, P. & Liski, J. 2011. Soil carbon model Yasso07 graphical user interface. Environmental Modeling and Software 26 (11): 1358-1362.



## Conclusions

- Projected Forest Land carbon balances exceed well the UNFCCC Forest Management Reference level of Finland 5.26 Tg C/year in scenarios LOW and MED. In the POT scenario Forest Land carbon balance is below this level.
- CC increases the carbon sink of trees and that of trees and soil combined; in soil pools it increases emissions slightly (Mineral soil) or considerably (Organic soil).
- Higher bioenergy wood utilization (BIO+) decreases carbon sink of Forest Land by ca. 3.2 Tg C/year, the main effect being in Trees and Mineral soils.

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