Mixed forests and climate change – does site fertility matter?

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Introduction
Climate change may lead to remarkable changes in the tree species composition. We evaluated biomass production and carbon sequestration potential of a forest stand with competing tree species (silver birch, Scots pine and Norway spruce) in ambient and changing climate in boreal forests.

Methods
We applied individual-based stand simulator (EFIMOD) that included a model for soil organic matter dynamics (ROMUL). The combined model simulates spatially explicit competition of trees for light and nutrients. Climate change scenarios were based on the runs of the ECHAM5 GCM. We simulated stand development with varied initial proportions of tree species in climatic conditions of southern Finland on sites that represented a range of fertility variation (poor, intermediate and rich sites).

Results
The dynamics of competing tree species was similar in ambient and changing climate. In mixed spruce-birch stands, spruce replaced birch, and more successfully on rich sites. In the spruce-pine stands, spruce tended to replace pine on rich and intermediate sites, with opposite trend on poor site. In pine-birch stands, the proportion of pine increased on poor site and decreased on intermediate and rich sites.

The highest average carbon stock in standing biomass across all site types was observed in mixed stands with three species and in spruce-dominated stands. (Fig 1, top). On the other hand, increased proportions of pine resulted in increasing soil C stocks. (Fig 1, below).

Climate change increased stand productivity and the increase in coniferous stands was more remarkable than in birch-dominated stands. The relative increase in biomass was highest on intermediate site type (Fig 2, top). Climate change negatively affected accumulation of organic matter in soil, especially in birch-spruce stands (Fig 2, below). In general, the negative effect of climate change on carbon accumulation in soil increased with increasing site fertility. However, in birch dominated sites the relative decrease was highest on intermediate site type.

Conclusions
• Climate had remarkable influence on stand productivity and carbon stock.
• Climate change had the most positive effect on forest carbon stock on mixed stands of three tree species and on spruce dominated coniferous stands (Fig. 3).
• Most remarkable positive response was obtained on sites of intermediate fertility level.

Fig. 1. Average carbon stock of biomass (top) and soil (below) over the whole simulation period (100 years) at ambient climate.

Fig. 2. Effect of climate change on the C stock of biomass (top) and soil (below).

Fig. 3. Change in the forest C stock over the simulation period.