EFFECTS OF MANAGEMENT ON STAND LEVEL CARBON STOCKS: A SIMULATION STUDY

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Background

We have augmented the stand simulator MOTTI with the forest soil carbon model Yasso (Fig. 1). MOTTI is a stand simulator that employs empirical growth models for the commercial tree species in Finland (the main ones are Scots pine, Norway spruce and birch). The growth models are tree-level, distance-independent, based on extensive data sets, and cover all areas in Finland. Temperature sum and other variables pertaining to geographical location adjust the growth of individual trees to different growing conditions.

Yasso (Fig. 2) takes litter (annual amount, both from trees and understorey vegetation) as input. The parameter values of Yasso (mainly the decomposition parameters) have been adjusted to varying temperature and moisture conditions with litter decomposition data. Yasso uses the chemical composition of litter to divide it to its internal pools of (fractions) of dead organic matter (Fig. 2). This information can be obtained from chemical analyses.

We use tree-level biomass equations for calculation of biomass on the basis tree dimensions that are predicted by MOTTI. Using tree biomass variables we calculate litter input from different tree compartments (e.g. foliage, branches, roots) for Yasso using litter production coefficients. We thus assume that part of the biomasses of the tree compartments turn into litter. We also consider litter from ground vegetation.

As both MOTTI and Yasso and litter production has been adjusted for Finnish conditions, we believe that this hybrid model is a useful tool for analyzing carbon sequestration in Finnish forest stands.

Examples

Thinnings

Fig. 3 shows a typical course of carbon stocks of trees and soil in a stand thinned according to a commercial schedule simulated by MOTTI-Yasso. The thinning intensity has a clear (and obvious) effect on carbon stocks (Fig. 4). Increasing the length of rotation increases the total carbon stock up to about 100 years in a Scots pine stand (Fig. 5). The effect is coming from increasing tree stock, the soil is showing an opposite trend.

Tree species

Pine and spruce sequester carbon equally in southern Finland; in the north spruce dominate (Fig. 6). Increase of soil C stock is greater in the north due to slower decomposition rate.

Forest

When a forest consisting of Scots pine stands that have the initial age distribution according to Fig. 7 is managed with different alternatives (Fig. 8), the outcome depends in the short term on both the schedule and the initial age distribution. The forest is a sink of carbon with all management alternatives during the first 20 years (Fig. 8); this is because most of the stands will not reach the clear cut age in this period (Fig. 7). Sequestration by the trees is much larger than by soil (Fig. 8). Even if the rotation age is increased by 10 years (85 → 95) the carbon gain decreases during the first 20 years. This is since many stands are coming to thinning stage (Fig. 7). Only abandoning cuttings keeps the C sequestration at the same level. As regards attainment of Kyoto targets in the first or later commitment periods, both effects of management on stand level (e.g. Fig. 5) and the initial age distribution of the forest should be considered.

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