Soil CO_2 respiration of forest floor after whole-tree harvesting of spruce stands

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Introduction

The relationship between production and decomposition determines whether a forest site is a sink or a source of atmospheric CO_2, but the absolute or relative contributions of photosynthetic and respiratory fluxes in forests managed in different ways are not yet well known. Forest harvesting reduces the amount of the living stand biomass and the corresponding amount of accumulated atmospheric carbon while the amount of recent plant litter increases. In addition to clear-cutting and residue removal, the site preparation also affects the decomposition conditions of the soil organic matter.

The aim of this study was to quantify soil CO_2 effluxes from clear-cut boreal forests managed in different ways after clear-cutting.

Fig 1. Aerial image of block 3 of the Längelmäki experiment with the clear-cut treatments in the middle of the figure. The control forest is on the right side of the clear-cut area. (Map site © Land Survey of Finland)

Material and methods

This study was carried out on three experimental areas located in Paltamo (North Central Finland), Längelmäki (South Central Finland) and Anjalankoski (SE Finland). Before clear-cut and treatments in 2008, the study sites were mature high-productive mesic spruce forest stands. The treatments, which were repeated with three (Längelmäki) or four (Anjalankoski, Paltamo) replicates on each location were:

1. Uncut forest (control);
2. Clear-cut, no soil preparation and no planting;(not measured for CO_2)
3. Clear-cutting, patch mounding, spruce plantation;
4. Clear-cutting, 70% logging residue removal, patch mounding, spruce plantation;
5. Clear-cutting, 70% logging residue removal, stump removal (25 stumps/ha left), patch mounding, spruce plantation;
6. Clear-cutting, 100% logging residue removal, 100% stump removal, patch mounding, spruce plantation.

Fig. 2. An undisturbed microsite prepared for soil respiration measurement (photo T. Murto).

The soil CO_2 efflux of each treatment replicate was measured from 6 spots within every above described treatment area.

The spots that were chosen represented:

1. Undisturbed microsites (resembling ground vegetation and humus before treatment)
2. Disturbed microsites (ground vegetation and humus clearly affected by harvesting operation),
3. Mounded microsites (soil preparation leaving no vegetation or humus)
4. Undisturbed microsites in uncut control forest

The soil CO_2 measurements were repeated during each vegetation period between 2007 (which was a calibration year) and 2012.

In this presentation, we compare the soil respiration observations of the different clear-cut treatments by subtracting them from the mean values of the controls for each block of each experiment and year by converting the control to represent 0.

Results and discussion

The overall mean soil CO_2 respiration of **the controls** was 1.01 (SD ±0.42),0.92 (SD±0.44) and 0.72 (SD±0.24) g CO_2 m^2 h^{-1} in the Anjalankoski, Längelmäki and Paltamo respective experiments. The differences in the soil respiration between traditional clear-cutting and logging residue harvesting of different intensities are quite small, while the differences between the different microsites are more pronounced (fig 3 a and b). So far, the soil CO_2 respiration rates of none of the treatments have reached the same level as in the uncut forest. In Paltamo the differences in soil respiration between control and treatments are getting smaller.

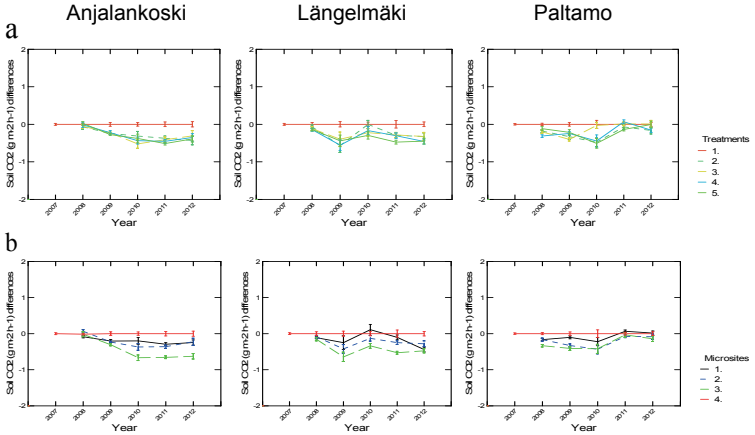

Fig 3. Differences (± SE) in soil CO_2 respiration (g m^2 h^{-1}) between the controls and the different treatments (a) and the different microsites (b) during the monitoring years. 2007 was a calibration year. The different treatments in figures (a) and (b) are described in the text.

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