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How time since last forest fire affects soil greenhouse gas (CO_2, CH_4 and N_2O) fluxes in hemiboreal Scots pine forest fire chronosequence

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Fire is the main natural disturbance in boreal forests and it is expected that its frequency will increase as a result of climate change.

The objective of this study was to assess the impact of forest fire and time since forest fire on soil greenhouse gas (CO_2, CH_4 and N_2O) emissions. The changes occurring in soil-atmosphere interactions (greenhouse gas emissions) were assessed along a fire chronosequence in hemiboreal Scots pine (*Pinus sylvestris* L.) stands of similar soil type and climate.

The study areas are located in north-western Estonia, in Vihterpalu (59^{o}13' N 23^{o}49' E) and Nõva (59^{o}10' N 23^{o}45' E). Six areas (with extensive fires 200 ha and more) have been chosen for the study: fire in 1837, 1940, 1951, 1982, 1997, and 2008. In all areas we are dealing with stand replacing fires. The time since last fire was first chosen from old inventory data, and later confirmed by taking increment cores. In all areas, three sample plots were established (all together 18 sample plots), that were randomly located in the study areas, and the distance between sample plots was at least 100 m.

Soil greenhouse gas fluxes were measured manually from all sample plots (measuring interval of one month). Manual chamber measurements were performed on 5 collars (transect north-south orientated and the distance between collars was 5 m) in each sample plot (all together 90 collars) from May till October. The collars (diameter 0.22 m, height 0.05 m) were placed at 0.02m depth in the organic soil layer above the rooting zone to avoid damage to roots. The vegetation inside the chamber was not damaged during the measurements.

The CO_2 concentration in the chamber headspace was registered for a 5-minute chamber deployment time at 5-sec intervals with a CO_2 probe (GMP343). Temperature and air humidity were recorded with a temperature and relative humidity sensor (HM70). The CH_4 and N_2O flux measurements were performed using the same collars and air samples from the chamber were collected with a 50-ml polypropylene syringe at 0, 1, 5, 10 and 15 min after the chamber was installed, and immediately stored into 12-ml glass vials. The samples were analyzed with an Agilent Gas Chromatograph model 7890A.

The soils in our study acted as sources of CO_2 and sinks for CH_4 and N_2O. Soil CO_2 efflux decreased after the fire, but increased with time since the fire. The CO_2 efflux was lowest in the area where fire occurred in 2008 and highest in the area where fire occurred in 1940. We found that the soil was a CH_4 sink through the post-fire chronosequence in all stand ages. The uptake of CH_4 was highest in the area where the fire occurred in 2008 and lowest in the area where the last fire was more than 100 years ago. Similarly, the soil was a N_2O sink through the post-fire chronosequence, except in the area where fire occurred in 1982. The uptake of N_2O was highest in the area where the fire occurred in 2008.