Geoderma 241–242 (2015) 230–237

Contents lists available at ScienceDirect

Geoderma

journal homepage: www.elsevier.com/locate/geoderma

Pyrogenic alterations of Podzols at the North-east European part of Russia: Morphology, carbon pools, PAH content

A.A. Dymov *, D.N. Gabov

Institute of Biology Komi Scientific Center Ural Division of Russian Academy of Science, Kommynisticheskay 28, Syktyvkar, Russian Federation

ARTICLE INFO

Article history:
Received 1 August 2014
Received in revised form 5 November 2014
Accepted 24 November 2014
Available online 5 December 2014

Keywords:
Forest fire
Pyrogenic carbon
PAHs
Soil organic carbon
Forest soils

ABSTRACT

Fires are a natural factor for taiga ecosystems of the North-European part of Russia. Pine forests on sandy soils often suffer from fires. The paper surveys in what extent fires in lichen pine forests (burnt 2, 10 and 16 years ago) affect soils and soil organic matter (SOM). Ground fires in lichen pine forests fully disturb soil litters. Changes in soil morphology of pyrogenic origin are observed in the topsoil down to depth of 20–30 cm. The greatest changes were found in soil 2-year fire affected site. The physicochemical soil properties of the sites affected by fire 10 and 16 years ago were similar to those at the reference sites. There are no great after-fire changes in nitrogen and carbon stocks in the soils. The concentration (and stocks) of total carbon and nitrogen in soil litter decreases at the first after-fire years. Mineral soil horizons, particularly the upper mineral layer, become enriched with combustion products, i.e. pyrogenic carbon and nitrogen of free and occluded fractions. There is a Ctot. increase in the upper mineral soil horizons possibly due to black carbon or to OM absorbed at the charcoal particles. Fires increase content of Polycyclic Aromatic Hydrocarbons (PAHs) in the soils, their concentration in the upper subhorizon of forest litter exceeds that of the background by 2–9 times. This increase is due to the presence of di- and trinuclear polyarenes.

1. Introduction

Boreal forests are essential for maintaining the carbon balance of the planet. Being a component of forest biogeocenoses, soils accumulate large amounts of carbon (Lal, 2005). Boreal forests are severely transformed by fires. Pyrogenesis is one of the principle factors affecting on morphological and physical properties of boreal forest soils (Chevychelov, 2002) and a major driver of carbon cycle (Bond-Lamberty et al., 2007; Loehman et al., 2014). Fire strongly transforms organic matter (OM) of taiga ecosystems. Ground fires disturb soil litter, the upper humus soil horizons, plant roots, and root detritus (Vedrova et al., 2012). Fire changes contribution of different plant detritus types in the biogeochemical cycle (Prokushkin et al., 2011). It also disturbs the balance between the atmosphere and the soil (Tarasov et al., 2011), and significantly changes microclimatic conditions (Evdokimenko, 2013). The study of fire affected areas in the North of Russia is underrepresented (Bodi et al., 2014). There are few works devoted to this issue in the North-European part of Russia. Despite being largely understudied, fires are one of the most important factors transforming taiga ecosystems of the European North. The fire rate and fire-affected forested area mainly depend on weather conditions in summer. Forest fires in virgin pine forests are a natural cyclic factor providing for their stable state (Torlopova and Il'chukov, 2007). Renewal of vegetation after fire, disturbance degree of phytocenoses, and structure of biogeocenoses depend on fire type, intensity and recurrence. Pine forest is a dominating forest community in the European North-east of Russia. They occupy 7.2 million ha in the Komi Republic or 25% of its forest-covered area (Kozubov et al., 1999). Pine forest in the middle-taiga subzone occupies sandy terraces and watershed terrains composed of sands and sandy loams, in places underlain by loams.

The aims of this work were to (i) investigate morphological and physicochemical properties of Albic Podzols after ground fires; (ii) reveal SOM changes in fire-affected soils; and (iii) estimate content of polyarenes in Albic Podzols after ground fires.

2. Materials and methods

2.1. Site description and soil sampling

The study was conducted in the middle taiga zone of the Komi Republic, Russia (Fig. 1). The mean annual temperature varies from +1 to −1 °C. The annual precipitation is 500–600 mm, with the maximum in May–October (Taskaev, 1997). The absolute altitudes of the studied area where soil pits were arranged varied from 100 to 150 m asl. The parent material is oligomictic sand of glaciofluvial origin. Locations of study sites are presented in Fig. 1. The characterization of the study plots and description of soil profiles can be found in Table 1. Soil profile photos are presented on Fig. 2. Information on fire dates and

* Corresponding author.
E-mail address: aadymov@gmail.com (A.A. Dymov).

http://dx.doi.org/10.1016/j.geoderma.2014.11.021
0016-7061/

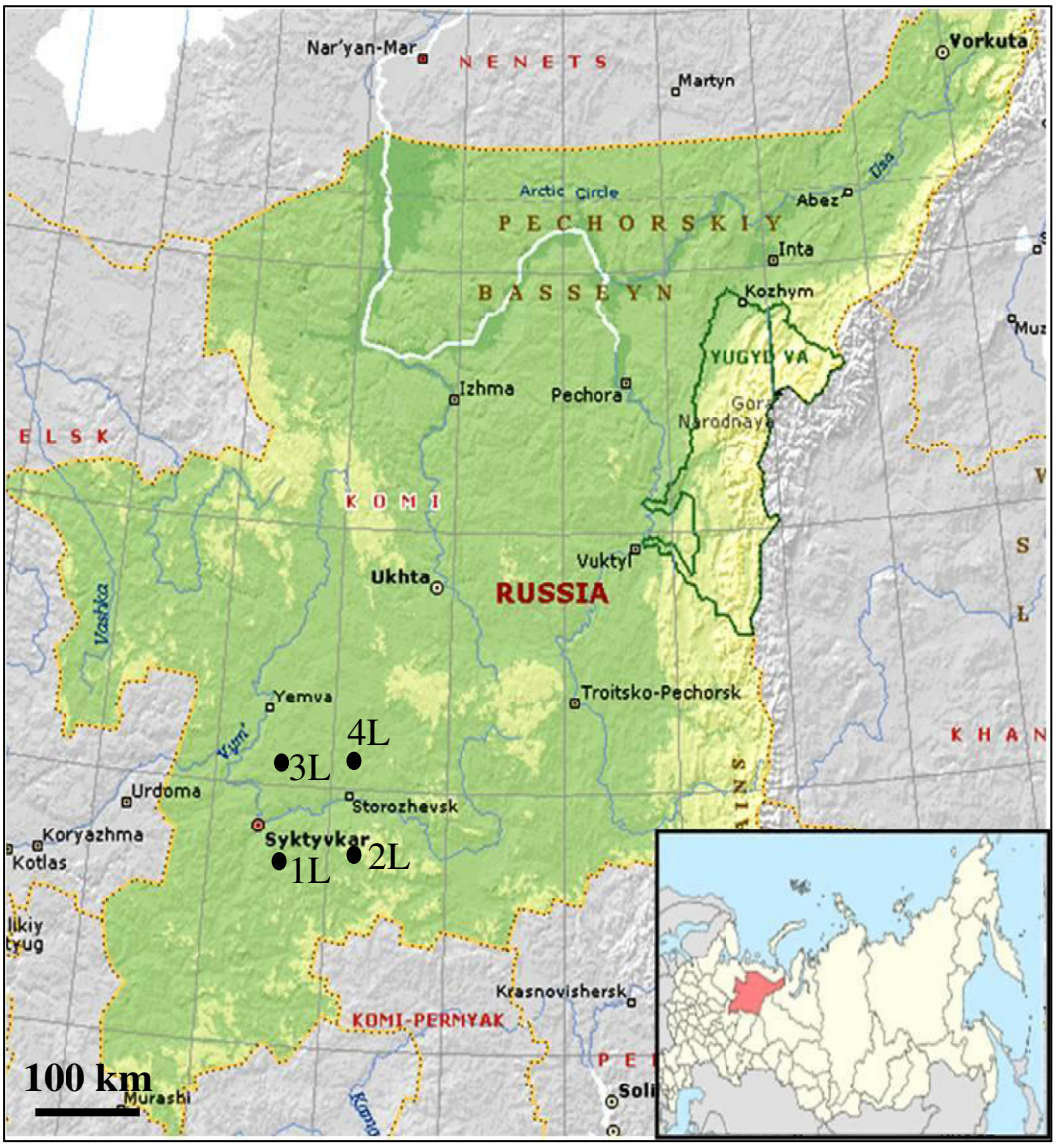

Fig. 1. Location of the study site.

characteristics was kindly furnished by the Forest Committee of the Komi Republic. The field diagnostics of the studied soils and the determination of their classification position were performed according to the World Reference Base for Soil Resources (FAO, 2006). The soil color characteristics were determined according to the Standard Soil Color Charts (1970) during the sampling. Soil sampling was carried out in 2013 and the thickness of each layer was measured separately. For chemical analysis, mixed samples (from five points) with an area of approximately 2 m^2 were collected. Samples were air-dried and living visible roots and all particles with a diameter >1 mm were removed by dry-sieving as a preparation for analysis. Organic layer samples were milled.

The study plots differ by fire characteristics. The most intensive ground fire happened at a 2 L plot. This fire completely burnt the forest litter and large woody remnants, and many trees died. Fire also fully disturbed the forest litter at the 3 L and 4 L sites, but only 20% of tree stand died. The upper litter subhorizon, large woody remnants and soil cover plants were fully burnt.

2.2. General physicochemical analyses of soils

The quantitative chemical analyses of the soils were performed in the certified Ekoanalit laboratory of the Institute of Biology (Komi Science Center, Urals Branch of the Russian Academy of Sciences)

Table 1
Characteristics of the study plots.

Abbreviation	Forest type before fire and its composition	Fire characteristics	Fire year/time gone after fire
1 L	Lichen pine, 10P	–	Control
2 L	Lichen pine, 10P	Ground, high intensity	2011/2 years
3 L	Lichen pine, 10P	Ground, medium intensity	2003/10 years
4 L	Lichen pine, 10P	Ground, medium intensity	1997/16 years