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SOIL TEXTURE CHANGES IN GRAY FOREST SOILS (GRAY LUVISOLS) INFLUENCED BY FOREST FIRES IN DECIDUOUS FORESTS

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Abstract

The paper presents results from investigation on soil texture changes caused by forest fires in the Northwestern region of Bulgaria. Gray Forest soils (Gray Luvisols, FAO 1990) influenced by strong surface fire and weak surface fire have been investigated. The sample plots are set up in burned and unburned control areas. They are correspondingly situated in the Lower forest vegetation zone (0–600 m a.s.l.) of the Moesian forest vegetation area. Soil samples have been taken three times for five years in order to investigate the dynamics of the changes. The fractions of sand, silt and clay have been determined by pipette method. A relation was established between soil texture changes and intensity of fires.

Key words: deciduous forests, forest fire, forest soils, soil texture, *Quercus petraea*.

Introduction

The existence and natural ecologic functioning of forest ecosystems depend on natural and anthropogenic fires. A global tendency of increasing the number, intensity and duration of forest fires has been observed in the recent decades. They influence on the growth and development of the forest for long-term period and affect soil-biological and biochemical processes (Kimmins 1996, Tashev and Malinova 1998, Prokushkin et al. 2000, Tsvetkov et al. 2001).

Forest fires should not be considered separately from the context for global climatic changes. The fire is an environmental factor whose importance has been increased by human activity. Its suppression is followed by extensive restoration activities in the affected areas. Young stands that are located in the Lower forest vegetation zone have been influenced more often (Alexandrov et al. 2002).

Soil properties are strongly dependent on the soil organic matter created by the vegetation. Both components are removed to a variable degree after fire impact. Consequently, fire has the potential to induce major changes in soils. The degree to which soil properties are altered by fire depends on the fire intensity and the amount of burned organic matter (DeBano et al. 1998, Erickson and White 2008, Úbeda et al. 2009). These in turn are influenced by the amount and the distribution of forest combustible materials, their moisture content and the weather conditions (Kimmins 1996).

Soil texture is a basic soil property and an important indicator of soil classification. It influences soil productivity and forest de-

velopment. For this reason, it is necessary to clarify the forest fire impact on the soil texture as well as the degree of the changes depending on the intensity of fire.

Generally, sandy soils contain less moisture and nutrient elements in comparison with loam and clay soils. Thus, coarse sandy soils as a rule favor forest stands composed of species with relatively low requirement for moisture and nutrients, whereas loam and clay soils often are favorable for trees with high moisture and nutrient requirements (Pritchett 1979).

Soil texture is defined by proportions of sand (63 μm – 2 mm), silt (2–63 μm) and clay (< 2 μm). The sand fraction is composed of rock fragments and primary minerals, especially quartz. Therefore, it is chemically completely inactive. Sand content directly influences on soil porosity and hydraulic properties. The silt fraction is dominated by primary minerals and has, therefore, a low chemical activity. The silt particles slow down the movement of water and air because of filling soil cavities among sand grains. The soil physical and chemical activity depends mainly on clay fraction (Petrova and Bogdanov 2012).

According to Velizarova et al. (2001), the surface fire impact on soil texture has been expressed by a disintegration of coarse fractions and an increase of fine fractions. Burned clay soils with a sand content less than 5 % and clay content more than 55 % have been investigated by Ketterings et al. (2000). They found a sharp increase in the amount of sand and a decrease in silt and clay. According to Ulery and Graham (1993) the fire causes decomposition of sand grains and leads to increase of silt fraction. Although the low chemical activity of silt fraction, when its share was dominant, it had ability to determine the deep alteration in chemical properties due to a sharp change in its content (Bogdanov 2012).

The paper aimed at establishing soil texture changes caused by forest fires in deciduous forests and the influence of fire intensity.

Material and Methods

Objects of this study were Gray Forest soils (Gray Luvisols, FAO 1990) influenced by fires in the regions of Rabisha and Dolni Lom. They are located in the Northwestern region of Bulgaria.

The sample and control plots have been set up in burned and unburned areas in order to investigate the soil texture changes. They are located in the Lower forest vegetation zone (0–600 m a.s.l.) of the Moesian forest vegetation area.

The soils in Rabisha region (43°42´ N, 22°38´ E) were influenced by weak surface fire under thirty-year-old plantation of durmast oak (*Quercus petraea* Liebl.) in July 2002. The sample and control plots were at 400 m above sea level, at southwest exposition with slope 10 °.

The soils in Dolni Lom region (43°30´ N, 22°46´ E) were influenced by strong surface fire under sixty-year-old plantation of durmast oak (*Quercus petraea*) in July 2007. The altitude was 450 m, at north-northwest exposition, slope 5 °.

The forest fires were classified on the basis of visible impact signs. According to fire intensity they were determined as follows:

– strong surface fire – the stems were burned to a height of more than 0.5–1 m

and the fire impact caused a destruction of the stand;

– weak surface fire – the stems were burned to a height of 0.5–1 m and the fire did not cause a destruction of the stand.

Soil samples have been taken one, three and five years after the fires in order to investigate the dynamics of soil texture changes caused by fires. Having in mind that the most significant changes of soil properties occur at 10–15 cm depth (Raison et al. 1985, Barnes et al. 1998, Neary et al. 2008, Bogdanov 2010), the samples were taken from the layer 0–15 cm.

The soil texture was determined by pipette method (ISO 11277). It was founded on separation of the mineral part of the soil into various size fractions and determination of the proportion of these fractions. A special attention was paid to the pre-treatment of the samples aimed at complete dispersion of primary particles. Therefore, cementing materials such as organic matter, salts, iron oxides and carbonates were removed.

The fractions of sand (63 μm – 2 mm), silt (2–63 μm) and clay (<2 μm) have been determined. After shaking with a dispersing agent, sand was separated from silt and clay with a 63 μm sieve. The silt and clay fractions were determined by sedimentation.

A textural class of the soils was determined according to U. S. Texture Triangle.

Results and Discussion

The results from investigated Gray Forest soils (Gray Luvisols, FAO 1990) located in Rabisha region are presented in Figure 1. In unburned control area the share of sand fraction was 49 %, the silt is 34 %

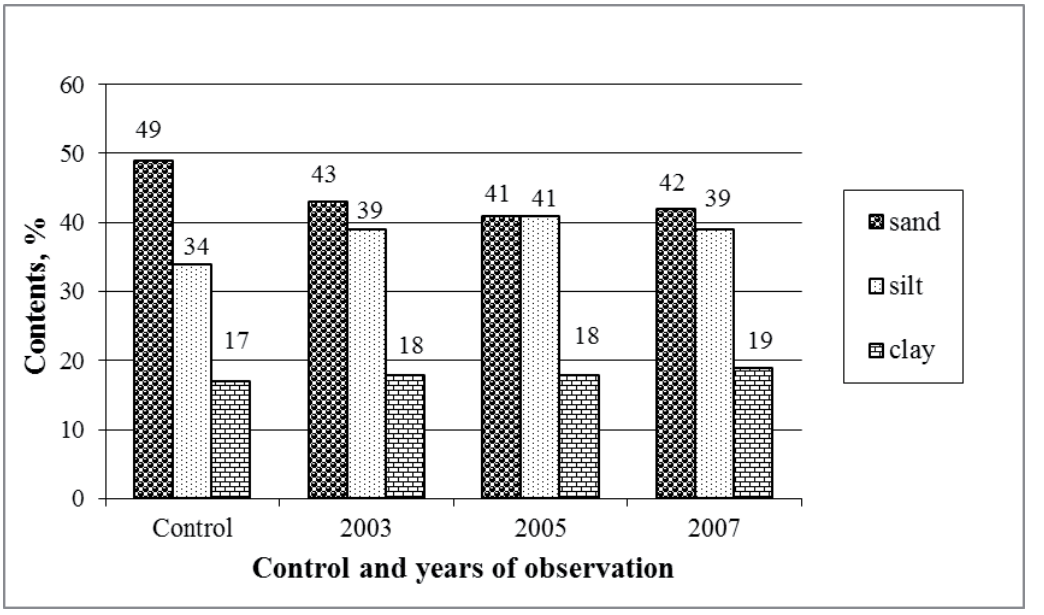

Fig. 1. Soil texture of Gray Forest soils influenced by weak surface fire.

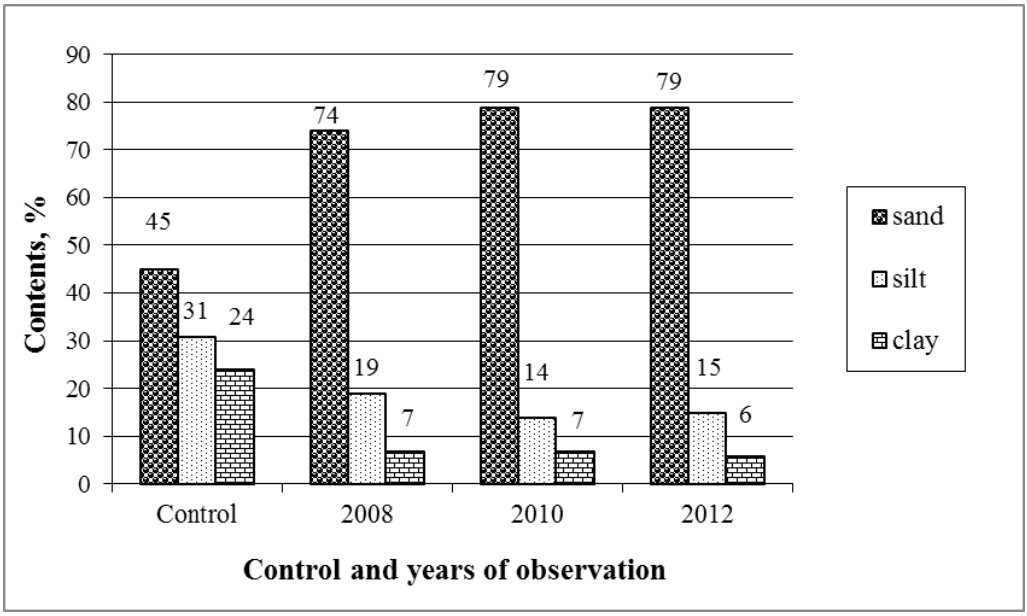

Fig. 2. Soil texture of Gray Forest soils influenced by strong surface fire.

and the fraction of clay was 17 %. The textural class was a Loam.

The data obtained from soil texture analyses showed that the weak surface fire affects mainly the proportion between fractions of sand and silt. The alteration of clay fraction was relatively low. Similar changes were found under burned coniferous stands (Bogdanov 2012).

A decrease in the amount of sand and an increase in silt one year after the fire was established (Figure 1). The share of sand decreased from 49 % to 43 % and the silt increased from 34 % to 39 %. The content of clay was increased by 1 % compared to control plot. The textural class was a Loam and has not changed during the whole period of investigation.

Three years after the fire, in Gray Forest soils influenced by weak surface fire a decrease in sand by 2 % and corresponding increase in silt was recorded. The share of clay did not change.

It was found that soil texture changes in the Rabisha region were kept five years after the fire. The differences in contents of sand and silt between burned and unburned soil were 7 % and 5 %, respectively. The share of clay continued to be 2 % more than in unburned control area.

The results from investigated Gray Forest soils (Gray Luvisols, FAO 1990) located in Dolni Lom region are presented in Figure 2. In unburned control area the share of sand fraction was 45 %, the silt is 31 % and the fraction of clay was 24 %. The textural class was a Clay loam.

In contrast to data obtained from analyzed soils influenced by weak surface fire in Rabisha region, different results were established in investigated soils located in

Dolni Lom region and affected by strong surface fire.

A sharp increase in sand and corresponding decrease in silt and clay was established one year after the fire. The sand increased from 45 % to 74 %. The silt decreased from 31 % to 19 % and the clay decreased by 17 % compared to control plot (Figure 2). The soil has changed over to textural class Sandy loam. Similar results for clay soils have been reported by Ketterings et al. (2000).

The alteration was more significant in Gray Forest soils influenced by strong surface fire as compared to the changes caused by weak surface fire. This fact is indicative for the importance of the fire severity that generally determines the characteristics of fire effect. It was due to a higher volume of burned biomass and more significant changes of vegetation. In the case of strong surface fire the stand has been destroyed and replaced by herbaceous and bush species.

It was found that the share of clay was changed more in Gray Forest soils located in Dolni Lom region. That is in conformity with a higher content of this fraction and shows the importance of the soil textural class for soil properties changes caused by forest fires.

Three years after the strong surface fire the sand increased and the silt decreased by 5 %. The amount of clay did not alter. The burned soil has changed over to textural class Loamy sand.

The differences between burned and unburned areas were kept five years after the fire. The share of sand in burned soil continued to be 79 %. The silt slightly increased and the clay decreased by 1 % compared to unburned soil. The textural class was not altered.

Conclusions

The forest fire causes different changes in investigated soils. The alterations depend on the soil textural class and fire intensity, which is defined by volume of burned biomass and effects on the vegetation. The larger volume of burned biomass and the deep changes of vegetation determine more significant alterations in soil texture.

The weak surface fire caused soil texture changes of burned Gray Forest soils (Gray Luvisols, FAO 1990), which were expressed in change of proportion mainly between fractions of sand and silt. The share of sand decreased and the silt increased compared to control plot. The clay fraction was altered to relatively less extent.

The strong surface fire caused contrary and more significant soil texture changes. The amount of sand increased compared to unburned area. Both silt and clay decreased. The strong surface fire affected to a higher extent the clay content of Gray Forest soils (Gray Luvisols, FAO 1990), which contain a larger proportion of this fraction.

A sharp change of clay fraction, which is characterized by a high chemical activity, might cause significant changes of soil chemical properties.

The results confirm the generally accepted opinion that the fire might cause long lasting changes in soil properties and forest development. Destroying the stands and soil organic matter, forest fires create conditions for erosion and alteration of soil texture.

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