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Dynamics of ground vegetation after surface fires in hemiboreal *Pinus sylvestris* forests

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Abstract

The aim of this work was to investigate the changes of ground vegetation (field layer: mosses, lichens; ground layer: herbs, shrubs, tree seedlings and saplings) and regeneration of tree species in pine forests after surface fires. The study area was located in Southern part of Lithuania in hemiboreal zone of Europe. The field and ground vegetation was recorded in forest stands burned in 1992 and 1994–2002 and compared with the nearby control fire untouched areas. We selected five burned areas for each year (total 50 burned stands). Vegetation sampling was conducted during July and August 2003. For vegetation description in each stand we systematically placed twenty 1 m × 1 m plots. Mann–Whitney nonparametric test was used to identify significant differences in vegetation between burned and untouched areas. It was determined that species richness increased after fire. Early successional species such as *Agrostis capillaris* L., *Calamagrostis epigejos* (L.) Roth, *Chamerion angustifolium* (L.) Holub, *Festuca ovina* L. and *Melampyrum pratense* L. invaded in burned areas immediately after fire. Abundance of dominant species (*Vaccinium myrtillus* L. and *Vaccinium vitis-idaea* L.) recovered after 5 years. Pioneer moss species (*Polytrichum piliferum* Hedw. and *Polytrichum juniperinum* Hedw.) replaced late successional mosses (*Dicranum polysetum* Sw., *Dicranum scoparium* Hedw., *Hylocomium splendens* (Hedw.) Schimp. and *Pleurozium schreberi* (Brit.) Mitt.). Species number in the shrub layer decreased. *Juniperus communis* L. was killed by fire. Amount of undergrowth decreased first 4 years after fire. Saplings of *Picea abies* (L.) Karst., disappeared at all. Fire stimulated regeneration of *Pinus sylvestris* L., especially first 4 years after fire. Herbaceous and dwarf shrubs recovered 5–6 years after fire, moss cover—9 years after fire. Differences in moss species composition still remained 11 years after fire. Main finding suggest that fire is favourable to biodiversity of pine forest ecosystems. Fires induce regeneration of pine trees and can be used for restoration of pine forest.

Keywords: Disturbance; Herbs; Lithuania; Mosses; Seedlings; Succession

1. Introduction

Fire is an important ecological factor regulating forest succession in boreal forests (Johnson, 1992; Egelmark, 1993; Parviainen, 1996; Ryan, 2002; Gromtsev, 1996). Overall effect of fire on ecosystems is complex. Fires can change below-ground physical, chemical and microbial processes eliminate aboveground biomass. Severe crown fires can change successional rates, alter vegetation species composition, C:N ratios, decrease mineralisation rates, result nutrient losses. Therefore, surface fires can promote herbaceous flora, increase plant available nutrients (Gromtsev, 2002, 1996; Parviainen, 1996). Fires affect the species composition, stand characteristics, regeneration conditions (Mälkönen and Levula, 1996; Ryoma and Laaka-Lindberg, 2005; Jayen et al., 2006). Fires favour shade-intolerant tree species (*Pinus sylvestris* L., *Betula* spp.) and eliminate such species as *Picea abies* (L.) Karst. (Zackrisson, 1977; Päätalo, 1998; Kauhanen, 2002).

Some herbaceous species are dependent on fire. Fires create gaps favourable for the regeneration and spreading. Prescribed fires, which follow natural disturbances regimes, can be used for forest ecological restoration (Partel et al., 2005; Reier et al., 2005; Ryan, 2002). In many areas foresters have removed fire from forest ecosystems (Gromtsev, 2002, 1996; Parviainen, 1996; Päätalo, 1998; Tinner et al., 1999).

In hemiboreal *Pinus*-dominated forests fire is essential ecological factor (Zackrisson, 1977; Kuuluvainen, 2002). Occurrence of fires in hemiboreal zone has decreased considerably during the last century, due to efficient fire prevention and control system. Nowadays, natural disturbances are recognized as important ecological factor affecting forest biodiversity (Angelstam, 1998; Bergeron et al., 2002;

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Kuuluvainen, 2002). Introduction of the use of controlled fire in forestry is now recognized (Granström, 1996; Parviainen, 1996).

Only sporadic observations were presented on fire impact to vegetation of pine forest ecosystems (Zackrisson, 1977; Karazija, 1988). There is a need for more thorough investigations on vegetation reestablishment after fire in pine forest ecosystems.

The aim of this work was to investigate the changes of ground vegetation (field layer: mosses, lichens; ground layer: herbs, shrubs, tree seedlings and saplings) and regeneration of tree species in pine forests after surface fires. The following questions were raised. (1) Does the species richness in field and ground layers increase after fire? (2) Does the species composition and cover in field and ground layers differ in burned areas? (3) Does the species composition in shrub layer differ in burned areas? (4) How long the changes induced by fire last in different vegetation layers? (5) Does the fire influence tree species regeneration?

2. Materials and methods

2.1. Study area

The study area is located in Southern part of Lithuania (54°11′–54°25′N, 24°55′–25°21′E) and falls in the transitional deciduous coniferous mixed forest hemiboreal zone of Europe (Ahti et al., 1968). Annual mean temperature ranges from +6.3 °C to +6.7 °C. Temperature of the warmest month (July) ranges from +16.5 °C to +17.5 °C; and the coldest month (January)—from −5.0 °C to −4.7 °C. Annual mean precipitation is between 650 and 750 mm. Period with snow continues from 75 to 90 days (Bukantis, 1994). Hilly landscape and poor sandy soils prevail. The height above sea level is about 150–250 m. Pure and mixed with birch and spruce Scot Pine forests predominate in the investigated territory. Dominant tree species in the region are: *P. sylvestris* (L.) H. Karst., *Betula pendula* Roth, *Betula pubescens* Ehrh., *Populus tremula* L. and *Picea abies* L. (Karazija, 1988). *Juniperus communis* L. and *Sorbus aucuparia* are most common shrub species. *Vaccinium myrtillus* L., *Vaccinium vitis-idaea* L., *Calluna vulgaris* L., *Festuca ovina* L., *Linaria vulgaris* Mill., *Luzula pilosa* (L.) Willd., *Pilosella officinarum* F.W. Schultz et Sch. Bip., and *Melampyrum pratense* L. prevail in the herb layer; and *Dicranum polysetum* Sw., *Dicranum scoparium* Hedw., *Hylocomium splendens* (Hedw.) Schimp. and *Pleurozium schreberi* (Brit.) Mitt. prevail in the moss layer.

In Lithuania the annual number of fires is about 700 (from 200 to 1600 per year); and total burned area range from 100 to 700 ha/year. Average burned area per one fire is 0.45 ha (Lithuanian Statistical Yearbook of Forestry, 2005). Number of fires per year depends on the meteorological conditions of the year. In Lithuania 84% of fires emerge in pine forests. In coniferous forests the highest number of fires emerges in age stands (50–80 years old)—58%; in young stands (10–40 years old)—36%; in mature and overmature (over 80 years old)—16%. In Lithuania surface fires prevail (97.3%), crown fires consist—1% and underground fires—1.7% (Lithuanian Statistical Yearbook of Forestry, 2005).

2.2. Vegetation sampling and data analyses

We used the chronosequence approach to describe the ground vegetation dynamics after fire by taking pine stands in similar sites according soil, topographic conditions and stand characteristics, but in different time periods after fire (Pickett, 1989). To consider the changes in ground vegetation we selected pure, middle-age (70 years old), *Vaccinium* type pine stands, which were burned in 1992 and 1994–2002. For burned sites selection we used forest protection service database. All forest fires in Lithuania are recorded by the forest protection service. Burned areas in stands were about 1.0 ha. To avoid variation *Vaccinium* type pine stands similar according soil, topographic conditions were chosen. Observations were made in 2003. Burned areas in the field were identified according fire scars on tree stems. The fire was low intensity, only ground vegetation was burned.

We selected five burned areas for each year (total 50 burned stands). We also selected control fire untouched stands near each burned area. We assumed that vegetation in control areas left unchanged and reflected initial vegetation composition before fire occurred. Vegetation sampling was conducted during July and August 2003. For vegetation description in each stand we systematically placed twenty 1 m × 1 m plots, in which we recorded species composition and projection cover (in percent) of dwarf shrubs, herbs and mosses. We also counted the amount of shrubs, saplings and seedlings in the plots. The term seedlings we used for distinguishing saplings of 1 year old. Overall shrubs, herbs and mosses cover was also estimated. Nomenclature followed Jankeviciene (1998).

From 20 plots data we calculated mean values for each burned and control fire untouched area. Then we averaged data for each burned and control area in different time separately.

Mann–Whitney nonparametric test was used to identify significant differences in vegetation projection cover, and amount of shrubs, saplings and seedlings between burned and untouched areas using the software STATISTICA.

3. Results

In burned and control areas we recorded 31 herbaceous and dwarf shrub species. Twenty-eight species occurred in burned and 17 in control areas (Tables 1 and 2). Fourteen herbaceous and dwarf shrub species occurred only in burned areas: *Achillea millefolium* L., *Conyza canadensis* (L.) Cronquist, *Filago arvensis* L., *Helianthemum nummularium* (L.) Mill., *Hypericum perforatum* L., *Knautia arvensis* (L.) Coult., *L. vulgaris* Mill., *L. pilosa* (L.) Willd., *P. officinarum* F.W. Schultz et Sch. Bip., *Rubus idaeus* L., *Rumex acetosa* L., *Veronica officinalis* L., *Vicia sylvatica* L. and *Viola rupestris* F.W. Schmidt. Three herbaceous and dwarf shrub species occurred only in control areas: *Chimaphila umbellata* (L.).W.P.C. Barton, *Deschampsia cespitosa* (L.) P. Beauv. and *Maianthemum bifolium* (L.) F.W. Schmidt (Tables 1 and 2).