Dynamics of ground vegetation after surface fires in hemiboreal *Pinus sylvestris* L. forests[1]

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Abstract

The aim of this work was to investigate the changes of ground vegetation (field layer: mosses, lichens, and 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 years and compared with the nearby control fire untouched areas. We selected 5 burned areas for each year (total 50 burned stands). Vegetation sampling was conducted during July and August of 2003. For vegetation description in each stand we systematically placed twenty 1x1 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 four years after fire. Saplings of *Picea abies* (L.) Karst., disappeared at all. Fire stimulated regeneration of *Pinus sylvestris* L., especially first four 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.

Introduction

Fire is an important ecological factor regulating forest succession in boreal forests (Johnson, 1992; Engelmark, 1993; Parviainen, 1996; Ryan, 2002; Gromtsev, 1996). Overall effect of fire on ecosystems is complex. Fires can change belowground physical, chemical and microbial processes eliminate aboveground biomass. Severe crown fires can change successional rates, alter vegetation species composition, C:N ratios, decrease mineralization rates, result nutrient losses. Therefore, surface fires can promote an herbaceous flora, increase plant available nutrients (Gromtsev, 2002, 1996; Parviainen, 1996). Fires affect the species

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composition, stand characteristics, regeneration conditions. Fires favor shade-intolerant tree species (*Pinus sylvestris* L., *Betula* spp.) and eliminate such species as Picea abies (L.) Karst. (Zackrisson, 1977; Päätalo, 1998; Kauhanen, 2002).

In many areas foresters have removed fire from forest ecosystems (Gromtsev, 2002, 1996; Parviainen, 1996; Päätalo, 1998; Tinner et al., 1999). 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 per 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 the future, with elevated temperature, the risk of fire may increase, because summers may become longer and drier.

In Lithuania 84% of fires emerge in pine forests. In coniferous forests the highest number of fires emerges in middle age stands (50-80 years) – 58%; in young stands (10-40 years) – 36%; in mature and over mature (over 80 years) - 16%. In Lithuania surface fires prevail (97.3%), crown fires consist - 1% and underground fires – 1.7% (Lithuanian statistical yearbook of forestry, 2005).

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

Importance of fire as a natural disturbance factor in Lithuania has not been well documented. Only sporadic observations were presented on fire impact to pine forest ecosystems (Karazija, 1988). There is a need for more thorough investigations on vegetation reestablishment after fire in pine forests ecosystems.

The aim of this work was to investigate the changes of ground vegetation (mosses, lichens and shrubs) in pine forests after surface fires.

Materials and Methods

The study area is located in Southern part of Lithuania and falls in the transitional deciduous coniferous mixed forest boreonemoral zone of Europe (Ahti et al. 1968).

We used the chronosequence approach to describe the early 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, *Vaccinium* type pine stands, which were burned in 1992 and 1994-2002 years. Observations were made in 2003. Burned area was identified according fire traces on tree stems. The fire was low intensity, only ground vegetation was burned.

We selected 5 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 of 2003. In twenty 1x1 m plots we recorded species composition and projection cover (in per cent) of dwarf shrubs, herbs and mosses. We also counted the amount of

shrubs, saplings and seedlings in the plots. Overall shrubs, herbs and mosses cover was also estimated. Nomenclature followed Jankeviciene (1998).

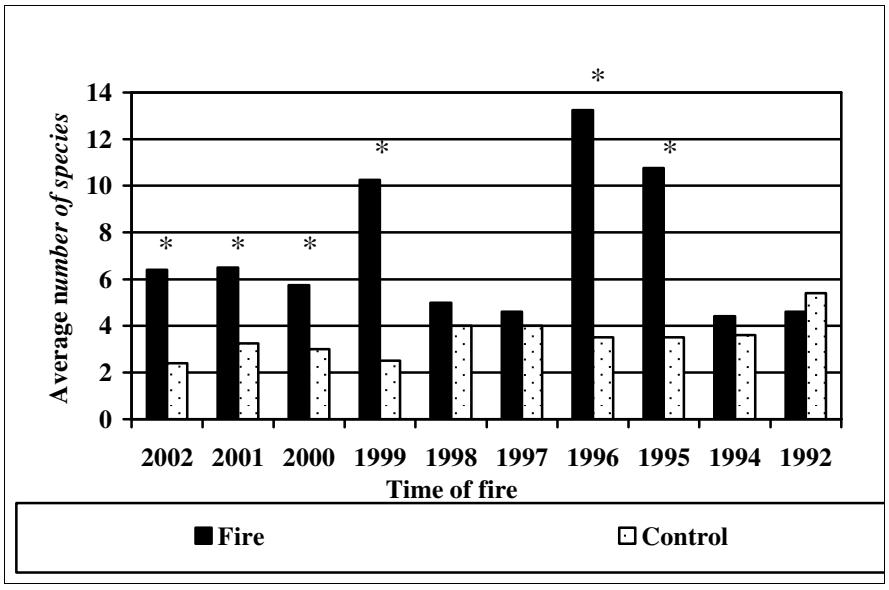
From twenty plots data we calculated mean values for each burned and control fire untouched area. Then we averaged data for each burned and control area in different time separately.

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.

Results

In burned and control areas we recorded 31 herbaceous and dwarf shrub species. 28 species occurred in burned and 17 in control areas. 14 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., *Linaria vulgaris* Mill., *Luzula pilosa* (L.) Willd., *Pilosella 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. 3 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.

Average herbaceous and dwarf shrub species number per 1 m2 in burned areas was always higher than in fire untouched control areas (Figure 1). In burned areas in average we recorded 4.4.-13.2 herbaceous and dwarf shrub species while in control areas - 2.4-5.4 species. In many cases the differences between burned and fire untouched control areas were significant ($p<0.05$).

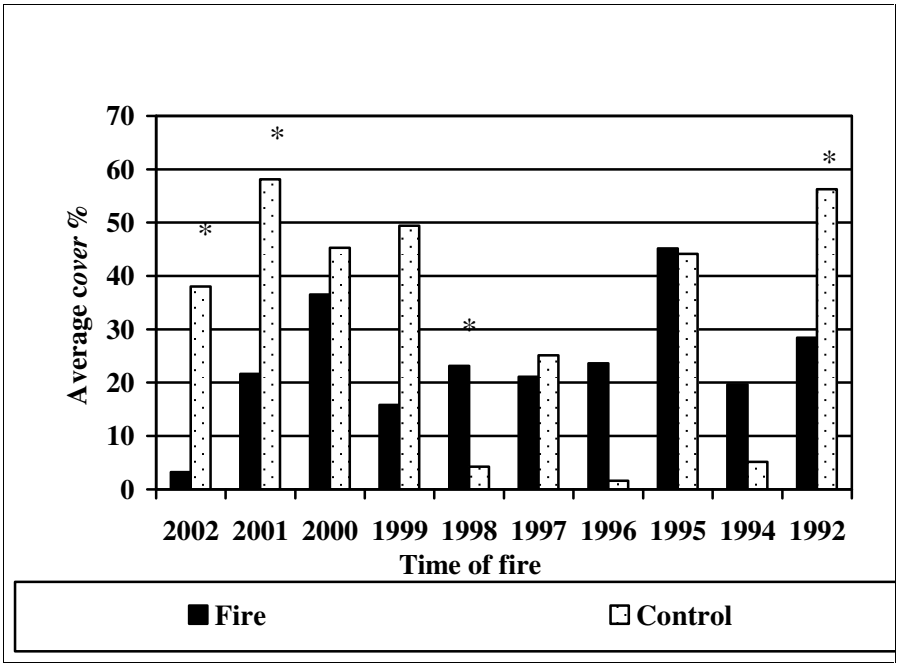


(* - Mann Whitney test $p<0.05$)

Figure 1. Average species number (in 1 m2 plots) of herb and dwarf shrub layer in burned and control areas. Data collected in 2003.

Average projection cover of herbaceous and dwarf shrub species ranged from 3.3% to 45.2% in burned areas, and from 1.6% to 58.1% in control areas (Figure 2). In areas burned in 1998, 1996, 1995 and 1994 the average projection cover was higher than in control areas. In areas burned more recently the average projection cover was lower than in control areas.

Vaccinium myrtillus L. and *Vaccinium vitis-idaea* L. comprised the largest proportion of the projection cover. Projection cover of the species was significantly lower in the first year after fire. *Calluna vulgaris* L. disappeared in burned areas of first four years, but it recovered and its abundance became higher than in control areas of older ones.



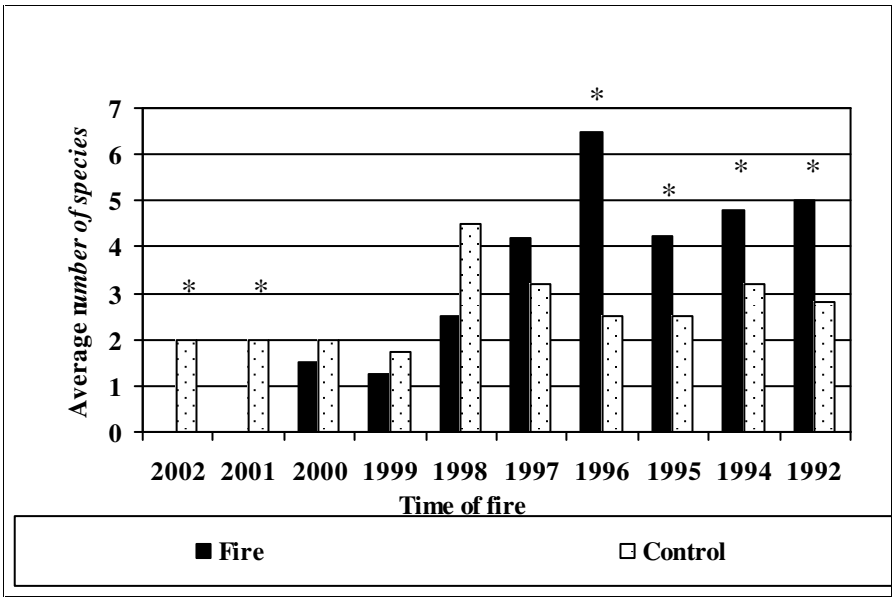
(* - Mann Whitney test p<0.05)

Figure 2. Average projection cover of herb and dwarf shrub layer in burned and control areas. Data collected in 2003.

Species of *Agrostis capillaris* L., *Calamagrostis epigejos* (L.) Roth, *Chamerion angustifolium* (L.) Holub, *Festuca ovina* L., *Melampyrum pratense* L. and *Solidago virgaurea* L. were more abundant in burned areas.

In burned and control areas we recorded 11 mosses and lichen species. 9 species occurred in burned and 7 in fire untouched control areas. 4 mosses species occurred only in burned areas: *Ceratodon purpurus* (Hedw.) Brid., *Funaria hygrometrica* Hedw., *Polytricum juniperinum* Hedw. and *Polytricum piliferum* Hedw. Lichens (*Cladonia arbuscula* (Wallr.) Flot. and *C. rangiferina* (L.) F.H.Wigg.) occurred only in control areas.

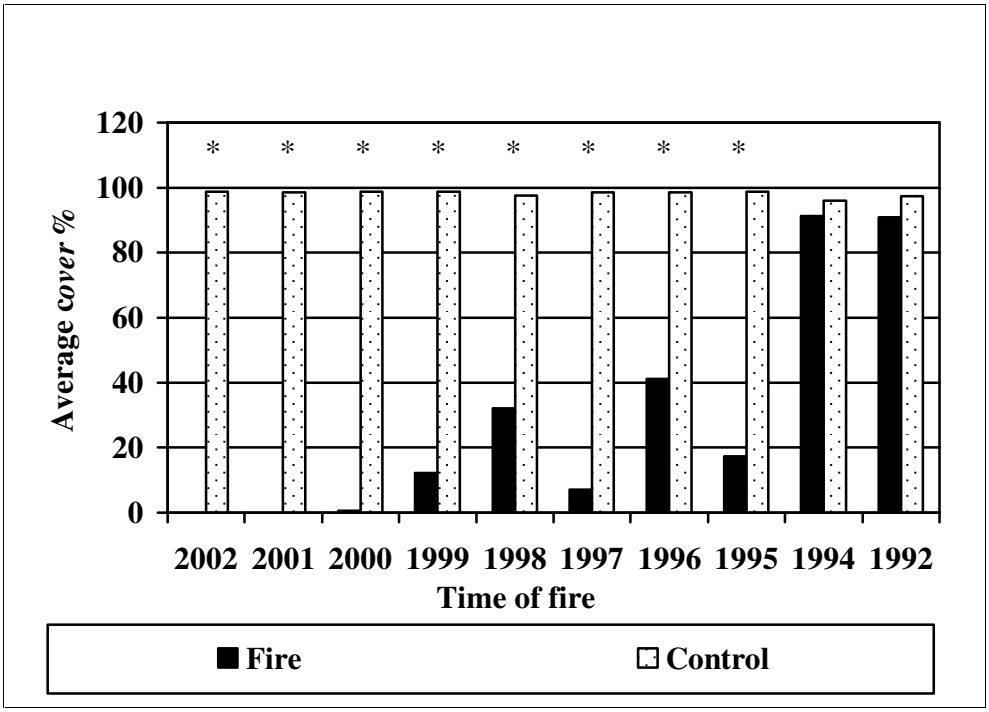
Average moss and lichen species number per 1 m2 in burned areas ranged from 0 to 6.5 while in control areas – from 1.8 to 4.5 species (Figure 3). In areas burned in 2002 and 2001 mosses were absent. In areas burned in 1997 and earlier the number of moss species was higher than in control areas.



(* - Mann Whitney test p<0.05)

Figure 3. Average species number of moss and lichen layer in burned and control areas. Data collected in 2003.

Average projection cover of mosses and lichens ranged from 0% to 97.2% in burned areas and from 96.0% to 96.8% in control areas (Figure 4).



(* - Mann Whitney test p<0.05)

Figure 4. Average projection cover of moss and lichen layer in burned and control areas. Data collected in 2003.

Abundance of mosses started to recover in areas burned in 2000 and reached the level of control in areas burned in 1994 and 1992. However, the species composition has changed. *Polytrichum juniperinum* Hedw. and *Polytrichum piliferum* hedw. have spread and predominated in areas burned in 1994 and 1992. Abundance of *Dicranum polysetum* Sw., *Dicranum scoparium* Hedw., *Hylocomium splendens* (Hedw.) Schimp. and *Pleurozium schreberi* (Brit.) Mitt. started to recover in areas burned in 1998.

Conclusions

Species richness increased after surface fire. Early successional species appeared 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.) after fire.

Changes of ground vegetation induced by surface fire remained 3-4 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.

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