

COMPARISON OF RESPONSE REACTION OF *PINUS SYLVESTRIS* L. AFTER FIRE IN *HYLOCOMIOSA* AND *VACCINIOSA TURF. MEL.*

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Abstract

Forest fires in Latvia occur every year. Research about vegetation and forest regeneration after forest fire is being carried out in Latvia, and sanitary conditions are being evaluated too; however, there are no large studies about the forest fire impact on radial growth dynamics of trees. The aim of the study was to analyse and compare the response reaction of a forest stand after fire in two forest site types – *Hylocomiosa* and *Vacciniosa turf. mel.* The object of the research was fire affected middle-aged managed Scots pine (*Pinus sylvestris* L.) stands in the aforementioned forest site types. The study compares radial growth dynamics of trees, tree mortality and forest stand sanitary conditions after fire in *Hylocomiosa* and *Vacciniosa turf. mel.* The observed fire impact on radial growth dynamics of trees was negative in both forest site types. Negative fire impact on sanitary conditions was observed, too.

Key words: forest fire, *Pinus sylvestris* L., forest stand sanitary conditions, growing stock after forest fire.

Introduction

Forests cover 3.07 million ha of Latvia's territory (State Forest Service, 2017 a). Forest industry plays an important role in the national economy – 20% of total country's export in 2015 was forest industry export and value added share of the forest industry in Latvia's gross domestic product in 2015 was almost 5.2% (JSC 'Latvian State Forests', 2015). One of the most common tree species is Scots pine – 34% ha of all forests are occupied by this species (State Forest Service, 2016 a). According to the State Forest Service (2016 b, 2017 b) data, fire in forest occurs every year, the annual average area of last ten years is around 333 ha (there is no data from year 2016). According to predictions about the climate change, the situation could be even worse. It is foreseen that the average air temperature will increase during the fire danger period, and frequency of extreme hot periods, too. Moreover, it is expected that temperature will not increase evenly during the summer months, but increase most during the extremely hot periods. One more prediction about favourable conditions for forest fires – it is expected that precipitation will increase only by 0 – 2% during summer, or even be reduced by 10 – 15% (Jansons, 2012).

Fire can have both positive and negative impact. Ground vegetation biodiversity after forest fires usually increases (Marozas, Racinskas, & Bartkevicius, 2007; Marozas *et al.*, 2011), which might be explained with an extra nutrients, released after burning of humus layer, where most of nutrients were inaccessible for the plants before fire (Certini, 2005). Fire can have a positive effect on Scots pine radial growth dynamics on dry mineral soils, but the impact of fire on tree radial growth dynamics in peat soil is negative (Freimane *et al.*, 2013), which might be explained with forest fire type. Subsurface fire damages tree roots more than surface fire (Freimane *et al.*, 2013, Freimane, 2015). In Lithuania five years after low intensity surface fire

on sandy soil growing middle-aged Scots pine, fire impact to tree-rings growth is not observed (Marozas *et al.*, 2011). In Northern Italy it is observed that after severe fire tree-rings in the first year are very narrow (Beghin *et al.*, 2011). Research carried out in Norway shows that during the first five years after forest fire the annual growth decreases, then it increases 1 – 20 years after forest fire, but after 20 years it decreases again (Blanck, Rolstad, & Storaunet, 2013). Certini (2005) pointed out that the availability of nutrients after forest fire often increases, but it is not in long-term.

Forest fire impact on tree stand is also expressed as tree mortality. Tree mortality depend on several factors – age of tree, diameter of tree, species of tree, forest fire type, intensity and duration. Older Scots pine trees are more resistant to fire than younger; in the young Scots pine stands were observed higher mortality after low intensity surface fire (Sidoroff *et al.*, 2007; Piha, 2011). It is found out that tree diameter is one more factor which affect tree resistance against fire (Fernandes *et al.*, 2008; Donis *et al.*, 2010; Piha, 2011, Freimane *et al.*, 2013). Tree species are next factor which determine tree viability after fire. Comparing fire resistance of three most common tree species in Latvia – Scots pine, Norway spruce (*Picea abies* (L.) Karst.) and silver birch (*Betula pendula* Roth) – most resistant is Scots pine (Donis *et al.*, 2010). It could be explained with its thick crust bark. Forest fire type, intensity and duration also determine tree viability after forest fire (Freimane, 2015).

Fire influence the forest stand sanitary conditions negatively, mostly insect damages are observed (Donis *et al.*, 2010, Freimane *et al.*, 2013, Freimane, 2015), but there is observed quite a lot cracked bark to trees growing on dried peat soil (Freimane *et al.*, 2013). Cracked bark opens up unprotected wood which is bounded by wood lumps and formed in the result of mechanical abrasion of bark, as well as in the

result of fire (Вакин, Полуобяринов, & Соловьев, 1980).

The aim of research was to analyse and compare response reaction of the forest stand after fire in two forest site types – *Hylocomiosa* and *Vacciniosa turf. mel.*

Materials and Methods

Research was carried out in Latvia, Zemgale district. Empirical data was collected at the end of vegetation period of 2012 and 2014 in managed middle-aged Scots pine stands – three growing in the forest site type *Hylocomiosa* (data collected in 2014, coordinates of the forest stand No. 1 – latitude 56.60991, longitude 23.81109, forest stand No. 2 – latitude 56.60599, longitude 23.66905, forest stand No. 3 – latitude 56.940588, longitude 23.925927) and one stand in forest site type *Vacciniosa turf. mel.* (data collected in 2012, coordinates of forest stand – latitude 56.63839, longitude 23.88408). In forest site type *Hylocomiosa* three circular sample plots in every forest stand were placed in the part unaffected by fire (control plots) and two sample plots were placed in the part of forest stand affected by fire, in forest site type *Vacciniosa turf. mel.* – five sample plots in the part of stand affected by fire, five - in unaffected by fire. Size of each sample plot was 500 m².

For this study, the impact on tree radial growth dynamics was evaluated six years after the forest fire. Forest fire type in *Hylocomiosa* – low (height of scorching up to 0.5 m) to medium (height of scorching from 0.5 to 1.5 m) intensity surface fire, but in *Vacciniosa turf. mel.* – severe (height of scorching more than 1.5 m) intensity surface fire and shallow (depth up to 0.25 m) subsurface fire (Roga, 1979; Bušs & Vanags, 1987).

Kraft class for every tree was determined in every sample plot (Miežīte *et al.*, 2013). Tree diameter at 1.3 m height above root collar was measured in the forest stands both affected and unaffected by fire. Peat layer measuring (with measuring rod) was done in *Vacciniosa turf. mel.*

To describe the forest fire impact on forest stand radial growth dynamics, 20 dominant stand fire affected trees and 60 fire unaffected trees were bored with Presler increment borer (I, II and III Kraft class trees) towards the sample plot center at 1.3 m height from tree root collar, for bored trees the tree height was measured (Liepa *et al.*, 2013). The collected wood samples were dried at room temperature and then sanded. Tree-ring widths were measured with Lin TAB microscope system. Forest fire impact on radial growth and fire impact effect was analysed using method for evaluation of the impact of environmental factors. The method is based on comparison of tree-ring widths in environmental factor affected and unaffected forest stand (Liepa & Zaļkalns, 2014).

For the evaluation of the tree stand sanitary conditions after fire, the maximum height of scorching was measured. Trees with insect damage, exposed roots, cracked barks were listed.

The collected data were processed mathematically and analyzed using Microsoft Office. Statistical significance was tested by ANOVA and t-Test: Paired Two Sample for Means.

Results and Discussion

After analysis of measured tree-ring widths, it was found that first six years after forest fire tree-ring widths are narrower than before fire occurred in both forest site types *Hylocomiosa* and *Vacciniosa turf. mel.* It is a reason for negative effect of forest fire impact (Fig. 1). In the first year after forest fire in forest site type *Hylocomiosa* the growing stock losses are 0.7 m³ ha⁻¹, over the next four years | it is approximately 1.8 m³ ha⁻¹ per year, and then in the sixth year – 9 m³ ha⁻¹. The average loss of growing stock per year is 1.5 m³ ha⁻¹. A longer period is needed after fire for better evaluation. It might be that in the first year after fire trees have stress, but later situation becomes better and positive impact of forest fire might be observed. For more objective explanation of fire impact on tree-ring widths and

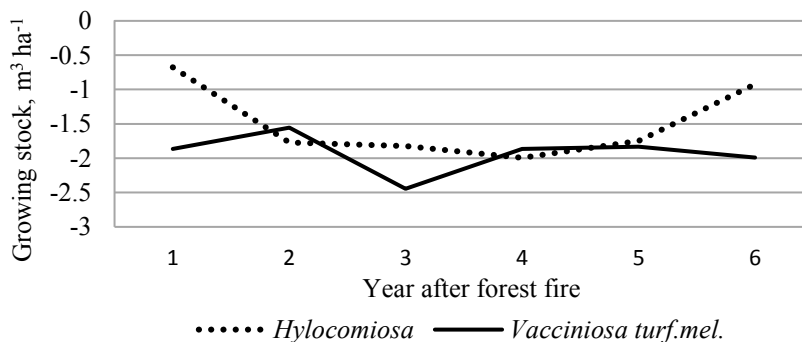


Figure 1. Effect of forest fire impact on growing stock.

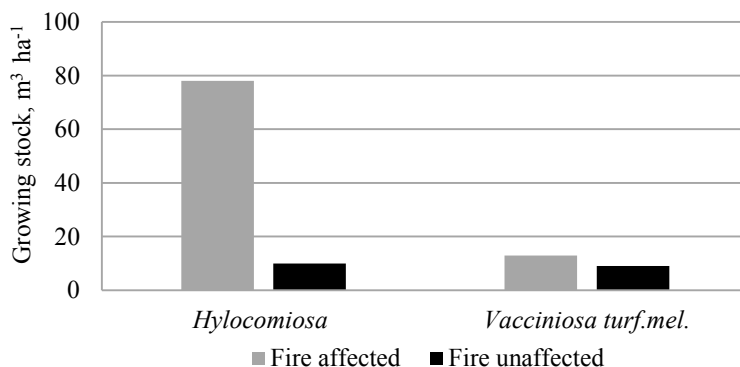


Figure 2. Tree mortality ($\text{m}^3 \text{ha}^{-1}$) in fire affected and unaffected forest area in forest site type *Hylocomiosa* and *Vacciniosa turf. mel.*

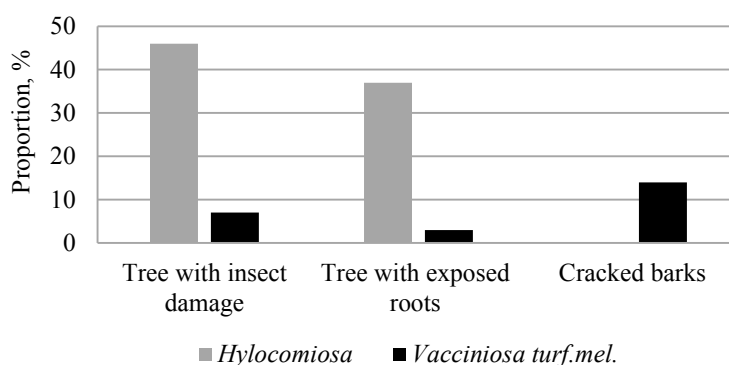


Figure 3. Type of damage and proportion in fire affected stands in forest site type *Hylocomiosa* and *Vacciniosa turf. mel.*

growing stock of middle-aged Scots pine growing in forest site type *Hylocomiosa* and *Vacciniosa turf. mel.* a larger study is needed. Research carried out by Marozas *et al.* (2011) shows that low intensity forest fire does not impact tree-ring growth within five years after fire.

In forest site type *Vacciniosa turf. mel.* the average loss of growing stock was higher – $2 \text{ m}^3 \text{ha}^{-1}$ per year. And the situation improvement was not observed in the sixth year, which could mean that fire impact on tree-ring widths and growing stock in *Vacciniosa turf. mel.* is more negative than in *Hylocomiosa*.

Tree mortality was observed in both forest site types *Hylocomiosa* and *Vacciniosa turf. mel.* (Fig. 2). Tree mortality after fire is also mentioned in literature (Sidoroff *et al.*, 2007; Piha, 2011; Eriksson *et al.*, 2013). In forest site type *Hylocomiosa* the tree mortality in fire affected part was higher than in *Vacciniosa turf. mel.*, respectively $78 \text{ m}^3 \text{ha}^{-1}$ and $13 \text{ m}^3 \text{ha}^{-1}$ on average, but in fire unaffected part the tree mortality was more or less the same – $10 \text{ m}^3 \text{ha}^{-1}$ (in *Hylocomiosa*) and $9 \text{ m}^3 \text{ha}^{-1}$ (in *Vacciniosa turf. mel.*). In both forest site types there was no significant difference between tree mortality in fire affected and unaffected parts (in *Hylocomiosa* $p > 0.05$, in *Vacciniosa turf. mel.*

$p > 0.05$), but for more objective evaluation a larger data set is needed.

The impact of fire on the forest stand sanitary conditions was negative. Figure 3 shows three different damages and their proportion of all measured trees in the fire affected stands. Trees with insect damages (46% of all fire affected trees in *Hylocomiosa*, 7% in *Vacciniosa turf. mel.*) and exposed roots (37% in *Hylocomiosa* and 3% in *Vacciniosa turf. mel.*) were observed in both forest site types, but cracked bark (14% of all fire affected trees) only in *Vacciniosa turf. mel.* It could be explained with forest site type, fire intensity (severe surface fire, average scorching height 2.2 m) and fire type, too (surface fire plus subsurface fire). The reason of a quite high difference between proportion of trees with insect damages in *Hylocomiosa* and *Vacciniosa turf. mel.* could be possible because of insect occurrence in certain tree stands in *Hylocomiosa* before forest fire.

Conclusions

Research results show that forest fire does not impact tree radial growth dynamic positively in forest site types *Hylocomiosa* and *Vacciniosa turf. mel.*

There are no significant differences between fire affected and unaffected tree mortality in forest site types *Hylocomiosa* ($p > 0.05$) and *Vacciniosa turf. mel.* ($p > 0.05$).

Fire had a negative impact on forest stand sanitary conditions in both forest site types. Trees with insects

and exposed roots were observed both in *Hylocomiosa* and *Vacciniosa turf. mel.*, but craced bark only in *Vacciniosa turf. mel.*

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