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SANITARY CONDITION OF *PICEA ABIES* (L.) KARST. YOUNG FOREST STANDS DEPENDING ON THE SPATIAL SPECIFICITY

Jelena RUBA, Olga MIEZITE, Imants LIEPA

Latvia University of Agriculture, Forest Faculty, Latvia

*Corresponding author: jelena.ruba@llu.lv

ABSTRACT

As a result of nature resources intensive use, most of ecosystems have been converted. Anthropogenic impact includes changes of forest stands structure and their spatial specificity in the forest area. Accordingly the sanitary state of Norway spruce young forest stands can be affected by different risk impact factors of management. The aim of the research was to analyze the spruce *Picea abies* (L.) Karst. young forest stands sanitary condition depending on forest plots spatial specificity and location in the forest areas. The data were collected in 4 regions of Latvia in spruce young forest stands (1 - 40 years old). The research was conducted in young natural and artificial stands (pure – 44, mixed – 42). In total 502 sample plots with a total area of 28250 m² were installed. The particular plot size (25, 50, 100 and 200 m) were selected depending on the stand average tree height, while their number depended on the forest stand area. A total area of investigated forest stands were 127.5 hectares. Results showed that the expression of spatial specificities depended on risk factors and their intensity, as well as the environmental characteristics. Damages caused by abiotic risk factors at different forest stands were not the same regarding intensity, nature and volume, but more or less closely were related to all site conditions. Spatial specificity of forest stands area (regular and irregular), as well as their location in the forest massif significantly affects the spruce young forests sanitary status (respectively $p=0.027$ and $p=0.002$). Different risk factors damage to forests, bordering with spruce or pine young growths, cutovers and various types of infrastructure, were identified as much more important.

Keywords: *forest stand, risk factor, sanitary condition.*

INTRODUCTION

Young forest stands of Norway spruce (*Picea abies* L. Karst.) from one to forty years take a relatively large area in Latvia - 5751.1 hectares (State Forest Service, 2016). It is easy to regenerate on medium fertile and fertile soil (Ošlejs, 2005). However, in recent years, forest owners have difficulties to grow high-quality young stands because of different risk factors of management which worsen sanitary state (Laivi š, 2005). Different risk factors will always affect stands more or less and they cannot avoid (Ruba *et al.*, 2013). For example, Slovakia stands are

most affected by the biotic factors, such as beetle (mainly, *Ips typographus*) and pathogenic fungi (mainly, *Armillaria*), who causes the most damage, so their activity, population dynamics and relations are widely studied.

The climatic conditions are regarded as one of the abiotic factors that mainly influence tree growth. Tree response to weather conditions may change depending on the species, origin, age, competition and location forest tract (Boddy and Jones, 2008). Forest owners managing spruce young stands are faced not only with the biotic and abiotic, but also with anthropogenic risk factors. The most of young forest stands of spruce in Europe have been modified by human activities and as result of it has changed the original structure of forest stands, in Central Europe decrease of spruce stands stability also was detected (Lamedica *et al.*, 2011). To minimize the impact of human activities and maintain the naturally developed stands in many places it is prohibited or limited an economic activity and the stand have turned into nature reserves or natural parks (Motta *et al.*, 2010). However, there are other opinions - that natural forest cultivation without human intervention is not acceptable (Zlatis, 2006). As is often the case that incorrect forest management has changed stands spatial structure, as the result increase the number of damage in young forest stands, worsen the health status of trees and the natural ecosystem transformation of unnatural. Therefore, changes in the spatial structure of the forest, to a greater extent, may affect the formation of the crown, tree growth and competition in the stand (Moeur, 1993). Changes in the forest structure are closely related to the different infrastructure objects creation in the forest (forest roads, drainage systems). Forest road network is one ecosystem, which is managed by a human, and it can positively or adversely affect the stands next to the existing plants and trees (Demir, 2007), therefore is important to assess the magnitude of the anthropogenic impact on this ecosystem (Gadow *et al.*, 2013). Irregular, naturally created shaped areas transformation into a regular and incorrectly performed thinning can lead to a deterioration of the health status in the young stands, causing a variety of diseases and insect invasion (Ruba *et al.*, 2014).

The aim of the research was to analyze impact of forest plots spatial structure on management of Norway spruce young forest stands). Tasks to achieve goal: to analyze impact of forest stands area spatial structure on sanitary condition of Norway spruce young stands (forms – regular, square, trapezium and irregular; to analyze young forest stands sanitary condition depending on the forest stands location in the forest tract; to determine impact significance on sanitary condition in young forest stands depending on form and location in the forest tract. Hypothesis: the form of forest area and location in the forest tract significantly impact the sanitary condition of Norway spruce young forest stands.

MATERIALS AND METHODS

The main indicator for choosing the number of sample plots was area of forest compartment. The average tree height (H) of the stand was the main indicator for choosing the type of sample plots. In the stand with H 12.0 m - 50 m sample plots were created with a circle radius of 3.99 m, while with H 12.0 m - sample

plots 200 m with a circle radius of 7.98 m. All trees in each of the temporary sample plots were counted, and each of them diameter at breast height (DBH) was measured. For DBH measuring electric calliper or simple calliper were used, tree heights for 20 – 30 trees were measured using VERTEX measuring instrument. In young forest stands was detected the following kinds of damage: biotic (insects, browsing, diseases), abiotic (frost, summer droughts) and anthropogenic (thinning), which were summed up and calculated the average parameters of tree damage occurrence (P) and intensity (R). The damage caused by various risk factors was divided into six damage degrees (Table 1).

Table 1. Evaluation of damage caused by biotic, abiotic and anthropogenic factors

Damage evaluation	Damage degree
Trees without indications of weakening or growth disturbances	0
Economically insignificant damage or faults	1
Economically significant damage	2
Highly damaged	3
Trees died in the current year	4
Dead trees	5

*According to Miezić et al., 2013; Ruba et al., 2013.

The following formula was used to determine the number of trees per hectare (1):

$$N = \frac{N_p \cdot 10000}{L}, \quad (1)$$

where N - number of trees per hectare according to the measured sample plot data (ha^{-1}), N_p - number of trees on the sample plot and L - area of the sample plot (m^2). Damage occurrence proportion was calculated using formula (2):

$$P = \frac{n \cdot 100}{N} \quad (2)$$

where P - damage occurrence proportion (%), n - the number of damaged trees (ha^{-1}) and N - total number of trees (ha^{-1}). The following formula was used to calculate the intensity of tree damage (3):

$$R = \frac{\sum n_i b_i \cdot 100}{N \cdot k} \quad (3)$$

where R - damage intensity proportion (%), n_i - the number of damaged trees (ha^{-1}), b_i - damage degree, N - total number of trees (ha^{-1}) and k - higher degree of damage (Miezić et al. 2013; Ruba et al. 2013).

Correlation between forms of forest areas and tree damage occurrence and intensity was determined using analysis of Anova with replication. Young forest stands of Norway spruce were selected in the age groups (1-10; 11-20; 21-30; 31-40).

Location in the forest massif was fixed to find out impact of the adjacent stands on sanitary condition of Norway spruce young forest stands. For research population 12 saplings objects were selected and analyzed: 6 artificially created (3 with square and 3 with trapezoidal shape) and 6 naturally developed (3 with irregular and 3 with square shape). All these forms were determined using forest digital map of Latvia State Forest Service (State Forest Service, 2016), while increases of each young forest stand were calculated by the following formula (4):

$$Z_{H_{vid}} = \frac{H_{vid}}{a}, (4)$$

where $Z_{H_{vid}}$ – mean increment of forest stand height, H_{vid} – average height of the stand (m); a - age (Liepa, 1996).

RESULTS AND DISCUSSION

Working on this study, authors had encountered for such hardships: there are many difficulties to find similar studies in literature, still lack of comprehensive knowledge about changes in spatial structure and information about current theme is not always publicly available. Other authors also had confronted the same problems (Griffiths *et al.*, 2014).

It's not enough to explore only the forest area, it is necessary to understand all processes taking place in the forest. One of the most important activities is to find out the impact of different disturbance regimes on ecosystem (Griffiths *et al.*, 2014).

In this study authors tried to find risk factors that most affect young forest stands of Norway spruce. One of the major risk factor is anthropogenic, because the following human activities like: naturally form of forest stands areas turning into a regular, various infrastructures objects creation in the forest massif increases the risk of biotic and abiotic damage and affects the sanitary condition in the stands.

Debeljak *et al.* (2014) have made statements that the initial state of forest stands and applied forest management could cause changes in the forest structure and composition in a short period of time (a few decades).

Previous and this research have shown that that forest areas, bordering with spruce or pine young growths, cutovers and various types of infrastructure (forest roads, block rides, amelioration system ditches) were identified as much more important (Ruba *et al.*, 2013). It was found that in regular square/artificially and square/naturally created areas of forest stands was recognized different types of damage: insects, diseases and browsing. Such damage also was detected in trapezoidal/artificially and undetermined/naturally created forest areas, only with a lower intensity of tree damage (Figure 1).

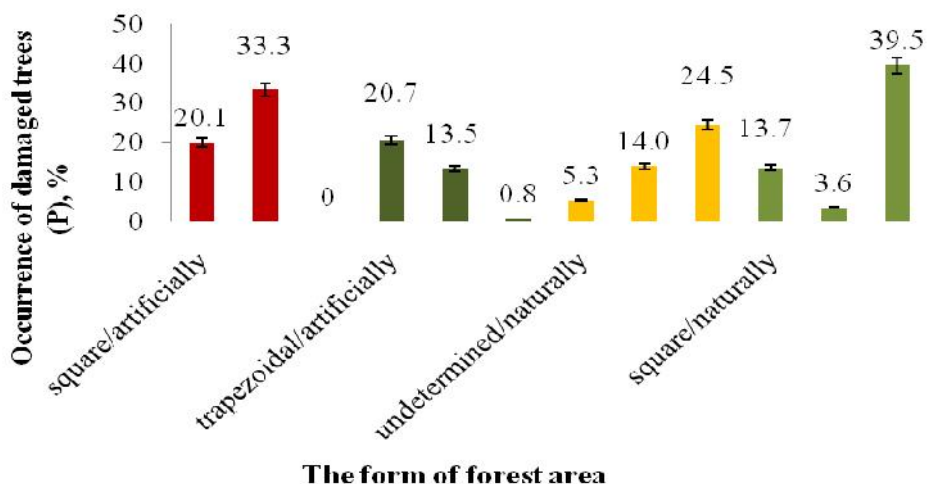


Figure 1. The relationship between the damage occurrence and forms of forest areas

Assessing tree damage and the stand height increases, it was concluded that there is no significant difference between the occurrence of damaged trees in pure and mixed stands ($p = 0.375 > 0.05$), while it is significant in different age groups: in mixed ($p = 0.003 < 0.05$) and pure stands ($p = 0.017 < 0.05$). There is no significant difference between the damaged tree intensity and height increases in pure stands ($p = 0.388 > 0.05$), and between age groups ($p = 0.127 > 0.05$), as well as in mixed stands between the damaged tree intensity and height increases ($p = 0.343 > 0.05$), and age groups ($p = 0.094 > 0.05$). The occurrence of damaged trees varies greatly between age groups (18.1 - 119.7%) in pure stands, while in the mixed stands (4.0 - 59.3%) (Table 2).

Table 2. Variation coefficients of tree damage occurrence and damage intensity in pure and mixed young stands according to age groups

Age groups	The occurrence of tree damage		The intensity of tree damage	
	In pure stand	In mixed stand	In pure stand	In mixed stand
1-10	119.7	50.1	10.7	4.6
11-20	18.1	59.3	2.5	3.0
21-30	110.0	4.0	19.4	1.2
31-40	111.8	15.2	18.6	3.0

* S

The sanitary condition is worse in the pure stands which height increases reaches 0.2 - 0.3 in the age group of 1-10 (average occurrence - 8.6%, intensity - 4.0%), in the same age group (average occurrence - 21.3%, intensity - 5.1%) height increases 0.4 - 0.5, but nevertheless in the mixed stands sanitary condition is better because of low damage (highest damage occurrence - 12.6%, intensity - 2.7%), in the age group of 21-30 and height increases 0.2 - 0.3 (Table 3).

Table 3. Values of tree damage occurrence and damage intensity in pure and mixed young stands according to age groups

The occurrence of tree damage					The intensity of tree damage				
Z _{Hvid}	1-10	11-20	21-30	31-40	Z _{Hvid}	1-10	11-20	21-30	31-40
0. 2-0. 3	8. 6	0. 7	0	6. 5	0. 2-0. 3	4. 0	0. 3	0	2. 6
0. 4-0. 5	21. 3	3. 6	0. 5	10. 3	0. 4-0. 5	5. 1	1. 5	0. 3	2. 6
0. 6-0. 7	1. 9	2. 2	6. 9	0	0. 6-0. 7	0. 6	0. 7	2. 9	0

*Source: Authors' elaboration

This once again proves that better to create mixed stands, because these are more resistant to windthrows (Lüpke and Spellmann, 1997), less suffer from various diseases (root rot) (Piri et al.,1990) and have better nutritional content than pure stands (Sverdrup and Stjernquist, 2002).

CONCLUSION

As much more important risk factors damaging forests, bordering with spruce or pine young growths, cutovers and various types of infrastructure. Spatial specificity of forest stands area (regular and irregular), as well as their location in the forest massif ($\chi^2 = 0.05 > p = 0.002$) significantly affects the spruce young forests sanitary status ($p = 0.027$ and $p = 0.002$). Damages caused by abiotic risk factors at different forest stands were not the same regarding intensity, nature and volume, but more or less closely were related to all site conditions, which either promotes or limits for certain damage risk factor in the likelihood and magnitude.

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