Changes in the Woody Vegetation of Macro Clearances in Vištytgiris Botanical-Zoological Reserve

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Abstract
An important factor in the development of forest ecosystem is the ability to regenerate. Natural intensity of self-thinning of a forest depends on the tree species and environmental conditions. Due to abiotic and biotic factors in a continuous forest tract, there appears a clearing, which, depending on the size, forms new growth conditions. Over time, the resulting new space is occupied by herbaceous and woody vegetation. Most often regeneration of a new forest depends on the size of the plot.

The study was conducted in 2013 during the growing season in a typical broadleaf forest stand. During the study woody vegetation and projection coverage of herbaceous vegetation was registered in large clearings. Light conditions in the plots and under tree canopies, as well as soil parameters were ascertained. Based on the collected data, the view of the structure of woody vegetation, projection coverage of herbaceous vegetation, light conditions, temperature, soil moisture content and pH changes were obtained. In order to clarify the influence of microclimatic conditions on natural forest regeneration, the data on light and soil characteristics were analyzed.

The aim of the study - was to determine the changes of woody and herbaceous vegetation in spruce stand clearings and to assess the impact of microclimate.

During the study it was found out that in large plots dominated species demanding higher amount of light, while herbaceous vegetation was attributed to the third, fourth groups of aggressiveness. Naturally regenerated seedlings condition was mostly influenced by light conditions and soil moisture content.

Key words: species composition, natural regeneration, forest plots, environmental conditions.

Introduction
The intensity of self-thinning in the forest depends on stand species composition, on the abundance and location of fruiting trees in the surroundings, soil type, relief and other conditions of the regenerating site (Ozolinčius, 2008; Riepšas, 2008). To ensure successful self-regeneration of a forest, it is important to identify favorable and unfavorable factors that determine the success of regeneration and the state of stand. For natural forest regeneration crucial is the distance to the seed source and soil potential to sprout seeds and maintain viable seedlings. Forest reproductive characteristics depend not only on tree species and age, but also on local conditions: light, heat, soil moisture, herbaceous vegetation and other irregularities (Ozolinčius, 2008; Suchockas, 2004).

Naturally regenerated seedlings are sensitive to sudden changes in the environment (light, temperature and humidity). Unable to withstand competition, most of them die. Taller (5-10 years) seedlings, which earlier could stand some shading, now require better light conditions. Later, in the absence of sufficient light, the saplings grow slower and become underbrush or die (Ministry of Environment, 2010). Solar radiation is the most important factor for all green plants, as well as for the existence of forest ecosystems. Light regime in forest plots depends on their structure and layout. Light demand of individual species of trees and shrubs depends on the age of the plant, vitality, growth conditions, stand species composition, structure, stocking level and other factors (Karazija, 2008; Ozolinčius, 2008; Barko and Adams, 1986). Soil moisture content is a key factor limiting seed germination and the development of seedlings. Average humidity in the forest is by about 9% higher than in the open field; thus, the new generation of forest has better growth conditions under the canopies of stands (Suchockas, 2004).

Forest is not an entire body; it is characterized by storeys, mosaic appearance and fragmentation. Forest structure is determined by the structure of plant communities; namely, spatial arrangement of its elements, composition of plant species, quantitative ratio of species, growth conditions. Clearings are a part of forest structure. According to Forest Management Guide of the State Forest Service under the Ministry of Environment, a clearing (a forest plot) is defined as an area of not less than 0.1 ha, which had been overgrown with a forest, but due to natural, anthropogenic or other factors was deprived of it for more than 10 years.

In an entire forest tract the formation of clearings is strongly influenced by abiotic and biotic environmental factors. Clearings, depending on the size, form new growth conditions. Over time, the communities of herbaceous and woody vegetation occupy a new space. Dead individuals or groups of several trees comprise small forest areas, called micro plots, while groups of dead trees comprise larger areas, called macro plots. Regeneration of the new forest mostly depends on the size of the clearing. In plots of different size dominate different light conditions, moisture content and the
amount of nutrients. Under the influence of prevailing conditions, plant species, which are adapted to certain tolerance for light, soil, moisture content regenerate in the plots (Sturrock, 2012; Sturtevant and Gustafson, 2004; McCarthy, 2001; Gray and Spies, 1996; White and Pickett, 1985).

Materials and Methods

The object of research – was large observation plots of broadleaved forests in Vištytis botanical-zoological reserve.

Vištytis botanical - zoological reserve is in the territory of Vilkaviškis district municipality. The reserve is located in the State Regional Park of Vištytis - in Vištytis forest, and it was established in 1992 to preserve typical broad-leaved forest communities with a rich and diverse flora and fauna. The reserve covers 657 hectares and the central part of Vištytis forest. According to the Lithuanian climatic classification, the object of study is in Sūduva subarea of Lithuanian Southeast Highland climatic region. The average annual precipitation is about 550-650 mm. Average annual air temperature - 7.5 °C, total solar radiation - ≥ 3500 MJ m², while absorbed solar radiation - 2800 MJ m² per year.


For the assessment of woody and herbaceous vegetation, five large experimental plots (~ 150 m²) were identified during the growing season (June) in 2013. To determine woody vegetation, a strip transect with a width of 2 m was used. The density of woody vegetation was measured up to 50 cm and above 50 cm. In subsequent calculations the number of woody plants was converted into trees ha⁻¹. For the assessment of projection coverage of grassy vegetation, in each large plot, 3 square-shaped plots of 1 m² (1 x 1 m size) were randomly selected. Projection coverage was determined visually. It was determined what surface (in percentage points) is covered by each species of herbaceous plants.

Soil moisture content, pH and temperature were determined using a portable device ‘WET’. These indicators were measured on soil surface and at a depth of 5 cm. On each site, measurements were conducted in the centre, and near the edge of the plot with three replications. Lighting was measured in the centre of each plot, at the edge and nearby the plot using the device ‘Hemi View Canopy System’. To analyze light intensity, hemispherical photographs and a computer program Hemi View were used. Direct, diffuse and total radiation was analyzed to determine light intensity in the plots.

In order to ascertain the influence of microclimatic conditions on the growth and development of vegetation, soil temperature, moisture, pH and light intensity in the plots were analyzed.

Results and Discussion

Different species are found in forest plots of varying size. In large forest plots species requiring more light and higher temperature are found. According to H.Ellenber (1991), Populus tremula L., Betula pendula Roth., Quercus robur L. are attributed to semi - light-demanding species. On average, Populus tremula L. was dominant tree species in large plots, and comprised five parts in the species composition (Table 1).

The lowest diversity of species composition was in the fifth plot (3 species), while the highest - in the second and fourth plots (5 species). Dominant species in large plots were Populus tremula L. (10 – 80%), Picea abies L. (10 – 60%), other species accounted for a small portion (10 – 20%) of the species composition. The maximum amount of Populus tremula L. natural regeneration was in the fifth plot (8 parts), while that of Picea abies L. – in the second plot (6 parts). In the first plot there was no woody vegetation, it was dominated only by grassy vegetation.

In calculations the number of woody plants was converted into trees ha⁻¹, using the proportions as in forest inventory. Having recalculated the amount of natural regeneration to trees ha⁻¹, it was found that stand density is higher than the norm. Only the density of natural regeneration of Tilia cordata L. and Quercus robur L. in the fourth plot and Tilia cordata L. in the second plot was lower than the norm.

The highest soil temperature in the center of the plot was in the fourth and fifth plots, respectively by 2.2 °C and 1.3 °C higher than the mean (24.8 ± 0.73 °C) one, while in the third plot it was by 2.1 °C lower than the mean (Figure 1).

Mean soil temperature on the edge of plots was 22.6 ± 0.59 °C, i.e by 1.5 °C higher than the lowest (the third plot – 21.1 °C), and by 1.9 °C lower than the highest (the fourth plot – 24.5 °C) soil temperature. In the fourth plot soil temperature in the forest was the highest (24.3 °C), while on other sites it was close to the mean (21.8 ± 0.83 °C). Minimum soil temperature difference between the center point, the edge and the forest was ascertained in the third plot,
while maximum - in the first, comprising respectively 1.0 °C and 5.3 °C.

A statistically significant relationship was found between soil temperature and the amount of Tilia cordata Mill. natural regeneration ($r = -0.82$, $p = 0.03$). Among other species no statistically significant relationship ($p>0.05$) was determined.

Soil moisture content variation between the center point, the edge and the forest was the lowest in the fourth plot, while the highest - in the third (Figure 2). The average soil moisture content in the center of plots was $4.88 \pm 1.79\%$, by 6.5% lower than in the second plot (11.4%). Moisture content determined in the center of the first and third plots was close to the average, respectively 5.0% and 4.9%, while in the fourth and fifth plots a very low soil moisture content was determined, 1.4 and 1.7% respectively. The highest soil moisture content was at the edge of the second (15.6%) and the third (17.5%) plots, by 40 – 60% higher than the average ($11.08 \pm 2.47\%$). The lowest soil moisture content was found at the edge of the first (by 34 % lower than the average) and

![Table 1](image)


![Soil Temperature](image)

**Figure 1.** Soil temperature in the centre, at the edge and in the forest of large plots.
Soil moisture content in the forest of the first plot was by 33% higher than the average (22.18 ± 4.85%), while in the fourth plot – by 74% lower.

A statistically significant relationship was found between soil moisture and the amount of natural regeneration of *Picea abies* L. (r = 0.96, p = 0.04), *Populus tremula* L. (r = -0.91, p = 0.05). No statistically significant relationship (p>0.05) was ascertained among other tree species.

The highest soil pH was measured in the centre of plots, the lowest - in the forest (Figure 3). The highest soil pH was in the centre of the first plot (pH = 6.24), while the lowest in the forest of the third plot (pH = 4.30) plot. A slightly acidic soil (pH = 6.0 to 6.9) was found in the centre and the edge of the first plot (respectively, pH = 6.24 and 6.19), and in the centre of the second plot (pH = 3.05). A slightly acidic soil was ascertained at the edge of the second plot (pH = 5.60), in the centre of the third (pH = 5.20), and in the centre and the edge of the fourth and the fifth plots (pH from 5.20 to 5.90). At the edge of the fourth plot soil pH (pH = 5.45) was close to the average (pH = 5.43 ± 0.24). Averagely acidic soil was found in the forest of all plots (pH from 4.30 to 4.90) and at the edge of the third plot (pH = 4.73).

A statistically significant relationship was ascertained between soil pH and the amount of regeneration of *Betula pendula* Roth. (r = -0.98, p = 0.05). Among the other species no statistically significant relationship (p>0.05) was ascertained.

Light conditions in the centre of forest plots, at the edge and in the forest are shown in Table 2. The maximum diffuse radiation was recorded in the center (395 MJ, m$^2$) and at the edge (298 MJ, m$^2$) of the first plot. Diffuse radiation in the forest of the first and second plots was close to the average (206 ± 3.7 MJ, m$^2$), respectively, 205 MJ, m$^2$ and 204 MJ, m$^2$. Average diffuse radiation in the center of the plot was 320 ± 24.0 MJ, m$^2$, direct radiation - 708 ± 61.0 MJ, m$^2$ and the total radiation - 1027 ± 59.0 MJ, m$^2$, while total radiation in the centre of the plot was 31.16%. The biggest difference (179 MJ, m$^2$) between the average direct radiation in the center was found in the third plot. Maximum total radiation (1178 MJ, m$^2$) in the centre was in the third plot, while the lowest (862 MJ, m$^2$) - in the fifth plot.

Under the impact of forest regeneration, a live soil cover is divided into groups of aggressiveness...
### Table 2

Results of lighting experiment in the center, at the edge of large plots and in the forest

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Light measurement location</th>
<th>Direct radiation</th>
<th>Dispersed radiation</th>
<th>Total radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Centre</td>
<td>395</td>
<td>563</td>
<td>959</td>
</tr>
<tr>
<td></td>
<td>Edge</td>
<td>298</td>
<td>421</td>
<td>719</td>
</tr>
<tr>
<td></td>
<td>Forest</td>
<td>205</td>
<td>620</td>
<td>825</td>
</tr>
<tr>
<td>2</td>
<td>Centre</td>
<td>316</td>
<td>677</td>
<td>993</td>
</tr>
<tr>
<td></td>
<td>Edge</td>
<td>261</td>
<td>458</td>
<td>719</td>
</tr>
<tr>
<td></td>
<td>Forest</td>
<td>204</td>
<td>864</td>
<td>1068</td>
</tr>
<tr>
<td>3</td>
<td>Centre</td>
<td>291</td>
<td>887</td>
<td>1178</td>
</tr>
<tr>
<td></td>
<td>Edge</td>
<td>240</td>
<td>519</td>
<td>759</td>
</tr>
<tr>
<td></td>
<td>Forest</td>
<td>215</td>
<td>742</td>
<td>957</td>
</tr>
<tr>
<td>4</td>
<td>Centre</td>
<td>341</td>
<td>805</td>
<td>1146</td>
</tr>
<tr>
<td></td>
<td>Edge</td>
<td>230</td>
<td>536</td>
<td>766</td>
</tr>
<tr>
<td></td>
<td>Forest</td>
<td>194</td>
<td>636</td>
<td>830</td>
</tr>
<tr>
<td>5</td>
<td>Centre</td>
<td>254</td>
<td>608</td>
<td>862</td>
</tr>
<tr>
<td></td>
<td>Edge</td>
<td>182</td>
<td>623</td>
<td>805</td>
</tr>
<tr>
<td></td>
<td>Forest</td>
<td>212</td>
<td>609</td>
<td>821</td>
</tr>
<tr>
<td>mean ± error</td>
<td>Centre</td>
<td>320 ± 24.0</td>
<td>708 ± 61.0</td>
<td>1027 ± 59.0</td>
</tr>
<tr>
<td></td>
<td>Edge</td>
<td>242 ± 19.1</td>
<td>511 ± 34.8</td>
<td>754 ± 16.2</td>
</tr>
<tr>
<td></td>
<td>Forest</td>
<td>206 ± 3.7</td>
<td>694 ± 49.0</td>
<td>900 ± 49.0</td>
</tr>
</tbody>
</table>

Figure 5. Projection coverage of grassy vegetation in large plots.
Grass cover of large plots is attributed to the third group of aggressiveness, with the exception of the first plot (entire cover of tall grasses shading the undergrowth) - the fourth group of aggression.

Projection coverage of the species composition of grassy vegetation cover ranges from 3% to 60% (Figure 5). Most species of herbaceous vegetation were found in the third and second plots, 13 and 12 species respectively, while the least (7 species) – in the fourth plot. The highest (60%) projection coverage was by *Calamagrostis arundinacea* L. (in the second and third plots), 40% projection coverage by *Melica nutans* L. (the fifth plot), *Vaccinium myrtillus* L. (the third plot), *Aegopodium podagraria* L. and *Urtica dioica* L. (the first plot), while projection coverage of other herbaceous plants ranged from 10 to 30%. The minimum projection coverage was by *Carex nigra* (L.) Reichard (the second plot), *Convallaria majalis* L. (the third plot) - 2% and *Juncus effusus* L. (the second plot), *Lamium purpureum* (L.) (the fifth plot) – 3%.

**Conclusions**

1. In large forest plots, semi light-demanding tree species dominated, and the largest portion comprised *Populus tremula* L. - five parts within species composition, while shade-preferring species *Picea abies* L. - three parts.
2. Soil temperature in the center of the plots was by 3.0 °C higher than the temperature in the forest, and this contributed to higher amount of diffuse radiation entering the centre of plots (diffuse radiation in the centre of plots comprised 320 ± 24.0 MJ, m², while in the forest - 206 ± 3.7 MJ, m²).
3. Natural forest regeneration was mostly influenced by soil moisture content. In the center of plots soil moisture content was by 8.72% lower than in the forest. In the centre of large plots, slightly acidic soil (pH = 5.77), prevailed, while the forest soil was averagely acidic (pH = 4.61).

**References**