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DYNAMICS OF GROUND COVER IN SCOTS PINE STANDS AFTER CLEAR-CUTTING

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While developing the principles of sustainable forestry and society prioritising forest management strategies with low forest use, clear-cutting of mature forests is currently causing strong debates in the region. The study on ground cover in Scots pine stands after clear-cutting included the assessment of the ground layer of non-living organic material (forest floor and dead wood) and the ground layer of live organic material (ground vegetation – mosses and vascular plants). The study was carried out in three sites located in Trakai, Varėna and Kazlų rūda districts. Each study site included the set of 1, 2 and 3 years old clear-cut plots and of the plots in Scots pine stands of different age groups (8–10, 15–20, 30–40, 70–80, and 101–130 years). The study results showed that the parameters of ground cover in Scots pine forests of *Pinetum vaccinio-myrtillosum* type reached the same level as in the mature stand 20–30 years after clear-cutting. The evaluation of non-living and live ground cover elements and diversity indicators does not allow the influence of clear-cutting to be considered as a completely negative effect on this type of Scots pine forest, because a higher abundance and species diversity of the ground vegetation was determined at different stages of stand development compared to a mature Scots pine forest.

Keywords: *Pinus sylvestris; ground vegetation; forest floor*

INTRODUCTION

Common practice shows that clear-cutting of the mature forest results in the complete removal of trees and partial removal of the vegetation of the lower layers of the stand, but it is recommended to leave some trees for biological diversity in the clear-cuts (Ministry of Environment of the Republic of Lithuania, 2010). Otherwise, there are no regulations on how other forest components (forest floor, ground vegetation species) could be prevented. Due to the significant changes in the microclimate at the clear-cuts compared to the mature forest, the changes in ecosystem biodiversity, resilience, and carbon balance are recorded (Keenan and Kimmins, 1993; Bradshaw et al., 2009). These changes can be of medium to long duration, depending on the soil, climate, or reforestation conditions. The lowest layers of vegetation (in this case – ground vegetation) have the closest contact with the soil and can be treated as the living ground layer. Furthermore, another ground layer consisting of forest floor and dead wood left in clear-cuts can be considered a non-living layer of organic material. Ground vegetation parameters respond quite quickly to changes in the environment, including clear-cutting. In fresh clear-cuts and at the early stages of reforestation until an open-canopy phase continues, stress-tolerant perennials and several pioneer species of vegetation prevail; after canopy closure, other competitive perennials prevail (Stefańska-Krzaczek et al., 2016). The ground vegetation communities vary considerably during the period from fresh clear-cut until the mature forest with relatively high differences fixed at the early phases of stand recovery (Karazija, 2002; Widenfalk and Weslien, 2009; Česonienė et al., 2018; 2019; Gustienė et al., 2022a;b). However, the stand must reach a certain age and balanced site conditions for indicator species to prevail (Stefańska-Krzaczek, and Szymura, 2015; Stefańska-Krzaczek et al., 2016).

For this study, typical Scots pine forests were chosen as characterized by rapid recovery after clear-cutting in this region (Kumar et al. 2018; Petrokas et al., 2020). The main study aim was to evaluate the dynamics of ground cover indices in Scots pine stands of *Pinetum vaccinio-myrtillosum* type after clear-cutting in Lithuania.

RESEARCH METHODS

This study was carried out in three study sites located in Trakai, Varėna and Kazlų rūda districts. Each study site included the set of 1, 2 and 3 years clear-cut plots and the study plots in Scots pine stands of different age groups (8–10, 15–

20, 30–40, 70–80, and 101–130 years). All study sites represented typical *Pinetum vaccinio-myrtilliosa* forest type (Karazija, 1988) and were established on medium-fertility mineral soil of normal moisture (Vaičys et al., 2006). The soil was characterised as Arenosol (IUSS Working Group WRB, 2015).

The study on ground cover in Scots pine (*Pinus sylvestris* L.) stands after clear-cutting included the assessment of the ground layer of non-living organic material (forest floor and dead wood) and the ground layer of live organic material (ground vegetation – mosses and vascular plants). The ground cover was assessed in July-August 2020–2022. For the assessment of ground cover, temporary plots of 2000 m^2 size were established. The forest floor and ground vegetation were assessed on 25 plots of 1 m^2. The vegetation species were described as moss layer and herb together with dwarf shrub layers. Aboveground compartments of ground vegetation were harvested within 25 × 25 cm plots; the samples were oven-dried at 105°C to a constant mass.

RESEARCH RESULTS AND DISCUSSION

Living and non-living biomass obtained in the Scots pine stand was in a range of 1.6–4.7 t ha^{-1}, and 9.2–40.0 t ha^{-1} across all ages, respectively. The aboveground biomass of the non-living ground cover components (forest floor and dead wood) differed significantly with stand age (Figure 1). The most significant decrease – by 4.3 times – was obtained in non-living layer mass during the first decade after clear-cutting. The ground vegetation mass comprised a relatively small proportion of the ground cover in the Scots pine stands of all ages and showed relatively similar values per stand rotation. The peak of ground vegetation mass was obtained during the second decade after clear-cutting.

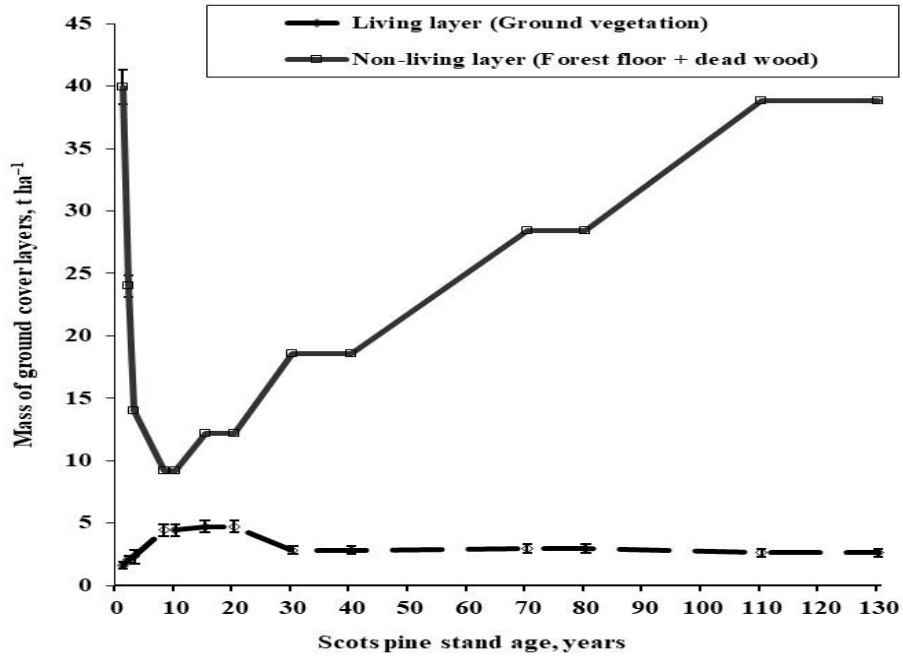

Figure 1. Dynamics of ground cover – living and non-living layers – mass during the Scots pine stands (*Pinetum vaccinio-myrtillosum* type) rotation following clear-cutting.

Across all ages of the Scots pine stand, the number of ground vegetation species – mosses and vascular plants – varied significantly. Although there were no unique ground vegetation species in the fresh clear-cuts, 6 unique species were recorded in the 2 years clear-cuts and 4 species in the 3 years clear-cuts (Figure 2A). Regardless of the specific species found in each of the studied sites, a total of 32 species were found in all ages of clear-cuts. The highest number of unique species of ground vegetation was obtained in the clear-cuts compared to the Scots pine stands of different ages until the mature forest (Figure 2B). Only 2 unique species were found in the 8–10 years and 70–80 years stands.

However, no unique species were obtained in the mature Scots pine forest. In total, 11 species of ground vegetation persisted throughout the whole stand rotation (approximately 100 years), i.e., they were found at all age groups of Scots pine stand, including the clear-cuts. Therefore, it showed that clear-cutting operations did not change the existence of the dominant ground vegetation species. Also, the Scots pine forest ecosystem successfully restores all ground cover layers when the stand recovers (see Figure 1).

The presented data illustrated the trends that explained the changes in ground cover mass (see Figure 1), but also the changes in species composition of the ground vegetation. In terms of biodiversity, clear-cutting does not reduce the total number of ground vegetation species – even more, the largest number of species was recorded shortly after the stand was under stress conditions (see Figure 2).

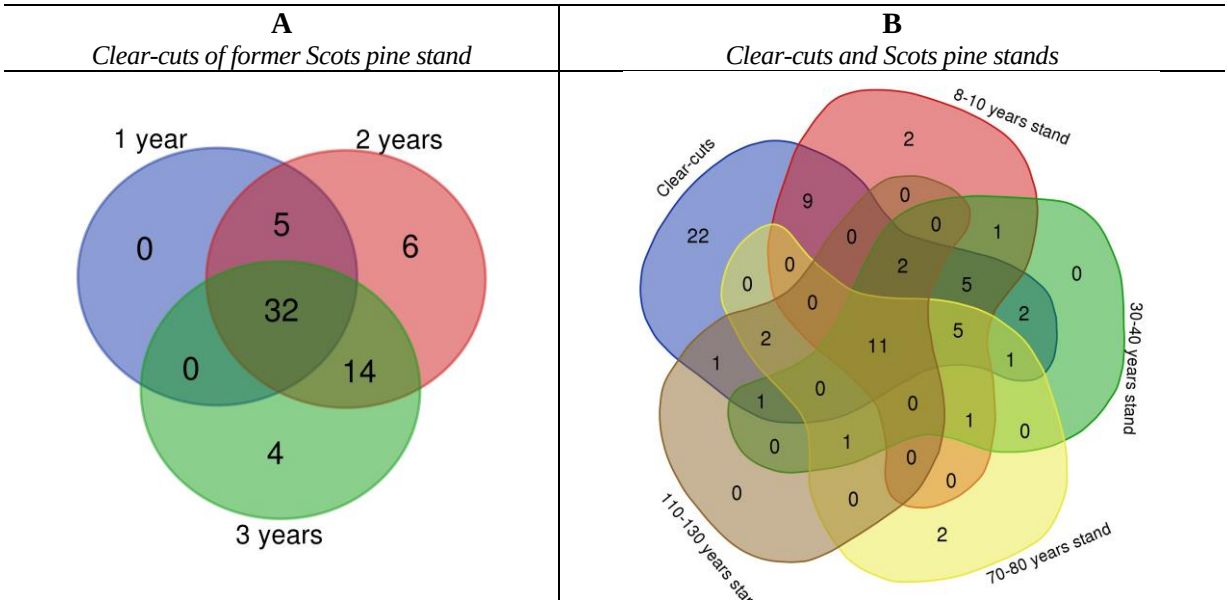

Figure 2. Diversity and similarity of ground vegetation species (including all species of mosses and vascular plants obtained in the studied plots) in 1–3 years old clear-cuts of former mature Scots pine stands (**A**), and in the clear-cuts, 8–10, 30–40, 70–80, and 101–130 years old Scots pine stands (**B**).

Most likely, the drastic changes in the structure of tree layers and the associated microclimate conditions of the site had the highest impact on such a change in ground cover. Similar dynamics were shown by the previous studies (Karazija, 2002; Hart and Chen, 2006; Stefańska-Krzaczek et al., 2016; Kumar et al., 2018). When the stand recovered after clear-cutting, the ground vegetation was consistently able to restore the communities typical for a mature stand, which led to the stabilization of the total ground cover layers.

CONCLUSIONS

When considering the entire stand rotation of the Scots pine forest of *Pinetum vaccinio-myrtillosum* type, the clear-cutting system significantly reduced the mass of the non-living layer of ground cover but supported a greater diversity of live ground layer, i.e., a temporary increase in ground vegetation species was recorded which increased the overall vegetation diversity over the entire development of forest ecosystem.

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