



# Changes in Understory Plant Populations after Clearcutting in Scots Pine-Dominated Forests <sup>†</sup>

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**Abstract:** Clearcutting causes significant changes in boreal forest ecosystems and has long-term effects on populations of understory plants. The aim of our study was to determine the impact of clearcutting on understory moss and vascular plant populations after clearcutting. The species diversity of particular populations in mature stands before cutting and after one year was determined. Our results corroborated changes in coverage, frequency, and prominence value of predominant Ericaceae plants. We determined the different response of *Vaccinium vitis-idaea* L., *V. myrtillus* L. and *Calluna vulgaris* (L.) Hull. Plant species that are particularly sensitive to clearcutting have been identified. Assessing the viability of moss populations in mature forest stands and deforested areas showed that moss species are most sensitive to environmental changes after clearcutting. These investigations could justify the conservation of sensitive forest plant populations and nonwood forest resources.

**Keywords:** cutting; forest; plant; population



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## 1. Introduction

Scots pine forests are important wood sources in Lithuania. However, they are commonly affected by intensive anthropogenic activity. As Godefroid et al. (2005) reported, tree extraction after clearcutting is the main cause of microclimate changes in the forest floor, for instance influencing the regeneration of tree seedlings [1]. Changes in soil properties after clearcutting affects nutrient uptake and promotes the appearance of other species in the forest ecosystems, including alien plants if an abundant local seed source is present [2]. The effects of clearcutting can be observed not only in above-ground plant parts but also underground (e.g., roots, rhizomes) [3].

The diversity of vascular plant species in the mature Scots pine forests is low, and members of the Ericaceae family *Vaccinium myrtillus* L. and *V. vitis-idaea* L. are the most abundant species [2]. Other authors have reported that clearcutting destroys roots and rhizomes of forest floor plants and reduces competitive abilities of forest plants in favour of nitrophilous plant species [4]. Tree extraction may also raise environmental stress induced by increased solar radiation and drought. *V. vitis-idaea* has been adapted to the infertile soils of coniferous forests. In the case of this plant, there is less information on the impact of forest management on populations [3]. Interestingly, a previous study [5] reported that tree density had negative effects on the development of *V. vitis-idaea*, whereas other authors [4] emphasized higher resistance of the species to increased light and drier soil conditions.

Our hypothesis was that drastic changes in the forest stand negatively affect shrub, grass, moss and lichen species. The aim of this study was to evaluate the initial changes in the diversity of understory plants species one year after clearcutting in Scots pine *Pinus sylvestris* L.-dominated forests.

## 2. Results and Discussion

The largest proportion of forest floor cover in both *Pinetum vacciniosum* (PV) and *Pinetum vaccinio-myrttilosum* (PVM) forests was composed of moss and lichen species (Tables 1 and 2).

**Table 1.** Changes in mean cover, frequency and prominence values of understory plant species in the managed *Pinetum vacciniosum* (PV) forest stands.

| Species                        | <i>Pinetum vacciniosum</i> , Mature Forest Stands |              |                  | <i>Pinetum vacciniosum</i> , Clear Cuttings |              |                  |
|--------------------------------|---------------------------------------------------|--------------|------------------|---------------------------------------------|--------------|------------------|
|                                | Cover, %                                          | Frequency, % | Prominence Value | Cover, %                                    | Frequency, % | Prominence Value |
| Herbs and shrubs               |                                                   |              |                  |                                             |              |                  |
| <i>Vaccinium myrtillus</i>     | 2.4                                               | 20           | 10.7             | 0.7                                         | 10           | 2.2              |
| <i>Vaccinium vitis-idaea</i>   | 4.3                                               | 40           | 27.2             | 0.45                                        | 10           | 1.4              |
| <i>Festuca ovina</i>           | 1.2                                               | 40           | 7.6              | 1.15                                        | 30           | 6.3              |
| <i>Calluna vulgaris</i>        | 3.6                                               | 40           | 22.8             | 0.4                                         | 10           | 1.3              |
| <i>Solidago virgaurea</i>      | 0.1                                               | 10           | 0.3              | 0.15                                        | 5            | 0.3              |
| <i>Arctostaphylos uva-ursi</i> | 1.9                                               | 15           | 7.4              | -                                           | -            | -                |
| <i>Spergula arvensis</i>       | -                                                 | -            | -                | 0.45                                        | 25           | 2.3              |
| <i>Hieracium sp.</i>           | -                                                 | -            | -                | 0.05                                        | 5            | 0.1              |
| <i>Calamagrostis epigejos</i>  | -                                                 | -            | -                | 0.35                                        | 15           | 1.4              |
| <i>Rumex acetosa</i>           | -                                                 | -            | -                | 0.05                                        | 5            | 0.1              |
| <i>Rumex acetosella</i>        | -                                                 | -            | -                | 0.25                                        | 10           | 0.8              |
| <i>Senecio vulgaris</i>        | -                                                 | -            | -                | 0.08                                        | 10           | 0.3              |
| <i>Veronica officinalis</i>    | -                                                 | -            | -                | 0.2                                         | 5            | 0.5              |
| Total cover                    | 13.5                                              |              |                  | 4.3                                         |              |                  |
| Mosses, lichens                |                                                   |              |                  |                                             |              |                  |
| <i>Pleurozium schreberi</i>    | 38.75                                             | 95           | 377.7            | 2.8                                         | 70           | 23.4             |
| <i>Dicranum polysetum</i>      | 40                                                | 100          | 400              | 17.4                                        | 100          | 174              |
| <i>Polytrichum juniperinum</i> | 0.05                                              | 5            | 0.1              | -                                           | -            | -                |
| <i>Hylocomium splendens</i>    | 2.15                                              | 15           | 8.3              | -                                           | -            | -                |
| <i>Cladonia rangiferina</i>    | 1.45                                              | 20           | 6.5              | 0.65                                        | 30           | 3.6              |
| Total cover                    | 82.4                                              |              |                  | 20.85                                       |              |                  |

**Table 2.** Changes in mean cover, frequency and prominence values of understory plant species in the managed *Pinetum vaccinio-myrttilosum* (PV) forest stands.

| Species                         | <i>Pinetum vaccinio-myrttilosum</i> , Mature Forest Stands |              |                  | <i>Pinetum vaccinio-myrttilosum</i> , Clear Cuttings |              |                  |
|---------------------------------|------------------------------------------------------------|--------------|------------------|------------------------------------------------------|--------------|------------------|
|                                 | Cover, %                                                   | Frequency, % | Prominence Value | Cover, %                                             | Frequency, % | Prominence Value |
| Herbs and shrubs                |                                                            |              |                  |                                                      |              |                  |
| <i>Vaccinium myrtillus</i>      | 14                                                         | 90           | 132              | 7.1                                                  | 80           | 64               |
| <i>Vaccinium vitis-idaea</i>    | 2.1                                                        | 40           | 13               | 5.2                                                  | 95           | 51               |
| <i>Festuca ovina</i>            | 2.3                                                        | 40           | 14               | 0.8                                                  | 20           | 4                |
| <i>Calluna vulgaris</i>         | 0.15                                                       | 5            | 0.3              | 0.2                                                  | 10           | 0.6              |
| <i>Lycopodium annotinum</i>     | 0.35                                                       | 5            | 0.8              | -                                                    | -            | -                |
| <i>Goodyera repens</i>          | 0.03                                                       | 5            | 0.1              | -                                                    | -            | -                |
| <i>Melampyrum pratense</i>      | 0.2                                                        | 15           | 0.8              | 0.2                                                  | 10           | 0.5              |
| Total cover                     | 19.13                                                      |              |                  | 13.5                                                 |              |                  |
| Mosses, lichens                 |                                                            |              |                  |                                                      |              |                  |
| <i>Pleurozium schreberi</i>     | 34.2                                                       | 100          | 342              | 26.7                                                 | 95           | 260              |
| <i>Ptilium crista-castrense</i> | 0.15                                                       | 5            | 0.3              | -                                                    | -            | -                |
| <i>Dicranum polysetum</i>       | 37.3                                                       | 95           | 364              | 16.7                                                 | 90           | 158              |
| <i>Polytrichum juniperinum</i>  | 0.15                                                       | 15           | 0.6              | -                                                    | -            | -                |
| <i>Ptilidium ciliare</i>        | 0.05                                                       | 5            | 0.1              | -                                                    | -            | -                |
| <i>Hylocomium splendens</i>     | -                                                          | -            | -                | 9.2                                                  | 30           | 50               |
| <i>Cladonia rangiferina</i>     | 0.83                                                       | 30           | 4.5              | 0.1                                                  | 10           | 0.3              |
| <i>Cladonia arbuscula</i>       | -                                                          | -            | -                | 0.1                                                  | 5            | 0.1              |
| Total cover                     | 72.7                                                       |              |                  | 52.8                                                 |              |                  |

*Pleurozium schreberi* (Wild. Ex Brid.) Mitt. and *Dicranum polysetum* Sw. were the dominant moss species in the mature forest stands. The total moss and lichen cover determined in PV and PVM was 82.4% and 72.7%, respectively. The frequency of vascular plant species ranged from 10% (*Solidago virgaurea* L.) to 40% (*V. vitis-idaea*, *Festuca ovina* L. and *Calluna vulgaris* (L.) Hull.) in the mature PV stand. The average cover of *V. vitis-idaea* was low, whereas its abundance in the separate growths was considerable. The average cover of *V. myrtillus* reached 2.4%. *V. myrtillus* was the most prominent species in PVM with a mean cover of 14% and frequency of 90%. The average cover of all vascular plants ranged from 13.5% (PV) to 19.13% (PVM) in mature stands.

It is important to determine how quickly new species appear in the clear-cut areas. In our study, seven invading species were detected in PV one year after cutting (Table 1). This process was concomitant with the changed cover, the frequency and the prominence values of forest vascular plants, mosses and lichens. Palviainen et al. [3] reported that mosses *Hylocomium splendens* (Hedw.) Scimp. and *Pleurozium schreberi* suffered following clearcutting. This is in accordance with our results.

Clearcutting has led to significant changes in the distribution of species and has affected their significance in the ecosystem. Compared with mature stands, total cover of vascular plants decreased from 13.5% to 4.3% in PV and from 19.1% to 13.5% in PVM. The valuable medicinal plant *Arctostaphylos uva-ursi* (L.) Spreng. was not detected in clear-cut sites, although its average cover in mature forest stands was 1.9% and its frequency reached 15%. It is important to note that new species of herbaceous plants that are not typical of forest ecosystems have emerged a year after cuttings in PV, though the average covering of each has not exceeded 1%. At the same time, the frequency of newly appeared *Spergula arvensis* L., *Rumex acetosella* L., and *Calamagrostis epigejos* (L.) Roth. exceeded 10% (Table 1). Miina et al. (2009) noted that the coverage of *V. myrtillus* also diminished as a result of clearcutting [6]. However, other authors reported an increase in *V. myrtillus* parameters, including percentage cover, shrub height, biomass, etc., following the clearcut [7].

In PVM, rare species *Lycopodium annotinum* L. and *Goodyera repens* (L.) R. Br. completely disappeared from the clear-cut areas (Table 2). The average cover and frequency of *V. vitis-idaea* increased here, and the prominence value of this species changed significantly. All parameters of *V. myrtillus* decreased after clearcutting.

The moss cover was significantly reduced in the cut areas of both forest types. The condition of all moss species was visually assessed as poor. Some moss species, e.g., *Ptilium crista-castrense* (Hedw.) De Not, *Ptilidium ciliare* (L.) Rabenh. and *Polytrichum juniperinum* Hedw. disappeared from clear-cut sites.

We can conclude that clearcutting destroys understory plant populations in Scots pine-dominated forests, however the reaction differs between species.

### 3. Material and Methods

Study plots were located in pine forests in southern Lithuania. The prevalent forest types in this region are *Pinetum vacciniosum* (PV) and *Pinetum vaccinio-myrtillosum* (PVM). The plots, covering 2.0 to 8.0 ha, were selected in the mature forest stands dominated by Scots pine (*P. sylvestris*) of an average age of 110–115 years (Figure 1). The stand volume ranged from 330–340 m<sup>3</sup>. All sites were located on oligotrophic soils of *Vaccinium* type. Common understory vascular plant species in PV include *V. vitis-idaea*, *V. myrtillus*, *Calluna vulgaris*, *Arctostaphylos uva-ursi*, and in PVM *V. vitis-idaea*, *V. myrtillus*, *Festuca ovina*. Mosses are dominant in both forest types, with average cover from 70 to 85%. The most abundant moss species are *Pleurozium schreberi* and *Dicranum polysetum*. Lichens *Cladonia rangiferina* and *C. arbuscula* are also detected in PV. The total cover of vascular plants in the latter is significantly lower (up to 12%) when compared with PVM (from 20% to 45%). The depth of the rather crude forest floor is on average 4 cm, with a pH of 4.4. The layer of mineral soil varies from 0 to 20 cm. PV is distinguished by very infertile soil (humus composes about 1.5–2%), whereas the humus amount in PVM reaches about 3% [8].



**Figure 1.** Mature forest stand (a) and clearcutting (b) plots.

The average cover, the frequency and the prominence of understory plant species were estimated in transects, and a 1 m<sup>2</sup> subplot (the frame with the net of 1 dm<sup>2</sup> square mesh) was used with 30 replications. Each species was described by a visual estimation of an average cover in percent. The species of grasses and dwarf shrubs were estimated separately from mosses and lichens, so the average cover exceeded 100% at some replications. The prominence value (PV) of each species was calculated by the formula  $PV = \sqrt{F \times C}$ . C—the average cover of the selected species, F—frequency (number of subplots in which the particular species was detected divided by the total number of subplots) [9].

#### 4. Conclusions

This study showed the initial effect of forest disturbance on understory vegetation caused by clearcutting. The determination of early changes in cover, frequency and prominence value of mosses and vascular plants is important in order to forecast the development and the natural restoration of the damaged forest habitats, and to propose methods of reforestation.

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