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Changes of Understory Plants Populations after Clear—Cuttings in Scots Pine—Dominated Forests †

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† Presented at the 1st International Electronic Conference on Biological Diversity, Ecology and Evolution, 15–31 March 2021; Available online: https://bdee2021.sciforum.net/.

Abstract: Clear—cuttings cause significant changes in boreal forest ecosystems and have long-term effects on populations of understory plants. The aim of our studies was to determine the impact of clear-cuttings on understory mosses and vascular plants populations after clear-cuttings. The species diversity of particular populations in mature stands before cuttings and after one year was determined. Results of investigations 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 clear—cuttings have been identified also. Assessing the viability of moss populations in mature forest stands and deforested areas showed that moss species are most sensitive to environmental changes after clear—cuttings. These investigations could justify the conservation of sensitive forest plant populations and non-wood forest resources.

Keywords: cutting; forest; plant; population

Citation: Česonienė, L.; Daubaras, R. Changes of Understory Plants Populations after Clear-Cuttings in Scots Pine-Dominated Forests. *Proceedings* **2021**, *68*, x. https://doi.org/10.3390/

Published: date

1. Introduction

Scots pine forests are important wood sources in Lithuania however, they are commonly affected by the intensive anthropogenic activity. As Godefroid et al. reported, tree extraction after clear-cutting is the main cause of the microclimate changes in the forest floor, for instance influencing regeneration of tree seedlings [1]. Changes in soil properties after clear—cuttings affect nutrient uptake and promote appearance of other species in the forest ecosystems including alien plants if an abundant local seed source is present [2]. The effects of clear-cuts can be observed not only in above-ground plant parts but also underground [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. Other authors reported that clear—cuttings destroy roots and rhizomes of forest floor plants and reduce 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 case of this plant there is less information on the impact of forest management on populations [3]. Interestingly, Jalonen and Vanha-Majamaa [5] reported that tree density had negative effects on the development of *V. vitis-idaea*, whereas Rodríguez and Kouki [4] emphasized higher resistance of the species to increased light and drier soil conditions.

Aim of this study was to evaluate the initial changes in the diversity of understory plants species one year after clear—cuttings in Scots pine *Pinus sylvestris* L. dominated forests.

2. Results and Discussion

The largest part of forest floor cover both in *Pinetum vacciniosum* (PV) and *Pinetum vaccinio-myrtillosum* (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	*Pinetum vacciniosum*, Mature Forest Stands			*Pinetum vacciniosum*, Clear Cuttings		
	Cover, %	Frequency, %	Prominence Value	Cover, %	Frequency, %	Prominence Value
Herbs and shrubs						
Vaccinium myrtillus	2.4	20	10.7	0.7	10	2.2
Vaccinium vitis-idaea.	4.3	40	27.2	0.45	10	1.4
Festuca ovina.	1.2	40	7.6	1.15	30	6.3
Calluna vulgaris	3.6	40	22.8	0.4	10	1.3
Solidago virgaaurea	0.1	10	0.3	0.15	5	0.3
Arctostaphyllos uva-ursi	1.9	15	7.4	-	-	-
Spergula arvensis	-	-	-	0.45	25	2.3
Hieracium sp.	-	-	-	0.05	5	0.1
Calamagrostis epigejos	-	-	-	0.35	15	1.4
Rumex acetosa	-	-	-	0.05	5	0.1
Rumex acetosella	-	-	-	0.25	10	0.8
Senecio vulgaris	-	-	-	0.08	10	0.3
Veronica officinalis	-	-	-	0.2	5	0.5
Total cover	**13.5**			**4.3**		
Mosses, lichens						
Pleurozium schreberi	38.75	95	377.7	2.8	70	23.4
Dicranum polysetum	40	100	400	17.4	100	174
Polytrichum juniperinum	0.05	5	0.1	-	-	-
Hylocomium splendens	2.15	15	8.3	-	-	-
Cladonia rangiferina	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 vacciniosum* (PV) forest stands.

Species	*Pinetum vaccinio-myrtillosum*, Mature Forest Stands			*Pinetum vaccinio-myrtillosum*, Clear Cuttings		
	Cover, %	Frequency, %	Prominence Value	Cover, %	Frequency, %	Prominence Value
Herbs and shrubs						
Vaccinium myrtillus	14	90	132	7.1	80	64
Vaccinium vitis-idaea	2.1	40	13	5.2	95	51
Festuca ovina	2.3	40	14	0.8	20	4
Calluna vulgaris	0.15	5	0.3	0.2	10	0.6
Lycopodium annotinum	0.35	5	0.8	-	-	-
Goodyera repens	0.03	5	0.1	-	-	-
Melampyrum pratense	0,2	15	0,8	0.2	10	0.5
Total cover	**19.13**			**13.5**		
Mosses, lichens						
Pleurozium schreberi	34.2	100	342	26.7	95	260
Ptilium crista-castrense	0.15	5	0.3	-	-	-
Dicranum polysetum	37.3	95	364	16.7	90	158

Polytrichum juniperinum	0.15	15	0.6	-	-	-
Ptilidium ciliare	0.05	5	0.1	-	-	-
Hylocomium splendens	-	-	-	9.2	30	50
Cladonia rangiferina	0.83	30	4.5	0.1	10	0.3
Cladonia arbuscula	-	-	-	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 virgaaurea* 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 the 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. Palvianinen et al. [3] reported that mosses *Hylocomium splendens* (Hedw.) Scimp. and *Pleurozium schreberi* suffered from clear-cuts. This is in accordance with our results.

Clear—cuttings have led to significant changes in the distribution of species and 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 *Arctostapyllos uva-ursi* (L.) Spreng. was not detected in clear-cut sites although its average cover in mature forest stand was 1.9% and 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 even an average covering of each had not exceeded 1%. At the same time the frequency of new appeared *Spergula arvensis* L., *Rumex acetosella* L., and *Calamagrostis epigejos* (L.) Roth. exceeded 10% (Table 1). Miina et al. noted that the coverage of *V. myrtillus* diminished as a result of clear—cuttings also [6]. However, other authors reported an increase in *V. myrtillus* parameters, including percentage cover, shrub height, biomass etc. following the clear-cut [7].

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

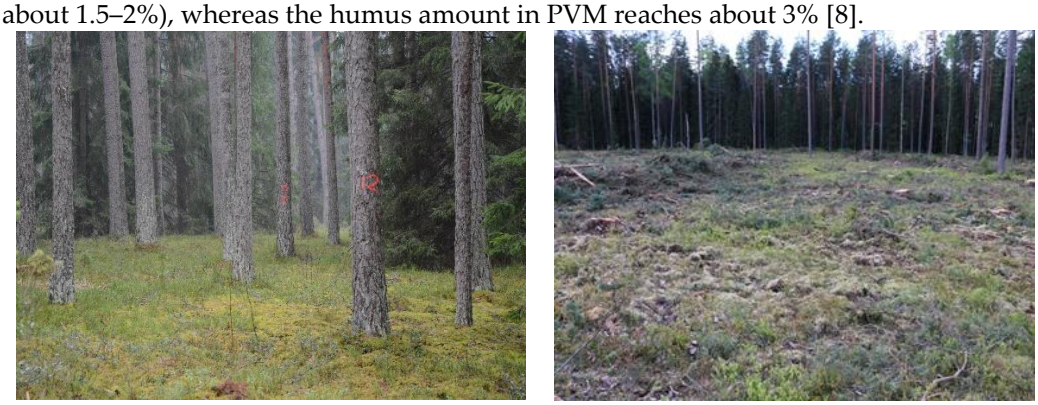
The moss cover was significantly reduced in the cut areas of both forest types. The condition of all moss species was visually assessed as poor. Some moss species e.g., *Ptilium crista-castrense* (Hedw.) De Not, *Ptilidium ciliare* (L.) Rabenh. and *Polytrichum juniperinum* Hedw. disappeared from clear-cut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

We can conclude that clear cuttings destroy understory plant populations in Scots pine dominated forests however reaction of species differs.

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 330–340 m^3. All sites were located on oligotrophic soils of *Vaccinium t*ype. Common understory vascular plant species in PV include *V. vitis-idaea*, *V. myrtillus*, *Calluna vulgaris*, *Arctostaphyllos uva-ursi*, and in PVM*: V. vitis idaea, V. myrtillus, Festuca ovina*.

Mosses are dominant in both forest types with the average cover from 70 to 85%. The most abundant moss species are *Pleurozium shreberi* 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%) if compared with PVM (from 20% to 45%). The depth of rather crude forest floor is on average 4 cm with pH of 4.4. The layer of mineral soil varies from 0 to 20 cm. PV is distinguished by very infertile soil (the humus compose about 1.5–2%), whereas the humus amount in PVM reaches about 3% [8].



(a) **(b)**

Figure 1. Mature forest stand (**a**) and clear-cuttings (**b**) plots.

The average cover, the frequency and the prominence of understory plant species were estimated in transects and 1 m^2 subplot (the frame with the net of 1 dm^2 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 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 clear—cuttings. Determination of early changes in cover, frequency and prominence value of mosses and vascular plants are important to forecast the development and the natural restoration of the damaged forest habitats and to propose methods of reforestation.

Author Contributions: Conceptualization and methodology, R.D.; investigation, L.Č and R.D.; writing—original draft preparation, L.Č. All authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement:

Informed Consent Statement:

Data Availability Statement:

Conflicts of Interest: The authors declare no conflict of interest.

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