Impact of clear-cuttings on the condition of bilberry (*Vaccinium myrtillus* L.) populations

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Clear-cutings cause considerable changes in forest ecosystems including physical and chemical soil conditions and understory vegetation. Forest restoration processes strongly depend on the level of this disturbance. Our aim was to evaluate short-term changes of the diversity of understory plants, of the vitality of *Vaccinium myrtillus* in *Pinus sylvestris* dominated forests after clear-cuttings. The estimation of understory vegetation was accomplished in the forest stands of the forest type *Pinetum vaccinio-myrtillosum*, the vegetative performance of *V. myrtillus* populations were determined in the mature forest stands and clear cutting areas. Our study corroborated significant changes of understory vegetation. The moss cover was reduced in the clear-cuttings areas, and the moss species *Ptilium crista-castrense, Ptilidium ciliaris and Polytrichum juniperinum* were found to be the most susceptible. Investigation of medicinal plant species *V. myrtillus* corroborated different reactions after the first year in clear-cuttings areas. Distribution and abundance of *V. myrtillus* decreased in this forest type. We detected significant changes in above- and underground parts and shrub number of *V. myrtillus* after one year in the clear-cut plots comparing to mature forest stand. There was a general increase in most of studied characters for *V. myrtillus* in clear-cuttings sites.

Clear-cutings, biomas. forest type, understory vegetation

Introduction

The diversity of vascular plant species in the mature Scots pine forest is not large with the dominating species of Ericaceae family. *Vaccinium myrtillus* is the prevalent forest berry plant. Their leaves are valuable medicinal row because of high contents of biologically active substances. These include different phenolic compounds which are distinguish by antioxidant, anticarcinogenic and antimicrobial properties. Phenolic compounds found in *V. myrtillus* are carbon-based substances and may fulfil defensive functions in their resistance to herbivores and parasites also (Witzell et al. 2013; Haukioja, 2005).

Since pine forests are an important wood sources, they are commonly affected by the intensive economic activity causing significant changes in the ecosystem. Tree extraction, generally performed as clear-cutting of large forest areas in plantation forests, is the main driver of the microclimate changes in the forest floor, for instance influencing regeneration of tree seedlings (Godefroid et al. 2005; Roberts and Zhu 2002). Clear-cuttings actions destroy rhizomes of forest floor plants and thereby lowers the shrub cover, reduces competitive abilities of Ericaceae plants with nitrophilous plant species. Changes of the microclimate and soil properties after clear-cuts affect also nutrient uptake and promote appearance of other species in the forest ecosystems. It was estimated that wood harvesting disturbance can make ecosystems in thinned stands more susceptible to invasion by alien plants if an abundant local seed source is present (Davis and Puettmann 2009).

The contradictory results are published about *V. myrtillus* growth in the clear-cutting areas. Some authors presented that ground cover of *V. myrtillus* was higher in the uncut forests than in clear-cuttings (Atlegrim and Sjö berg 1996). However, positive influence of clear-cutting were estimated in the other studies (Nielsen et al 2007; Nybakken et al., 2013).

Our goals were to evaluate the initial changes of the diversity of understory plants species and the vitality of *V. myrtillus* after clear-cuttings in the forest type *Pinetum vaccinio-myrtillosum.*

Materials and methods

The study plots were located in the boreal forests in Southern Lithuania. Plots were selected in the mature forest stands with dominated Scots pine (*Pinus sylvestris*). The plots, covering 2from .4 to 7.1 ha, were selected in the mature forest stands on average age of 115-130 years. The stand volume ranged 330-335 m^3. All sites were located on oligotrophic soils of *Vaccinium t*ype. The depth of rather crude forest floor is on average 2-4 cm with pH of 4.4. The upper layer of mineral soil varies from 0 to 20 cm (Navasaitis et al. 2003). One year before sampling, part of each plot was clear cutted with tree stems, roots and branches removed. Our sampling was therefore conducted at clear-cuttings subplots with control samples taken at intact (mature) forest sites.

The commonly vascular plant species in the forest type *Pinetum vaccinio-myrtillosum* are *V. vitis idaea, V. myrtillus, Festuca ovina,* and *Calluna vulgaris*. Mosses are dominant in this forest type with the total coverage from 70 to 85%. The most abundant moss species are *Pleurozium shreberi* and *Dicranum polysetum*. Lichenes *Cladonia sp.* are detected in this forest type also. The total cover of vascular plants is from 20% to 40%.

The average cover, the frequency and the prominence of understory plant species were estimated in transects and $1m^2$ 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.

By the estimation of *V. myrtillus* populations total number of shrubs, fresh weight of above-ground part and rhizomes, total length of rhizomes were determined in the subplots of 1 m^2. The average weight of one shrub as well as the average amount of shrubs per 1 m length of rhizomes were calculated.

Statistical data analysis using MATLAB v8.2 software was performed on data representing vegetative characteristics of *V. myrtillus* collected in mature forest

stands and clear-cut areas. Statistical data mining included descriptive statistics analysis, hypotheses testing, and k-means clustering technique. Before the clustering analysis principal component analysis (PCA) was carried out not only to reduce number of variables and to obtain orthogonal principal components representing variance of the initial data in decreasing order, but also to have availability to represent data scatter plots after clustering analysis in the principal component space. The number of significant principal components was chosen according to Cattell's scree plot test. Then k-means clustering analysis (KMCA) followed to cluster the data to groups.

Results

V. myrtillus was the most prominent species in the mature stands of forest type *Pinetum vaccinio-myrtillosum* with the mean cover of 14% and considerable frequency of 90% (Fig. 1). The average cover of all vascular plants was 19.1%. The largest part of forest floor cover was comprised from moos species *Pleurozium schreberi* and *Dicranum polysetum.* The total moss cover determined in *Pinetum vaccinio-myrtillosum* forest types comprised 72.7%.

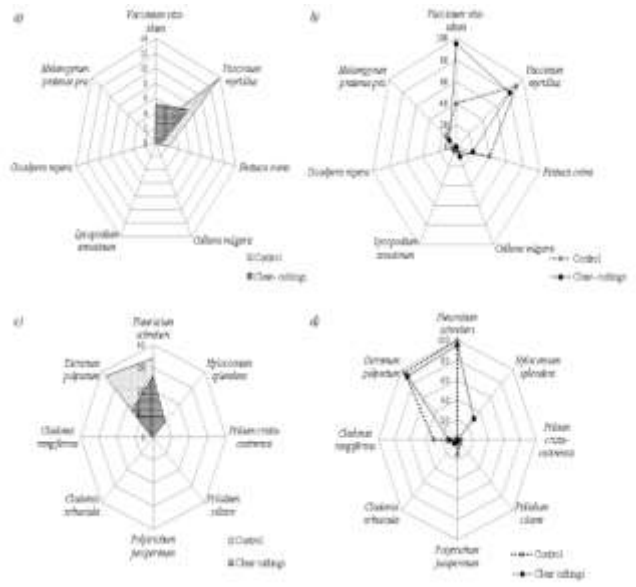

Fig. 1. The average cover and frequency of understory vegetation in the forest type *Pinetum vaccinio-myrtillosum*: *a* – the average cover of vascular plants, %; *b* - the frequency of vascular plants, %; *c* - the average cover of mosses and lichens, %; *d* - the frequency of mosses and lichens, %

1 pav.. *Gyvosios dirvožemio dangos augalų vidutinis projekcinis padengimas ir dažnumasmiško tipas Pinetum vaccinio-myrtillosum: a-induočių augalų projekcinis padengimas, %; b-induočių augalų dažnumas, %; c- samanų projekcinis padengimas, %; d-samanų dažnumas,%*

Large changes in the species abundance were determined in the first year after clear-cuttings. Compared with the mature stand, total cover of vascular plants decreased from 19.1% to 13.5% in in the clear-cuttings of *Pinetum vaccinio-myrtillosum*. The average cover of *V. myrtillus* was reduced till 7.1%. Assessing changes in the forest type *Pinetum vaccinio-myrtillosum* it was found that *Lycopodium annotinum* and *Goodyera repens* were completely disappeared in the cutting areas. Nevertheless, an average cover and frequency of *V. vitis-idaea* increased and prominence value of this species changed significantly from 13 to 51.

By evaluation of viability of *V. myrtillus* populations after clear-cuttings it is important to compare vegetative characteristics of shrubs both in the mature stands and clear-cuttings area in *Pinetum vaccinio-myrtillosum* forest type.

It can be supposed that this rhizomatous plant spreading from the underground parts could survive after forest disturbance. Nevertheless, *V. myrtillus* populations were affected by growth site in the investigated forest types. The Euclidean distance between centroids of the clusters could help to reveal the closeness of the clusters. The calculated distances were 2.25 for *V. myrtillus* in *Pinetum vaccinio-myrtillosum*. The overlapping (misclustering) percentage showed the impact of data scatter on clustering. The misclustering rate percentage for *V. myrtillus* was 11.5%.

The analysis showed that there are significant changes in weight of above- and underground biomass, length of rhizomes, amount of shrubs/m^2 , average weight of a shrub in the clear-cut sites comparing to the mature forest stands (Fig. 2).

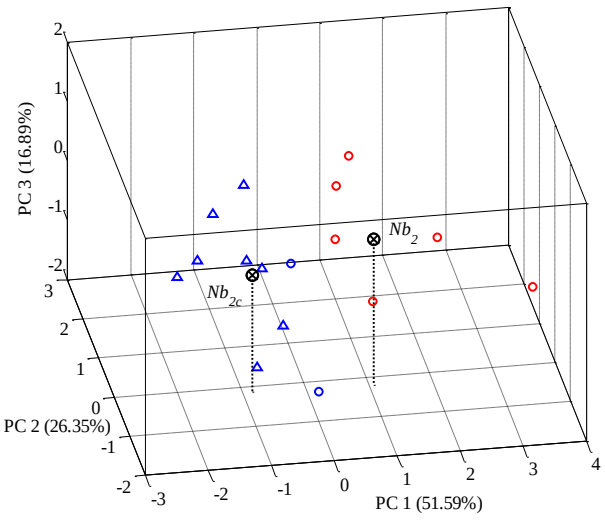

Fig. 2. Results of KMC analysis of *Pinetum vaccinio- myrtillosum* mature forest stands and clear-cuttings area: triangles - mature forest stand, circles -cutting area

2 pav. *KMCA duomenų sklaida, klasifikuojant brandaus medyno ir plyno kirtimo mėlynės populiacijos charakteristikas (mėlyna – I grupė, raudona - II grupė; trikampiai – brandus miškas, apskritimai – plynieji kirtimai*

We can summarize that *Vaccinium myrtillus* population showed statistically reliable dependency on forest disturbance in *Pinetum vaccinio-myrtillosum* forest types.

Discussion

In our study domination of understory vascular plants in *Pinetum vaccinio-myrtillosum* forest type was expressed by 3-7 species. Even mosses were distinguished by

exceptionally high prominence in the mature forests. Investigations of distribution and abundance of non-timber forest plant species *V. myrtillus* revealed negative reaction after the first year in clear-cut areas. Mean cover, frequency and prominence value of *V. myrtillus* decreased. This process was concomitant with the changed cover, the frequency and the prominence values of common vascular plants, mosses and lichens.

Nevertheless, our investigations corroborated increasing of *V. myrtillus* under- and aboveground biomass, number of shrubs per metre length of rhizome, number of shrubs/m^2 one year after clear-cuttings in the forest type *Pinetum vaccinio-myrtillosum*. These dwarf shrubs accumulate carbon and nutrients reserves in the old shrubs and underground parts and it is reason for resistance to physical damages (Pakonen et al., 1991; Salemaa et al., 1999). Other authors reported the increase of *V. myrtillus* measures including percentage cover, shrub height, biomass etc. after clear-cuttings also (Nielsen et al., 2007; Nybakken et al., 2013).

Notwithstanding the decrease of biomass of *V. myrtillus* during the first seven years after clear-cuttings was determined by Palviainen et al.,(2005). *V. myrtillus* species is growing by shrubs from the underground rhizomes so investigation of development of its population will be continue.

Conclusions

1. Our focal plant *V. myrtillus* is able to survive after clear-cut damages because of developed rhizomes. Nevertheless, mean cover of *V. myrtillus* decreased from 14% to 7.1%. Frequency and prominence values were lower in the clear-cuttings area also.

2. The moss cover was significantly reduced in the cutted areas. The condition of all moss species was visually assessed as poor. The species *Lycopodium annotinum* and *Goodyera repens* completely disappeared after clear-cuttings.

3. Statistical analysis revealed that there are significant changes in vegetative characteristics of *V. myrtillus* after a year in clear-cut sites comparing to the mature forest stands.

4. Evaluation of short-term effect of clear-cuts on understory plants is important to predict the subsequent development of forest ecosystem.

Acknowledgments

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Plynųjų kirtimų poveikio mėlynės (*Vaccinium myrtillus* L.) populiacijų būklei tyrimai

Santrauka

Plynieji kirtimai sukelia didelius miško ekosistemų pasikeitimus. Laba staigiai pakitę apšvietimo ir temperatūros sąlygos veikia dirvožemio cheminę sudėtį, entomofaunos ir gyvosios dirvožemio dangos rūšinę įvairovę. Miško atsistatymo procesas taip pat priklauso nuo kirtimų metu padarytų mechaninių pažeidimų, surenkant kirtimų atliekas. Todėl plynųjų kirtimų poveikio įvaireiems miško ekosistemos komponentams yra svarbūs, numatant miško atkūrimo kirtavietėse ypatumus. Mūsų tikslas buvo nustatyti gyvosios dirvožemio dangos rūšių įvairovės ir mėlynės *Vaccinium myrtillus* populiacijų reakciją pirmaisiais metais po plynųjų kirtimų *Pinetum vaccinio-myrtillosum* miško tipo kirtavietėsee. Gyvosios dirvožemio dangos induočių augalų ir samanų įvairovė buvo nustatyta brandžiuose medynuose ir greta esančiose plynose kirtavietėse. Mėlynės krūmokšnių antžeminės ir požeminės masės svoris, šakniastiebių ilgis, krūmokšnių skaičius, krūmokšnių aukštis tai pat buvo vertinami ir brandžiuose medynuose ir kirtavietės. Tyrimų rezultatai patvirtino, kad jau pirmaisiais metais išryškėja statistiškai patikimi gyvosios dirvožemio dangos augalų projekcinio padengimo ir dažnumo pokyčiai tarp kirtavietės ir brandaus medyno. Ypač blogėjo samanų būklė, o samanų rūšys *Ptilium crista-castrense, Ptilidium ciliaris ir Polytrichum juniperinum* išskirtos kaip labai jautrios. Šios rūšys kirtavietėse išnyko. Mėlynės populiacijos pirmųjų metų kirtavietėse išlieka, nes šis augalas suformuoja itin stiprią požeminę dalį, kurioje sukaupia maisto medžiagų atsargas. Tačiau mėlynės projekcinis padengimas ir dažnumas tirtose *Pinetum vaccinio-myrtillosum* kirtavietėse sumažėjo. Kirtavietėse ir brandžiuose medynuose nustatyti statistiškai patikimi skirtumai požeminės ir antžeminės masės, šakniastiebių ilgio ir krūmokšnių skaičiaus atžvilgiu. Taigi, pirmaisiais metais po kirtimo pagrindiniai mėlynės vegetatyvinės dalies rodikliai padidėjo.

Plynieji kirtimai, biomasė, miško tipas, gyvosios dirvožemio dangos augalai

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