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DEVELOPMENT OF GROUND VEGETATION FOLLOWING SHELTERWOOD CUTTINGS IN PINE FORESTS, LITHUANIA

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The aim of study was to assess the development of ground vegetation and regeneration in pine forests on sand soil after shelterwood cuttings. The study was carried out in eastern part of Lithuania. We selected pine stands in which shelterwood cuttings were applied within 2004 and 2009. We located plots in the each shelterwood cutting of different year (1, 2, 3, 4 and 5 years). The size of plot was 100 m^2 (10x10 m). All mosses, lichens, herbaceous vegetation and dwarf shrubs were recorded and projection cover was assessed. Seedlings and saplings were counted in twenty 1x1 m subplots. Average species number of ground vegetation in control stands was significantly lower than in shelterwood cuttings. The most abundant herbaceous species in control stands were *Vaccinium myrtillus* L. and *Vaccinium vitis-idaea* L. In shelterwood cuttings the light demanding species such as *Calamagrostis arundinacea* L., *Chamerion angustifolium* L., *Pteridium aquilinum* L., and *Agrostis capilaris* L. prevailed. Projection cover of ground vegetation decreased after shelterwood cuttings at once due to mechanical disturbance. Later total projection cover of herbaceous vegetation increased due to changed environmental conditions. The most intensive regeneration Scots pine was in 2-3 years old shelterwood cuttings; while Silver Birch had the most intensive regeneration in 4-5 years old shelterwood cuttings.

Key words: Undergrowth, herbaceous plants, shelterwood cutting, pine forests.

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INTRODUCTION

Scots pine (*Pinus sylvestris* L.) is the most abundant tree species in the Lithuania. Scots pine is spread across a large range of habitats, but most abundant on poor soils from dry sands to raised bogs. Pine forests cover 725.5 thousands ha in Lithuania (Lithuanian forests‘ statistics... 2010). The major part of pine forests occurs in south eastern part of Lithuania.

Following sustainable forestry principles shelterwood cuttings in pine forests became widely used in a recent decade (Juodvalkis 2008, Riepsas 2008). Shelterwood cuttings similar to clear cuttings cause a change of microclimatic conditions under the forest canopy. After cuttings the radiation, temperature increase and humidity decreases under a canopy (Mitchell & Kirby 1989, James et al. 1994, Ryyppo et al. 1998, Langvall & Orlander 2001).

Ground vegetation changes a lot following cuttings Kuuluvainen & Juntunen 1998, Nilssonet et al. 2000, Valkonen et al. 2002). Regeneration of tree species depends on microklimatic factors and a competition for space, nutrient and light. Herbaceous vegetation can increase mortality of saplings (Dolling 1996) and create a special micro-environment (Steijlen et al. 1995, Zackrisson et al. 1995). There are a lot of studies on clear cutting's effect on vegetation change and following tree species regeneration. Less attention was paid on ground vegetation and regeneration after shelterwood cuttings.

The aim of the study was to assess a development of ground vegetation and regeneration of pine species in pine forests on sand soil after shelterwood cuttings.

MATERIAL AND METHOD

The study was carried out in an eastern part of Lithuania in the forests of Svencioneliai forest state enterprise. The pine forest on dry poor fertility soil sites prevail. We selected pine stands in which shelterwood cuttings were applied within 2004 and 2009. The density of the stands after cutting was 30%. Pine stands close to shelterwood cuttings on the similar soils were chosen as control. We located 2-5 plots (selected according dominant sinusia in the cutting) in the each shelterwood cutting of different year (1, 2, 3, 4 and 5 years respectively). 36 plots were located in total (5-7 in each year cutting and control). The size of plot was 100 m^2 (10x10 m). All mosses, lichens, herbaceous vegetation and dwarf shrubs were recorded and projection cover was estimated.

Seedlings and saplings in the plots were counted in twenty 1x1 m subplots arranged in a transect. The species names were recorded and amount counted.

The mean and standard error was counted for the analyses using MS EXCEL software. The t-test was applied to test significance of the difference between parameter.

RESULTS AND DISSCUSSION

We found 11 species in average per one m^2 in ground vegetation in control stands and from 14 to 16 species in average in the shelterwood cuttings. Average species number of ground vegetation in control stands was significantly lower than in shelterwood cuttings (Fig. 1). Other studies found that richness of species increases in non-clear cuttings within several first years (Gilliam et al. 1995, Halpern & Spies 1995). Our data showed no significant increase of species number after the first 5 years after shelterwood cuttings.

43 herbaceous species, 6 moss and 2 lichen species were found in total (1 table). The most abundant herbaceous species in control stands were *Vaccinium myrtillus* L. and *Vaccinium vitis-idaea* L. Less abundant there were *Calluna vulgaris L.*, *Melampyrum pratense* L. and *Festuca ovina* L. These species did not totally disappear after shelterwood cuttings but their projection cover decreased. In shelterwood cuttings light demanding species such as *Calamagrostis arundinacea L.*, *Chamerion angustifolium L.*, *Pteridium aquilinum* L., and *Agrostis capilaris L.* have spread. *Pteridium aquilinum* L., *Solidago virgaurea* L., *Peucedanum oreoselinum L.*, *Galeopsis sp.* were found only in 1-3 years old cuttings and were absent in 4-5 years old cuttings.

Pleurozium schreberi Brid. had the highest projection cover in control stands. *Hylocomium splendens* Hedw.), *Dicranum polysetum* Sw. and *Ptilium crista-castrensis* Hedw. were less abundant. Average projection cover of *Pleurozium schreberi Brid.* in shelterwood cuttings was twice lower than in control stands.

Fig.1. Number of herbaceous species after shelterwood cuttings (0 - control). Values are given as mean ± SE.

Table 2. Average projection cover (mean±SE %) of ground vegetation after shelterwood cuttings of different years

Name of species	Control	Years after shelterwood cutting				
		1	2	3	4	5
Vaccinium myrtillus	22.502±5.12	7.600±2.66	11.222±2.26	7.333±2.01	6.000±0.91	2.750±0.86
Vaccinium vitis-idaea	22.500±4.79	2.802±1.88	6.000±2.16	8.334±2.07	8.250±1.80	5.500±1.10
Calluna vulgaris	4.002±1.44	0.202±0.20	0.891±0.54	1.003±0.55	2.125±0.64	4.625±1.02
Melampyrum pratense	3.167±1.51	1.204±0.97	0.228±0.15	0.450±0.34	1.380±0.80	0.006±0.00
Calamagrostis arundinacea	0.337±0.21	2.202±1.96	3.558±1.82	14.444±7.66	12.375±5.28	16.375±3.53
Festuca ovina	2.168±1.25	0.002±0.00	0.338±0.33	0.671±0.55	1.453±0.16	1.254±0.82
Chamerion angustifolium	-	0.002±0.00	0.004±0.00	0.008±0.00	0.255±0.16	0.005±0.00
Rumex acetosella	-	-	0.226±0.22	0.558±0.34	0.255±0.16	0.630±0.37
Senecio vulgaris	-	-	0.006±0.00	0.117±0.11	0.008±0.00	0.005±0.00
Luzula pilosa		0.006±0.00	0.007±0.00	0.007±0.00	0.626±0.62	0.003±0.00
Calamagrostis epigeios	0.002±0.00	0.202±0.20	0.224±0.15	2.444±2.20	1.375±0.71	0.626±0.62
Carex ericetorum	-	0.002±0.00	-	0.002±0.00	0.006±0.00	0.005±0.00
Convallaria majalis	-	0.006±0.00	0.558±0.56	0.001±0.00	0.001±0.00	1.251±0.82
Trientalis europaea	0.003±0.00	0.002±0.00	0.002±0.00	0.003±0.00	0.001±0.00	-
Agrostis capillaris	-	0.002±0.00	0.002±0.00	0.112±0.11	0.125±0.13	0.003±0.00
Pteridium aquilinum	-	1.400±0.98	3.890±1.62	1.111±1.11	-	-
Rubus idaeus	-	-	0.556±0.56	0.226±0.15	0.376±0.37	
Hypochaeris radicata	-	-	-	0.003±0.00	0.004±0.00	0.001±0.00
Rubus saxatilis	-	2.002±2.00	0.002±0.00	0.556±0.56	-	0.003±0.00
Peucedanum oreoselinum	-	0.602±0.00	0.002±0.00	0.112±0.00	-	-
Arctostaphylos uva-ursi	-		0.001±0.00	0.002±0.00	0.125±0.13	0.376±0.37
Solidago virgaurea	-	0.004±0.00	0.001±0.00	0.002±0.00	0.001±0.00	-
Fragaria vesca	-	0.002±0.00	0.001±0.00	-	1.000±1.00	0.003±0.00
Anthoxanthum odoratum	-	0.002±0.00	0.002±0.00	-	-	0.001±0.00
Veronica officinalis	-	0.002±0.00	-	0.002±0.00	-	0.001±0.00
Galeopsis sp.	-	0.002±0.00	0.001±0.00	0.001±0.00	-	-
Mycelis muralis	-	-	0.001±0.00	0.001±0.00	-	0.001±0.00
Potentilla erecta	-	0.002±0.00	-	0.001±0.00	-	0.001±0.00
Chelidonium majus	-	0.002±0.00	-	-	0.001±0.00	-
Clinopodium vulgare	-	0.002±0.00	-	0.001±0.00	-	-
Campanula sp.	-	0.002±0.00	-	-	-	-
Carex digitata	-	0.002±0.00	-	-	-	-
Diphasiastrum complanatum	-	0.002±0.00	-	-	-	-
Galium mollugo	-	1.000±0.00	-	-	-	-
Hypericum perforatum	-	-	-	0.001±0.00	-	-
Knautia arvensis	0.002±0.00	-	-	-	-	-
Lathyrus sylvestris	-	-	-	0.001±0.00	-	-
Lycopodium clavatum	-	0.002±0.00	-	-	-	-
Maianthemum bifolium	-	-	-	0.001±0.00	-	-
Polygonatum odoratum.	-	-	-	-	-	0.001±0.00
Taraxacum officinale	-	0.002±0.00	-	-	-	-
Trifolium alpestre	-	0.002±0.00	-	-	-	-
Pleurozium schreberi	55.000±5.63	23.000±4.36	17.222±2.06	17.222±3.83	31.875±4.90	23.750±6.65
Hylocomium splendens	20.833±6.51	21.000±5.10	13.444±2.43	4.889±1.15	6.875±1.62	4.125±2.40
Dicranum polysetum	4.500±1.36	2.200±1.96	3.446±1.14	5.111±1.83	6.375±1.16	4.876±1.35
Ptilium crista-castrensis	5.000±1.83	-	1.222±0.72	1.222±0.72	2.000±0.89	0.126±0.12
Polytrichum juniperinum	-	-	-	-	0.626±0.62	0.505±0.19
Cladonia rangiferina	0.333±0.21	0.200±0.20	-	0.667±0.55	0.001±0.00	-
Cladonia arbuscula	-	1.000±1.00	0.001±0.00	0.112±0.11	-	0.001±0.00
Dicranum scoparium	-	-	0.001±0.00	0.556±0.56	-	0.001±0.00

Fig.2. Projection of herbaceous vegetation after shelterwood cuttings (0 - control). Values are given as mean ± SE.

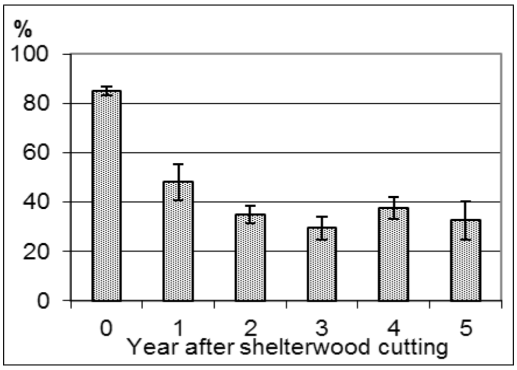

Fig.3. Projection of moss layer after shelterwood cuttings (0 - control). Values are given as mean ± SE.

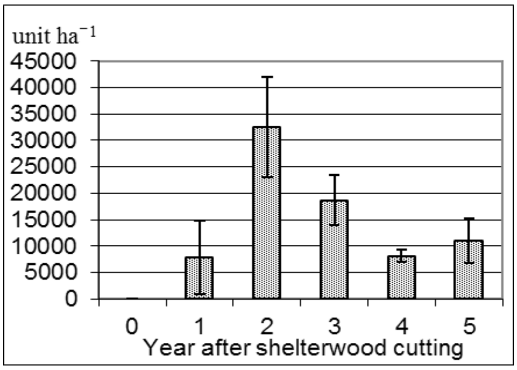

Fig.4. Amount of Scots Pine (Pinus sylvestris) seedlings after shelterwood cuttings (0 - control). Values are given as mean ± SE.

Fig.5. Amount of Silver Birch (Betula pendula) seedlings after shelterwood cuttings (0 - control). Values are given as mean ± SE.

Other studies found similar changes of ground vegetation after different cuttings (Bailey et al. 1998, Tomas et al. 1999, Battles et al. 2001). Studies in clear cuttings (Karazija 1988) showed that *Vaccinium myrtillus* L. and *Vaccinium vitis-idaea* L. changes in the same manner as in shelterwood cuttings.

The highest average projection cover of herbaceous vegetation was recorded in control stands (49.2%). In shelterwood cuttings average projection cover of herbaceous vegetation ranged from 18.0 to 34.4%. As age of shelterwood cuttings increased, the projection cover of herbaceous vegetation increased as well up to three years old cuttings (Fig. 2).

Projection cover of herbaceous vegetation decreased after shelterwood cuttings at once due to mechanical disturbance. Later total projection cover of herbaceous vegetation increased due to changed environmental conditions: temperature, light and precipitation. Projection cover of shade species which are common for stand tends to decrease while light demanding species tends to increase.

The highest projection cover of moss layer was also in control stands (85.0%), while in shelterwood cuttings projection cover ranged from 48.0 to 29.4%. Moss layer decreased sharply the first year after shelterwood cuttings (Fig. 3).

Projection cover of moss layer as well as herbaceous vegetation first year after cuttings decreased due to mechanical disturbance; and later due change of environmental conditions.

Regeneration of Scots pine (*Pinus sylvestris L.*) started within first year after shelterwood cuttings. The highest amount of one year seedlings was found in the second year after shelterwood cuttings. As time passed after shelterwood cuttings, amount of one year seedlings decreased (Fig. 4).

Regeneration of Silver birch (*Betula pendula* Roth.) started one year later. Number of seedlings was highest within 4-5 years after shleterwood cuttings, thus two years later than the number of pine seedlings (Fig. 5).

The most intensive regeneration of Scots pine was in 2-3 years old shelterwood cuttings; while Silver Birch had the most intensive regeneration in 4-5 years old shelterwood cuttings. It means, that the most favourable conditions for germination of pine seedlings appear in the first two-three years after cuttings. Such favourable conditions may appear from decreased projection cover of herbaceous vegetation and low abundance of Silver Birch that did not make competition.

It is particularly important that sufficient amount of seeds (seminal year) would be present during this period and therefore it is necessary to combine cuttings with seminal year (Gabrilavicius et al. 2009).

CONCLUSIONS

Average species number of ground vegetation per 1 m^2 in control stands was significantly lower than in shelterwood cuttings. The most abundant herbaceous species in control stands were *Vaccinium myrtillus* L. and *Vaccinium vitis-idaea* L. In shelterwood cuttings the light demanding species such as *Calamagrostis arundinacea L.*, *Chamerion angustifolium L., Pteridium aquilinum* L., and *Agrostis capilaris L.* prevailed.

Projection cover of ground vegetation decreased after shelterwood cuttings at once due to mechanical disturbance. Later total projection cover of herbaceous vegetation increased due to changed environmental conditions.

The most intensive regeneration Scots pine was in 2-3 years old shelterwood cuttings; while Silver Birch had the most intensive regeneration in 4-5 years old shelterwood cuttings.

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