Age-related Dynamics of Pine Forest Communities in Lithuania

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Investigations of the structure of pine communities of different age were carried out in order to ascertain permanency of indicators of site conditions' and regularities of regeneration. Mostly the pine stands of dry sites - *Vacciniosa* and *Vaccinio-myrtillosa* types - were investigated.

Communities of older cutting areas and young forming stands distinguish themselves by the greatest species variety and the thickest cover of grass-semishrubs. Species composition is the poorest in thick young stands and middle-aged stands. Nevertheless moss cover in stands at this stage is rather thick. Therefore differences in phytocoenotical structure among different stages of pine stands' development are expressed less than in spruce stands. Undergrowth composition in pine stands depends on stands' age.

The communities of analyzed types of pine stands are rather similar according to species composition but they differ in stands' productivity. They can be indicated according to the differences in phytocoenotical structure and plants-determinants a part of which are characteristic of certain stages of stand development, while others are not so common though more permanent.

Ecological conditions in the course of pine stands age change a little.

Pine underwood is quite abundant in pine stands of *Vacciniosa* type. Therefore stand of different age structure can form naturally. Spruce underwood prevails in *Vaccinio-myrtillosa* type pine stands; therefore, regeneration of pine stands here is related to phenomena of a catastrophic type.

Key words: pine stands, ground cover vegetation, undergrowth, underwood, phytoindication, age-related dynamics, biodiversity.

Introduction

The importance of research of forest communities age dynamics was discussed thoroughly in the report on spruce stands' age dynamics (Karazija 2002). This work is important in order to determine species indicating site conditions, to ascertain regularities of biodiversity changes during natural forest development and processes of regeneration.

In the course of forest communities age changes a number of investigations was carried out in spruce stands (Siren 1955, Dyrenkov *et al.* 1970, Kairiūkštis 1973, Leibundgut 1978, Vaitiekus, Karazija 1986, Georgijevskij 1992, Kuuluvainen *et al.* 1998 *etc.*), beech stands (Jensenn, Hofmann 1996; Roder *et al.* 1996, *etc.*). Pine stands were investigated less (Jaroshewich 1970, Brakenhielm *et al.* 1980, Andrzejczyk, Brzeziecki 1995, Kuvajev *et al.* 1995, Romanova 1996). The reason for this might be that pine forests are not the dominating stands in most of European countries. Pine stands are most widespread stands in Lithuanian forests. They occupy 37% of the total forest area. Nevertheless, investigations of this kind were not carried out.

The aim of investigations, the results of which are presented in this paper was to determine changes in the vegetation species composition of lower layers of pine communities in the course of stands' aging in order to ascertain permanency of forest type indicators, possibilities for changes of ecological conditions and regularities of regeneration. As far as pure pine forests and pine forests with a little admixture have been investigated a change in stands' composition has not been analysed.

Material and methods

Investigations have been conducted on pine forests of two types – *Vacciniosa* and *Vaccinio-myrtillosa* mostly - on mineral soils that are in stands on comparatively dry sites. Data of 242 temporary and 4 permanent observation plots were used.

Permanent plots have been delineated in cutting areas in which young pine forests formed later. These plots have been under observation for 10-25 years and inspected regularly every 3-5 years. Registration and cartography of all layers of vegetation has been performed.

Temporary plots have been chosen in stands of different age. When choosing objects for investigation priority was conferred on forests where stand plots (areas) of different age but the same forest type, were found at small distances. Stand age of the plot investigated has been determined by 3-5 borings with the aid of an age borer, the height of 5-9 dominating trees has been measured with a highmeter. Other inventory indices (tree diameter, sum of stand's cross-sections, volume) have been obtained measuring trees in temporary round-plots (Juknys *et al.* 1982).

Vegetation composition and structure of lower layers have been investigated by the methods acknowledged in geobotany and forest science (Sukachev, Zon 1961, Braun-Blanquet 1964, Vorobyev 1967, Martinov 1992) with certain changes (Karazija 1978, 1988). Undergrowth and underwood have been described in transects 2 m wide or in the squares of 4 m^2 distributed systemically, total area of which in every plot investigated was not less than 100 m^2. The amount of different species of undergrowth according to height groups has been determined as well as abundance of different species according to the Braun-Blanquet scale. Underwood has been grouped according to tree species, their age and vitality. Tally of herb and moss cover has been carried out by the method of microsquares (1 m^2), by singling out 20-25 of them in one observation plot. In these squares species composition and project cover of different species have been determined.

Analysing changes in communities composition the data within forest type were grouped according to age periods, the span of which increased with increasing stand age, as changes are most rapid in the phase of stand formation (Karazija 1988). Ecological conditions in communities' sites and their changes were evaluated with the help of H. Ellenberg (1950, 1991) indices of plants' ecological values taking into account abundances of species and L. Ramenskij (1953, 1956) comparative ecological tables of plants.

Results

The change in ground cover vegetation.

In the course of aging the cover of herb-semishrub and moss-lichen in pine stands as well as in spruce stands change from both points of view – quantitative and qualitative.

Indices of phytocoenotical structure of ground cover vegetation in pine communities of different age indicating its change in the course of stand aging are presented in Table 1. It can be seen clearly that the greatest total number of species of herbal plants and semishrubs, especially in *Vacciniosa* type pine stands, is found in stand communities aged 26-50 years, that is thicket (pole stand) age, when the projection cover of these plants is least. Although community's phytocoenotical structure characteristic of mature stand starts forming at that time and species having prevailed in cutting areas are not extinct completely yet, the reason for this ostensible biodiversity is different – great number of descriptions (plots), as the peculiarities (in-

Table 1. Indices of the phytocoenotical structure of pine forest ground cover vegetation in the communities of different pine age

Index	Stand's age, years												
	1	2-5	6-10	-	16-25	26-35	36-45	46-55	56-65	66-75	76-85	86-100	100-120
	Vacciniosa type pine stand												
Number of plots	3	4	4	-	6	18	26	9	3	10	5	8	6
General number of herb-semishrub species	17	22	28	-	25	35	36	25	21	34	26	35	33
Number of light demanding species	6	10	9	-	6	6	6	5	4	7	4	7	6
Average number of herb-semishrub species in the plot	9.5±0.3	12.0±0.1	13.5±1.6	-	7.5± 0.6	6.3±0.6	7.2±0.3	6.9±0.6	7.7±1.1	8.2±0.7	8.4±0.8	9.9±1.5	10.0±0.7
Average projection cover of herb-semishrub, %	6±2	32±7	48±5	-	14±3	12±2	18±1	21±3	25±3	25±2	21±2	21±3	22±3
General number of moss-lichen species	8	12	19	-	15	12	16	9	9	14	12	13	13
Average number of moss-lichen species in the plot	6±0.7	5.3±0.6	7.8±1.1	-	5.3±0.8	3.8±0.3	3.9±0.4	3.8±0.5	4.0±0.9	5.0±0.7	5.8±0.7	5.5±0.7	6.8±0.6
Average projection cover of moss-lichen, %	56±3	26±3	33±4	-	76±5	90±2	91±91	90±3	94±2	85±3	80±4	81±3	76±4

Table 1 continued

Index	Stand's age, years														
	1	2-5	6-10	11-15	16-25	26-35	36-45	46-55	56-65	66-75	76-85	86-100	101-120	121-140	141 &>
Vaccinio-myrtillosa pine stand															
Number of plots	3	5	6	4	6	13	19	15	10	8	20	6	10	4	5
General number of herb-semishrub species	17	38	48	32	29	45	61	43	51	36	58	36	46	42	35
Number of light demanding species	4	12	12	7	5	6	6	4	4	4	7	5	5	4	3
Average number of herb-semishrub species in the plot	10± 2.1	18± 4.4	20.3± 2.8	15.6± 4.0	8.8± 2.2	9.6± 0.8	10.1± 0.7	9.7± 0.6	12.9± 2.2	10.1± 2.4	12.4± 1.5	12.3± 1.9	12± 2.7	14± 2.6	10± 1.3
Average projection cover of herb-semishrub,%	6±2	44±6	60±4	66±5	28±5	25±4	30±2	34±2	35±2	30±3	44±1	46±3	39±4	48±3	27±4
General number of moss-lichen species	4	10	14	14	12	16	17	13	16	14	19	13	19	12	12
Average number of moss-lichen species in the plot	3.5± 0.4	4± 0.4	6.9± 1.0	6.7± 1.0	3.6± 0.8	3.2± 0.4	4.1± 0.4	4.2± 0.4	4.9± 0.5	5.5± 0.7	4.7± 0.8	5.3± 0.3	6.5± 0.8	4.8± 0.4	5.8± 0.6
Average projection cover of moss-lichen, %	27±5	12±2	35±2	60±3	56±3	88±2	84±1	82±2	73±2	82±2	67±2	69±3	65±2	82±3	69±4

cluding species composition) are characteristic of every community. Therefore average number of species in the plot should be considered a better mark of biodiversity. Communities of older cutting areas and forming up young stands are in the first place from this point of view. Mature pine communities follow them. Thick young stands and middle-aged pine communities are characteristic of the poorest phytocoenotical composition. Pole stands and middle-aged stands are thickest, crown projection area is greatest and canopy level highest (Kairiūkštis, Juodvalkis 1985), the quantity of light is least, therefore a number of herbal vegetation species and their projection cover is least too. Later at the stage of stand's self-thinning the quantity of light in the stand's undercrown increases, species composition of phytocoenosis enriches. However, the greatest diversity is observed in cutting areas where species of the forest and newly originating light demanding species of cutting areas grow in the same community. The number of light demanding species indicates forming up of such species. It is determined according to the H. Ellenberg (1991) scale for light demand and data on the changes in vegetation species composition are presented in Tables 2, 3 and 4. Mass of herbal vegetation is greatest at the stages of cutting areas and forming up young stand. Projection cover of herbs expresses this quite well.

Similar changes are observed in species composition of moss-lichen cover. Species diversity is greatest in forming up stand, while least – at the stage of thicket and middle-aged stands. In addition to "shrubish" lichen (*Cladonia sylvatica (L.) Hoffm., C.rangiferina (L.) Web., C. alpestris (L.) Robenh.*) also other lichen species (*C. pyxidata (L.) Fr., C. cornuta (L.) Schaer. etc.*) start appearing in cutting areas. However, density of moss cover changes differently. Moss cover in cutting areas is stunted (it is only in first years after felling the quantity of moss characteristic of stands is quite big), though it recovers completely when young stand forms up. The density of moss cover in middle-aged stands exceeds even communities of mature stands (Fig.1).

Table 2. Ground cover vegetation of different forming stages of *Vacciniosa* type pine forest (Kazlų Rūda forest enterprise, Višakio Rūda district)

Plant name	Projection cover, %			
	Mature pine stand	2 years old cutting area	10 years old cutting area (pine plantation)	20 years old pine stand
Agrostis tenuis Sibth.		0.1		
Calamagrostis epigeios (L.) Roth		5.1	0.1	
Festuca ovina L.	0.3	5.7	0.1	0.3
*Festuca rubra*L.		1.3	0.3	
Poa pratensis L.		0.5		
Carex pilulifera L.		1.5		
Calluna vulgaris (L.) Hull.	2.7	4.6	49.0	15.7
Hieracium pilosella L.		1.3		
Melampyrum pratense L.	1.6			0.2
Oenothera biennis L.		0.5		
Rumex acetosella L.	0.1	0.3		
Scorzonera humilis L.	0.1			0.2
Senecio vernalis W. et K.		0.1		
Spergularia campestris (All.) Aschers.		0.7		
Vaccinium vitis idaea L.	4.7			3.6
Vaccinium myrtillus L.	3.9			
Ceratodon purpureum (Hedw.) Brid.		21.2		
Cetraria islandica (L.) Ash.	0.9		0.2	0.1
Cladonia alpestris (L.) Rabenh	0.1		0.1	0.1
Cladonia rangiferina (L.) Web.	4.3		0.2	0.2
Cladonia sylvatica (L.) Hoffm.	0.7	0.1	0.3	0.6
Cladonia spec.		1.5		
Dicranum polysetum Michx.	10.7	4.6	0.4	2.0
Pleurozium Schreberi (Brid.) Mitt.	55.1	2.1	15.0	59.6
Pohlia nutans (Hedw.) Lindb.		3.2		
Polytrichum juniperinum Hedw.		1.0		

Table 3. Age-related changes in abundance of characteristic plants of ground cover vegetation in *Vacciniosa* type pine stands

Plant name	Average projection cover (%) and class of constancy* in the stands (cutting areas) of different age (years)											
	1	2-5	6-10	16-25	26-35	36-45	46-55	56-65	66-75	76-85	86-100	100 >
Agrostis tenuis Sibth.	-	+/II	+/II	-	-	+/I	+/I	-	+/I	-	-	-
Antennaria dioica (L.) Gaertn.	+/II	+/II	+/II	-	-	-	-	-	-	-	-	-
Arctostaphylos uva ursi (L.) Spreng.	+/II	+/II	+/II	+/III	+/I	r/I	-	+/II	+/II	+/II	+/II	1/II
Calamagrostis spec.	1/II	19/IV	13/V	3/III	3/IV	2/III	2/IV	+/II	+/III	+/II	2/III	+/II
***Calluna vulgaris* (L.) Hull.**	**1/IV**	**2/IV**	**29/V**	**7/V**	**1/II**	**+/III**	**1/IV**	**1/III**	**3/IV**	**2/V**	**1/IV**	**3/V**
Carex ericetorum Poll.**	+/IV	+/IV	+/IV	+/II	+/I	r/I	-	-	+/I	+/III	+/I	+/I
Conyza canadensis (L.) Corn.**	-	1/II	+/II	-	-	-	-	-	-	-	-	-
Chamaenerium angustifolium (L.) Holub. **	+/II	+/IV	+/II	+/I	+/II	+/II	+/II	-	r/I	-	-	
Diphasium complanatum (L..) Holub.**	–	-	-	-	-	r/1	-	-	-	+/I	+/II	+/I
***Festuca ovina* L.**	**1/IV**	**4/IV**	**9/V**	**1/V**	**1/III**	**+/II**	**1/IV**	**1/IV**	**+/III**	**+/III**	**1/III**	**1/V**
Hieracium pilosella L.**	+/IV	1/IV	+/III	+/II	+/II	+/II	+/I	+/II	+/II	-	+/II	+/III
Hieracium umbelatum L.**	+/II	+/II	+/II	-	+/I	-	-	-	r/I	-	+/II	+/I
Melampyrum pratense L.	+/II	+/I	+/II	+/IV	+/II	r/1	+/I	1/V	1/III	1/IV	+/III	1/IV
Rumex acetosella L.**	+/II	1/V	+/II	-	+/I	+/I	+/II	+/II	+/I	+/II	+/II	+/I
Solidago virgaurea L.**	+/I	+/II	+/III	+III	+/III	+/II	+/II	+/II	+/I	+/I	+/II	+/III
*Spergula spec.***	-	+/IV	+/II	-	-	-	-	-	-	-	-	-
Thymus spec.	-	+/II	+/II	+/II	-	-	-	-	+/I	+/I	+/I	-
***Vaccinium myrtillus* L.**	**+/V**	**+/II**	**+/II**	**+/V**	**1/IV**	**5/IV**	**8/V**	**8/V**	**8/V**	**6/V**	**7/V**	**3/V**
***Vaccinium vitis idaea* L.**	**+/IV**	**1/III**	**+/IV**	**2/V**	**1/IV**	**3/IV**	**6/IV**	**7/IV**	**8/V**	**9/V**	**4/V**	**9/V**
Ceratodon purpureus (Hedw.) Brid.	+/II	8/IV	-	-	-	-	-	-	-	-	-	-
Cladonia spec.	**1/V**	**2/V**	**7/V**	**8/V**	**1/III**	**1/III**	**+/II**	**1/II**	**2/IV**	**2/IV**	**1/III**	**2/V**
Dicranum spec.	20/V	11/V	6/V	28/V	12/V	3/V	5/V	5/V	13/V	16/V	22/V	22/V
Hylocomium splendens (Hedw.) Brid.	+/II	-	-	+/II	4/II	5/IV	4/V	3/III	8/IV	6/IV	9/V	6/IV
***Pleurozium Schreberi* (Brid.) Mitt.**	**35/V**	**3/IV**	**6/V**	**38/V**	**71/V**	**81/V**	**80/V**	**85/V**	**54/V**	**55/V**	**46/V**	**48/V**
Pohlia nutans (Hedw.) Lindb.**	-	1/II	7/IV	1/I	-	-	-	-	-	-	-	-
Polytrichum piliferum Hedw.	+/IV	1/III	7/IV	1/I	+/I	+/I	-	-	+/I	+/I	1/II	1/IV

* Class of constancy according to methodics of Br.-Blanquet (1964) is determined; 1-20% I class, 21-40% - II class, etc.
** The prevalence of these plants is similar in the *Vaccinio-myrtillosa* type communities as well.

Regularities of changes in biocoenotical structure of live ground cover are rather similar in both compared forest types. When compared *Vaccinio-myrtillosa* type pine stands to *Vacciniosa* type the following differences are observed:

1) due to more favourable site conditions the general number of herb-semishrub species in the plot and projection cover is greater;

2) extinction of moss cover in cutting areas is expressed more, as well as it's thinning out in mature and over-mature stands. Moss stunting in cutting areas could be explained by their species composition: open light is completely intolerable for *Hylocomium splendens* (Hedw.) Brid., which is quite abundant in stands of this type. In mature stands the reason for moss cover thinning out most probably is the appearance of spruce underwood.

Table 4. Age-related changes in abundance of characteristic plants of ground cover vegetation in *Vaccinio-myrtillosa* type pine stands

Plant name	Average projection cover (%) and class of constancy* in the stands (cutting areas) of different age (years)														
	1	2-5	6-10	11-15	16-25	26-35	36-45	46-55	56-65	66-75	76-85	86-100	101-120	121-140	141& >
Achilea milefolium L.	-	r/II	r/II	+/II	-	r/I	r/I	-	-	-	-	-	-	-	-
Agrostis tenuis Sibth.	+/II	12/V	1/III	1/IV	-	+/I	-	+/I	+/I	+/I	+/II	+/II	+/I	+/II	-
Calamagrostis spec.	2/V	12/V	34/V	3/V	1/III	1/V	2/IV	2/IV	1/IV	+/IV	1/IV	1/IV	+/IV	2/V	1/IV
Calluna vulgaris (L.) Hull.	+/II	2/III	14/V	41/V	22/V	5/V	1/IV	1/V	+/IV	1/IV	2/III	2/IV	1/IV	2/V	1/IV
Convallaria majalis L.	-	+/II	+/II	+/II	+/II	1/III	1/III	+/II	2/III	+/II	+/II	+/III	1/III	2/IV	+/IV
Chimaphila umbelata (L.) Barton	-	-	-	-	-	r/I	+/I	-	-	+/I	+/I	+/II	+/II	+/III	+/II
Dryopteris carthusiana (Vill.) Fuchs*	-	-	-	+/II	-	-	+/II	r/I	+/I	+/II	+/I	r/I	-	r/I	-
Festuca ovina L.	+/II	2/V	5/V	2/IV	+/IV	1/III	2/IV	+/III	1/III	+/IV	2/IV	5/IV	1/IV	4/V	+/II
Jasione montana L.	-	1/III	+/II	-	-	-	r/I	-	r/I	-	-	-	-	-	-
Lycopodium clavatum L.	-	-	-	-	-	r/I	+/I	+/I	-	+/I	+/I	1/III	+/I	+/IV	+/III
Luzula pilosa (L.) Willd.*	+/II	-	-	+/IV	+/II	+/II	+/II	+/II	+/IV	1/III	1/IV	1/IV	+/IV	1/V	+/V
Melampyrum pratense L.	+/II	+/II	-	1/II	+/III	2/V	2/IV	2/V	1/III	2/V	3/V	2/V	1/IV	2/IV	+/IV
*Mycelis muralis (L.) Dum.**	-	-	-	-	-	-	+/II	-	-	+/I	+/I	+/I	-	+/II	+/I
Peucedanum oreoselin. (L.) Moench.	-	1/II	1/II	1/II	+/II	+/II	+/I	r/I	+/I	-	+/I	+/I	-	r/I	+/I
Polygonatum odoratum (Mill.) Druce.	-	+/II	r/III	-	+/I	+/I	+/I	+/I	+/I	-	-	+/I	+/I	-	-
Pteridium aquilinum (L.) Kuhn.*	-	+/I	-	+/II	-	-	+/I	1/I	1/II	+/I	1/I	+/I	1/III	+/II	+/I
Rubus idaeus L.*	-	-	+/II	1/IV	+/II	1/II	2/III	1/II	1/III	1/II	+/I	-	+/I	-	-
Rubus saxatilis L.*	-	-	-	+/II	-	-	+/I	+/II	1/III	-	+/II	-	+/I	+/II	-
Scorzonera humilis L.	-	-	+/II	+/V	+/II	+/II	+/I	+/II	+/II	r/I	+/I	r/I	+/II	+/II	+/I
Senecio spec.	-	+/III	+/II	+/II	r/I	-	-	-	-	-	r/I	-	-	-	-
Taraxacum officinale Web.*	-	+/II	+/II	+/II	-	+/II	-	r/I	-	-	-	-	-	-	-
Trientalis europaea L.	-	-	r/II	-	-	+/I	1/II	+/II	+/I	+/II	+/II	+/II	+/III	+/III	+/III
Vaccinium myrtillus L.	4/V	+/III	+/II	2/IV	1/III	4/IV	10/V	17/V	17/V	16/V	19/V	21/V	18/V	19/V	14/V
Vaccinium vitis idaea L.	2/IV	+/IV	+/IV	2/V	2/IV	3/IV	7/IV	7/V	4/V	4/V	7/V	10/V	6/V	7/V	5/V
Veronica officinalis L.	+/II	+/III	+/II	-	-	-	+/I	+/I	+/I	-	+/I	-	r/I	+/II	+/I
Ceratodon purpureus (Hedw.) Brid.	-	2/III	4/II	-	-	-	-	-	-	-	-	r/I	-	-	-
Dicranum spec.	5/V	2/V	1/II	6/V	4/IV	7/V	6/V	6/V	3/V	5/V	5/V	14/V	8/V	10/V	6/V
Hylocomium splendens (Hedw.) Brid.	6/V	-	-	3/III	4/III	10/IV	13/IV	21/V	20/V	24/V	20/V	20/V	24/V	24/V	22/V
Pleurozium Schreberi (Brid.) Mitt.	10/V	2/V	1/IV	39/V	41/V	64/V	57/V	47/V	46/V	46/V	33/V	31/V	30/V	32/V	36/V
Polytrichum juniperinum Hedw.		-	10/IV	6/V	+/III	+/II	+/II	+/I	+/I	+/IV	+/II	1/IV	+/II	+/II	+/I
Ptilium crista castrensis Hedw.	-		-	+/II	+/II	+/II	5/IV	8/IV	4/IV	6/IV	5/IV	1/III	5/IV	9/V	2/III

* These plants are more characteristic of the forest communities of more fertile sites, though they happen to grow in *Vaccinio-myrtillosa* type stands, this way distinguishing them from *Vacciniosa* type.

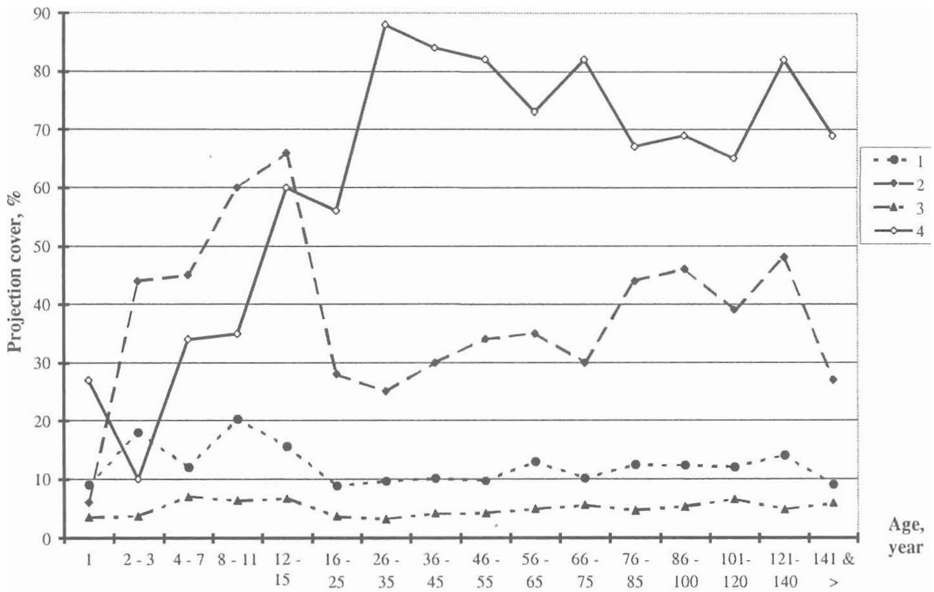

Figure 1. Age related changes in ground cover vegetation in communities of ***Vaccinio-myrtillosa*** type pine forest: 1- average number of herb-semishrub species in the plot, 2- average projection cover of herb-semishrub, %, 3- average number of moss-lichen species in the plot, 4- average projection cover moss-lichen, %.

The changes in phytocoenotical structure of the communities are determined by prevalence of separate species and abundance of changes with the increasing stand age. Vegetation composition of 4 pine communities formed up in the same site conditions but of different age, situated in close proximity to one another (data presented in Table 2) is a good illustration of regularities of live ground cover changes in *Vacciniosa* type pine stands. As one can see from the table, plants characteristic of mature stands communities of this type – *Melampyrum pratense* L., *Vaccinium vitis idaea* L., *V.myrtillus* L., *Scorconera humilis* L. – have disappeared after stand felling, while others have spread out – *Calamagrostis epigeios* (L.), Roth., *Festuca ovina* L., *Calluna vulgaris* (l,) Hull. The latter started prevailing latest of all, but rather abundantly. The moss cover has changed completely. Moss characteristic of the forest has reduced (*Dicranum polysetum* Michx., *Pleurozium Schreberi* (Brid.) Mitt.), but new species have appeared (*Ceratodon purpureum* Hedw., *Cladonia spec.*). However, the abundance of the most characteristic moss species of this type (*Pleurozium schreberi*) was restored in a 20 year old young stand.

The summarized data on the changes in more characteristic live ground cover vegetation are presented in Tables 3, 4 and Figure 2.

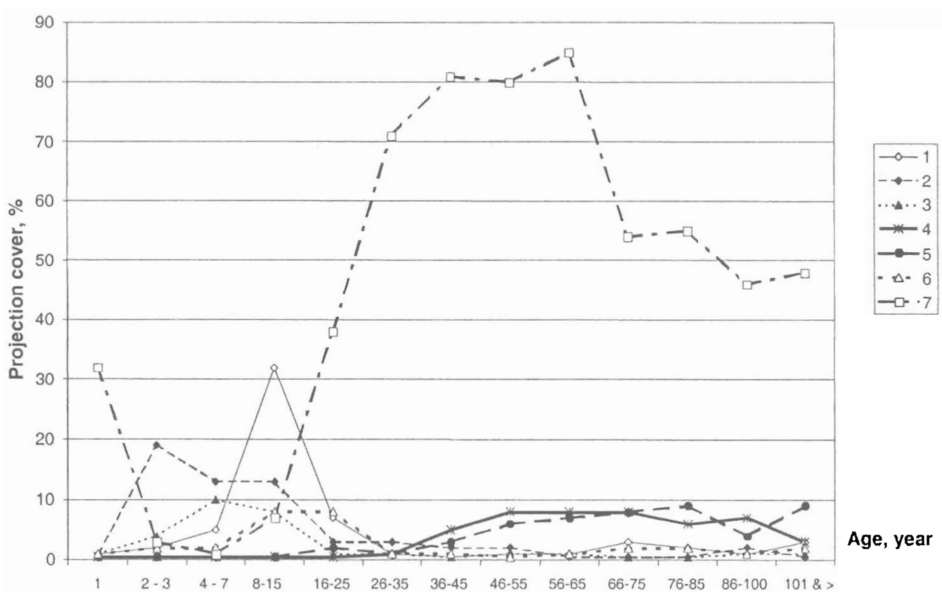

Figure 2. Change in abundance of mostly characteristic plant species of ***Vacciniosa*** type pine forest ground cover vegetation in different ages of stand (1-*Calluna vulgaris*; 2-*Calamagrostis spec.*, 3-*Festuca ovina*, 4-*Vaccinium myrtillus*, 5-*Vaccinium vitis-idaea*, 6-*Cladonia spec.*, 7-*Pleurozium Schreberi*)

The species are considered to be more characteristic if the degree of permanency is not less than the third class at least in one stand phase, i.e. they are encountered in approximately 50% of communities, and if that species are typical of corresponding sites (Karazija 1988). It is clear from the Tables that two groups of plants different from the point of view of ecological needs distinguish themselves clearly: forest vegetation and vegetation of cutting areas and forming up young stands. *Vaccinium vitis idaea* L., *V.myrtillus* L., *Diphasium complanatum* (L.) Rothm., *Lycopodium clavatum* L., *Mycelis muralis* (L.) Dum., *Trientalis europaea* L. and moss *Pleurozium schreberi* (Brid.) Mitt., *Hylocomium splendens* (Hedw.) Brid., *Ptilium crista castrensis* Hedw. are attributed to the first group. The species of this group that are spread less disappear completely in cutting areas, the most abundant and less sensitive species are met in all the phases, though thin out in cutting areas.

The abundant group of cutting areas vegetation should be separated into two parts as well. The most abundantly spread out plants like *Calluna vulgaris* (L.) Hull., *Calamagrostis spec.*, *Festuca ovina* L. survive in all the phases of stand development though considerably thinned out. Other species disappear after the stand forms up, unless single plants occur in mature, thinned out stands.

The third group of species should be mentioned – these are more permanent species, occurring not abundantly in all phases of stand development. Out of these the following species are characteristic of *Vacciniosa* type pine stands: the *Rumex acetosella* L., lichen (*Cladonia spec.*), *Arctostaphylos uva ursi* (L.) Spreng; of *Vaccinio-myr*tillosa type – *Convalaria majalis* L., *Peucedanum oreoselinum* (L.) Moench., *Polygonatum odoratum* (Mill.) Druce, *Pteridium aquilinum* Kuhn.

The majority of species of the two groups mentioned earlier are characteristic of both analysed forest type communities. The pine stands of *Vacciniosa* and *Vaccinio-myrtillosa* types though being quite different according to stand productivity and the process of successions, are very similar according to species composition of the communities. In the floristic classification of vegetation they are attributed to one *Vaccinio myrtilli–Pinetum* association. Therefore, it is very important to find reliable indicators that would enable us to determine typological affiliation of forest communities. The following distinctive features of *Vacciniosa* and *Vaccinio-myrtillosa* types can be set according to the data of Tables 3 and 4:

a) different phytocoenotical structure – in *Vaccinio-myrtillosa* type pine stands such species as *Vaccinium myrtillus* L., *Hylocomium splendens* (Hedw.) Brid are represented much more abundantly;

b) in *Vaccinio-myrtillosa* type pine stands species - determinants of more fertile sites are encountered; *Dryopteris carthusiana* (Vill.) Fuchs, *Luzula pilosa* L. Wild., *Mycelis muralis* (L.) Dumort, *Rubus saxatilis* L., *Trientalis europaea* L., *Lycopodium clavatum* L. and characteristic of cutting areas: *Achilea milifolium* L., *Senecio spec.*, *Veronica officinalis* L. area characteristic of stands;

c) species of the third group that are especially significant in determining typological affiliation of young stands.

In spite of rather distinct differences of species composition and biocoenotical structure among communities of separate stands' development phases transition among them is not so distinct as in spruce stands. Therefore, though corresponding stands' development phases – cutting area (up to 5 years), crown closing (6-12 years), thicket (16-45 years), self-thinning (46-85 years) and stabilization stages can be distinguished out, there are conditional features: borderlines between the last three stages are especially vague.

The changes in ecological conditions.

The change in stands' structure related to their age influences the change in site's ecological conditions, which expresses itself in species composition of vegetation.

Making use of H. Ellenberg (1991) indices of plants' ecological values and L. Ramenskij (1956) ecological tables by methods proposed by them we have evaluated sites' ecological conditions in stands' communities of different age. The data presented in Table 5 show that vegetation of cutting areas is more light demanding, the most shady at thicket stage, while inclination to light demand is seen in mature stands again. However, in all the periods of age the degree of light demand stays high enough (there are 9 degrees in the scale), as all the plants of pine stands are not shade demanding.

The index of humidity determined by H. Ellenberg as well as by L. Ramensky method ranges slightly. The values are higher in middle-aged stands. Hence, there are no signs of bogging up of cutting areas. The index of acidity (Reaktionszahl) ranges a little, though no regular changes have been found. The degree of nitrogenicity according to H. Ellenberg and trophism according to L.Ramenskij changes insignificantly as well, though a certain increase of indices in the stands 30-70 years old, i.e. in the stand of self-thinning, was noticed. The data are more even when L.Ramenskij method is used.

Summarizing it should be pointed out, that ecological indices during the whole cycle of stand's de-

Table 5. Indices of ecological conditions in the pine stand communities of different age determined according to indication value of plants

Indices	Groups of communities according to stands (cutting areas) age, years														
	1	2-5	6-10	11-15	16-25	26-35	36-45	46-55	56-65	66-75	76-85	86-100	101-120	121-140	141 & >
Communities of *Vacciniosa* type pine stands															
Light demand	6.4	7.0	6.9		6.6	5.9	5.7	5.8	5.7	6.2	6.3	6.2	6.3		
Humidity according to Ellenberg	4.0	3.9	3.8		4.3	4.4	4.5	4.5	4.5	4.5	4.4	4.3	4.4		
Humidity according to Ramenskij	67	67	66		68	69	69	69	68	68	67	68	67		
pH (reaction)	3.3	3.5	3.5		3.0	3.3	3.6	3.3	2.9	3.4	3.2	3.5	3.3		
Nitrogenity	2.6	2.8	2.6		2.2	3.0	3.3	3.1	2.5	2.7	2.4	2.5	2.0		
Trophism (acc. Ramenskij)	5.2	5.0	5.2		5.1	5.9	6.0	5.8	5.4	5.4	5.1	5.5	5.0		
Communities of *Vaccinio-myrtillosa* type pine stands															
Light demand	5.6	6.3	6.6	6.4	6.2	5.8	5.9	5.2	5.7	5.4	5.8	5.7	5.9	6.1	5.4
Humidity according to Ellenberg	4.1	4.2	4.3	4.6	4.7	4.9	4.8	4.6	4.0	4.9	4.4	4.6	4.5	4.5	4.1
Humidity according to Ramenskij	68	68	68	68	69	69	70	69	70	70	70	69	69	68	69
pH (reaction)	3.6	3.8	3.6	3.9	4.0	3.9	4.5	3.6	3.5	3.5	4.8	3.6	4.2	4.1	3.5
Nitrogenity	3.0	3.3	3.3	3.3	2.7	3.1	3.4	3.2	3.2	3.4	3.1	3.1	3.1	3.1	2.8
Trophism (acc. Ramenskij)	5.9	5.8	5.9	5.9	6.1	6.0	6.5	6.2	6.6	6.4	6.5	6.0	6.0	5.9	6.1

velopment change insignificantly. Even the increase in light demand index is not great, though this might be due to inaccuracy of indices values under the conditions of Lithuania as well.

Dynamics of undergrowth abundance.

In natural pine stands undergrowth is not characteristic of species diversity and abundance. The communities in which the amount of undergrowth would have edificatory influence on the functioning of forest biogeocoenosis are few. In all stands of pine on mineral soil sites junipers (*Juniperus communes* L.) (though they occur seldom in *Myrtillosa* and *Oxalidosa* type), mountain ashes (*Sorbus aucuparia* L.) and buckthorns (*Frangula alnus* Mill.) (the latter are sparse in *Cladoniosa* type) grow. However, the ratio of species varies greatly in different types of pine stands. In stand of *Cladoniosa* type the juniper undergrowth is usually sparse. *Salix spec.* appears in *Myrtillosa* type and starts prevailing in the undergrowth of bogged up pine stands. In *Oxalidosa* type hazel (*Corylus avellana* L.) prevails, the quantity of other shrub species is generous too.

The undergrowth in *Vacciniosa* type is sparse, junipers prevail there, the projection cover of them may reach up to 20-30% sometimes. The mountain ashes (*Sorbus aucuparia* L.), buckthorns (*Frangula alnus* Mill.) grow, though usually small shrubs only, without distinct picture of undergrowth. Very seldom goat willow (*Salix caprea* L.) or other accidental species (*Berberis vulgaris* L., *Rosa spec.*) occur.

In the not thick undergrowth of *Vaccinio-myrtillosa* type pine stands mountain ashes (*Sorbus aucuparia* L.) prevail. Juniper is much more sparse here than in *Vacciniosa* type. Buckthorns (*Frangula alnus* Mill.) occur often though usually they are just tiny shrubs. Hazels (*Corylus avellana* L.) of similar type and single shrubs of other types grow there too. Specific variants of the communities of this type happen – pine stands with thick mountain ashes undergrowth in the Curonia spit and edaphic subtype in soils of carbonate gravel with plentiful hazels, where undergrowth influences significantly regeneration processes. However, these rare specific cases are not going to be analysed here. In other *Vaccinio-myrtillosa* type pine stands of normal thickness thick undergrowth was not found, usually its thickness seldom exceeds 0.1.

The change of undergrowth in the course of stands' aging is not very distinct. The dispersion of stands' undergrowth abundance of one age group is greater often than differences among age classes. The change in its species composition is especially small. Therefore, in order to highlight the differences among separate stands' age groups more the communities investigated were divided into five age stages of forest communities' development mentioned before. Undergrowth indices according to these stages are presented in Table 6. It shows that the number of undergrowth forming shrubs is least in cutting areas. Along with stand forming, species composition of undergrowth regenerates too. At the thicket stage already all the species characteristic of the corresponding type occur and even accidental (*Malus sylvestris* Mill., *Pyrus communis* L., *Rosa spec.*, *Ribes spicatum* Robson, *Viburnum opulus* L., etc.). However, all the shrubs are very tiny and general projection cover is very low. With the stand's aging permanency and quantity of undergrowth increases, examples of heftier shrubs

Table 6. The change in undergrowth at different stages of pine stand development

Indices	Cutting areas	Stage of stand formation	Thicket stage	Self-thinning stage	Stabilization stage
Communities of *Vacciniosa* type					
Constancy of undergrowth (number of plots with undergrowth), %	60	75	79	70	84
Number of found undergrowth species	3	3	5	5	4
Juniperus communis: class of constancy	II	III	III	IV	IV
Abundance – median and maximum value*	r/+	+/1	+/2	+/3	+/2
Sorbus acucuparia: class of permanency	II	II	II	III	III
Abundance – median and maximum value*	r/+	r/+	+/+	+/+	+/1
Frangula alnus: class of constancy	II	II	III	III	IV
Abundance – median and maximum value*	r/+	+/+	+/+	+/+	+/1
Communities of *Vaccinio-myrtillosa* type					
Constancy of undergrowth (number of plots with undergrowth), %	67	86	81	85	92
Number of found undergrowth species	4	5	7	7	5
Sorbus acucuparia: class of constancy	III	III	IV	IV	IV
Abundance – median and maximum value*	r/1	+/1	+/2	+/2	+/2
Frangula alnus: class of constancy	III	III	IV	IV	III
Abundance – median and maximum value*	r/1	+/1	+/1	+/1	+/1
Juniperus communis: class of constancy	I	II	I	II	III
Abundance – median and maximum value*	r/+	+/1	+/+	+/2	+/2
Corylus avellana: class of constancy	-	-	I	I	I
Abundance – median and maximum value*			+/+	+/+	+/+

*Abundance is expressed in Br.-Blanquet points everywhere

occur. The greatest abundance diversity is among junipers (*Juniperus communus* L.). It is worth pointing out that the most abundant juniper undergrowth was found in the stand of self-thinning (not stabilization) stage of *Vacciniosa* type pine stands. The shrubs of other species are never found in large quantities in the undergrowth.

The quantity and species composition of underwood.

The analysis is conducted on the data on appearance of natural seedlings in stands starting with the thicket stage. The issues of regeneration in cutting areas are to be resolved. The data on the general number of spontaneous trees are presented in Table 7. Pine underwood in *Vacciniosa* type communities starts appearing at the end of stand's self-thinning stage only, that is beginning with age 60-70 years. In 70% of investigated mature plots pine underwood was found. The average quantity of underwood in one plot was up to 990 units per 1 ha, in several plots even more than 3,000 pine underwood units were found. The quantity of viable and perspective underwood was less. However, the fact itself that spontaneous trees appeared shows possibilities to use the spontaneous regeneration to establish new stands if certain cutting methods are applied.

The underwood of other species is not perspective, except some cases with birch tree. It is clear that the number of young birch trees in mature stands is not so small, though their viability usually is not high and the probability of species change is low. It should be stressed that regeneration of birch, as well as pine, improves after surface fires. Young spruce are frequent (in 71% of cases), in quite big quantity sometimes, though their viability is low, they stunt in cutting areas, those having survived are not capable to compete with pines. Oaks are quite a frequent component of underwood. As one can see, the number of them is greatest in middle-aged stands and in these at the thicket stage, in which moss cover is thickest and under which jay is hiding acorns. All these oaks are not perspective, they have neither economical nor more prominent phytocoenotical value, though they should be marked as an element of the flora and a certain component of wild animals' food. Rare asps have the same role.

In the communities of *Vaccinio-myrtillosa* type regularities of birch, oak and aspen underwood appearance are similar to *Vacciniosa* type, though the number of spontaneous oaks and their viability is slightly

Table 7. Probability of underwood (plots number with underwood) and average amount of underwood at different stages of development in pine stands

Tree species	Indices	Stages of stand development				
		thicket	self-thinning		stabilization	
			46-70 y.	70-90 y.	mature	over mature
Communities of *Vacciniosa* type pine forests						
Pine	probability, %	4	12	33	71	
	average number units/ha	5±4	8±6	310±170	990±210	
Birch	probability, %	20	28	59	78	
	average number units/ha	61±25	40±17	193±52	463±105	
Aspen	probability, %	13	5	8	14	
	average number units/ha	38±12	12±9	5±4	10±7	
Spruce	probability, %	34	42	60	71	
	average number units/ha	86±25	195±53	230±90	220±78	
Oak	probability, %	36	46	35	36	
	average number units/ha	120±33	160±48	47±23	50±17	
Communities of *Vaccinio-myrtillosa* type pine forests						
Pine	probability, %	6	8	15	41	44
	average number units/ha	7±6	16±10	108±58	341±120	222±82
Spruce	probability, %	56	78	67	71	89
	average number units/ha	272±54	1390±190	1040±173	1741±145	1122±235
Birch	probability, %	56	56	50	53	67
	average number units/ha	87±23	168±35	158±49	118±43	211±60
Aspen	probability, %	28	20	15	18	22
	average number units/ha	30±15	86±40	72±38	41±18	22±14
Oak	probability, %	72	60	69	52	33
	average number units/ha	270±38	205±32	290±40	376±55	44±22

greater in the first one (even the second layer from oaks starts forming sometimes). Pine underwood is significantly less here. The main reason for a decrease in pine and birch underwood is the course of spruce underwood development. The spruce underwood starts appearing already at the thicket stage of stands. It increases at the self-thinning stage (on average more than 1000 units per ha); some spruces reach the second layer. If just single plots with spruce in the second layer are found at the self-thinning stage, more or less thick second layer of spruce comprise nearly 30% of mature stands. The quantity of over-mature stands of such kind approaches 80%. The light in under crown decreases. In relation to that not only the quantity of pine underwood but of spruce too decreases. Therefore, the conclusion can be drawn that in the natural development of stands, without interference of man natural disasters shift species composition from pine to spruce.

The self-regeneration regularities of *Myrtillosa* type pine stands are similar very much to those in *Vaccinio-myrtillosa* type pine stands, except that in the self-regeneration of spruce is more intensive.

Cladoniosa type stands are characteristic of more abundant quantity of pine underwood than *Vacciniosa* type pine stands. As far as *Cladoniosa* type pine stands are rather thin quite frequently, pine underwood starts appearing in younger stands. Therefore, formation of pine stands of different tree age of this type is possible.

Discussion

As it has been stated before, 5 stages of forest communities development can be distinguished in pine stands. However, differences of phytocoenotical structure among these stages are not so distinct as in spruce stands (Karazija 2002). If in spruce stands at the thicket stage practically no vegetation of lower layers is left, at the corresponding stage in pine stands the moss cover is completely regenerated. Borderlines between stages, especially the later ones, are rather conditional.

By comparing the data presented in the article with the research data on age-related changes in pine stands in other regions many common regularities and differences can be found. Not only the classical works of I.Melehov and his students (Melehov 1954, 1959, Melehov *et al.* 1965, Chertovskoj 1963, *et al.*) but many other authors present the data about prevalence of characteristic vegetation in cutting areas. However, composition of vegetation in cutting areas depends on geographical locality. For example, in cutting areas of pine stand in Germany (Schretzenmayr 1969) and Finland (Walter 1968) *Deschampsia flexuosa* (L) Trin appears abundantly, while in Lithuania's conditions the importance of this plant is more significant just in coastal forests. In Russian taiga forests *Chamaenerion angustifolium* (L) Scop. is an important edificator in cutting areas, while in cutting areas of Lithuania's forests no prevalence of it has been found. The main edificators in cutting areas of Lithuania's dry pine stands are *Calamagrostis spec.*, *Festuca ovina* L. and *Calluna vulgaris* (L.) Hull.

The quantity and species composition of moss and lichen in the course of stands' age is similar in all the pine stands in North Europe (Walter 1968, Yaroshewich 1970, Andrzejczyk, Brzeziecki 1995, Kuvaev *et al.* 1995), except in the Ukraine locates more southward the dynamics of moss cover is different (Andrushchenko 1975).

Most of scientists investigating the dynamics of pine stand communities' age (Brakenhielm *et al.* 1980; Ipatov *et al.* 1995; Kuvaev *et al.* 1995; Andrzejczyk, Brzeziecki 1995 et al) distinguish stages of development, however they are different quite frequently. Just initial and mature (climax) stages coincide, though the latter sometimes (Brakenhielm *et al.* 1995, Ipatov *et al.* 1995) is divided into the stages of culmination and breaking down.

Discussing phytoindicational indices of the change in ecological conditions and their differences in comparison with spruce stands (Karazija 2002) it should be stressed that on sites of dry pine stands even under the conditions of humid Lithuanian climate no signs of bogging up in cutting areas are noticed. The increase of trophism (nitrogenicity) at the stage of stand's intense self-thinning is found. As far as this is found in spruce stands too, apparently, this is a regularity.

According to the data of underwood investigation the communities of two investigated types regardless of their phytocoenotical similarity are quite different from the point of view of development type. If the regeneration of *Vacciniosa* type pine stands (like *Cladoniosa* pine stands on even poorer sites) is comparatively successful, in pine stands of *Vaccinio-myrtillosa* type pine underwood is nearly absent and the species composition is shifted from pine to spruce. T. Andrzejczyk and B. Brzeziecki (1995) interpret a similar phenomenon (abundance of spruce and oak underwood) in pine stands of northern Poland as a possible result of alogenic change of environmental conditions. However, the appearance of spruce underwood is no novelty as in many pine stands of this type admixture of spruce or second layer of it is observed. The authors mentioned before point out as well that in the investigated stands two past periods of pine regeneration following stand destruction are determined. The assumption is possible that spruce admixture in stands composition is characteristic of pine stands of this type and the range of its quantity depends on different natural (and anthropogenic) impacts.

Research data presented in the article comprise stands aged only up to 180 years and the stage of natural breaking down is not included. Therefore no direct answer can be given what model of development is characteristic of pine stands – permanent climax (Clements 1916) or cyclic forest development (Daubenmire 1968, Remmert 1985). However, taking into account the structure of the stands, course of regeneration, the fact that there is a large number of pine stands, even pure ones, on *Vaccinio-myrtillosa* type sites where spruce prevails in the underwood, as well as the references in the literature concerning certain periods of pine self-regeneration, one can assume that various processes take part. On poorer sites (*Vacciniosa, Cladoniosa* types) the possibility exists to form climax type pine stands of trees of different age in the course of natural development. On more fertile sites the possibility of cyclic development of pine stands is observed.

Conclusions

1. In pine stands the cutting areas (except the first year after felling) and communities of forming up young stands distinguish themselves by the greatest variety of vegetation species and the abundance of live soil cover. The thickets of young stands and the communities of the middle-aged stands are poorest. However, in contrast to the spruce stands, the moss cover specific to mature stands regenerates at the thicket stages already in the communities of young stands. Therefore, even though stands' development stages parallel to spruce stands can be distinguished – the cutting area, stand closure, thicket, self-thinning and stabilization – differences between the latter three are much less prominent.

2. As the stands' composition and structure changes in the course of aging, the indicator signs of site change too. To define typological attribute of species composition in pine stands of *Vacciniosa* and *Vaccinio-myrtillosa* type that ares close to each other the following signs suit best of all:

a) different phytocoenotical structure;

b) plants-determinants which are found just in one type of communities; there are two categories of them – the first ones are more frequent though specific of certain stand's development stages only, the second ones are rather rare but they depend less upon stand age.

3. With the help of phytoindication methods it has

been determined that ecological conditions change little in the course of aging. The light demanding vegetation spreads out in cutting areas, though there is quite a large number of light demanding plants at other stand development stages too. No change in the humidity conditions has been noticed in the cutting areas of dry pine stands. The degree of site's trophism has increased a bit at the self-thinning stage.

4. The species composition of the undergrowth depends insignificantly on the pine stands' age. The more abundant undergrowth has been found in the older stands, however, the pine stands of the types investigated (with rare exceptions) do not reach such an abundance of undergrowth which could influence the process of stands' formation.

5. In the *Vacciniosa* type older pine stands quite a large amount of pine, not so small quantity of birch underwood has been found. Therefore, as the "windows" of crown layer's appear, the formation of different-aged stands, sometimes mixed with birch, is possible at the climax stage of forest development. The underwood of other species has practically no influence on the process of forest communities' formation. Spruce regenerates abundantly in *Vaccinio-myrtillosa* type pine stands and the corresponding succession takes place. The regeneration of pine stands and the conversion to birch stands is influenced by various catastrophic natural phenomena and certain human activity. Therefore, the formation of pine stands of this type goes on according to the model of cyclic forest development possibly.

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ВОЗРАСТНАЯ ДИНАМИКА ЛЕСНЫХ СООБЩЕСТВ СОСНЯКОВ

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Резюме

Исследования структуры сообществ сосняков разного возраста выполнены с целью выяснения стабильности индикаторов лесорастительных условий и закономерностей возобновления. Исследования проведены в сосновых лесах, произрастающих на минеральных почвах, в основном двух типов леса – брусничноно и бруснично-черничного. Использованы постоянные и временные пробные площади.

Наибольшим биологическим разнообразием и наиболее густым травяно-полукустарничко-вым покровом отличаются сообщества старых вырубок и формирующихся сосновых молодняков. Наиболее бедными по видовому составу являются густые молодняки и средневозрастные сосняки. Однако моховой покров в насаждениях этой стадии довольно густой. Поэтому различия фитоценотической структуры между сообществами разных возрастных стадий сосняков значительно меньше, чем в ельниках.

Видовой состав подлеска мало зависит от возраста сосняков. Незначительно изменяются и экологические условия с возрастом древостоев.

Сообщества анализируемых двух типов леса довольно сходные по их общему видовому составу, но различаются по составу и производительности древостоев. Для их типологического диагноза наиболее подходящими признаками являются различия фитоценотической структуры и растения-детерминанты, часть которых свойствены для соответствующих возрастных стадий развития древостоев, другие – более редкие, но более постоянные.

В брусничных сосняках встречается довольно обильный сосновый подрост, что указывает на возможность формирования разновозрастного древостоя. В бруснично-черничных сосняках доминирует еловый подрост; восстановление сосняков связано лишь с явлениями катастрофического характера.

Ключевые слова: сосняки, живой напочвенный покров, подлесок, подрост, фитоиндикация, возрастная динамика, биологическое разнообразие.