Structure and dynamics of silver fir (*Abies alba* Mill.) population in forest communities of the Świętokrzyski National Park. I. The population structure

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Abstract

The paper presents the spatial, age and size structures of individuals in silver fir population. The studies were conducted in fir forest and Carpathian beechwood. It was found that fir trees were distributed randomly, whereas seedlings, new growth and up-growth had clumped distribution. The growth and development of individuals in aggregations and outside them were analysed. The stress was put on the impact of spatial structure on the process of population regeneration. Age pyramid was flat with its base very wide. About 40% of trees in the population were dead.

Key words: *Abies alba*, spatial structure, density, age and size structures of individuals in a population

INTRODUCTION

Silver fir is a component of forests of lower montane zone in the mountains and uplands of southern and central Poland. It is mainly associated with the forests of central Europe, having in Poland north-eastern margin of its range (Gostyńska-Jakuszczyńska 1972). This structural component of forest phytocoenoses is valued for its biocoenotic role and high timber production. It has an impact on microclimate by damping temperature oscillations a tree stand (Jedliński 1922, Dziubałtowski 1930). The species also affects favourably soil conditions due to its litter which decays quickly and does not acidify the substrate (Krysztolik 1963). According to Jaworski and

Zarzycki (1983) a silver fir is the species that slightly stabilizes forest environment due to its strong, mostly tap root system.

For the last twenty years fir has been recessing from the area of its natural range (Bernadzki 1983, Antczak 1984). For the last few decades also within the Świętokrzyski National Park gradual dying of fir stands has been observed (Krysztolik 1963, Sierpiński 1977, Wiąckowski 1977). This may have been caused by many abiotic and biotic agents. In 1925 the capacity of fir stands in the Świętokrzyskie Mts was still great (Bernadzki 1967). Severe winter 1928/29 caused big damage (Krysztolik 1963, Krysztolik and Zieliński 1976). The mass dying of silver fir started in the forest stands thinned by inappropriate management, hence more sensitive to other harmful factors. War years 1939-1945 were damaging to fir stands, because of considerable clear cutting, and so was severe winter 1962/63. The dying within the Park has been intensified for the last decade due to the gradation of fir leafroller (Sierpiński 1977, Wiąckowski 1978, Huruk and Kapuściński 1982).

Fir tree stands within the Świętokrzyskie Mts have been well studied. However, only a few works concern the Park (Krysztolik 1963, 1964, Zieliński 1974, Mazur 1984, Bróz 1985, Kapuściński 1985). The present paper is the first of the two works on the structure and dynamics of fir populations in the communities of the Świętokrzyski National Park. It contains the evaluation of the distribution, age and size of individuals in a population, the properties which reflect populational processes, habitat conditions and species biological properties. The studies were to answer the question in what developmental phase the analysed population was and whether the regeneration process went well.

METHODS

The studies were conducted in 1979-1984 in three forest phytocoenoses: one representing silver fir forest *Abietetum polonicum* (Dziub. 1928) Br.-Bl., Vlieg 1939, the other two – Carpathian beechwood *Dentario glandulosae-Fagetum* Klika 1927. Fir individuals in each community were considered one coenopopulation: A – coenopopulation of fir forest, variable fir proportion in the ground layer and undergrowth; B – coenopopulation of Carpathian beechwood, high fir proportion, southern slopes of the Łysogóry; C – coenopopulation of Carpathian beechwood, slight fir admixture, northern slopes of the Łysogóry (Fig. 1). These were the grounds for the description of a local fir population (L) inhabiting the Łysogóry (the core of the National Świętokrzyski Park). The populations were observed within the strict reserve where human interference into tree stand structure for the last 30 years has been limited.

Fig. 1. The Świętokrzyski National Park — a scheme. A — silver fir coenopopulation in the fir forest, B and C — silver fir coenopopulations in the Carpathian beechwood

The studies were carried out within the strict reserves in 117, 201, B-1, 139, 140 and 153 forest divisions. In each phytocoenose permanent study areas were established with their sizes decreasing: i.e. 1 ha (3 each), 0.25 ha and 100 m² divided into 1 m² plots (6 in the fir forest and 3 in each beechwood, Fig. 2). Following groups of fir individuals were distinguished: seedlings — those which had cotyledons, new growth — individuals not higher than 0.5 m (seedlings excluded) growing in the ground layer, up-growth — individuals with height ranging from 0.5 to 5 m growing in the undergrowth, and trees — individuals higher than 5 m with their crowns in the tree layer. 1 ha study areas were used to obtain the distribution maps of trees and aggregations of juvenile individuals (new growth and up-growth). In 0.25 ha areas trees and up-growth individuals were counted and sampled to assess their age, size and vitality. In the transects new growth individuals and seedlings were mapped and their size and age evaluated. Tree age was determined with the Pressler's borer, that of up-growth — from the number of annual rings, whereas that of new growth — from the number of annual rings and annual height increments. The vitality was established from the number of apical buds on the apical shoot and the last shoot height increment.

Additionally 16 aggregations of new growth and up-growth were marked outside study areas in the fir forest and beechwood B. The observations were carried out in 2-m-wide transect that crossed aggregations and was divided

Fig. 2. Study area scheme. a — analysed phytocoenose area, b — 1 ha area, c — 0.25 ha area, d — transect 2 m × 50 m, 1-3 — 0.25 ha area: 1 — with high proportion of fir new growth, 2 — with high proportion of fir up-growth, 3 — with low proportions of fir new growth and up-growth

into 1 m² plots. Age, height and vitality of individuals were established. The properties of individuals were also assessed in the phytocoenose part without aggregations.

To analyse spatial structure of coenopopulations the distribution maps of trees, up-growth, new growth and seedlings were constructed. The coefficients of mean crowding of seedlings and new growth were calculated (Liyod 1967, after Collier et al. 1978). Empirical density distribution of seedlings and new growth was compared to Poisson's distribution, their conformity tested by the Chi-square test for the goodness of fit (Oktaba 1966). To evaluate tree distribution median runs test was applied (Greń 1982).

RESULTS

POPULATION SPATIAL STRUCTURE

Tree density varies from 16 to 356 individuals per 1 ha within all coenopopulations (Table 1). The maps of alive tree distribution and results of the median runs test indicated their random distribution (Fig. 3). Also dead and alive trees taken together were randomly distributed.

New growth and up-growth occurred in aggregations mainly. The aggregations in fir forest and Carpathian beechwood differed from each other in size and the area occupied (Fig. 3). The number of aggregations was the highest in coenopopulation C (75 per ha), while their total area — the biggest in coenopopulation B (1864 m² per ha, Table 2). The aggregations of new growth

and up-growth in fir forest and in the Carpathian beechwood C were distributed at random, whereas in the Carpathian beechwood B they were grouped.

Up-growth density is similar in the communities of fir forest and Carpathian beechwood B (27-355 individuals per 100 m²), but much smaller in Carpathian beechwood C (Table 1). From the statistical analyses, coefficients of mean crowding (Table 3) and cartograms it was inferred that, generally speaking, the distribution of new growth was clumped. Random distribution was correlated only with low mean new growth density. Random distribution was typical of the coenopopulation of Carpathian beechwood C.

Seedlings were most numerous in fir forest coenopopulation (4-289 per 100 m²), less abundant in Carpathian beechwood B and scarce in Carpathian beechwood C (Table 1). As that of new growth seedling distribution was mainly clumped, random only in the areas with low mean density.

The properties of individuals in and outside aggregations

Density in aggregations was at average 6 individuals per 1 m², outside them it was tenfold lower. Mean individual height was similar (Table 4). Individual vitality varied: individuals without apical buds were three times more numerous outside aggregations (15%); the proportion of individuals with 1-3 buds was similar (84%); and individuals with 4-6 buds tenfold more abundant in the aggregations. Mean height increment of an apical shoot was doubled for individuals in aggregations (4.1 cm). The differentiation between individuals growing in and outside aggregations concerned mainly vitality; new growth and up-growth individuals in aggregations formed more apical buds and had higher height increment of apical shoot (Table 5).

The structure of new growth and up-growth aggregations

Within 16 analysed aggregations central and peripheral parts were distinguished. Their boundaries were determined on the grounds of diversified individual height and their different density in the centre and on the peripheries (Fig. 4). The structure of divided aggregations was analysed in respect of height, age and density of individuals.

Mean height of individuals in the centre was 50.0 cm, whereas the individuals on the peripheries were at average 39 cm high (Table 6). In the centre individuals were more variable in their height (from some cm to 2 m) than on the peripheries (rarely higher than 1.5 m). In the centre height frequency distribution had 3-4 classes and was more symmetrical, while on the peripheries individuals were grouped in two first height classes (Fig. 5).

Mean age of individuals in the centre and on the peripheries was similar, 16 and 15 years respectively (Fig. 5). In the aggregations growing under tree canopy the correlation between height and age was more close in the centre than

Table

Number of fir individuals in study areas and mean (A) and Carpathian

Coenopo- pulation	Study area	Number of individuals								
		per 100 m ²		per 0.25 ha				seedlings		
		seed- lings	new growth	up-growth		trees		$\bar{x}$	min.	max.
				alive	dead	alive	dead			
A	1	181	318	216	11	68	40	13 667	400	28 900
	2	289	169	460	16	44	31			
	3	30	38	7	3	68	62			
	1'	148	243	47	2	64	75			
	2'	168	151	210	8	86	32			
	3'	4	68	5	4	89	62			
B	1	113	355	294	9	25	17	10 233	8 500	11 300
	2	109	156	520	17	17	10			
	3	85	39	28	15	9	3			
	1'	—	231	—	—	—	—			
	2'	—	134	—	—	—	—			
	3'	—	27	—	—	—	—			
C	1	17	222	167	23	20	16	700	100	1 700
	2	3	104	230	35	9	9			
	3	1	10	70	13	4	4			
	1'	—	69	—	—	—	—			
	2'	—	18	—	—	—	—			
	3'	—	24	—	—	—	—			

1-3 — study areas with replicates: 1 — with high proportion of fir new growth, 2 — with high proportion of fir up-growth, 3 — with low proportions of fir new growth and up-growth.

on the peripheries. In gaps this relationship was, as a rule, opposite (Fig. 6). The differentiation of height and age of individuals within aggregations was reflected in the coefficients of variation (23-122 for height and 15-55 for age). Hence height was more variable than age within aggregations.

To assess density of individuals in the centre and on the peripheries two aggregation types were analysed: these dominated by new growth, and those where up-growth prevailed. The former exhibited 1.5 times bigger density in the centre (9 per 1 m²) than on the peripheries (statistically significant difference). In the latter mean density in the centre and on the peripheries was similar (c. 4 individuals per 1 m², Table 6).

1

density per ha, in coenopopulations in the fir forest
beechwood (B and C)

Density per 1 ha														
new growth			up-growth						trees					
$\bar{x}$	min.	max.	alive			dead			alive			dead		
			$\bar{x}$	min.	max.	$\bar{x}$	min.	max.	$\bar{x}$	min.	max.	$\bar{x}$	min.	max.
16 450	3 800	31 800	630	20	1840	29	88	64	279	176	356	201	124	300
15 700	2 700	35 500	1 123	152	2 080	55	36	68	68	36	100	40	12	68
7 450	1 000	22 200	623	280	920	95	52	140	44	16	80	39	16	64

Table 2

Number and total area of aggregations dominated by: new growth (a), up-growth (b), in coenopopulations in the fir forest (A) and Carpathian beechwood (B and C)

Coenopo- population	Mean aggregation number per 1 ha			Total aggregation area (m ²)		
	a	b	a + b	a	b	a + b
A	37	17	54	485	290	775
B	27	26	53	590	1274	1864
C	19	56	75	194	490	684

Fig. 3. Distribution of trees and aggregations of fir new growth and up-growth within 1 ha areas, in fir populations in the fir forest (A) and Carpathian beechwood (B and C)

Table 3

Coefficients of mean crowding of seedlings and new growth individuals in coenopopulations in the fir forest (A) and Carpathian beechwood (B and C)

Coenopopulation	Study area	Coefficient of mean crowding (number of individuals per 1 m ²)	
		seedlings	new growth
A	1	3.8	5.8
	2	4.2	7.3
	3	8.5	2.5
	1'	3.1	2.6
	2'	0.6	0.7
	3'	0	1.3
B	1	1.8	4.7
	2	2.2	4.0
	3	1.1	4.5
	1'	—	2.3
	2'	—	1.1
	3'	—	0.2
C	1	1.2	4.6
	2	0	0.8
	3	0	1.7
	1'	—	0
	2'	—	0
	3'	—	0.3

1-3 as in Table 1.

Table 4

Density, height and age of fir individuals within and outside aggregations

		Density (indiv. per 1 m ²)	Height (cm)	Age (years)
Aggregations	fir forest (A)	5.3 ± 0.6	38.8 ± 1.3	12.7 ± 0.2
	Carpathian beechwood (B)	5.9 ± 0.6	44.0 ± 0.3	18.0 ± 0.3
	mean value for both communities	5.6 ± 0.4	41.4 ± 0.9	15.1 ± 0.2
Areas outside aggregations	fir forest (A)	0.8 ± 0.2	41.8 ± 7.2	—
	Carpathian beechwood (B)	0.5 ± 0.1	43.0 ± 6.9	—
	mean value for both communities	0.7 ± 0.2	42.4 ± 7.0	—

Mean values are given with 0.05 confidence semi-interval.

Table 5

Vitality parameters of fir new growth and up-growth individuals and outside aggregations in coenopoulations in the fir forest (A) and Carpathian beechwood (B and C)

	Guoup of individuals	Coeno-population-	Mean crown diameter (cm)	Individu-als with no apical buds (%)	Individu-als with 1-3 apical buds (%)	Individu-als with 4-6 apical buds (%)	Mean heigh increment of apical shoot (cm)
Aggregations	new growth	A	37±3	3	91	6	2.85±0.28
		B	35±3	0	97	3	2.54±0.25
	up-growth	A	145±58	14	65	21	4.70±0.61
		B	146±43	3	82	15	6.40±0.93
Areas outside aggregations	new growth	A	36±3	3	96	1	2.02±0.15
		B	37±3	1	99	0	1.65±0.13
	up-growth	A	151±46	32	66	1.5	2.23±0.35
		B	146±39	25	73	2	2.47±0.38

Table 6

Density, height and age of fir individuals in the centre of aggregations and on their peripheries

Property	Mean of 16 aggregations		Aggregations with higher proportion of			
	centre	peripheries	new growth		up-growth	
			centre	peripheries	centre	peripheries
Density (indiv. per m ²)	6.3±0.9	5.2±0.5	9.2±1.5	6.5±0.9	3.9±0.6	4.1±0.4
Height (cm)	50.5±1.9	38.8±1.2	—	—	—	—
Age (years)	16.3±0.4	15.0±0.3	—	—	—	—

General means are given with 0.05 confidence semi-interval.

From the data on clumped distribution of juvenile silver fir individuals it was found that:

— Fir population from the Carpathian beechwood community with high fir proportion in the ground layer and undergrowth was divided into large aggregations distributed in groups. In the other two phytocoenoses aggregations were small and occurred at random.

— Individuals in the aggregation centres were higher and slightly older than those on the peripheries. Density in new-growth-dominated aggregations was higher in the centre.

Fig. 4. Aggregations of juvenile fir individuals under tree canopy. a — number of individuals in transect 2 m² plots; b — mean individual height; c — mean individual age; 12, 14 — numbers of selected aggregations

Fig. 5. Frequency distribution of height and age of fir individuals in the centre of aggregations and on their peripheries. 6, 8, 10 — numbers of selected aggregations

— Correlation coefficients between age and height of individuals were higher in the centre of the aggregations which grew under tree canopy than on their peripheries.

— Individuals within aggregations exhibited better vitality than those outside them.

POPULATION AGE STRUCTURE

Age pyramid was flat with a very wide base. Individuals less than 10 years old accounted for 90% of a population (Fig. 7). New growth individuals were, as a rule, younger than 20 years, those of the up-growth were mainly 20-40, although some of them 70 years old. Tree age (both dead and alive) ranged from 60 to 80 years. Dead trees formed 40% of a population (Fig. 8).

The differences between populations concerned mainly the age of individu-

Fig. 6. Correlation between age and height of fir individuals in aggregations, in gap and under tree canopy. Dark dots indicate individuals on the peripheries; light — in the aggregation centre. 1, 4, 6, 14 — numbers of selected aggregations; r — correlation coefficient for: c — centre and p — peripheries of an aggregation

Fig. 7. Age pyramid of local silver fir population (L)

Fig. 8. Age distribution within groups of fir individuals in fir coenopopulations in the fir forest (A), Carpathian beechwood (B and C), and in a local population (L); fraction of dead, standing fir trees, 100% — dead and alive fir trees together

als of new growth and up-growth. The former were usually younger in fir forest than in Carpathian beechwood. Also up-growth individuals younger than 20 years were more numerous in the fir forest. In the community of the Carpathian beechwood C relatively older up-growth individuals grew (Table 7).

Table 7

Age of fir individuals in coenopopulations in the fir forest (A) and Carpathian beechwood (B and C)

Coenopopulation	Study area	Age (years)							
		new growth	mean	alive up-growth	mean	dead up-growth	mean	alive trees	dead trees
A	1	10.8±0.9	n = 356	24.7±3.1	n = 150	39.9±3.9	n = 100	n = 51	n = 35
	2	11.5±1.0		27.6±2.7		44.5±4.5			
	3	5.0±0.8		35.3±5.2 ^x		43.9±4.3 ^x			
			9.2±0.5		26.0±1.8		44.1±1.9	70.5±2.7	68.1±4.2
	1'	8.9±1.1		19.0±2.3		45.5±3.4			
	2'	11.8±1.1		23.3±4.0		47.5±4.3			
B	3'	6.7±0.8		—		—			
	1	11.5±0.8	n = 180	23.7±1.5	n = 90	49.7±3.4	n = 60	n = 17	n = 14
	2	12.1±0.9	12.2±0.5	27.0±1.8	28.9±1.9	51.5±6.0	51.1±2.4	90.9±6.1	76.0±7.1
C	3	13.1±1.0		36.0±4.1		52.0±3.1			
	1	14.1±1.3	n = 160	33.3±3.5	n = 88	43.5±4.7	n = 60	n = 20	n = 12
	2	13.2±1.0	13.4±0.8	43.2±5.7	37.6±2.0	50.3±4.1	38.7±6.7	73.0±6.0	70.0±10.8
	3	12.6±1.8		34.4±2.3		43.0±2.6			

* Data from study areas 3 and 3' together. n — sample size.

Means are given with 0.05 confidence semi-interval — for study areas, and general mean — for coenopopulation.

1-3 as in Table 1.

SIZE STRUCTURE OF INDIVIDUALS IN A POPULATION

The height frequency distribution of individuals in a fir population is assymmetrical, positively skewed, 94% individuals lower than 50 cm (Fig. 9). Most new growth individuals were 10-40 cm high, at average 23 cm, whereas those of the up-growth — 50-100 cm, at average 107 cm. Mean height of dead individuals in the up-growth was much higher than that of alive. In tree group individuals 15-25 m high prevailed. Mean tree height was 18 m. The absence of undercanopy trees (5-10 m high) was very characteristic of the analysed population (Table 8).

Fig. 9. Height frequency distribution of fir individuals in a local population (L)

The analysed populations differed only slightly in respect of the height of individuals but considerably in respect of their vitality. In the Carpathian beechwood C, both in new growth and up-growth individuals with 4-6 apical buds were considerably fewer than in other communities. These individuals had also much lower height increment of the apical shoot (Fig. 10).

CORRELATION BETWEEN AGE AND HEIGHT IN FIR INDIVIDUALS

The age-height relationship was closer in the new growth than in the up-growth. The strongest correlation held for new growth in the Carpathian beechwood C and up-growth in the Carpathian beechwood B. The differences in the height of individuals grew with their age, in new growth they amounted to 30 cm, in the up-growth — to 2 m (Fig. 11).

DISCUSSION

In the studies on the silver fir population it has been considered to what degree structural properties reflecting the current state of a population may be used to analyse the undergoing processes. It is commonly known that spatial

Table 8

Height of fir individuals in coenopopulations in the fir forest (A) and Carpathian beechwood (B and C)

Coeno- popu- lation	Study area	Height							
		(cm)						(m)	
		new growth	mean	alive up-growth	mean	dead up-growth	mean	alive trees	dead trees
A	1	27.0 ± 2.8		105.0 ± 11.7		185.0 ± 27.0			
	2	25.6 ± 3.2		114.0 ± 14.6		175.0 ± 28.5			
	3	10.4 ± 0.8		146.2 ± 23.3 ^x		165.5 ± 25.6 ^x			
			21.1 ± 1.2		111.0 ± 6.7		179.5 ± 12.0	21.1 ± 0.8	17.8 ± 1.0
	1'	21.8 ± 3.0		81.7 ± 4.2		192.5 ± 35.8			
	2'	27.6 ± 3.0		112.0 ± 13.6		177.5 ± 26.9			
	3'	12.6 ± 1.6		—		—			
B	1	22.8 ± 2.3		79.0 ± 2.5		152.5 ± 24.7			
	2	27.6 ± 2.1	24.2 ± 1.2	118.0 ± 13.4	101.3 ± 6.1	160.8 ± 11.5	160.8 ± 11.5	23.3 ± 0.9	20.3 ± 0.9
	3	22.0 ± 1.8		107.0 ± 10.2		157.5 ± 17.6			
C	1	23.1 ± 2.6		102.0 ± 10.3		175.0 ± 34.0			
	2	25.3 ± 2.4	24.5 ± 1.3	128.0 ± 16.0	108.3 ± 6.8	210.0 ± 26.5	185.0 ± 16.7	20.7 ± 1.0	17.2 ± 3.0
	3	19.1 ± 3.3		94.0 ± 5.6		170.0 ± 27.3			

^x Data from study areas 3 and 3' together. n — sample size.

Means are given with 0.05 confidence semi-interval — from study areas, and general mean — for coenopopulation.

1-3 as in Table 1.

Fig. 10. Vitality of individuals in fir new growth (n) and up-growth (u) in coenopopulations in the fir forest (A) and Carpathian beechwood (B and C)

organization determines reproduction, mortality, and hence population dynamics (Andrzejewski and Symonides 1982, Falińska and Gliwicz 1986). Many works showed that an increase in the density is associated with either the delay of individual development as in perennials, or in its acceleration like in many annuals (Sukaczew 1941, Rabotnow 1950, Symonides 1974, 1978, Wilkoń-Michalska 1976), as well as with lower fruit and seed production (Zarzycki 1965a) etc. These relationships are connected with inter- and intraspecific competition (Zarzycki 1965a and b).

The importance of clumped distribution of juvenile fir individuals for the process of population regeneration has been related to self-thinning capacity in trees. The process is density-dependent and leads on the elimination of the weakest and the smallest individuals, hence regulates the population qualitatively and quantitatively (White and Harper 1970, Łomnicki 1980, Westoby and Howell 1986). In fir population the process starts in new growth aggregations where it is most intense. It results in lower density of up-growth aggregations. Self-thinning rate is higher in the centre than on the

Fig. 11. Correlation between age and height of fir individuals in new growth and up-growth, in coenopopulations in the fir forest (A) and Carpathian beechwood (B and C); r — correlation coefficient

peripheries (Mazur 1984). Hence height frequency distribution of individuals in aggregations is non-uniform: in the centre individuals are higher and more variable in spite of their similar age.

One of the reasons for the self-thinning being more intense in the centre than on the peripheries of aggregations is their higher density. Specific microclimate within aggregations which promotes the growth and develop-

ment of individuals may be the other reason. Hence individuals that survive juvenile phase originate mainly from the aggregation centre.

In the centre of aggregation individuals may survive better due to better light access. According to Biernacki (personal communication) the aggregations currently occupying space under tree canopy originated in gaps or other sites with better light conditions. In opinions of others the groups create more favourable conditions for the growth and development of young silver fir trees, which in future may enter tree layer (Morozow 1953, Bellon et al. 1956, Bernadzki 1971, Graniczny 1971, Winnicki 1979).

The aggregations of juvenile fir individuals play an important role in the regeneration of a population. High density increases mortality, but on the other hand accelerates development of survivors. Intraspecific competition causes that survivors which in future will become trees are the strongest. It has been proved by higher vitality of individuals in aggregations than outside them.

Each phytocoenose studied creates different conditions for the regeneration of fir population. More favourable conditions undoubtedly result in the presence of compact aggregations with many individuals in early developmental phases. Among three communities studied Carpathian beechwood B was the best. However, also fir forest creates favourable conditions.

It is worth mentioning that in respect of fir regeneration Carpathian beechwood C differs more from the other beechwood than from fir forest community. These two vast beechwood complexes within the Park differ, to some extent, in the proportion of vascular plants, abundance of the character-species (*Dentaria glandulosa*), and the cover of ground layer and undergrowth. One of them is definitely better developed. But mostly they differ in the proportion of fir in the layers of vertical forest structure.

The locations of these phytocoenoses also differ: southern and northern slopes. Different exposition results in different microclimate and other abiotic factors. The observations of better fir regeneration on southern slopes with Carpathian beechwoods within the Świętokrzyski National Park confirm those of Jaworski (1973) on the fir regeneration in the communities of Carpathian beechwood and thermophilous fir wood.

The studies on the age and size structure of silver fir population have been used to determine its developmental phase. Wide base of age pyramid, the fact that most individuals do not exceed 0.5 m indicate that new growth is abundant, and in spite of high proportion of dead trees the process of regeneration takes its proper course. Hence fir population is only in the initial phase of regression, which is further confirmed by the presence of standing dead trees in all the phytocoenoses studied.

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Struktura i dynamika populacji jodły (Abies alba Mill.) w zbiorowiskach leśnych Świętokrzyskiego Parku Narodowego. I. Struktura populacji

Streszczenie

Praca jest pierwszą częścią szerszych badań, dotyczących struktury i dynamiki populacji jodły. Przedstawiono w niej ocenę cech strukturalnych populacji jodły, takich jak: struktura przestrzenna, struktura wieku oraz wielkości osobników populacji. Badania prowadzono w latach 1979-1984 w trzech fitocenozach leśnych Świętokrzyskiego Parku Narodowego. Jedna fitocenoza reprezentuje zespół boru jodłowego, zaś dwie buczynę karpacką. Osobniki jodły rosnące w tych fitocenozach potraktowano jako trzy cenopopulacje (A, B i C). Stanowiły one podstawę do przeprowadzenia charakterystyki lokalnej populacji jodły. Strukturę przestrzenną populacji określono jako skupiskową. Decyduje o niej przede wszystkim rozmieszczenie siewek, nalotu

i podrostu; drzewa rozmieszczone są losowo. Rozmieszczenie losowe stwierdzono również u siewek i osobników z nalotu na obszarach o mniejszym ich zagęszczeniu. Skupiska rozmieszczone losowo są mniejsze i zajmują mniejszą łączną powierzchnię, niż rozmieszczone grupowo.

Skupiska osobników juvenilnych jodły, stymulujące proces wydzielania się osobników poprzez większe zagęszczenie niż na obszarach poza nimi, pełnią ważną rolę w procesie odnawiania się jodły. Duże zagęszczenie w skupiskach wzmacnia śmiertelność, ale zarazem przyspiesza rozwój osobników przeżywających. Konkurencja wewnątrzgatunkowa powoduje, że osobniki przeżywające, które w przyszłości mogą zająć miejsce wśród drzew, są najsilniejsze. Na poparcie tej tezy dowiedziono, że żywotność osobników jodły rosnących w skupiskach jest większa niż na obszarach o małym ich zagęszczeniu. W związku z tym tworzenie się dużych, rozmieszczonych grupowo skupisk bardziej sprzyja odnawianiu się populacji, jak to zaobserwowano w buczynie karpackiej na południowym stoku Łysogór, niż małych rozmieszczonych losowo skupisk, jak w borze jodłowym i buczynie karpackiej na stokach północnych pasma. Piramida wieku wskazuje na duży udział osobników składających się na nalot jodły. Stanowią one ponad 90% populacji. Potwierdza to rozkład wysokości osobników. Proces naturalnego odnawiania się przebiega zatem prawidłowo.

Mniej optymistycznie wygląda sytuacja drzew. Prawie połowę stojących drzew stanowią osobniki martwe. Udział tych drzew sięga 40%, wykazując pewne zróżnicowanie w poszczególnych fitocenozach. Wymieranie drzew jest prawdopodobnie związane z działaniem czynników zewnętrznych, które jak dotąd okazały się niekorzystne tylko dla tej grupy osobników. Duży udział martwych drzew wskazuje na regresję populacji. Licznie reprezentowane osobniki z nalotu i podrostu pozwalają jednak uznać aktualną fazę rozwoju populacji jako początkową fazę regresji.