CHANGES OF THE VALUATION FEATURES OF MATURE PINE STANDS IN THE EXPERIMENTAL FORESTS DISTRICT ZIELONKA IN THE PERIOD FROM 1963 TO 2004

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Abstract. The primary objective of the research project was to determine the variability of the taxation characters of pine stands during individual cycles of forest management work in the period extending from 1963 to 2004. The authors assessed changes in the forest species composition which took place in the Zielonka Experimental Forest District, especially, the proportion of Scots pine. It is evident from the performed analyses that the share of pine in the discussed object decreased during the examined period of time by nearly 7% and, in 2004, it reached the level of 82.7%. The oak increased its share from 5.1% of the forest area in 1963 to 12.3% in 2004. The obtained results corroborate a systematic increase of the stand current increment and volume. Changes in the proportion of forest sites (19% in 1963 and 78% in 2004) indicate that there is a need for the modification in the ways of forest management, especially in the case of pine stands which are artificial and unsuitable for the site.

Key words: pine stands, current volume increment, stand volume taxation traits

INTRODUCTION

The Zielonka Experimental Forest District, which is a part of the Murowana Goślina Experimental Enterprise, is a very valuable research object for the Faculty of Forestry of August Cieszkowski Agricultural University in Poznań which makes it possible to carry out investigations in all areas of forest sciences. The establishment and development of experimental forests is associated with the post-war activities and development of the Faculty of Forestry of the then Poznań University. A very detailed discussion of the history of the organisational activities of this Faculty, as well as the then condition and developmental perspectives of experimental forest can be found in a paper published by Zabielski [1967]. The above-mentioned elaboration contains, among others, characterization of objects of exceptional economic, forest and natural importance as well as the

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description of the forest prepared on the basis of the forest management plan for 1963. In the description, stand productivity was characterized by the net mean increment of large timber volume (m^3/ha) because, at that time, it was impossible to determine current increment which is the basic criterion of productivity of individual stands as well as entire forest districts. This problem was undertaken by Magnuski [1981] and Miś [1983, 1994].

The forest management plan prepared for the Zielonka Experimental Forest District for the year 2004 encourages to make certain comparisons which allow identification of changes taking place in the species composition of these forests, especially in the proportion of Scots pine and in the taxation characters of pine stands. The primary objective of this study was to determine the variability of the taxation characters of pine stands during the individual cycles of management work and during the entire period from 1963 to 2004.

METHODS AND EXPERIMENTAL MATERIAL

The object of investigations was forests of the Zielonka Experimental Forest District of the total area of 4550 ha (according to the state on 1.01.2004). The experimental material comprised:

1) informatics database for the above-mentioned forest district compiled by BULiGL in Poznań (the state on 1.01.2004),
2) analogue forest management database from years 1963 to 1994 (valuation descriptions, general description),
3) numerical map of the forest district prepared by BULiGL in Poznań (the state on 1.01.2004).

Employing appropriate informatics methods, the authors compiled their own databases of pine stands over 80 years of age growing on the fresh mixed coniferous forest site (BMśw) and fresh mixed broad-leaved forest site (LMśw) in the Zielonka Experimental Forest District. During work with the informatics database, the structural question language (SQL) was employed which, thanks to the application of the WHERE clause, allowed selection of stands which corresponded to the research assumptions.

Identical databases of stands were developed from analogue databases by means of seeking out appropriate data and feeding them into the computer. The MS SQL Server 2005 application was used during the process of development of the above-mentioned bases.

Stand bases comprise lists which contain the forest address, stand area and valuation features. They were divided into two most numerously represented sites, namely: fresh mixed coniferous forest site (BMśw) and fresh mixed broad-leaved forest site (LMśw). Next, using the Statistica 7.1 software, the obtained data were elaborated statistically. The following characteristics were subjected to analysis:

– stand stocking (Zd),
– site index (B),
– technical quality (Jt),
– mean height and breast height diameter (H – m, D – cm),
– stand volume (V – m^3/ha),
– the coverage of the stand surface by underwood and underbrush (Pdr, Pds).

Lists of comparisons of mean valuation features were elaborated dividing them into BMśw and LMśw as well as in accordance with the consecutive cycles of forest management work. Moreover, mean volume per hectare of the forest surface as well as the current increments were calculated in order to compare them with the data from forest management plans from the entire forest district.

RESULTS

The proportion of pine as the dominant species in the forests of the Zielonka Forest District in the course of the analysed five consecutive cycles of management work was always very high (Table 1). Nevertheless, a falling trend in the share of this forest tree species was observed in the successive management periods in favour of the oak, so that in the last cycle (2004), Scots pine occupied approximately 84% of the forest surface in the entire forest district, whereas the oak – 12%.

Table 1. Percentage proportion and surface occupied by the individual main tree species during the consecutive cycles of forest management in the Zielonka Experimental Forest District
Tabela 1. Procentowy udział i powierzchnia zajmowana przez poszczególne gatunki główne dla pięciu kolejnych cykli prac urządzeniowych w Nadleśnictwie Doświadczalnym Zielonka

Main tree species Gatunek panujący	1963		1973		1984		1994		2004	
	ha	%	ha	%	ha	%	ha	%	ha	%
So	2 644.06	89.80	2 816.13	89.92	3 527.15	86.92	3 477.74	85.28	3 313.01	82.73
Md	2.09	0.07	12.56	0.40	9.24	0.23	16.64	0.41	20.00	0.50
Św	15.85	0.54	14.76	0.47	16.94	0.42	11.03	0.27	11.56	0.29
Db	150.20	5.10	184.93	5.90	363.71	8.96	439.74	10.78	494.35	12.34
Bk	8.89	0.30	10.90	0.35	14.30	0.35	12.07	0.30	38.13	0.95
Brz	15.89	0.54	14.44	0.46	23.27	0.57	27.13	0.67	37.61	0.94
Ol	74.81	2.54	60.97	1.95	73.71	1.82	76.26	1.87	77.41	1.93
Olsz	8.25	0.28	6.08	0.19	4.61	0.11	2.61	0.06	4.31	0.11
Tp	24.46	0.83	11.15	0.36	24.82	0.61	14.77	0.36	8.27	0.21

The calculated current volume increment for pine stands as well as their mean volume per 1 hectare was compared with the data from all stands in the examined forest district (Table 2). The mean volume of mature pine stands in each of the consecutive cycles of management work was higher than the corresponding volume of all stands in the entire forest district as well as pine stands of all age classes reaching its highest value – 410 m^3/ha in the last decade. On the other hand, it was lower than the corresponding volume of mature oak stands. The current increment of mature pine wood was higher only in the first two periods (1963, 1973) but during the remaining periods, it was lower in comparison with the increment for all the stands in the examined forest district.

Table 2. Mean volume and current volume increment of pine stands set against some selected indices of the Zielonka Forest District

Tabela 2. Przeciętna zasobność i przyrost bieżący miąższości drzewostanów sosnowych na tle wybranych wskaźników Nadleśnictwa Doświadczalnego Zielonka

Index – Wskaźnik	Unit Jed-nostka	Year – Stan na				
		1963	1973	1984	1994	2004
Zielonka Forest District – Nadleśnictwo Zielonka						
Mean volume per 1 ha Przeciętna zasobność na 1 ha pow. leśnej	m^3	209	209	218	256	331
Mean volume per 1 pine stands Przeciętna zasobność na 1 ha pow. leśnej drze-wostanów sosnowych	m^3	191	211	207	254	325
Mean volume of final cutting products per 1 ha Przeciętna miąższość użytków rębnych na 1 ha	m^3	–	3.64	2.74	2.15	2.33
Current volume increment per 1 ha Bieżący przyrost na 1 ha	m^3	3.73	3.81	3.84	5.55	7.96
Coniferous site Udział siedlisk borowych	%	81	79	79	80	22
Broad-leaved site Udział siedlisk lasowych	%	19	21	21	20	78
Mean stands age Przeciętny wiek drzewostanów	years lata	55	58	57	63	65
Pine stands over 80 years of age – Drzewostany sosnowe w wieku powyżej 80 lat						
Mean volume per 1 ha Przeciętna zasobność na 1 ha pow. leśnej	m^3	354	367	351	312	410
Current volume increment per 1 ha Bieżący przyrost miąższości na 1 ha	m^3	3.94	4.10	3.71	3.69	5.25
Oak stands over 80 years of age – Drzewostany dębowe w wieku powyżej 80 lat						
Mean volume per 1 ha Przeciętna zasobność na 1 ha pow. leśnej	m^3	470	441	412	428	519

The performed investigations comprised 332 mature pine stands, of which 228 stands were situated on the BMśw site and 104 stands – on the LMśw site. Mean valuation features for these stands are presented in Table 3. Up to 1994, the number of mature pine stands situated on the BMśw site was higher than those growing on the LMśw site. The reversal of these proportions recorded in 2004 was caused by the application of a new diagnostic method of forest site types. The mean value of stocking up to 1994 ranged from 0.8 to 0.9, although the highest value was achieved by the examined stands during the last cycle (2004). The BMśw site index for the consecutive decades was identical – I/II, whereas on the LMśw site – I or I/ll. The mean technical quality did not change in the course of the successive cycles of the management work and amounted to 2. The mean height and breast height diameter were found similar in the consecutive decades (26-27 m and 32-34 cm, respectively). The highest stand volume of 417 m^3/ha

Table 3. Comparison of mean valuation features of pine stands over 80 years of age
Tabela 3. Zestawienie średnich elementów taksacyjnych drzewostanów sosnowych w wieku powyżej 80 lat

Year Rok	N	P, ha	Zd	B	Jt	H	D	V	Pdr	Pds
BMśw										
1963	46	216.88	0.9	I/II	2	27	34	345	x	0.6
1973	46	245.51	0.9	I/II	2	27	33	372	0.5	0.7
1984	58	286.47	0.8	I/II	2	26	33	331	0.2	0.8
1994	57	316.99	0.8	I/II	2	26	34	321	0.2	0.7
2004	21	88.66	1.0	I/II	2	27	34	417	0.2	0.7
LMśw										
1963	11	42.00	0.8	I	2	26	33	363	x	0.6
1973	13	75.80	0.9	I/II	2	27	33	363	0.1	0.8
1984	11	54.71	0.9	I	2	26	34	371	0.3	0.9
1994	10	64.09	0.7	I/II	2	25	32	302	0.5	0.8
2004	59	252.09	0.9	I/II	2	26	33	402	0.4	0.7

was determined in pine stands growing on the BMśw site during the last cycle of management work, while the lowest volume value was recorded in the case of pine wood during the penultimate cycle (1994) situated on the LMśw site (302 m^3/ha).

Moreover, basic statistical parameters for the mean height and breast height diameter as well as for the stand volume were calculated for all the examined stands (Table 4). The highest variability coefficient for the tree height was found in pine stands on the LMśw site during the penultimate cycle of management work (6.53%). A significantly higher variability was determined with regard to the mean breast height diameter for the stands on the LMśw site during the first decade (12.42%). Its lowest value was determined during the last cycle of management work for the BMśw site (9.08%).

The mean mature stand volume on the examined sites up to 1994 ranged from 302 to 372 m^3/ha. The results of the last inventory showed that it increased from 402 to 417 m^3/ha (Fig. 1).

The distribution of the mean tree height in the pine stands over 80 years of age for the last cycle of the management work (2004) was similar to normal (Fig. 2). Certain irregularities were recorded in the case of the distribution of the mean breast height diameter on the BMśw site in 2004 (Fig. 2). It varied from the normal distribution due to the excessively low number of stands with the mean breast height diameter of 33-36 cm.

The test of the least significant difference (LSD) carried out in the course of the analysis of variance revealed statistically significant differences only in the case of the stand volume (Table 5). Bold type indicates significant differences between stand volumes in the consecutive cycles of the management work. It is visible that the last two decades (1994, 2004) exerted the strongest influence.

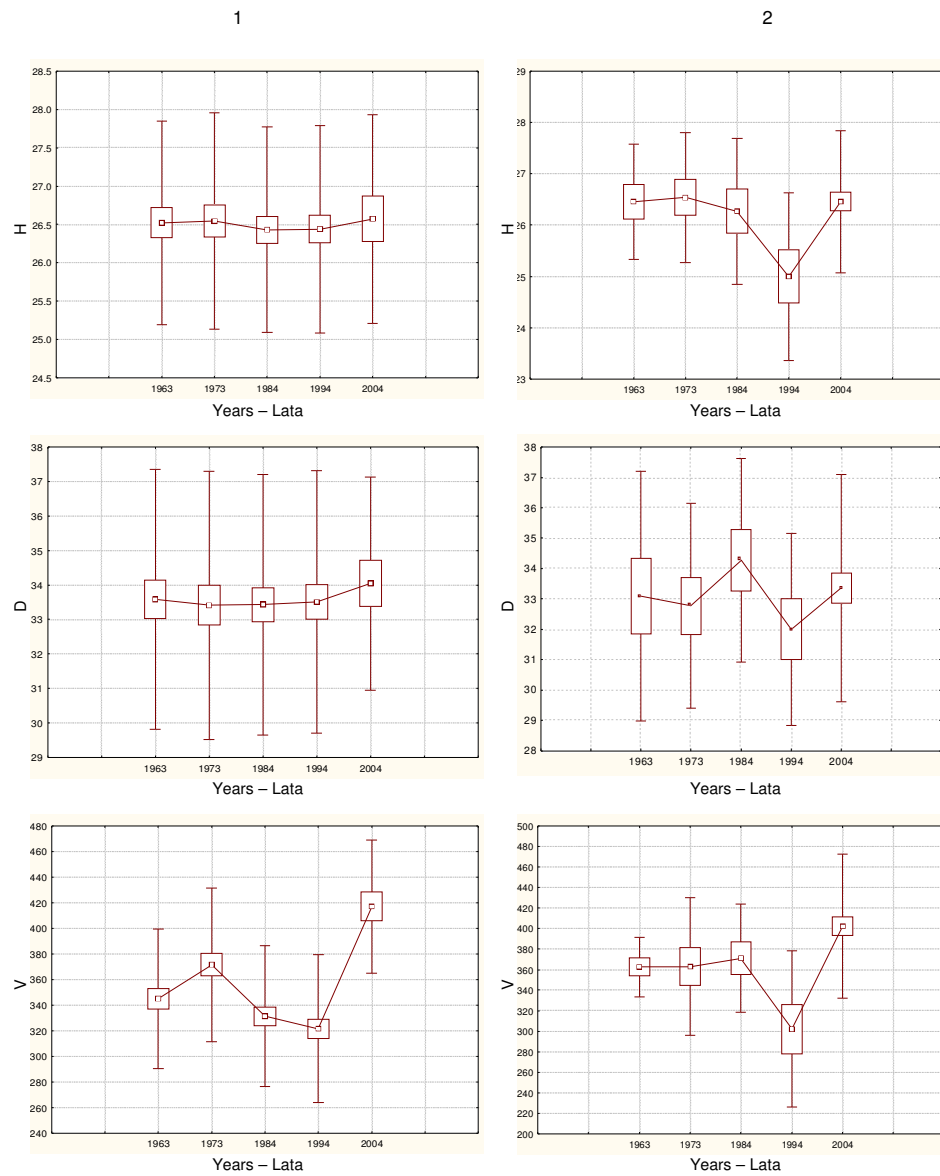1   2

Fig. 1. Mean height (H) and breast height diameter (D) of trees and volume (V) of mature pine stands: 1 – BMśw site, 2 – LMśw site

Rys. 1. Średnia wysokość (H) i pierśnica (D) drzew oraz zasobność (V) dojrzałych drzewostanów sosnowych: 1 – siedlisko BMśw, 2 – siedlisko LMśw
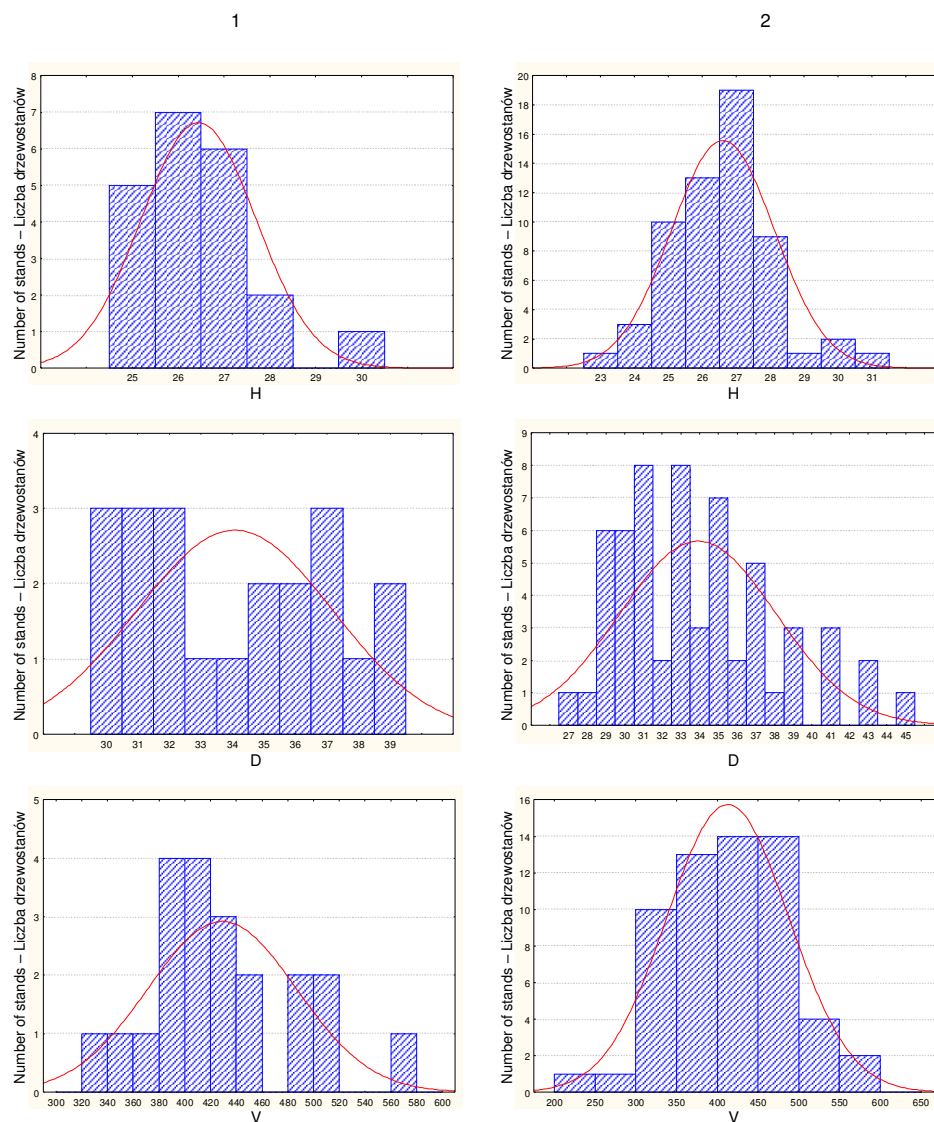
Fig. 2. Histograms of the mean height (H) and breast height diameter (D) of trees and volume (V) of mature pine stands of over 80 years of age: 1 – BMśw site, 2 – LMśw site

Rys. 2. Histogramy przeciętnej wysokości (H) i pierśnicy (D) drzew oraz zasobności (V) drzewostanów sosnowych w wieku powyżej 80 lat: 1 – siedlisko BMśw, 2 – siedlisko LMśw

Table 4. Comparison of basic statistical parameters for the mean height and breast height diameter as well as for stand volume for all the examined stands over 80 years of age for five consecutive cycles of the management work in the Zielonka Forest District

Tabela 4. Zestawienie podstawowych parametrów statystycznych dla przeciętnej wysokości i pierśnicy drzew oraz zasobności drzewostanów sosnowych w wieku powyżej 80 lat dla pięciu kolejnych cykli prac urządzeniowych w Nadleśnictwie Doświadczalnym Zielonka

Year Rok	Site TSL	Basic statistical parameters – Podstawowe parametry statystyczne								
		n	0	x_{max}	x_{min}	R	s^2	s	Δx	V, %
1	2	3	4	5	6	7	8	9	10	11
Mean height – Przeciętna wysokość drzew										
1963	BMśw	46	26.5	30	23	7	1.77	1.33	0.20	5.01
	LMśw	11	26.5	28	25	3	1.27	1.13	0.34	4.26
1973	BMśw	46	26.5	30	23	7	1.99	1.41	0.21	5.31
	LMśw	13	26.5	28	25	3	1.60	1.27	0.35	4.77
1984	BMśw	58	26.4	30	23	7	1.79	1.34	0.18	5.07
	LMśw	11	26.3	28	23	5	2.02	1.42	0.43	5.41
1994	BMśw	57	26.4	30	23	7	1.82	1.35	0.18	5.11
	LMśw	10	25.0	28	22	6	2.67	1.63	0.52	6.53
2004	BMśw	21	26.6	30	25	5	1.86	1.36	0.30	5.13
	LMśw	59	26.5	30	23	7	1.91	1.38	0.18	5.22
Breast height diameters – Przeciętna pierśnica drzew										
1963	BMśw	46	33.6	45	28	17	14.25	3.77	0.56	11.24
	LMśw	11	33.1	39	28	11	16.89	4.11	1.24	12.42
1973	BMśw	46	33.4	45	28	17	15.14	3.89	0.57	11.64
	LMśw	13	32.8	39	28	11	11.36	3.37	0.93	10.28
1984	BMśw	58	33.4	45	27	18	14.25	3.77	0.50	11.29
	LMśw	11	34.3	41	31	10	11.22	3.35	1.01	9.77
1994	BMśw	57	33.5	45	27	18	14.47	3.80	0.50	11.35
	LMśw	10	32.0	39	28	11	10.00	3.16	1.00	9.88
2004	BMśw	21	34.0	39	30	9	9.55	3.09	0.67	9.08
	LMśw	59	33.4	45	27	18	14.06	3.75	0.49	11.24
Stand volume – Zasobność drzewostanów										
1963	BMśw	46	345	480	180	300	2 950.00	54.31	8.01	15.74
	LMśw	11	363	410	300	110	841.82	29.01	8.75	8.00
1973	BMśw	46	372	483	268	215	3 610.56	60.09	8.86	16.17
	LMśw	13	363	483	231	252	4 518.08	67.22	18.64	18.51
1984	BMśw	58	331	503	173	330	3 032.03	55.06	7.23	16.62
	LMśw	11	371	450	292	158	2 771.00	52.64	15.87	14.19
1994	BMśw	57	321	490	189	301	3 339.25	57.79	7.65	17.98
	LMśw	10	302	400	156	244	5 772.40	75.98	24.03	25.14
2004	BMśw	21	417	530	335	195	2 707.49	52.03	11.35	12.48
	LMśw	59	402	571	236	335	4 921.74	70.16	9.13	17.44

Table 5. The LSD test for the volume (V) of pine stands over 80 years old on the BMśw and LMśw sites
Tabela 5. Test NIR dla zasobności (V) drzewostanów sosnowych w wieku powyżej 80 lat na siedliskach BMśw i LMśw

Number of cycle Numer cyklu	LSD test; Variable V; MS = 259.10, df = 5.0000 Test NIR; zmienna V; Błąd: MS międzygrupowe = 259,10, df = 5,000				
	year rok	{1} 354.00	{2} 367.50	{3} 351.00	{4} 311.50	{5} 409.50
1	1963		0.439887	0.859477	**0.045959**	**0.018278**
2	1973	0.439887		0.352344	**0.017678**	**0.047713**
3	1984	0.859477	0.352344		0.057657	**0.014993**
4	1994	**0.045959**	**0.017678**	0.057657		**0.001729**
5	2004	**0.018278**	**0.047713**	**0.014993**	**0.001729**	

RECAPITULATION AND CONCLUSIONS

The following observations can be made on the basis of the performed analyses:
- Scots pine was found to decrease gradually in proportion in forests on the entire investigated area during the examined period of time from 89.8% in 1963 to 82.7% in 2004.
- The proportion of larch increased from 0.1% of the forest area (1963) to 0.5% (2004).
- The proportion of spruce decreased from 0.5% (1963) to 0.3% (2004).
- During the examined period of time, oak was found to increase gradually its proportion in stands from 5.1% of the forest area in 1963 to 12.3% – in 2004.
- Beech increased its proportion from 0.3% (1963) to almost 1% (2004).
- Alder and poplar decreased their share of the forest area (alder – from 0.3% to 0.1% and poplar – from 0.8% to 0.2%), whereas the proportion of birch increased (from 0.5% to 0.9%).
- The productivity of the examined forests increased steadily and in 2004 the current volume increment (of the main stand) was estimated at the level of 7.96 m^3/ha /year.
- The mean stand volume on the forest area increased from 209 m^3/ha (1963) to 331 m^3/ha.
- The mean oak stand volume (2004) of 80 years of age was higher than the stand volume of pine trees of the same age by 109 m^3.

The above-presented observations allowed the authors to draw the following conclusions:

1. The transformation of the tree species composition of forests in the Zielonka Experimental Forest District was, primarily, the result of the growing dynamics of growth and regeneration of oak as well as the acceptance of the clear cutting forest management and the areas under pine stands.

2. The obtained results corroborated the occurrence of the phenomenon of a steady increase of the current increment of stands and their volume.

3. The proportion of broad-leaved forest stands increased during the examined period of time nearly four times (from 19% in 1963 to 78% in 2004). This fact will have a significant impact on changes in current management methods, especially in this part of pine stands which are completely artificial and unsuitable for the site properties.

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ZMIENNOŚĆ CECH TAKSACYJNYCH DOJRZAŁYCH DRZEWOSTANÓW SOSNOWYCH W NADLEŚNICTWIE DOŚWIADCZALNYM ZIELONKA W OKRESIE OD 1963 DO 2004 ROKU

Streszczenie. Głównym celem pracy było określenie zmienności cech taksacyjnych drzewostanów sosnowych w poszczególnych cyklach prac urządzeniowych w okresie 1963-2004. Określono zmiany, którym podlega skład gatunkowy lasów Nadleśnictwa Doświadczalnego w Zielonce, a w szczególności udział sosny zwyczajnej. Z przeprowadzonej analizy wynika, że udział sosny zmniejszał się w badanym okresie o około 7%, osiągając w 2004 roku wartość 82,7%. Dąb zwiększył areał od 5,1% powierzchni leśnej (1963 r.) do 12,3% (2004 r.). Uzyskane wyniki potwierdzają systematyczne zwiększanie się przyrostu bieżącego drzewostanów oraz ich zasobności. Zmiana udziału siedlisk lasowych (19% w 1963 r. i 78% w 2004 r.) wskazuje na konieczność modyfikacji sposobów zagospodarowania lasu, zwłaszcza w sztucznych i niedostosowanych do siedliska drzewostanach sosnowych.

Słowa kluczowe: drzewostany sosnowe, przyrost bieżący miąższości, zasobność drzewostanów, cechy taksacyjne