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SCOTS PINE (*PINUS SYLVESTRIS* L.) CROWN CONDITION IN THE LUBIN FOREST DISTRICT (WROCŁAW RDSF) IN YEARS 2002-2004*

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Abstract. In years 2002-2004 eight pairs of experimental surfaces, one from the 3rd and one from the 4th age class, were established in pure pine stands in the Lubin Forest District. In each of these sample plots crown defoliation, the condition of the assimilation apparatus, height increment and shoot vitality of 25 trees of the main stand were assessed. Differences between mean defoliations were compared using for this purpose the standard error of the difference of two means (for P = 0.95). The performed analysis was carried out for each of the experimental surfaces and for the given entire age class during three experimental periods (i.e. years 2002-2003, 2003-2004 and 2002-2004) as well as for pairs of surfaces and age classes in the consecutive three years of observations (2002, 2003 and 2004).

Key words: Lubin Forest District, Scots pine, defoliation, complex assessment

INTRODUCTION

In 1990s, following far-reaching political, social and economical transformations in Poland, a significant reduction in the level of industrial emissions took place which exerted a noticeable effect on the improvement in forest tree and stand conditions. However, the problem of the influence of industry on forests still exists and requires continuous monitoring.

The Lubin Forest District is situated in the direct neighbourhood of the Legnica-Głogów Copper Centre (LGCC) which, for a number of years, exerted a substantial and negative impact on the condition of the neighbouring forest stands. According to the forest management plan from 1994, forests belonging to the Lubin Forest District were situated in the mild (I), moderate (II) and strong (III) damage zones and, locally, in

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some places, the zone of industrial scrub (IV) also occurred. The condition of forests of the examined forest district was affected by the emissions of the local copper processing plant as well as the transgenic contamination from Western Europe.

In years 2002-2004, the scientific staff and students doing their final papers at the Department of Forest Management of the Poznań Agricultural University carried out investigations in the Lubin Forest District (Wrocław Regional Directorate of State Forests – RDSF) connected with monitoring of the crown condition of Scots pine (*Pinus sylvestris* L.) trees. Data collected in 2002 were used to characterize the crown conditions of pine trees in the Legnica-Głogów Copper Centre [Jaszczak and Gołojuch 2002].

The performed studies allowed to determine defoliation as well as three tree crown traits which were essential for the so called complex evaluation which constituted the basis for the determination of the range of the damage zones in the forests which were affected by the industrial air emissions [Dmyterko 1992, 1993, 1994, 1996, Instrukcja... 1994]. It was an original solution applied in Poland which was characterized by the evaluation of standing and not felled sample trees. This method was universally applied in this forest district in the course of forest management work [Jaszczak 1996] as well as in a number of experiments investigating the condition of uneven-aged monocultures in the Experimental Forest District in Siemianice [Jaszczak and Małys 1998], correlations between the biosocial position of trees and the level of their damage indices [Jaszczak 2000 a, b, c] or the relationship of damage indices and the identification of definite number of forest damage zones [Jaszczak 2005 c].

The observations conducted in successive two years were treated as controls – the obtained results, on the one hand, were to give answer to the question if, in the discussed period, the state of tree crowns was stable or if it underwent significant alterations in consecutive years and, on the other, if there was a statistically significant difference between mean defoliations and complex assessments of stands of the 3rd and 4th age class. The second of the two problems had already been discussed by Jaszczak [2005 a] for a larger group of forest districts, but the results reported by him indicated that there was a need for further investigations on possibilities and usefulness of utilization for forest monitoring of averaged results from pairs of uneven-aged surfaces established close to one another. Therefore, this study provides another opinion in this discussion.

OBJECT AND RESEARCH METHOD

From the point of view of the natural-forest division, the Lubin Forest District is situated in the 5th Silesian Region, in the District of the Lower Silesia Plain, Mezoregion of the Dalkowskie Hills. A small part of the Forest District is situated within the boundaries of the 3rd Wielkopolski-Pomorski Region, in the Lubuskie Lake District, Mezoregion of the Głogów Marginal Stream Valley. From the point of view of the physico-geographical division, the Lubin Forest District is situated in the Sub-Province of the Central European Lowland, Silesian Lowland Macro-Region. Administratively, the District belongs to the Wrocław Regional Directorate of State Forests.

Observations were conducted in years 2002, 2003 and 2004 in pure pine stands 41 to 80 years of age in which the total of 8 pairs of sample plots were established, one from each the 3rd and 4th age classes. In each case, the sample plot comprised 25 trees selected from the main stand. The centre of the sample plot was made stable using a small

pole, while compass placed over it served to determine cardinal points. The tree which happened to grow closest to the centre was designated with number one and next six trees were selected from each of the cardinal directions (N, S, W and E) which were growing closest to the plot centre. A detailed description of the sample plot selection, the assessment of the loss of the assimilation apparatus as well as the criteria and the way of the complex tree crown evaluation based on the following three characteristics: the condition of the assimilation apparatus (trait A), height increment (trait B) and shoot vitality (trait C) is presented in a study elaborated by Jaszczak [2005 b] as well as in the Forest Management Instruction [Instrukcja... 1994].

The collected data were grouped separately for each sample plot and age classes and then basic descriptive statistics of the defoliation and complex assessment (minimum, maximum, mean variation, standard deviation, variability coefficient) were calculated. The author compared differences between mean defoliations and points of complex assessment with the assistance of the standard error of the difference of two means (for P = 0.95). The performed analysis was carried out for each plot and the entire given age class in three experimental periods (years 2002-2003, 2003-2004 and 2002-2004) as well as pairs of surfaces and age classes in the consecutive three years of observation (2002, 2003 and 2004).

RESULTS

Defoliation

The basic defoliation descriptive characteristics on individual sample plots in the consecutive three years of observations are presented in Tables 1 (the 3rd age class) and 2 (the 4th age class). It is evident from them that in the case of the 3rd age class stands, the mean defoliation in 2002 ranged from 23.80% to 27.80% – on average 25.50%, in 2003 – from 21.40% to 25.00% – on average 23.62% and in 2004 – from 20.60% to 30.83% – on average 24.62%. In the case of the 4th age class, the mean defoliation in 2002 ranged from 24.20% to 30.20% on average 26.73%, in 2003 – from 23.40% to 27.08% – on average 25.20% and in 2004 – from 23.54% to 31.20% – on average 26.53%.

In the year 2002, the mean defoliation of two pairs of sample plots (numbers 1 and 2, and 5 and 6) was identical; in five cases it was lower and in one case (plots number 13 and 14) – higher for the sample plot of the 3rd class of age. In 2003, the mean defoliation was lower for all surfaces of the 3rd age class, whereas in 2004 only for one pair of surfaces (numbers 13 and 14) the mean defoliation was higher for the 3rd age class. The general comparison of the 3rd and 4th age classes revealed that the mean loss of the assimilation apparatus in each year was lower for the group of the younger stands; in 2002 – by 1.23%, in 2003 – by 1.58% and in 2004 – by 1.91%. Simultaneously, the mean defoliation in both age classes was the lowest in 2003 (23.62% in the 3rd age class and 25.20% in the 4th age class) and the highest – in 2002 (25.50% in the 3rd age class and 26.73% in the 4th age class).

In years 2002 and 2003, the defoliation variability for both age classes was similar, while in 2004 – it was slightly higher. The variability coefficient for the 3rd class of age

Table 1. Basic descriptive characteristics of defoliation on individual sample plots III age class and in consecutive three years of observations
Tabela 1. Podstawowe charakterystyki opisowe defoliacji na kolejnych powierzchniach III klasy wieku i ogółem w trzech latach obserwacji

Plots numbers Powierzchnia numer	Year of observations Rok obserwacji	Defoliation, % – Defoliacja, %			Variance Wariancja %	Standard deviation Odchylenie standardowe	Variability coefficient Współczynnik zmienności %
		minimum minimum	maximum maksimum	mean średnia			
1	2002	15	30	24.20	9.75	3.12	12.9
	2003	20	25	23.60	5.25	2.29	9.7
	2004	15	35	22.80	29.33	5.42	23.8
3	2002	15	30	23.80	11.00	3.32	13.9
	2003	20	30	25.00	6.25	2.50	10.0
	2004	15	25	22.50	10.87	3.30	14.7
5	2002	20	30	26.00	6.25	2.50	9.6
	2003	20	30	24.20	7.67	2.77	11.4
	2004	20	35	26.00	12.50	3.54	13.6
7	2002	20	40	26.60	14.00	3.74	14.1
	2003	15	25	22.60	10.67	3.27	14.5
	2004	15	35	26.00	29.17	5.40	20.8
9	2002	20	30	24.20	9.75	3.12	12.9
	2003	15	30	21.40	19.83	4.45	20.8
	2004	15	30	20.60	13.17	3.63	17.6
11	2002	20	30	25.00	6.25	2.50	10.0
	2003	20	30	23.60	7.33	2.71	11.5
	2004	20	30	23.20	8.08	2.84	12.3
13	2002	25	40	27.80	14.75	3.84	13.8
	2003	15	35	24.17	23.19	4.82	19.9
	2004	20	50	30.83	57.97	7.61	24.7
15	2002	15	40	26.40	19.83	4.45	16.9
	2003	10	35	24.20	18.08	4.25	17.6
	2004	15	55	25.20	59.33	7.70	30.6
Total III age class Razem III klasa wieku	2002	15	40	25.50	12.81	3.58	14.0
	2003	10	35	23.62	12.83	3.58	15.2
	2004	15	55	24.62	35.01	5.92	24.0

Table 2. Basic descriptive characteristics of defoliation on individual sample plots IV age class and in consecutive three years of observations
Tabela 2. Podstawowe charakterystyki opisowe defoliacji na kolejnych powierzchniach IV klasy wieku i ogółem w kolejnych latach obserwacji

Plots numbers Powierzchnia numer	Year of observations Rok obserwacji	Defoliation, % – Defoliacja, %			Variance Wariancja %	Standard deviation Odchylenie standardowe	Variability coefficient Współczynnik zmienności %
		minimum minimum	maximum maksimum	mean średnia			
2	2002	20	30	24.20	9.75	3.12	12.9
	2003	20	30	24.17	7.97	2.82	11.7
	2004	15	30	23.54	18.43	4.29	18.2
4	2002	25	30	26.60	5.67	2.38	8.9
	2003	20	35	27.08	12.86	3.59	13.2
	2004	20	35	26.25	18.09	4.25	16.2
6	2002	25	35	26.00	6.25	2.50	9.6
	2003	20	25	24.60	1.92	1.38	5.6
	2004	20	35	26.60	14.00	3.74	14.1
8	2002	20	45	28.00	22.92	4.79	17.1
	2003	10	35	23.40	20.25	4.50	19.2
	2004	20	35	26.20	21.42	4.63	17.7
10	2002	25	55	30.20	38.50	6.21	20.5
	2003	20	35	27.00	10.42	3.23	12.0
	2004	25	60	31.20	67.25	8.20	26.3
12	2002	20	30	25.80	5.58	2.36	9.2
	2003	20	35	24.40	13.17	3.63	14.9
	2004	15	35	24.00	20.83	4.56	19.0
14	2002	25	30	26.20	4.75	2.18	8.3
	2003	15	35	25.00	12.50	3.54	14.1
	2004	15	45	25.80	30.58	5.70	22.1
16	2002	25	30	26.80	6.00	2.45	9.1
	2003	15	30	26.00	12.50	3.54	13.6
	2004	15	45	28.54	33.65	5.80	20.3
Total IV age class Razem IV klasa wieku	2002	20	55	26.73	14.72	3.84	14.4
	2003	10	35	25.20	12.65	3.56	14.1
	2004	15	60	26.53	32.68	5.72	21.5

in the consecutive years of investigations ranged from 9.6% to 16.9% – 14.0% on average (2002), from 9.7% to 20.8% – 15.2% on average (2003) and from 12.3% to 30.6% – on average 24.0% (2004). On the other hand, the variability coefficient for the 4th age class fluctuated in the successive years of the experiment as follows: from 8.3% to 20.5% – 14.4% on average (2002), from 5.6% to 19.2% – 14.1% on average (2003) and from 14.1% to 26.3% – on average 21.5% (2004).

Table 3 presents the comparison and assessment of differences between mean defoliations for individual sample plots and both age classes in the three years in which the observations were conducted which were obtained employing the standard error of the difference of two means (for P = 0.95). It is clear from this Table that, during the first experimental period (years 2002-2003), the mean tree crown defoliation underwent significant changes on six (3rd age class) and five (4th age class) surfaces. During the second experimental period (years 2003-2004), the significance of differences concerned

Table 3. Absolute differences of mean defoliations of tree crowns and its evaluation performed with the aid of standard error (P = 0.95) for individual sample plots and age classes in consecutive years of experiments

Tabela 3. Bezwzględne różnice średnich defoliacji koron drzew i jej ocena za pomocą błędu standardowego (P = 0,95) dla poszczególnych powierzchni i klas wieku w kolejnych okresach badawczych

Plots of the III age classes Powierzchnie III klasy wieku				Plots of the IV age classes Powierzchnie IV klasy wieku			
number numer	differences of mean defoliations between years, % różnice średnich defoliacji pomiędzy latami, %			number numer	differences of mean defoliations between years, % różnice średnich defoliacji pomiędzy latami, %		
	2002-2003	2003-2004	2002-2004		2002-2003	2003-2004	2002-2004
1	0.60**	0..80**	**1.40*****	2	0.03**	0.63**	0.66**
3	**1.20*****	**2.50*****	**1.30*****	4	0.48**	0.83**	0.35**
5	**1.80*****	**1.80*****	0.00*	6	**1.40*****	**2.00*****	0.60**
7	**4.00*****	**3.40*****	0.60**	8	**4.60*****	**2.80*****	**1.80*****
9	**2.80*****	0.80**	**3.60*****	10	**3.20*****	**4.20*****	1.00**
11	1.40**	0.40**	**1.80*****	12	**1.40*****	0.40**	**1.80*****
13	**3.63*****	**6.67*****	**3.03*****	14	**1.20*****	0.80**	0.40**
15	**2.20*****	1.00**	1.20**	16	0.80**	**2.54*****	**1.74*****
Total age class Razem klasa wieku	**1.88*****	**1.00*****	**0.88*****	Total age classs Razem klasa wieku	**1.52*****	**1.33*****	0.20**

*No difference.
**Difference statistically non-significant, P = 0.95.
***Difference statistically significant, P = 0.95.
*Brak różnicy.
**Nieistotna statystycznie różnica, P = 0,95.
***Istotna statystycznie różnica, P = 0,95.

four surfaces in both 3rd and 4th age classes. In the third period of investigations (years 2002-2004), the significance of differences referred to five (3rd age class) and three (4th age class) sample plots. In the case of age classes, the significance of differences of the mean defoliation concerned all the three experimental periods as regards the younger surfaces, while in the case of older plots, it referred only to two of the consecutive periods (i.e. years 2002-2003 and 2003-2004). In the course of a longer period of time (years 2002-2004), the mean tree crown defoliation of the 4th age class stands did not undergo statistically significant differences.

In the case of individual surfaces, the greatest number of statistically significant differences of mean defoliations was observed comparing years 2002 and 2003 in which, respectively, the highest and the lowest mean loss of the assimilation apparatus was recorded for the 3rd and 4th age classes. Altogether, during the three experimental years, stands of the 3rd age class showed more statistically significant differences of the mean defoliation (62.5% of cases) than stands of the 4th class (50.0% of cases).

Table 4 presents the comparison and assessment of differences between mean defoliations for the individual pairs of surfaces and both age classes in the consecutive three years of experiments which were carried out with the assistance of the standard error of the difference of two means (for P = 0.95). It is evident from the Table that the statistical significance of differences of the mean defoliation in the first year of observations (2002) was confirmed for five out of eight pairs of experimental surfaces and, additionally, in the case of four pairs of surfaces (numbers: 3 and 4, 7 and 8, 9 and 10 as well as 11 and 12) – the mean surface defoliation of the 3rd age class was lower from the mean defoliation of surfaces of the 4th age class, while in one case the situation was reverse (plots number 13 and 14). In the second year of studies (2003), the significance of differences referred only to three pairs of surfaces (in each case, the mean defoliation of surfaces of the 3rd class was lower than the mean defoliation of the surfaces of the 4th age class), while in the third experimental year (2004), it concerned four pairs of surfaces and in the case of three pairs, the mean defoliation of surfaces of the 3rd age class was lower than the mean defoliation of surfaces of the 4th age class (surfaces number: 3 and 4, 9 and 10 as well as 15 and 16), while in one case, the situation was reverse (surfaces 13 and 14). At the same time, the mean of the tree crown defoliation of the 3rd age class was statistically significantly lower in each year of observations in comparison with the mean tree crown defoliation of the 4th age class.

When discussing research results from years 2002 and 2003 which were conducted in eighteen forest districts, Jaszczak [2005 a] concluded that the mean defoliation of Scots pine tree crowns was usually lower for the mean tree crown defoliation of the 4th age class but only in 26.6% of cases these differences were statistically significant. The results of this study showed that a similar situation occurred in the Lubin Forest District because, during three years of observations, in 20 out of 24 cases, the mean defoliation of tree crowns was lower for the 3rd age class, but only in 50.0% of these cases the differences was statistically significant. For individual pairs of surfaces, the greatest number (5 out of 8) of statistically significant differences of mean defoliations was found in 2002 in which the mean loss of the assimilation apparatus was the highest for both the 3rd and the 4th age classes, while the smallest number (3 out of 8) of statistically significant differences of mean defoliations was found in 2003 in which the mean tree crown opening up was found the lowest, both for the 3rd and 4th age classes.

Table 4. Absolute differences of mean defoliations of tree crowns and its evaluation performed with the aid of standard error (P = 0.95) for individual pairs of sample plots and age classes in consecutive years of experiments
Tabela 4. Bezwzględne różnice średnich defoliacji koron drzew i jej ocena za pomocą błędu standardowego (P = 0,95) dla poszczególnych par powierzchni i klas wieku w kolejnych okresach badawczych

Pair of surfaces Para powierzchni	Differences of mean defoliations in year, % Różnica średniej defoliacji w roku, %		
	2002	2003	2004
1 a 2	0.00*	0.57**	0.74**
3 a 4	**2.80*****	**2.08*****	**3.75*****
5 a 6	0.00*	0.40**	0.60**
7 a 8	**1.40*****	0.80**	0.20**
9 a 10	**6.00*****	**5.60*****	**10.60*****
11 a 12	**0.80*****	0.80**	0.80**
13 a 14	**1.60*****	0.83**	**5.03*****
15 a 16	0.40**	**1.80*****	**3.34*****
III and IV age class III a IV klasa wieku	**1.23*****	**1.58*****	**1.91*****

*No difference.
**Difference statistically non-significant, P = 0.95.
***Difference statistically significant, P = 0.95.
*Brak różnicy.
**Nieistotna statystycznie różnica, P = 0,95.
***Istotna statystycznie różnica, P = 0,95.

Complex assessment

Basic descriptive characteristics of the complex evaluation on individual surfaces during the consecutive three years of observations are presented in Tables 5 (the 3rd age class) and 6 (the 4th age class). It is evident from them that the mean number of points in 2002, in the case of the 3rd age class stands, ranged from 3.24 pts. to 4.80 pts. – on average 4.14 pts., in 2003 from 3.52 pts. to 4.36 pts. – on average 3.95 pts. and in 2004 from 3.52 pts. to 4.79 pts. – on average 4.25 pts. In the case of the 4th age class, the mean number of points of the complex assessment in 2002 ranged from 4.08 pts. to 5.48 pts. – on average 4.64 pts., in 2003 from 4.00 pts. to 5.16 pts. – on average 4.48 pts. and in 2004 from 4.24 pts. to 5.52 pts. – on average 4.74 pts.

In the year 2002, the mean point number of the complex assessment of one pair of surfaces (number 5 and 6) was identical, in six cases – it was lower and in one case (surface numbers 13 and 14), it was higher for the surface of the 3rd age class. In 2003, the mean number of points was lower for seven surfaces of the 3rd age class and identical for one pair of surfaces (5 and 6). In 2004, the mean number of points was lower for seven surfaces and higher for one pair of surfaces (7 and 8) of the 3rd age class. Altogether, when comparing the 3rd and 4th age classes, it was found that the mean number

Table 5. Basic descriptive characteristics of complex assessment on individual sample plots III age class and in consecutive three years of observations
Tabela 5. Podstawowe charakterystyki opisowe oceny kompleksowej na kolejnych powierzchniach III klasy wieku i ogółem w trzech latach obserwacji

Plots numbers Powierzchnia numer	Year of observations Rok obserwacji	Complex assessment, pts Ocena kompleksowa, pkt			Variance Wariancja %	Standard deviation Odchylenie standardowe	Variability coefficient Współczynnik zmienności %
		minimum minimum	maximum maksimum	mean średnia			
1	2002	3	5	3.52	0.34	0.59	16.6
	2003	3	5	3.96	0.54	0.73	18.6
	2004	3	6	4.28	0.96	0.98	22.9
3	2002	2	6	3.24	0.52	0.72	22.3
	2003	3	7	4.04	0.62	0.79	19.5
	2004	3	5	3.88	0.20	0.45	11.6
5	2002	3	6	4.72	0.79	0.89	18.9
	2003	3	6	4.32	0.48	0.69	16.0
	2004	3	6	4.44	0.76	0.87	19.6
7	2002	2	6	4.32	1.56	1.25	28.9
	2003	2	5	3.80	0.42	0.65	17.0
	2004	3	6	4.56	1.17	1.08	23.8
9	2002	3	6	4.08	0.58	0.76	18.6
	2003	3	5	3.52	0.34	0.59	16.6
	2004	2	6	3.52	0.68	0.82	23.4
11	2002	3	6	3.72	0.56	0.75	20.2
	2003	3	6	3.88	0.61	0.78	20.1
	2004	3	5	3.88	0.19	0.44	11.3
13	2002	3	6	4.68	0.73	0.85	18.2
	2003	2	6	3.75	0.98	0.99	26.4
	2004	3	7	4.79	1.65	1.28	26.8
15	2002	4	6	4.80	0.83	0.91	19.0
	2003	2	6	4.36	0.74	0.86	19.7
	2004	3	7	4.64	0.99	0.99	21.4
Total III age class Razem III klasa wieku	2002	2	6	4.14	1.02	1.01	24.4
	2003	2	7	3.95	0.63	0.80	20.2
	2004	2	7	4.25	0.97	0.98	23.2

Table 6. Basic descriptive characteristics of complex assessment on individual sample plots IV age class and in consecutive three years of observations
Tabela 6. Podstawowe charakterystyki opisowe oceny kompleksowej na kolejnych powierzchniach IV klasy wieku i ogółem w trzech latach obserwacji

Plots numbers Powierzchnia numer	Year of observations Rok obserwacji	Complex assessment, pts Ocena kompleksowa, pkt			Variance Wariancja %	Standard deviation Odchylenie standardowe	Variability coefficient Współczynnik zmienności %
		minimum minimum	maximum maksimum	mean średnia			
2	2002	3	6	4.08	0.49	0.70	17.2
	2003	3	6	4.25	0.54	0.74	17.3
	2004	4	6	4.50	0.61	0.78	17.3
4	2002	3	6	4.28	1.21	1.10	25.7
	2003	4	6	4.92	0.86	0.93	18.9
	2004	4	7	4.65	0.98	0.99	21.2
6	2002	4	6	4.72	0.54	0.74	15.6
	2003	4	5	4.32	0.23	0.48	11.0
	2004	4	6	4.68	0.73	0.85	18.2
8	2002	3	7	4.96	1.04	1.02	20.6
	2003	2	6	4.00	0.67	0.82	20.4
	2004	3	6	4.44	1.17	1.08	24.4
10	2002	4	7	5.48	0.84	0.92	16.8
	2003	4	7	5.16	0.81	0.90	17.4
	2004	4	8	5.52	1.09	1.05	18.9
12	2002	3	6	4.16	0.56	0.75	17.9
	2003	3	6	4.16	0.72	0.85	20.4
	2004	2	6	4.24	0.69	0.83	19.6
14	2002	4	6	4.72	0.63	0.79	16.8
	2003	3	6	4.56	0.67	0.82	18.0
	2004	4	6	4.88	0.69	0.83	17.1
16	2002	4	6	4.68	0.81	0.90	19.2
	2003	2	6	4.52	1.26	1.12	24.8
	2004	2	6	4.96	1.17	1.08	21.8
Total	2002	3	7	4.64	0.93	0.96	20.8
IV age class Razem	2003	2	7	4.48	0.83	0.91	20.3
IV klasa wieku	2004	2	8	4.74	1.00	1.00	21.1

of points of the complex assessment was lower for the group of younger stands: in 2002 – by 0.50 pts, in 2003 – by 0.53 pts. and in 2004 – by 0.49 pts. At the same time, the lowest mean number of points for both age classes was recorded in 2003 (the 3rd age class – 3.95 pts., the 4th age class – 4.49 pts.), and the highest – in 2004 (the 3rd age class – 4.25 pts., the 4th age class – 4.74 pts.).

The variability of the complex assessment for both age classes was similar in all the three years of observations. The variability coefficient for the 3rd age class during the consecutive experimental years ranged from 16.6% to 28.9% – on average 24.4% (2002), from 16.0% to 26.4% – on average 20.2% (2003) and from 11.3% to 26.8% – on average 23.2% (2004). On the other hand, the variability coefficient for the 4th age class during the consecutive experimental years ranged from 15.6% to 25.7% – on average 20.8% (2002), from 11.0% to 24.8% – on average 20.3% (2003) and from 17.1% to 24.4% – on average 21.1% (2004).

Table 7 presents the comparison and assessment of differences between the mean number of points of the complex assessment for individual experimental surfaces and both age classes in three years of studies carried out using the standard error of the difference of two means (for P = 0.95). It is clear from the Table that, during the first period of research (years 2002-2003), the mean number of points of the tree complex assessment underwent significant changes on seven (the 3rd age class) and four (the 4th age class) surfaces. During the second experimental period (years 2003-2004), the significance of differences concerned five (the 3rd age class) and six (4th age class) surfaces. In the third year of studies (2002-2004), the significance of differences involved four surfaces of the 3rd and 4th age classes each. In the case of both age classes, the significance of differences of the mean number of points referred to all the three research periods with the value of the difference slightly higher for the 3rd age class in the case of each period.

In the case of individual surfaces, the greatest number of statistically significant differences of the mean number of points of the complex evaluation, in the case of the 3rd age class, referred to the period 2002-2003 (seven out of eight pairs of surfaces), whereas in the case of the 4th class of age – to the period of 2003-2004 (six out of eight pairs of surfaces). On the other hand, in the case of the comparisons of years 2002 with 2004, equal or the lowest number of statistically significant differences (four out of eight pairs of surfaces) is characteristic.

Table 8 shows the comparison and assessment of differences between the mean number of points of the complex assessment for individual pairs of surfaces and both age classes in the successive three years of investigations carried out with the assistance of the standard error of the difference of two means (for P = 0.95). It is evident from this Table that in each of the three years of studies the statistical significance of differences of the mean number of points was confirmed in the case of five out of eight number of surfaces (numbers: 3 and 4, 9 and 10 as well as 11 and 12) but only for three pairs of surfaces, this referred to each year of observations. In the case of each year of research, the mean number of points of the complex assessment of tree crowns of the 3rd age class was statistically significantly different from the mean number of points of the complex assessment of tree crowns of the 4th age class.

Jaszczak [2005 c] reported that the pine tree crown damage of the 3rd age class was usually smaller than the tree crown damage of the 4th age class but only in 40% the damage differences of the individual stand pairs were statistically significant. The results

Table 7. Absolute differences of mean complex assessment of tree crowns and its evaluation performed with the aid of standard error (P = 0.95) for individual sample plots and age classes in consecutive years of experiments
Tabela 7. Bezwzględne różnice średnich ocen kompleksowych koron drzew i jej ocena za pomocą błędu standardowego (P = 0,95) dla poszczególnych powierzchni i klas wieku w kolejnych okresach badawczych

Plots of the III age classes Powierzchnie III klasy wieku				Plots of the IV age classes Powierzchnie IV klasy wieku			
number numer	differences of mean complex assessment between years, pts różnice średnich ocen kompleksowych pomiędzy latami, pkt			number numer	differences of mean complex assessment between years, pts różnice średnich ocen kompleksowych pomiędzy latami, pkt		
	2002-2003	2003-2004	2002-2004		2002-2003	2003-2004	2002-2004
1	**0.44*****	**0.32*****	**0.76*****	2	0.17**	**0.25*****	**0.42*****
3	**0.80*****	**0.21*****	**1.01*****	4	**0.64*****	0.27**	**0.37*****
5	**0.40*****	0.12**	**0.28*****	6	**0.40*****	**0.36*****	0.04**
7	**0.52*****	**0.76*****	0.24**	8	**0.96*****	**0.44*****	**0.52*****
9	**0.56*****	0.00*	**0.56*****	10	**0.32*****	**0.36*****	0.04**
11	0.16**	0.00*	0.16**	12	0.00*	0.08**	0.08**
13	**0.93*****	**1.04*****	0.11**	14	0.16**	**0.32*****	0.16**
15	**0.44*****	**0.28*****	0.16**	16	0.16**	**0.44*****	**0.28*****
Total age class Razem klasa wieku	**0.17*****	**0.29*****	**0.13*****	Total age class Razem klasa wieku	**0.15*****	**0.25*****	**0.10*****

*No difference.
**Difference statistically non-significant, P = 0.95.
***Difference statistically significant, P = 0.95.
*Brak różnicy.
**Nieistotna statystycznie różnica, P = 0,95.
***Istotna statystycznie różnica, P = 0,95.

of this study confirm the fact that young stands are characterised by smaller crown damages than old stands. In each of the three years of observations, significant differences involved 62.5% of stand pairs and in each of these cases the mean number of points of complex assessment was lower for the 3rd age class.

Jaszczak [2000 c, 2001, 2004] as well as Wójcik and Buczkowski [2002] postulated the determination of the forest damage zones more frequently than once every 10 years which was associated with suggested better recognition of the change dynamics taking place in the forest environment. The results presented in this study indicate that the condition of tree crowns, from the point of view of the complex evaluation, underwent statistically significant changes in short – one or two-year-periods, which corroborates the above-mentioned recommendation.

Table 8. Absolute differences of mean complex assessment of tree crowns and its evaluation performed with the aid of standard error (P = 0.95) for individual pairs of sample plots and age classes in consecutive years of experiments
Tabela 8. Bezwzględne różnice średnich ocen kompleksowych koron drzew i jej ocena za pomocą błędu standardowego (P = 0,95) dla poszczególnych par powierzchni i klas wieku w kolejnych okresach badawczych

Pair of surfaces Para powierzchni	Differences of mean complex assessment in year, pts Różnica średniej oceny kompleksowej w roku, pkt		
	2002	2003	2004
1 a 2	**0.56*****	**0.29*****	0.22**
3 a 4	**1.04*****	**0.88*****	**0.40*****
5 a 6	0.00*	0.00*	**0.24*****
7 a 8	**0.64*****	0.20**	0.12**
9 a 10	**1.40*****	**1.64*****	**2.00*****
11 a 12	**0.44*****	**0.28*****	**0.36*****
13 a 14	0.04**	**0.81*****	0.09**
15 a 16	0.12**	0.16**	**0.32*****
III and IV age class III a IV klasa wieku	**0.50*****	**0.53*****	**0.49*****

*No difference.
**Difference statistically non-significant, P = 0.95.
***Difference statistically significant, P = 0.95.
*Brak różnicy.
**Nieistotna statystycznie różnica, P = 0,95.
***Istotna statystycznie różnica, P = 0,95.

CONCLUSIONS

In years 2002-2004, the condition of Scots pine (*Pinus sylvestris* L.) trees on individual experimental plots, as expressed by the mean defoliation and points of the complex assessment of their crowns was dynamic and underwent statistically significant changes.

The mean tree crown defoliation of younger stands in the three consecutive years of observations was lower than the mean tree crown defoliation of older stands; however, only in 50% of cases this difference was statistically significant.

The mean number of points of the complex assessment in the three consecutive years of observations was by 62.5% lower for the 3rd age class stands and in each of these cases, this difference was statistically significant.

In the course of management work, the assessment of the crown condition in pine stands should be carried out more frequently than every 10 years.

The research results obtained in the course of this study confirm the necessity of further investigations on possibilities and usefulness of utilization in forest monitoring of averaged results of uneven-aged pairs of surfaces established close to one another, for example one surface each in the 3rd and 4th age class stands instead of drawing conclusions about the state condition on the basis of the results of only one surface.

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STAN KORON SOSNY ZWYCZAJNEJ (*PINUS SYLVESTRIS* L.) W NADLEŚNICTWIE LUBIN (RDLP WROCŁAW) W LATACH 2002-2004

Streszczenie. Obserwacje prowadzono w latach 2002, 2003 i 2004 w litych drzewostanach sosnowych w wieku od 41 do 80 lat, w których założono łącznie osiem par powierzchni próbnych, po jednej z III i IV klasy wieku. Powierzchnię tworzyło zawsze 25 drzew wybranych z drzewostanu głównego, dla których oceniano defoliację oraz trzy cechy koron: stan aparatu asymilacyjnego (cecha A), przyrost wysokości (cecha B) i żywotność pędów (cecha C). Zebrane dane pogrupowano dla każdej z powierzchni i klas wieku, a następnie obliczono dla nich podstawowe statystyki opisowe defoliacji. Porównano różnice pomiędzy przeciętnymi defoliacjami i punktami oceny kompleksowej za pomocą błędu standardowego różnicy dwóch średnich (dla P = 0,95). Analiza dotyczyła każdej z powierzchni i ogółem danej klasy wieku w trzech okresach badawczych (lata 2002-2003, 2003-2004 i 2002-2004) oraz par powierzchni i klas wieku w kolejnych trzech latach obserwacji (2002, 2003 i 2004). Stwierdzono, że w Nadleśnictwie Lubin w latach 2002--2004 stan drzew sosny zwyczajnej (*Pinus sylvestris* L.) na poszczególnych powierzchniach, wyrażony średnią defoliacją i oceną kompleksową ich koron, był dynamiczny i ulegał statystycznie istotnym zmianom (tab. 3 i 7). Średnia defoliacja koron drzew drzewostanów młodszych była mniejsza w kolejnych trzech latach obserwacji od średniej defoliacji koron drzewostanów starszych, jednak tylko w 50% przypadków była to różnica statystycznie istotna (tab. 4). Średnia liczba punktów oceny kompleksowej w kolejnych trzech latach obserwacji była niższa w 62,5% dla drzewostanów III klasy wieku i w każdym z przypadków była to różnica statystycznie istotna (tab. 8). Uzyskane wyniki potwierdzają, że ocena uszkodzeń drzewostanów sosnowych w toku prac urządzeniowych powinna być wykonywana częściej niż co 10 lat.

Słowa kluczowe: Nadleśnictwo Lubin, sosna zwyczajna, defoliacja, ocena kompleksowa

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