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DEFOLIATION OF SCOTS PINE (*PINUS SYLVESTRIS* L.) CROWNS OF THE IIIRD AND IVTH AGE CLASSES AND ITS SIGNIFICANCE FOR THE INTERPRETATION OF RESULTS OF FOREST MONITORING IN POLAND*

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Abstract. In years 2002 and 2003, pairs of experimental plots were established in some selected forest divisions in pine stands of the IIIrd and IVth age class and, on each of these surfaces, crown defoliation of 25 trees from the main stand was assessed according to the, so called, European criteria. Mean defoliations were calculated for each experimental plot and this information was used to allocate individual stands to the appropriate defoliation class. Moreover, the author investigated, whether there were statistically significant differences among mean defoliations and referred the findings to the membership of specific pairs of stands to a defoliation class.

Key words: Scots pine, defoliation, class defoliation, age class

INTRODUCTION

The tree crown defoliation is a basic, albeit still questioned, criterion used in forest monitoring in Poland and other European countries to evaluate the condition and health status of forest ecosystems [Sporek 1990, Ghosh and Innes 1995, Ghosh et al. 1995, Lech 1995, 1999, 2000, Ozolinčius and Stakėnas 1995, Sierota 1995 a, b, 1997, 1998, Spiecker 1995, Vacek et al. 1996, Wawrzoniak et al. 1999, Jaszczak 1999 a, b, 2000 a, b, 2001, 2002, 2003, Wójcik 2000, Wójcik and Czarnecka 2001, Wulff 2002, Jaszczak et al. 2003]. The obtained results are presented in various inventories. In Poland, within the framework of forest biological monitoring, all forest stands are divided into two groups: up to and over 60 years of age. This classification can be attributed to the fact that it is

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universally accepted that younger stands have been exposed to unfavourable external factors for a shorter period f time and, consequently, are more vigorous and less damaged than older stands [Bernadzki 1986; Marszałek 1990].

In years 2001-2004, experiments were carried out at the Chair of Forest Management of the Agricultural University of Poznań investigating differences in the defoliation and damage indices determined using the stand method of Scots pine (*Pinus sylvestris* L.) in relation to the biosocial position of individual trees and stand damage zone. The obtained results included, among others, mean defoliations and membership to the defoliation class of pairs of stands one of which belonged to the third and the other to the fourth age class. This made it possible, on the one hand, to determine if the difference of mean defoliations of uneven-aged pairs of stands was statistically significant or not and, on the other hand, to establish mutual correlations between the difference of the mean defoliation and the membership of pairs of stands to the defoliation class. The recognition of interrelationships in this field is of considerable importance for the interpretation of forest monitoring results and this study aimed to provide a valuable insight into these problems and, in doing so, improve the monitoring of forests and their conditions. In particular, it tried to answer the question, whether the evaluation of the condition of forests should depend on the assessment of the condition of one stand or the averaged condition of a pair of stands of different ages.

RESEARCH OBJECTS AND METHODS

In the period from the middle of June to the middle of September 2002, the total of 128 experimental surfaces were established in the following forest divisions: Głogów, Legnica, Lubin and Wołów (Wrocław RDSF[*]), Góra Śląska, Karczma Borowa, Przedborów, Syców and Włoszakowice (Poznań RDSF) and in the Siemianice Experimental Forest Division. A year later, from the end of June to the beginning of September 2003, the total of 90 experimental plots were established in the forest divisions: Lubsko and Szprotawa (Zielona Góra RDSF), Rudziniec, Złoty Potok and Strzelce Opolskie (Katowice RDSF), Buda Stalowska and Puławy (Lublin RDSF) and Staszów (Radom RDSF). The choice of the above-mentioned forest divisions was prompted by the fact that, according to forest management plans, these areas were characterised by the occurrence of damage zones caused by industrial contaminations of the atmospheric air (I, II, and III). A comprehensive list of forest divisions together with numbers allocated to them (used in the results) is shown in Table 1.

The initial selection of stands was performed on the basis of the stand description and the general map of stands and sites. Ultimately, experimental plots were established in pairs in pine monocultures which had not been damaged in the previous three years by biotic or abiotic factors (e.g. fire). Other conditions included: the requirement that the stands of the III and IV age class should be situated side by side; if possible, no underwood or undercrop should occur (in order not to hinder observations) and, finally, that the stands should be situated in FCF, MFCF or MFB-LF[**]. The final decision concerning

[*] Regional Direction of State Forests – RDSF

[**] FCF – Fresh Coniferous Forest, MFCF – Mixed Fresh Coniferous Forest; MFB-LF – Mixed Fresh Broad-leaved Forest

Table 1. List of forest divisions in which observations were carried out in years 2002 and 2003
Tabela 1. Wykaz nadleśnictw, w których w latach 2002 i 2003 prowadzono obserwacje

Number of the forest division Numer nadleśnictwa	*Forest division Nadleśnictwo*	*Number of the forest division Numer nadleśnictwa*	*Forest division Nadleśnictwo*
Year 2002 – Rok 2002		*Year 2003 – Rok 2003*	
1	*Głogów*	*11*	*Buda Stalowska*
2	*Góra Śląska*	*12*	*Lubsko*
3	*Karczma Borowa*	*13*	*Puławy*
4	*Legnica*	*14*	*Rudziniec*
5	*Lubin*	*15*	*Staszów*
6	*Przedborów*	*16*	*Strzelce Opolskie*
7	*Doświadczalne Siemianice*	*17*	*Szprotawa*
8	*Syców*	*18*	*Złoty Potok*
9	*Włoszakowice*		
10	*Wołów*		

the choice of the pair of stands was taken in the forest. Stand pairs were allocated successive numbers, so that the first pair was assigned numbers 1 and 2, the second – 3 and 4 etc. with odd numbers being given to the III age class and even numbers – to the IV age class stands. All experimental plots were established in typical fragments of stands, as far as it was possible, and each one always included 25 trees of the main stand (i.e. 1, 2 and 3 Kraft classes). The centre of the plot was marked with a pole and the compass placed above it served to identify world directions. The tree growing closest to the plot centre was designated as tree number 1 and then six trees growing closest to the centre along each world direction were selected (N, S, W and E) and marked with chalk, writing the number on the previously de-barked and painted in red place.

Defoliation was estimated on each sample tree by two valuators for the upper and middle part of the crown using 5% valuation intervals and inspecting the tree from different directions from the distance not smaller than the height of the tree. According to literature on the subject [Gärtner 1987, Richtlinie... 1991, Instruction... 1994, Gussone 1995], the number of needle yearlies is an important character. This character was assessed using the following key:

– number of yearlies over 3.0 – defoliation 0-10% – defoliation class 0,
– number of yearlies from 2.5 to 3.0 – defoliation 15-25% – defoliation class 1,
– number of yearlies from 1.5 to 2.0 – defoliation 30-60% – defoliation class 2,
– number of yearlies 0.5 to 1.0 – defoliation 65-95% – defoliation class 3,
– number of yearlies 0.0 – defoliation 100% – defoliation class 4.

The valuators used binoculars (with 8 x 50 magnification) and special colour tables of losses of tree assimilation apparatus [Müller and Stierlin 1990]. The final defoliation value was the result of evaluation of both valuators.

The performed office work included calculations of the mean defoliation of each stand and its allocation to the appropriate defoliation class as well as the absolute difference of mean defoliations for individual tree pairs. In order to ascertain whether differences of

stand defoliation means were statistically significant, the *t* Student test was performed for each surface pair using, for this purpose, the *Statistica 6.0 PL* software and then the results of the test were compared with the membership of stands to defoliation classes and, finally, the mean defoliation of individual stand pairs was calculated and they were then assigned to the appropriate defoliation class. The proportion of defoliation classes for each age class individually and jointly for the two age classes was compiled for each year of observations.

RESULTS

Table 2 presents mean crown defoliations of trees of the III and IV age class as well as their differences for the individual pairs of experimental plots. It is evident from this Table that, in 2002, the lowest mean defoliation in the examined stands was 21.2% (III age class) and 20.4% (IV age class), whereas the highest – 31.4% and 33.6%, respectively. So the range of the mean defoliation in the younger stands was 10.2% and in the older ones – 13.2%. In 2003, the lowest mean defoliation was 20.6% (III age class) and 23.4% (IV age class), while the highest – 32.8% and 33.6%, respectively, hence the range of the mean defoliation in the younger stands was 12.2% and in the older ones – 10.2%. The absolute differences of the mean defoliation between the III and IV age classes ranged from 0.0% to 6.0% (2002) and from 0.0% to 5.2% (2003). In 2002, in 13 cases (20.31%), while in 2003 – in 14 cases (13.11%) the mean crown defoliation of trees of the III age class was higher than that of the IV age class. Jointly, in both years of observation, it referred to 24.77% of surface pairs. In 2002, in 15 cases (23.44%) and in 2003 – in 14 cases (31.11%) differences of the mean defoliation between the III and IV age classes were, at the significance level $\alpha = 0.05$, statistically significant, although not all of them 'positive' for the III age class. Out of the total of 109 pairs of stands, this referred to 29 cases (i.e. 26.60%), of which 22 were 'positive' for the III age class and 6 – for the IV age class. In 2002, the mean defoliation was identical for four and in 2003 – for one pair of surfaces. Jointly, for the two years of observations, it concerned 4.59% of stand pairs.

Table 3 presents the comparison of defoliation classes between the III and IV age classes. It is evident from this Table that out of the total of 28 (25.69%) cases – 20 (31.25%) in 2002 and 8 (17.78%) in 2003, the defoliation class of the III age class was by one class lower than the defoliation class of the IV age class. The situation was reverse in the total of 8 (7.34%) cases – 2 (3.12%) in 2002 and 6 (13.33%) in 2003. Generally speaking, in the case of 36 pairs of stands (i.e. 33.03%), the membership of the III and IV age class to the defoliation class was different, while in 73 cases (i.e. 66.97%) identical, despite a different mean defoliation for both stands from a given pair.

Comparing differences of defoliation means and defoliation classes for individual stand pairs, it can be concluded that in 17 (15.60%) cases – 8 (12.50%) cases in 2002 and 9 (20.00%) cases in 2003, it happened that the statistically significant difference of defoliation means corresponded to different allocations of surfaces to defoliation classes. On the other hand, with reference to 29 cases of statistically significant differences of the mean defoliation, the described situation concerned 58.62% of stand pairs, while with reference to 36 cases of different defoliation classes, the described phenomenon concerned 47.22% of stand pairs.

Table 2. Mean defoliations on tree crowns on surfaces of the III and IV age class and differences between them
Tabela 2. Średnie defoliacje koron drzew na powierzchniach III i IV klasy oraz różnice między nimi

Defoliation, % – Defoliacja, %												
III age class III klasa wieku	*IV age class IV klasa wieku*	*Difference III – IV Różnica III – IV*	*III age class III klasa wieku*	*IV age class IV klasa wieku*	*Difference III – IV Różnica III – IV*	*III age class III klasa wieku*	*IV age class IV klasa wieku*	*Difference III – IV Różnica III – IV*	*III age class III klasa wieku*	*IV age class IV klasa wieku*	*Difference III – IV Różnica III – IV*
Year 2002 – Rok 2002			[5] 23.8	26.6	–2.8*	[9] 24.6	25.2	–0.6	[14] 26.8	28.0	–1.2
[1] 27.0	28.2	–1.2	[5] 26.0	26.0	0.0	[9] 24.6	25.8	–1.2	[14] 28.4	25.8	+2.6*
[1] 26.2	26.4	–0.2	[5] 26.6	28.0	–1.4	[9] 22.4	22.4	0.0	[14] 26.6	26.4	+0.2
[1] 25.0	28.2	–3.2	[5] 24.2	30.2	–6.0*	[10] 27.0	27.6	–0.6	[14] 26.2	26.4	–0.2
[1] 27.2	28.6	–1.4	[5] 25.0	25.8	–0.8	[10] 27.0	28.6	–1.6	[14] 26.2	27.2	–1.0
[1] 27.6	27.8	–0.2	[5] 27.8	26.2	+1.6	[10] 27.4	27.2	+0.2	[14] 25.8	27.0	–1.2
[1] 27.2	26.6	+0.6	[5] 26.4	26.8	–0.4	[10] 27.4	26.4	+1.0	[15] 25.4	23.6	+1.8*
[1] 25.0	26.4	–1.4	[6] 23.2	26.0	–2.8*	[10] 26.0	28.2	–2.2*	[15] 23.6	25.8	–2.2*
[2] 22.6	24.0	–1.4	[6] 23.8	25.2	–1.4	[10] 27.2	26.0	+1.2	[15] 22.8	24.8	–2.0*
[2] 21.6	24.2	–2.6	[6] 22.8	26.8	–4.0*	*Year 2003 – Rok 2003*			[15] 23.6	26.0	–2.4*
[2] 25.0	25.4	–0.4	[6] 26.0	28.4	–2.4	[11] 25.2	24.4	+0.8	[15] 24.8	25.0	–0.2
[2] 22.2	24.8	–2.6*	[6] 26.2	25.6	+0.6	[11] 24.0	24.2	–0.2	[16] 27.0	26.2	+0.8
[2] 26.2	28.2	–2.0*	[6] 22.8	23.0	–0.2	[11] 25.8	24.2	+1.6*	[16] 26.4	26.8	–0.4
[2] 27.0	28.8	–1.8	[6] 24.2	26.0	–1.8	[11] 23.2	25.4	–2.2*	[16] 27.4	27.8	–0.4
[3] 24.0	25.0	–1.0	[6] 31.4	28.2	+3.2*	[11] 24.0	24.2	–0.2	[16] 26.8	26.4	+0.4
[3] 24.0	25.0	–1.0	[6] 30.6	29.6	+1.0	[12] 22.4	26.6	–4.2*	[16] 27.8	27.2	+0.6
[3] 24.4	24.2	+0.2	[6] 28.4	33.6	–5.2*	[12] 24.8	25.2	–0.4	[16] 25.8	24.8	+1.0
[3] 24.4	25.6	–1.2	[7] 21.4	25.6	–4.2*	[12] 23.0	27.0	–4.0*	[17] 20.8	24.8	–4.0*
[3] 21.8	22.6	–0.8	[7] 24.4	24.4	0.0	[12] 26.8	26.6	+0.2	[17] 20.6	26.0	–5.4*
[3] 21.2	25.2	–4.0	[7] 22.6	24.4	–1.8	[12] 24.6	23.6	+1.0	[17] 23.3	24.5	–1.2
[3] 22.8	23.0	–0.2	[7] 24.2	23.4	+0.8	[12] 20.6	24.6	–4.0*	[17] 24.0	24.0	0.0
[4] 26.6	28.0	–1.4	[7] 25.2	20.4	+4.8*	[12] 23.4	24.2	–0.8	[17] 22.2	23.4	–1.2
[4] 27.8	27.4	+0.4	[7] 23.8	26.8	–3.0*	[13] 32.4	33.6	–1.2	[18] 25.2	25.6	–0.4
[4] 24.4	25.8	–1.4	[8] 25.8	29.4	–3.6*	[13] 28.4	29.4	–1.0	[18] 24.8	25.8	–1.0
[4] 24.0	25.2	–1.2	[8] 26.0	27.0	–1.0	[13] 29.6	31.8	–1.2	[18] 26.4	24.8	+1.6
[4] 24.8	25.0	–0.2	[8] 25.4	24.8	+0.6	[13] 30.0	35.2	–5.2*	[18] 25.8	25.4	+0.4
[4] 22.2	25.6	–3.4*	[9] 25.6	26.8	–1.2	[13] 29.6	29.8	–0.2	[18] 25.6	24.2	+1.4*
[5] 24.2	24.2	0.0	[9] 24.0	27.0	–3.0*	[13] 32.8	33.4	–0.6			

*Difference significant at the significance level $\alpha = 0.05$; – defoliation of the III age class < IV age class; + defoliation of the III age class > IV age class; 0 – defoliations of the III and IV age classes are identical.

*Różnica istotna na poziomie istotności $\alpha = 0{,}05$; – defoliacja III klasy wieku < IV klasy wieku; + defoliacja III klasy wieku > IV klasy wieku; 0 – defoliacja III i IV klasy wieku jest identyczna

Table 3. Defoliation classes of tree crowns on surfaces of the III and IV age classes and differences between them
Tabela 3. Klasy defoliacji koron drzew na powierzchniach III i IV klasy oraz różnice między nimi

Defoliation, % – Defoliacja, %											
III age class III klasa wieku	*IV age class IV klasa wieku*	*Difference III – IV Różnica III – IV*	*III age class III klasa wieku*	*IV age class IV klasa wieku*	*Difference III – IV Różnica III – IV*	*III age class III klasa wieku*	*IV age class IV klasa wieku*	*Difference III – IV Różnica III – IV*	*III age class III klasa wieku*	*IV age class IV klasa wieku*	*Difference III – IV Różnica III – IV*
Year 2002 – Rok 2002			[5] 1	2	–1	[9] 1	2	–1	[14] 2	2	0
[1] 2	2	0	[5] 2	2	0	[9] 1	2	–1	[14] 2	2	0
[1] 2	2	0	[5] 2	2	0	[9] 1	1	0	[14] 2	2	0
[1] 1	2	–1	[5] 1	2	–1	[10] 2	2	0	[14] 2	2	0
[1] 2	2	0	[5] 1	2	–1	[10] 2	2	0	[14] 2	2	0
[1] 2	2	0	[5] 2	2	0	[10] 2	2	0	[14] 2	2	0
[1] 2	2	0	[5] 2	2	0	[10] 2	2	0	[15] 2	1	+1
[1] 1	2	–1	[6] 1	2	–1	[10] 2	2	0	[15] 1	2	–1
[2] 1	1	0	[6] 1	2	–1	[10] 2	2	0	[15] 1	1	0
[2] 1	1	0	[6] 1	2	–1	*Year 2003 – Rok 2003*			[15] 1	2	–1
[2] 1	2	–1	[6] 2	2	0	[11] 2	1	+1	[15] 1	1	0
[2] 1	1	0	[6] 2	2	0	[11] 1	1	0	[16] 2	2	0
[2] 2	2	0	[6] 1	1	0	[11] 2	1	+1	[16] 2	2	0
[2] 2	2	0	[6] 1	2	–1	[11] 1	2	–1	[16] 2	2	0
[3] 1	1	0	[6] 2	2	0	[11] 1	1	0	[16] 2	2	0
[3] 1	1	0	[6] 2	2	0	[12] 1	2	–1	[16] 2	2	0
[3] 1	1	0	[6] 2	2	0	[12] 1	2	–1	[16] 2	1	+1
[3] 1	2	–1	[7] 1	2	–1	[12] 1	2	–1	[17] 1	1	0
[3] 1	1	0	[7] 1	1	0	[12] 2	2	0	[17] 1	2	–1
[3] 1	2	–1	[7] 1	1	0	[12] 1	1	0	[17] 1	1	0
[3] 1	1	0	[7] 1	1	0	[12] 1	1	0	[17] 1	1	0
[4] 2	2	0	[7] 2	1	+1	[12] 1	1	0	[17] 1	1	0
[4] 2	2	0	[7] 1	2	–1	[13] 2	2	0	[18] 2	2	0
[4] 1	2	–1	[8] 2	2	0	[13] 2	2	0	[18] 1	2	–1
[4] 1	2	–1	[8] 2	2	0	[13] 2	2	0	[18] 2	1	+1
[4] 1	1	0	[8] 2	1	+1	[13] 2	2	0	[18] 2	2	0
[4] 1	2	–1	[9] 2	2	0	[13] 2	2	0	[18] 2	1	+1
[5] 1	1	0	[9] 1	2	–1	[13] 2	2	0			

0 – lack of difference of defoliation classes; –1 – the defoliation class of the III age class < the defoliation class of the IV age class; +1 – the defoliation class of the III age class > the defoliation class of the IV age class

0 – brak różnicy klas defoliacji; –1 – klasa defoliacji III klasy wieku < klasy defoliacji IV klasy wieku; +1 – klasa defoliacji III klasy wieku > klasy defoliacji IV klasy wieku

Mean defoliations of individual stand pairs and their membership to the defoliation class are presented in Table 4. It is evident from this Table that, in 2002, the mean defoliation of stand pairs ranged from 22.2% to 31.00%, whereas in 2003 – from 22.2% to 33.1%. Consequently, the range of the mean defoliation in 2002 was 8.8% and in 2003 – 10.9%.

Table 4. Mean defoliation and membership to the defoliation class of stand pairs in the two years of observations
Tabela 4. Średnia defoliacja i przynależność do klasy defoliacji par drzewostanów w obu latach obserwacji

Mean defoliation Średnia defoliacja	*Defoliation class Klasa defoliacji*	*Mean defoliation Średnia defoliacja*	*Defoliation class Klasa defoliacji*	*Mean defoliation Średnia defoliacja*	*Defoliation class Klasa defoliacji*	*Mean defoliation Średnia defoliacja*	*Defoliation class Klasa defoliacji*
Year 2002 – Rok 2002		[5] 25.2	2	[9] 24.9	1	[14] 27.4	2
[1] 27.6	2	[5] 26.0	2	[9] 25.2	2	[14] 27.1	2
[1] 26.3	2	[5] 27.3	2	[9] 22.4	1	[14] 26.5	2
[1] 26.6	2	[5] 27.2	2	[10] 27.3	2	[14] 26.3	2
[1] 27.9	2	[5] 25.4	2	[10] 27.8	2	[14] 26.7	2
[1] 27.7	2	[5] 27.0	2	[10] 27.3	2	[14] 26.4	2
[1] 26.9	2	[5] 26.6	2	[10] 26.9	2	[15] 24.5	1
[1] 25.7	2	[6] 24.6	1	[10] 27.1	2	[15] 24.7	1
[2] 23.3	1	[6] 24.5	1	[10] 26.6	2	[15] 23.8	1
[2] 22.9	1	[6] 24.8	1	*Year 2003 – Rok 2003*		[15] 24.8	1
[2] 25.2	2	[6] 27.2	2	[11] 24.6	1	[15] 24.9	1
[2] 23.5	1	[6] 25.9	2	[11] 24.1	1	[16] 26.6	2
[2] 27.2	2	[6] 22.9	1	[11] 25.0	1	[16] 26.6	2
[2] 27.9	2	[6] 25.1	2	[11] 24.3	1	[16] 27.6	2
[3] 24.5	1	[6] 29.8	2	[11] 24.1	1	[16] 26.6	2
[3] 24.5	1	[6] 30.1	2	[12] 24.5	1	[16] 27.5	2
[3] 24.3	1	[6] 31.0	2	[12] 25.0	1	[16] 25.3	2
[3] 25.0	1	[7] 23.5	1	[12] 25.0	1	[17] 22.8	1
[3] 22.2	1	[7] 24.4	1	[12] 26.7	2	[17] 23.3	1
[3] 23.2	1	[7] 23.5	1	[12] 24.1	1	[17] 23.9	1
[3] 22.9	1	[7] 23.8	1	[12] 22.6	1	[17] 24.0	1
[4] 27.3	2	[7] 22.8	1	[12] 23.8	1	[17] 22.8	1
[4] 27.6	2	[7] 25.3	2	[13] 33.0	2	[18] 25.4	2
[4] 25.1	2	[8] 27.6	2	[13] 28.9	2	[18] 25.3	2
[4] 24.6	1	[8] 26.5	2	[13] 30.7	2	[18] 25.6	2
[4] 24.9	1	[8] 25.1	2	[13] 32.6	2	[18] 25.6	2
[4] 23.9	1	[9] 26.2	2	[13] 29.7	2	[18] 24.9	1
[5] 24.2	1	[9] 25.5	2	[13] 33.1	2		

The proportions of defoliation classes in both years of experiments, taking into account the division of stands into two age classes as well as the two age classes together, are shown in Table 5, which was compiled on the basis of the data from Tables 3 and 4. It is evident from this Table that in the year 2002, in both age classes, the most numerous were stands classified as the second defoliation class – 54.67% in the III age class and 73.44% in the IV age class, whereas the proportion of stands classified as the first defoliation class amounted to 45.33% and 26.56%, respectively. When pairs of stands were compared, it was also the second defoliation class that was the highest (60.94%), while the share of the first class amounted to 39.06%.

Table 5. Proportion of defoliation classes in consecutive years of observation in the III and IV age class and jointly in the III and IV age classes
Tabela 5. Udział klas defoliacji w kolejnych latach obserwacji w III, IV oraz łącznie w III i IV klasie wieku

Defoliation class Klasa defoliacji	*Proportion of trees, % – Udział drzew, %*					
	III class alone tylko III klasa wieku		*IV class alone tylko IV klasa wieku*		*III and IV class jointly III+IV klasa wieku razem*	
	year 2002 rok 2002	*year 2003 rok 2003*	*year 2002 rok 2002*	*year 2003 rok 2003*	*year 2002 rok 2002*	*year 2003 rok 2003*
1	*45.33*	*26.56*	*42.22*	*37.78*	*39.06*	*48.89*
2	*54.67*	*73.44*	*57.78*	*62.22*	*60.94*	*51.11*
Total – Razem	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*

In the year 2003, in both age classes, most stands were also assigned to the second defoliation class – 57.78% in the III age class and 62.22% in the IV age class, whereas the proportion of the first defoliation class amounted to 42.22% and 37.78%, respectively. When pairs of stands were considered, slightly more of them were assigned to the second defoliation class (51.11%), in comparison to 48.89% classified as first defoliation class.

CONCLUSIONS

1. The mean crown defoliation of Scots pine (*Pinus sylvestris* L.) of the III age class was in 81 cases lower and in 28 cases higher than the mean defoliation of the IV age class. This corroborates, to a certain degree, the hypothesis that younger stands are in better condition and more vigorous than older stands.

2. On the basis of two years of observations, it was found that in 26.6% of cases differences of mean defoliations of individual stand pairs were statistically significant, although they were not always favourable for the III age class. Hence, the age of stands exerted only a certain influence on the crown condition of Scots pine trees growing in conditions where external factors were similar and, therefore, its significance for the interpretation of forest monitoring results is limited.

3. The statistically significant difference of the mean defoliation was not always accompanied by different memberships of stands to defoliation classes and adversely – the different membership of stands to defoliation classes was not always accompanied by

statistically significant differences of mean defoliations. This confirms that the analysis, interpretation and evaluation of the obtained results are difficult and ambiguous.

4. The estimation of the mean defoliation for stand pairs of different membership to age classes allowed the author to capture and take into account differences in the membership to defoliation classes occurring between the III and IV age classes.

5. The obtained results indicate the need for further investigations concerning the possibility and usefulness of utilisation in forest monitoring of mean results of pairs of uneven-aged surfaces established close to each other, for example one experimental plot each in stands of the III and IV age class.

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DEFOLIACJA KORON SOSNY (*PINUS SYLVESTRIS* L.) III I IV KLASY WIEKU I JEJ ZNACZENIE DLA INTERPRETACJI WYNIKÓW MONITORINGU LASÓW W POLSCE

Streszczenie. W latach 2002 i 2003 w wybranych nadleśnictwach założono parami powierzchnie próbne w drzewostanach sosnowych III i IV klasy wieku. Na każdej powierzchni oceniano defoliację koron 25 drzew z drzewostanu głównego, wg tzw. kryteriów europejskich. Dla każdej powierzchni obliczono średnią defoliację, a na jej podstawie przynależność drzewostanów do klasy defoliacji. Sprawdzono obecność lub też brak statystycznie istotnej różnicy średnich defoliacji i odniesiono to do przynależności poszczególnych par drzewostanów do klas defoliacji. Stwierdzono, że średnia defoliacja koron sosny zwyczajnej III klasy wieku była zazwyczaj niższa od średniej defoliacji IV klasy wieku. W 26,6% przypadków różnice średnich defoliacji poszczególnych par drzewostanów były statystycznie istotne, jednak nie zawsze były one korzystne dla III klasy wieku. Statystycznie istotnej różnicy średniej defoliacji nie zawsze towarzyszyły różne przynależności drzewostanów do klas defoliacji i odwrotnie – różnej przynależności drzewostanów do klas defoliacji nie zawsze towarzyszyły statystycznie istotne różnice średnich defoliacji.

Słowa kluczowe: sosna zwyczajna, defoliacja, klasa defoliacji, klasa wieku

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