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TREE CROWNS CONDITION OF THE MAIN SCOTS PINE (*PINUS SYLVESTRIS* L.) TREE STAND IN SOME SELECTED FOREST DIVISIONS IN 2003*

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Abstract. The study presents observation results of the condition of tree crowns in 2003 in the following forest divisions: Szprotawa, Lubsko, Złoty Potok, Rudziniec, Strzelce Opolskie, Puławy, Buda Stalowska and Staszów. The total of 2250 trees were assessed and the evaluated trees were growing in pine stands of the IIIrd and IVth age class in the zone of mild, moderate and severe damages. The evaluation was based on studies performed on experimental plots with 25 trees from the main stand.

Key words: Scots pine, mean defoliation, distribution of defoliation, defoliation classes, defoliation index, damage index

INTRODUCTION

Scots pine (*Pinus sylvestris* L.) is the main indicator species in Poland used in forest monitoring which allows the identification of changes occurring in the forest environment in the result of the action of various types of factors. The choice of this tree species can be attributed, on the one hand, to its universality of occurrence and, on the other, to its exceptional susceptibility to adverse phenomena taking place in forest ecosystems. This tree species is also employed by the research workers of the Department of Forest Management in their various investigations and observations associated with the assessment of the functioning and state of forest ecosystems in conditions of anthropo-exogenous threats. Detailed results of such investigations were presented in numerous publications and concerned the Zielonka Primeval Forest, the Polish Lowland, the Siemianice Experimental Forest Division, as well as some selected forest divisions situated in the Poznań and Wrocław Regional Directions of the State Forests (RDLP).

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This study presents the results of the observations made in 2003 concerning the condition of tree crowns from main Scots pine (*Pinus sylvestris* L.) stands from eight forest divisions which, administratively, belong to the following Regional Directions of State Forests ((RDLP): Zielona Góra, Katowice, Lublin and Radom.

According to forest management plans, the forest conditions of the examined objects are influenced either by: trans-border contaminations (Szprotawa, Lubsko and Buda Stalowska forest divisions) or direct neighbourhood of various industrial plants such as: the Częstochowa Foundry, Rudniki Cement Works and Upper Silesian Industrial Region (Złoty Potok Forest Division), Kędzierzyn Nitrogen Works, Strzelce Opolskie and Górażdże Cement Works, Blachownia Power Plant (Rudziniec and Strzelce Opolskie forest divisions), Puławy Nitrogen Works (Puławy Forest Division) and Połaniec Power Plant (Staszów Forest Division). However, it should be clearly stated that in all management plans it was strongly stressed that the size of emissions had decreased considerably in recent years either as the result of decreased production (or bankruptcies of enterprises) or the installation of special equipment limiting the harmful effects of emissions.

Research object Obiekt badań	Region Kraina	District Dzielnica
Forest division Szprotawa, working circle Małomice Nadleśnictwo Szprotawa, obręb Małomice	V – Śląska	1 – Równina Dolnośląska
Forest division Lubsko, working circle Brody Nadleśnictwo Lubsko, obręb Brody	III – Wielkopolsko-Pomorska	6 – Pojezierze Lubuskie
Forest division Złoty Potok, working circle Olsztyn Nadleśnictwo Złoty Potok, obręb Olsztyn	VI – Małopolska	6 – Wyżyna Woźnico-Wieluńska i 8 – Wyżyna Krakowsko-Częstochowska
Forest division Rudziniec, working circle Toszek Nadleśnictwo Rudziniec, obręb Toszek	V – Śląska	5 – Równina Opolska i 6 – Kędzierzyńsko-Rybnicka
Forest division Strzelce Opolskie Nadleśnictwo Strzelce Opolskie		
– working circle Małomice obręb Zdzieszowice,	V – Śląska	6 – Kędzierzyńsko-Rybnicka
– working circle Kamień and Kadłub obręb Kamień i Kadłub	V – Śląska	5 – Równina Opolska
Forest division Puławy Nadleśnictwo Puławy		
– working circle Puławy obręb Puławy	IV – Mazowiecko-Podlaska i VI – Małopolska	3 – Równina Warszawsko-Kutnowska i 5 – Nizina Podlaska i Wysoczyzna Siedlecka
– working circle Żyrzyn obręb Żyrzyn	IV – Mazowiecko-Podlaska	5 – Nizina Podlaska i Wysoczyzna Siedlecka
Forest division Buda Stalowska Nadleśnictwo Buda Stalowska		
– working circle Buda Stalowska obręb Buda Stalowska	VI – Małopolska	10 – Nizina Sandomierska
Forest division Staszów Nadleśnictwo Staszów		
– working circle Golejów obręb Golejów	VI – Małopolska	9 – Wyżyna Środkowo-Małopolska

The objective of the performed investigations was to characterise and compare the general condition of pine stands in the above-mentioned objects. Detailed statistical analyses of the results obtained within the framework of this topic depending on the biosocial position of trees, their age and the zone of damage will be published in a separate paper.

RESEARCH OBJECTS

The observations were made in stands of the following eight forest divisions: the Szprotawa and Lubsko administered by the RDLP in Zielona Góra, Rudziniec and Strzelce Opolskie belonging to the Katowice RDLP, Puławy and Buda Stalowska from the Lublin RDLP and Staszów situated in the Radom RDLP.

The study introduced the concept of "research object" because the performed observations were not always made on the area of the entire forest division. The list of these objects, including the natural region and province they were situated in, is presented beside.

The choice of specific working circles resulted from the fact of the occurrence in these working circles of different damage zones caused by the industrial pollution of the atmospheric air. The object area distribution according to damage zones determined in the forest management plan in individual forest divisions was as follows:

Research object Obiekt badań	Zone I I strefa	Zone II II strefa	Zone III III strefa	Zone IV IV strefa
	[ha]			
Forest division Szprotawa, working circle Małomice Nadleśnictwo Szprotawa, obręb Małomice	7 070.30	2 929.48	x	x
Forest division Lubsko, working circle Brody Nadleśnictwo Lubsko, obręb Brody	9 697.33	2 326.26	x	x
Forest division Złoty Potok, working circle Olsztyn Nadleśnictwo Złoty Potok, obręb Olsztyn	x	7 282.40	x	x
Forest division Rudziniec, working circle Toszek Nadleśnictwo Rudziniec, obręb Toszek	x	4 786.68	x	x
Forest division Strzelce Opolskie Nadleśnictwo Strzelce Opolskie				
– working circle Małomice – obręb Zdzieszowice	1 748.09	2 686.06	38.46	x
– working circle Kamień – obręb Kamień	6 310.05	x	x	x
– working circle Kadłub – obręb Kadłub	5 960.48	852.17	x	x
Forest division Puławy – Nadleśnictwo Puławy				
– working circle Puławy – obręb Puławy	2 129.50	1 221.21	708.89	638.63
– working circle Żyrzyn – obręb Żyrzyn	1 369.20	3 741.24	216.72	x
Forest division Buda Stalowska Nadleśnictwo Buda Stalowska				
– working circle Buda Stalowska – obręb Buda Stalowska	2 612.96	x	x	x
Forest division Staszów – Nadleśnictwo Staszów				
– working circle Golejów – obręb Golejów	14 531.68	6 805.95	x	x

RESEARCH METHODS

The sample plots were located in pairs in pure pine stands of the IIIrd and IVth age classes and were distributed relatively evenly in a given research object. The total of 90 experimental plots were established, of which 36 plots were located in the zone of mild damages (I), 50 – in the zone of moderate damages (II) and 4 – in the zone of severe damages (III). The total of 2250 trees were observed. A given experimental plot consisted of 25 mean sample trees belonging to the main stand. Within the framework of field works carried out in July and August, two valuators assessed the defoliation and crown condition of each tree using the method applied to determine forest damage zones [Zasady... 1994]. Employing the Excel 2002 program, the collected data was later used to calculate: the mean defoliation, proportion of trees of different defoliation size, proportion of trees in defoliation classes, defoliation index as well as the damage index, according to complex evaluation. The detailed formula and schemes can be found in other publications [Jaszczak 2003 a, b, Jaszczak and Gołojuch 2002, 2003].

RESULTS

The most important tree crowns characteristics in individual research objects can be found in Table 1.

The mean defoliation of younger stands ranged from 21.8% (the Szprotawa Forest Division) to 30.0% (the Puławy Forest Division), whereas in older stands – from 24.3% (the Szprotawa Forest Division) to 31.8% (the Puławy Forest Division). The mean defoliation in the stands of the IVth age class in the Szprotawa, Lubsko, Rudziniec, Puławy, Buda Stalowska and Staszów forest divisions was by 0.1 to 2.5% higher in comparison with the mean stand defoliation of the IIIrd age class. The situation was reverse in the Złoty Potok and Strzelce Opolskie forest divisions and the recorded difference was small amounting to 0.3% in both cases. The mean defoliation of 25% and more, which is significant for the condition of forests, was observed in the Złoty Potok, Rudziniec, Strzelce Opolskie and Puławy forest divisions (stands of the IIIrd and IVth classes), as well as in the Lubsko Forest Division (IVth age class).

The defoliation index of the IIIrd age class stands ranged from 2.52 (the Szprotawa Forest Division) to 3.29 (the Puławy Forest Division) and in older stands – from 2.78 (the Szprotawa Forest Division) to 3.47 (the Puławy Forest Division). In the case of the Szprotawa, Lubsko, Rudziniec, Puławy, Buda Stalowska and Staszów forest divisions, the mean defoliation index of the IVth age class stands was higher than the mean defoliation index of the IIIrd age class stands and this difference ranged from 0.02 to 0.26. The situation was reverse in the Strzelce Opolskie Forest Division and the difference was 0.05. The defoliation index in the Złoty Potok Forest Division was identical.

The damage index of the IIIrd age class stands ranged from 1.24 (the Szprotawa Forest Division) to 1.85 (the Puławy Forest Division) and in older stands – from 1.35 (the Szprotawa Forest Division) to 1.92 (the Puławy Forest Division). The mean damage index of the IVth age class stands was by 0.02 to 0.12 higher in nearly all forest divisions in comparison with the mean damage index of the IIIrd age class stands and the only exception was in the Złoty Potok Forest Division where the situation was reverse and the difference amounted to 0.03.

Table 1. Major mean characteristics of the tree crown condition of the III[rd] and IV[th] age class stands in individual research objects
Tabela 1. Podstawowe średnie charakterystyki stanu koron drzew drzewostanów III i IV klasy wieku w kolejnych obiektach badań

Object Obiekt	Average size Średnia wielkość			
	age, years wiek, lata	DEF, %	$W_{DEF.}$	$W_{USZ.}$
	Stands of the III age class Drzewostany III klasy wieku			
Szprotawa	48	21.8	2.52	1.24
Lubsko	52	23.3	2.70	1.46
Złoty Potok	52	25.3	2.93	1.54
Rudziniec	51	26.4	3.01	1.68
Strzelce Opolskie	49	26.6	3.03	1.67
Puławy	53	30.0	3.29	1.85
Buda Stalowska	52	24.3	2.80	1.46
Staszów	55	23.9	2.74	1.37
	Stands of the IV age class Drzewostany IV klasy wieku			
Szprotawa	73	24.3	2.78	1.35
Lubsko	74	25.2	2.87	1.56
Złoty Potok	68	25.0	2.93	1.51
Rudziniec	73	26.5	3.03	1.70
Strzelce Opolskie	74	26.3	2.98	1.71
Puławy	67	31.8	3.47	1.92
Buda Stalowska	67	24.4	2.83	1.49
Staszów	65	24.9	2.89	1.49

DEF – mean defoliation.
$W_{DEF.}$ – mean defoliation index.
W_U – mean damage indem.
DEF – średnia defoliacja.
$W_{DEF.}$ – średni wskaźnik defoliacji.
W_U – średni wskaźnik uszkodzenia.

It is evident from the above-presented characterisation that the best condition of tree crowns, from among all the research objects, was observed in the Szprotawa Forest Division, while the worst – in the Puławy Forest Division. The observed differences were: with regard to mean defoliation – 8.2% (the III[rd] age class stands) and 7.5% (the IV[th] age class stands), the defoliation index – 0.77 and 0.69, respectively and the damage index – 0.61 and 0.57, respectively.

Table 2 shows directions of membership changes of the examined stands in damage zones.

It is evident from this table that, in the case of 60% of the stands (26 younger stands and 28 older ones), changes in the membership in damage zones did not take place. In the case of 22.2% of the stands (12 younger and 8 older stands), an improvement in their position was observed, whereas 17.8% of the stands (7 younger and 9 older stands) deteriorated. The transfer to a lower damage zone concerned stands in the following forest divisions: Puławy (5), Złoty Potok (4), Staszów (5), Szprotawa (4) and Lubsko (3), while stands in the Strzelce Opolskie (6), Puławy (4), Buda Stalowska (3), Lubsko (2) and Staszów (1) forest divisions moved to a higher damage zone. In the case of the Strzelce Opolskie and Rudziniec forest divisions, no changes in the damage membership zones were recorded.

Table 2. Direction of changes in the membership of the examined stands in individual objects to damage zones in the IIIrd and IVth age classes
Tabela 2. Kierunki zmian w przynależności badanych drzewostanów w kolejnych obiektach do stref uszkodzenia w III i IV klasie wieku

Object Obiekt	Direction of changes in the membership of the stands to zones Kierunki zmian w przynależności drzewostanów do stref									
	from I to I z I do I		from I to II z I do II		from II to I z II do I		from II to II z II do II		from III to II z III do II	
	A	B	A	B	A	B	A	B	A	B
Szprotawa	3	3	–	–	2	2	–	–	–	–
Lubsko	2	2	1	1	3	–	1	4	–	–
Złoty Potok	–	–	–	–	1	3	4	2	–	–
Rudziniec	–	–	–	–	–	–	6	6	–	–
Strzelce Opolskie	–	–	3	3	–	–	3	3	–	–
Puławy	–	–	2	2	1	–	1	2	2	2
Buda Stalowska	4	3	1	2	–	–	–	–	–	–
Staszów	2	1	–	1	3	1	–	2	–	–
Total Razem	11	9	7	9	10	6	15	19	2	2

A – stands of III age class.
B – stands of IV age class.
A – drzewostany III klasy wieku.
B – drzewostany IV klasy wieku.

Table 3 portrays the percentage proportion of trees with different degrees of crown defoliation in individual research objects.

It is clear from this table, that both in the case of stands of the IIIrd (with the exception of the forest division in Puławy) as well as the IVth age classes, the greatest number of trees were characterised by the defoliation of 25%. Its mean proportion in younger stands ranged from 48.0% (the Szprotawa Forest Division) to 71.2% (the Złoty Potok Forest Division) and only in the Puławy Forest Division trees with 30% defoliation were dominant (proportion 46.7%). In the case of older stands, the proportion of trees of 25% defoliation ranged from 44.7% (the Puławy Forest Division) to 81.6% (the Złoty Potok Forest Division).

Table 3. Percentage share of trees of different degree of their crown defoliation in the stands of the III[rd] and IV[th] age class in individual research objects
Tabela 3. Procentowy udział drzew o różnej wielkości defoliacji ich koron w drzewostanach III i IV klasy wieku w kolejnych obiektach badań

Object Obiekt	Proportion of trees of crown defoliation, % Udział drzew o defoliacji ich koron, %											
	5	10	15	20	25	30	35	40	55	60	65	70
Stands of III age class Drzewostany III klasy wieku												
Szprotawa		1.6	12.8	32.8	48.0	4.0		0.8				
Lubsko	0.6	0.6	6.8	21.7	58.9	10.3	1.1					
Złoty Potok				11.2	71.2	13.6	3.2	0.8				
Rudziniec				1.3	66.0	30.7	2.0					
Strzelce Opolskie				2.7	64.0	27.3	5.3	0.7				
Puławy					26.7	46.7	21.2	4.0	0.7	0.7		
Buda Stalowska			0.8	21.6	68.0	7.2	2.4					
Staszów			0.8	25.6	65.6	8.0						
Stands of IV age class Drzewostany IV klasy wieku												
Szprotawa			0.8	26.4	60.0	9.6	2.4			0.8		
Lubsko			1.2	13.1	63.4	21.1	1.2					
Złoty Potok		0.8		6.4	81.6	10.4	0.8					
Rudziniec					67.4	29.3	3.3					
Strzelce Opolskie				4.7	63.3	29.3	2.0	0.7				
Puławy				13.3	44.7	34.0	5.3	1.3	0.7			0.7
Buda Stalowska			0.8	16.0	76.0	7.2						
Staszów				12.8	75.2	10.4	1.6					

In general, in the case of the III[rd] age class, the range of defoliation varied from 5 to 60%, whereas in older stands – from 10 to 70%. However, this range was different in individual forest divisions. Assuming at least a 10% proportion, it can be said that in the case of younger stands, the greatest number of trees were characterised by 15 to 25% defoliation (the Szprotawa Forest Division – 93.6%) or from 20 to 25% (the Buda Stalowska Forest Division – 89.6% and Staszów – 91.2%) or from 20 to 30% (the Lubsko Forest Division – 90.9% and the Złoty Potok Forest Division – 96.0%) or from 25 to 30% (the Rudziniec Forest Division – 96.7% and the Strzelce Opolskie – 91.3%), or from 25 to 35% (the Puławy Forest Division – 94.6%). On the other hand, in the case of older stands, the greatest number of trees were characterised by the defoliation ranging from 20 to 25% (the Szprotawa Forest Division – 86.4% and the Buda Stalowska Forest Division – 92.0%) or from 20 to 30% (the Puławy Forest Division – 92.0% and the Staszów Forest Division – 98.4%) or from 25 to 30% the Złoty Potok Forest Division – 92.0%, Rudziniec – 96.7% and Staszów Forest Division – 98.4%) or from 25 to 30% (the Złoty Potok Forest Division – 92.0%, Rudziniec – 96.7% and the Strzelce Opolskie Forest Division – 92.6%).

The percentage proportion of trees in defoliation classes in individual research objects is presented in Table 4.

Table 4. Percentage proportion of trees in defoliation classes of their crowns in the stand III[rd] and IV[th] age classes in individual research objects
Tabela 4. Procentowy udział drzew w klasach defoliacji ich koron w drzewostanach III i IV klasy wieku w kolejnych obiektach badań

Object Obiekt	Proportion of trees in defoliation class, % Udział drzew w klasie defoliacji, %			
	0	1	2	3
	Stands of III age class Drzewostany III klasy wieku			
Szprotawa	1.6	93.6	4.8	
Lubsko	1.2	88.4	10.4	
Złoty Potok		82.4	17.6	
Rudziniec		67.3	32.7	
Strzelce Opolskie		66.7	33.3	
Puławy		26.7	73.3	
Buda Stalowska		90.4	9.6	
Staszów		92.0	8.0	
	Stands of IV age class Drzewostany IV klasy wieku			
Szprotawa		87.2	12.8	
Lubsko		77.7	22.3	
Złoty Potok	0.8	88.0	11.2	
Rudziniec		67.4	32.6	
Strzelce Opolskie		68.0	32.0	
Puławy		58.0	41.3	0.7
Buda Stalowska		92.8	7.2	
Staszów		88.0	12.0	

It is evident from this Table that in stands of both III[rd] and IV[th] age classes, the majority of trees were assigned to the first class of defoliation. The proportion of this class in younger stands ranged from 67.3% (the Rudziniec Forest Division) to 93.6% (the Szprotawa Forest Division) and it was only in the Puławy Forest Division that the second defoliation class was dominant (73.3%). In the case of older stands, the percentage of the first defoliation class ranged from 58.0% (the Puławy Forest Division) to 92.8% (the Buda Stalowska Forest Division). Also the second defoliation class was found to occur in all the forest divisions of both groups of stands. Its proportion, in the case of the III[rd] age class stands, ranged from 4.8% (the Szprotawa Forest Division) to 73.3% (the Puławy Forest Division), while in the IV[th] age class stands – from 7.2% (the Buda Stalowska Forest Division) to 41.3% (the Puławy Forest Division). In addition, there were also some trees found in the '0' defoliation class (the Szprotawa and Lubsko forest divisions – III[rd] age class and the Złoty Potok Forest Division – IV[th] age class), as well

as in the third defoliation class (the Puławy Forest Division – IVth age class) but their proportions were negligible (ranging from 0.7 to 1.6%).

Table 5 shows the proportion of trees of different degrees of crown damage. It is clear from this table that in the case of the third age class stands in the Szprotawa, Lubsko, Złoty Potok, Buda Stalowska and Staszów forest divisions, the majority of tree crowns exhibited mildly damaged crowns and the proportion of these trees ranged from 54.4% (the Złoty Potok Forest Division) to 88.8% (the Szprotawa Forest Division). On the other hand, in the Rudziniec, Strzelce Opolskie and Puławy forest divisions, the most numerous was the group of trees with moderately damaged crowns and their proportion ranged from 68.0% (the Strzelce Opolskie Forest Division) to 84.7% (the Puławy Forest Division).

Table 5. Percentage share of trees of different degrees of their crown damage in stands of the IIIrd and IVth age classes in individual research objects
Tabela 5. Procentowy udział drzew o różnych stopniach uszkodzenia ich koron w drzewostanach III i IV klasy wieku w kolejnych obiektach badań

Object Obiekt	Proportion of trees [%] of Udział drzew [%] o koronach			
	intact crowns nieuszkodzonych	mildly damaged crowns słabo uszkodzonych	moderately damaged crowns średnio uszkodzonych	severely damaged crowns silnie uszkodzonych
	Stands of III age class Drzewostany III klasy wieku			
Szprotawa		88.8	11.2	
Lubsko		69.8	30.2	
Złoty Potok		54.4	45.6	
Rudziniec		29.3	70.7	
Strzelce Opolskie		32.0	68.0	
Puławy		15.3	84.7	
Buda Stalowska		65.6	34.4	
Staszów		83.2	16.8	
	Stands of IV age class Drzewostany IV klasy wieku			
Szprotawa		75.2	24.8	
Lubsko		54.5	45.5	
Złoty Potok		56.0	44.0	
Rudziniec		62.0	38.0	
Strzelce Opolskie		20.6	79.4	
Puławy		10.7	88.7	0.6
Buda Stalowska		56.8	43.2	
Staszów		64.8	35.2	

However, in the case of the IVth age class stands from the Szprotawa, Lubsko, Złoty Potok, Rudziniec, Buda Stalowska and Staszów forest divisions, most tree crowns were only mildly damaged and their proportion ranged from 54.5% (the Lubsko Forest Division) to 75.2% (the Szprotawa Forest Division). On the other hand, in the Strzelce Opolskie and Puławy forest divisions, the most numerous group of trees was that of moderately damaged tree crowns with their proportions of 79.4 and 88.7%, respectively. Moreover, in the Puławy Forest Division, a small share (0.7%) of severely damaged tree crowns was observed.

SUMMING UP

The above-presented results prove that the condition of pine stands from the examined research objects fluctuated at the border of mild and moderate damages. The first group comprised tree stands from the Lubsko and Szprotawa forest divisions and the condition of those trees was affected primarily by trans border contamination, whereas the second group – stands from the Puławy, Rudziniec and Strzelce Opolskie forest divisions whose state was influenced by direct and close neighbourhood of industrial enterprises. The condition of stands in the remaining research objects can be defined as intermediate between the above-described two groups.

The highest indices of tree crown damages were accompanied by high defoliation and high defoliation index (the Rudziniec, Strzelce Opolskie and Puławy forest divisions). Similarly, the lowest damage indices were accompany by the lowest defoliation and defoliation index (the Szprotawa and Lubsko forest divisions).

The proportion of trees with the crown defoliation exceeding 25% and at least moderately damaged was, generally speaking, the highest in the Rudziniec, Strzelce Opolskie and Puławy forest divisions and the lowest – in the Lubsko, Szprotawa and Staszów forest divisions.

CONCLUSIONS

1. The condition of Scots pine (*Pinus sylvestris* L.) tree crowns of the main stand in the examined stands was found better in younger stands (IIIrd age class).

2. The greatest number of trees showed 25 and 30% defoliation and their crowns were classified as mildly and moderately damaged.

3. In 2003, from among all the examined research objects, the best condition of tree crowns was found in the Szprotawa and Lubsko forest divisions, while the worst – in the Puławy, Rudziniec and Strzelce Opolskie forest divisions.

4. It appears evident from the above that the Upper Silesian Industrial Region and the Nitrogen Plant in Puławy continue to have a negative influence on the condition of pine tree stands.

5. The condition of all of the research objects should still be treated as unsatisfactory and warning and requiring continuous attention of local foresters.

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STAN KORON DRZEW DRZEWOSTANU GŁÓWNEGO SOSNY ZWYCZAJNEJ (*PINUS SYLVESTRIS* L.) W WYBRANYCH NADLEŚNICTWACH W 2003 ROKU

Streszczenie. Praca przedstawia wyniki obserwacji stanu koron z 2003 roku w nadleśnictwach: Szprotawa, Lubsko, Złoty Potok, Rudziniec, Strzelce Opolskie, Puławy, Buda Stalowska i Staszów. Ocenie poddano łącznie 2250 drzew rosnących w drzewostanach sosnowych III i IV klasy wieku, w strefie uszkodzeń słabych, średnich i silnych, na podstawie badań powierzchni próbnych z 25 drzewami z drzewostanu głównego.

Słowa kluczowe: sosna zwyczajna, średnia defoliacja, rozkład defoliacji, klasy defoliacji, wskaźnik defoliacji, wskaźnik uszkodzenia

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