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STAND STRUCTURE AND SPECIES COMPOSITION IN THE 'CZMOŃ' NATURE RESERVE

STRUKTURA DRZEWOSTANÓW I SKŁAD GATUNKOWY W REZERWACIE PRZYRODY „CZMOŃ"

Summary. The 'Czmoń' nature reserve was established in 1998 to protect oak-hornbeam forest (*Galio sylvatici-Carpinetum betuli*) – a plant community rare in the Wielkopolska region. The reserve covers the area of 23.65 ha of forest in which also other plant communities rare in this region are found (*Querco-Ulmetum minoris* and *Fraxino-Alnetum*). Both communities of natural character, as well as degenerated communities, can be found in this reserve. This can be attributed to the type of forest management conducted in this area earlier. The objective of this study was to characterise the stand structure and species composition in this reserve and to trace potential changes in stands resulting from the abandonment of treatments associated with forest management. On potential forest sites of oak-hornbeam forest, elm-oak riparian forest and ash-alder riparian forest, forest communities at different stages of development and forms of degeneration are found to occur. On the basis of the species composition analysis of the undergrowth layer, the quantity of dead trees and shrubs, as well as the DBH distribution of living trees, we found an advancing process of regeneration in the direction of communities complying with potential vegetation. The highest proportion of dead trees was determined among those tree species growing in the reserve which were site (*Pinus sylvestris*) or geographically (*Populus canadensis*, *Fagus sylvatica*) alien for this particular area. In the undergrowth layer, a domination of oak--hornbeam forest and riparian forest tree species (primarily *Carpinus betulus* and *Acer pseudoplatanus*) was recorded. Absence of pedunculate oak (*Quercus robur*), as well as massive dying out of ash (*Fraxinus excelsior*) occurring in the undergrowth layer is perplexing.

Key words: oak-hornbeam forest, *Galio-Carpinetum*, nature protection, Wielkopolska, species composition, dead trees

Introduction

The knowledge of stand structure and species composition helps to get information about the history and dynamics of populations which form them. In addition, it may help to analyse forest ecosystem transformations, which take place because of man's activities and natural factors. Data about the structure of stands (species, spatial – vertical and horizontal, age, DBH, etc.) can also be useful in the course of making economical decisions and application of protection methods. The analysis of structure of stands under protection in which management works are no longer carried out makes it possible to know the direction of changes taking place in them as well as potential hazards associated with them.

The 'Czmoń' nature reserve was established in 1998 on the area of 23.65 ha to protect one of the best-preserved fragments of oak-hornbeam forests in the central part of the Wielkopolska region (LISIEWSKA and KRÓL 2007). However, the history of protection of this area goes back to the end of 1980s (BERNAT 1989). Until then, forest management on the area of the reserve was conducted on the basis of the existing forest management plans. From 1988 onwards, only sanitary treatments (removal of pine, alder and birch dead standing trees) or treatments aiming at stand conversion were carried out.

The area of the reserve was the object of numerous scientific investigations in the past. Researchers assessed, among others, the condition of the vegetation cover (BERNAT 1989, OLEJNIK 1989, ŻUKOWSKI and JACKOWIAK 1992), avifauna (WINIECKI 2001), as well as fungal biota (LISIEWSKA and KRÓL 2007). Research work continued also in the course of designing of the reserve protection plan (PLAN OCHRONY... 2006). The previous research indicated a high natural value of this area.

The aim of this study was to describe the vertical and horizontal structure and species composition of stands in 'Czmoń' nature reserve. Apart from the analysis of the current forest condition, the obtained data made possible to trace potential changes in stands resulting from the cessation of treatments associated with forest economy. Repetition of investigations in future will also allow assessment of the effectiveness of protection treatments employed in the area of the reserve.

Material and methods

According to KONDRACKI's (2002) regionalisation, the 'Czmoń' nature reserve is situated in the province of Central European Lowland, sub-province of South-Baltic Lake districts, the region of the Warta-Odra River glacial valley and the Śrem Basin mesoregion. According to the natural-forest regionalisation, the area of the reserve is situated in the IIIrd Wielkopolska-Pomorze Region and 7th District of Wielkopolska-Kujawy Lowland (TRAMPLER et AL. 1990). Administratively, the reserve is situated within the area of Babki Forest District (Czmoń Forest Range) in Śrem commune. The climatic conditions in the nature reserve, similarly to the entire region of Wielkopolska, are characterised by a fairly short and mild winter and summer with a greater quantity of precipitation and a considerable proportion of days with moderate or considerable clouding (WOŚ 1994). On the basis of the data collected in years 1988-1998, the average

annual temperature in the area of the reserve amounted to 8.8°C, while the mean annual precipitation – 555.5 mm. The vegetation period extended for approximately 220 days. Soils found in the area of the reserve belong to two subtypes: to grey-brown and mucky--mineral soils. Stand characteristics according to the state on January, 1st 2006 is presented in Table 1 (PLAN OCHRONY... 2006).

Table 1. Characteristics of stands growing in the 'Czmoń' nature reserve (state on 01.01.2006; PLAN OCHRONY... 2006)
Tabela 1. Charakterystyka drzewostanów rosnących w rezerwacie przyrody „Czmoń" (stan na 1 stycznia 2006 roku; PLAN OCHRONY... 2006)

Sub-compartment Pododdział	Area Powierzchnia (ha)	Site type Typ siedliskowy	Species composition Skład gatunkowy	Age (years) Wiek (lata)	DBH Pierśnica (cm)	Height Wysokość (m)	Dead trees Martwe drzewa
1	2	3	4	5	6	7	8
a	1.61	Lw	*Populus*	39	21	26	Dying poplar trees (80%), ash diseases (20%) Obumierające topole (80%), choroby jesionu (20%)
b	1.35	OlJ	7 *Alnus*	29	16	16	Dead trees – absence Posusz – brak
			1 *Betula*	29	19	17	
			1 *Picea*	22	–	4	
			1 *Fraxinus*	22	–	2	
c	2.06	Lw	7 *Fraxinus*	48	24	21	Dead trees (5%) Posusz (5%)
			2 *Betula*	48	24	20	
			1 *Alnus*	48	19	19	
d	5.15	Lśw	5 *Carpinus*	126	33	18	Dead trees (1-2%) Posusz (1-2%)
			3 *Quercus*	126	50	24	
			2 *Alnus*	126	45	22	
f	3.65	Lśw	US – *Pinus*	72	25	30	Dead pine trees (10%) Posusz sosnowy (10%)
			LS – *Carpinus*	35	7	–	
g	1.65	Lw	5 *Betula*	72	26	19	Dead trees (10%) Posusz (10%)
			3 *Alnus*	72	26	19	
			1 *Carpinus*	72	26	19	
			1 *Pinus*	72	27	22	

Table 1 – cont. / Tabela 1 – cd.

1	2	3	4	5	6	7	8
h	1.96	Lw	*Quercus*	126	42	22	Dead trees – single oaks Posusz – pojedyncze dęby
i	2.72	Lw	5 *Alnus*	72	24	20	Dead trees (5%) Posusz (5%)
			4 *Fraxinus*	72	38	23	
			1 *Betula*	72	40	23	
j	1.56	Lw	8 *Fraxinus*	82	–	25	Ash diseases (20%) Choroby jesionu (20%)
			2 *Quercus*	82	–	24	
k	1.56	Lśw	US – 8 *Pinus*	72	26	19	Dead trees (2%) Posusz (2%)
			US – 2 *Quercus*	72	27	20	
			LS – 8 *Carpinus*	35	12	12	
			LS – 1 *Quercus*	35	12	14	
			LS – 1 *Acer*	35	13	13	

US – upper storey, LS – lower storey.
US – warstwa wysoka, LS – warstwa niska.

Forests of the reserve occur on three types of sites. The largest area is occupied by the fresh broadleaved forest site type in its strongly fresh variant (12.32 ha) corresponding to the oak-hornbeam forest of *Galio sylvatici-Carpinetum corydaletosum*. The area of 9.60 ha is covered by moist broadleaved forest site associated with the elm-ash riparian forest of the *Querco-Ulmetum minoris* association. On the area of 1.35 ha, ash-alder swamp forest site was found with a community classified as belonging to the alder-ash riparian forest association of *Fraxino-Alnetum* (PLAN OCHRONY... 2006). Moreover, LISIEWSKA and KRÓL (2007) found a community of thermophilous oak forest *Potentillo albae-Quercetum* in the north-eastern part of the reserve.

According to the Regulation of the Minister of Environment of August, 14th 2001 (ROZPORZĄDZENIE... 2001), as well as the 92/43/EEC Council Directive of May, 21st 1992 regarding the protection of natural habitats (Habitat Directive; DYREKTYWA RADY... 1992), all sites identified in the reserve area are subject to legal protection.

Field studies were carried out from August to November 2012. Stand structure of the 'Czmoń' nature reserve was determined on the basis of 21 experimental plots distributed on the entire area of the reserve (Fig. 1), with at least one of them situated in each sub-compartment. If a stand within boundaries of one sub-compartment was non--homogeneous, a greater number of experimental plots was established so as to describe the total stand variability found in the reserve. The size of individual experimental plots

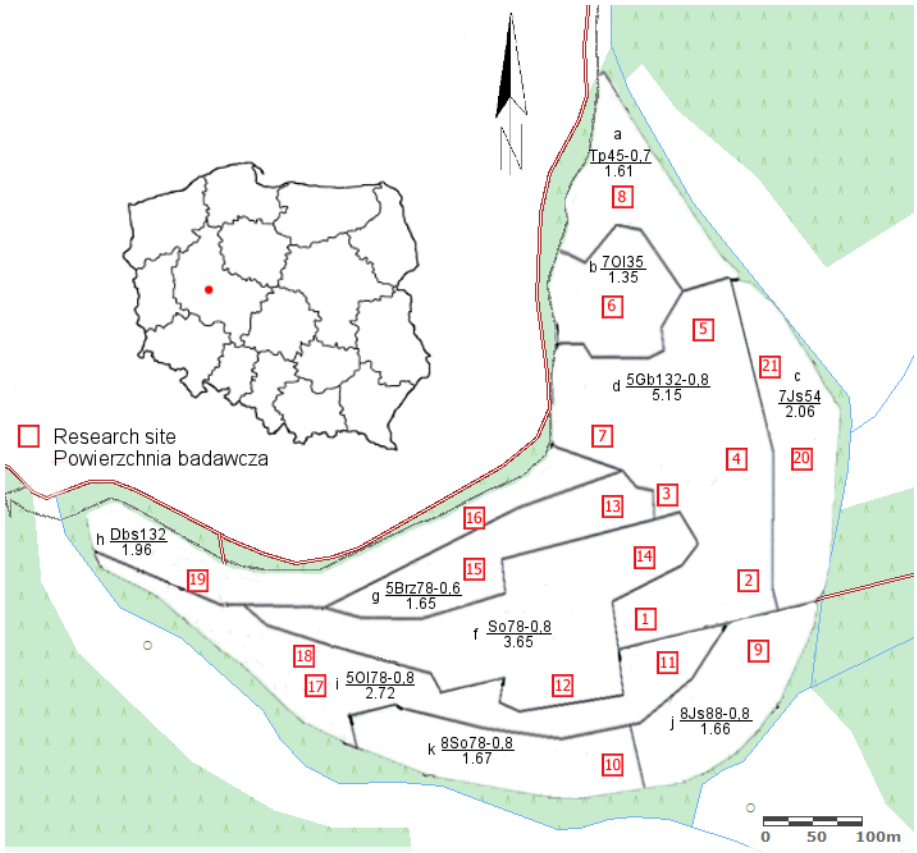

Fig. 1. Distribution of research sites selected for stand structure analysis in the 'Czmoń' nature reserve
Rys. 1. Rozmieszczenie powierzchni badawczych wytypowanych do analizy struktury drzewostanów na terenie rezerwatu przyrody „Czmoń"

depended on the size of homogeneous stands and ranged from 0.076 ha to 0.3 ha. Within each experimental plot, using the 'crosswise' method, diameters at breast height (DBH) of all trees with $d_{1.3m} > 3.5$ cm were measured in the following three layers: upper storey, lower storey as well as shrubs and undergrowth and the developing lower stand storey. DBHs of some trees from the undergrowth layer and the developing lower storey exceeded 7 cm; however due to their small height and, in general, scarce occurrence, they were included in this layer and not in the lower storey. In addition, separately for each species, the number of trees with smaller dimensions was recorded. In order to determine stand height structure, trees representing the entire DBH range were selected for a given species within boundaries of each sub-compartment. The number of these trees was proportional to the number of trees in the DBH class. Within boundaries of the entire reserve, DBHs of 4538 trees were measured as well as heights of 468 trees.

Measurements within the areas of four artificial gaps in stands established with the aim of stand conversion (comps. 92 f and 92 k) were conducted in the same way as in the case of a pure stand. Within confines of all artificial gaps, DBHs of all trees with the height of over 1.3 m and the DBH of more than 3.5 cm were measured.

In addition, in the area of the entire nature reserve, circumferences of the most magnificent trees of different species were measured.

Names of trees and shrubs were given after SENETA and DOLATOWSKI (2004), while names of plant associations – after BRZEG and WOJTERSKA (2001).

Results

The total of 24 species of trees and shrubs were found on 21 experimental plots distributed in the entire nature reserve. The layer of tall trees comprised 11 species, the layer of low trees – 15 species, whereas in the layer of shrubs and undergrowth, 20 species of trees and shrubs were identified (Table 2).

Table 2. Woody species composition and densities (live + dead) in three main stand storeys for particular sub-compartments of the reserve (number of trees and shrubs per 1 ha)
Tabela 2. Skład gatunkowy i zagęszczenia drzew i krzewów (żywe + suche) w trzech głównych warstwach lasu w poszczególnych wydzieleniach rezerwatu (liczba drzew i krzewów na 1 ha)

Sub-compartment Pododdział	Upper storey Warstwa wysoka	Lower storey Warstwa niska	Shrubs and undergrowth Krzewy i podrost
1	2	3	4
a	*P. canadensis* (219+67) *F. excelsior* (10+0)		*C. sanguinea* (7781+1819) *C. betulus* (552+19) *C. avellana* (924+0) *F. excelsior* (695+400) *F. sylvatica* (667+10) *P. avium* (333+48) *Q. robur* (38+0) *A. glutinosa* (19+0) *E. europaea* (10+0) *Pyrus* sp. (10+0) *U. laevis* (10+0)
b	*A. glutinosa* (1040+67)		*C. sanguinea* (3538+374) *P. avium* (890+269) *A. glutinosa* (621+239) *C. avellana* (105+7) *F. excelsior* (75+7) *C. betulus* (75+0)

Table 2 – cont. / Tabela 2 – cd.

1	2	3	4
			A. pseudoplatanus (15+0) *C. monogyna* (7+0) *P. spinosa* (7+0) *S. nigra* (0+7)
c	*F. excelsior* (117+106) *B. pendula* (111+22) *A. glutinosa* (11+0)	*C. betulus* (100+0) *A. pseudoplatanus* (28+0) *T. cordata* (22+0) *U. glabra* (17+0) *A. platanoides* (6+0) *F. excelsior* (6+33)	*C. avellana* (2411+828) *A. pseudoplatanus* (456+67) *C. sanguinea* (339+67) *C. betulus* (128+28) *F. excelsior* (11+22) *U. laevis* (11+0) *A. platanoides* (6+0) *B. pendula* (6+0) *P. avium* (6+6) *T. cordata* (6+0)
d	*Q. robur* (58+1) *F. excelsior* (17+0) *C. betulus* (10+0) *P. abies* (4+0) *A. pseudoplatanus* (1+0)	*C. betulus* (232+4) *A. pseudoplatanus* (7+0) *Q. robur* (2+0) *F. excelsior* (1+0) *T. cordata* (1+0)	*A. pseudoplatanus* (698+121) *C. avellana* (185+16) *C. betulus* (218+19) *C. sanguinea* (19+1) *F. excelsior* (5+3) *C. monogyna* (2+0)
f (excluding artificial gaps) (z wyłączeniem gniazd)	*P. sylvestris* (464+14) *P. abies* (8+0) *B. pendula* (8+0) *Q. robur* (6+0) *A. pseudoplatanus* (4+0) *C. betulus* (2+0) *F. excelsior* (3+0) *U. laevis* (0+3)	*C. betulus* (124+0) *P. sylvestris* (73+20) *A. pseudoplatanus* (34+0) *Q. robur* (52+0) *F. excelsior* (12+2) *B. pendula* (3+3) *P. avium* (2+0) *U. laevis* (0+6)	*C. avellana* (1335+444) *C. betulus* (462+45) *C. sanguinea* (194+30) *A. pseudoplatanus* (87+18) *P. avium* (24+0) *U. laevis* (19+9) *F. excelsior* (4+0) *Q. robur* (6+0) *P. sylvestris* (0+5)
g	*B. pendula* (155+5) *P. sylvestris* (135+5) *A. pseudoplatanus* (45+0) *Q. robur* (28+0) *A. glutinosa* (3+0) *B. pubescens* (3+0)	*C. betulus* (135+3) *P. sylvestris* (18+13) *A. pseudoplatanus* (18+0) *B. pendula* (10+3) *A. glutinosa* (8+3) *Q. robur* (10+0)	*C. avellana* (1830+583) *A. pseudoplatanus* (1188+158) *C. sanguinea* (630+85) *C. betulus* (178+30) *U. laevis* (33+0)

Table 2 – cont. / Tabela 2 – cd.

1	2	3	4
		B. pubescens (8+0) *U. laevis* (3+0)	*E. europaea* (13+0) *F. excelsior* (13+0) *B. pendula* (3+0) *P. avium* (3+0) *Q. robur* (0+8)
h	*Q. robur* (178+0) *B. pendula* (6+2) *P. sylvestris* (4+0) *F. excelsior* (6+0)	*C. betulus* (304+2) *Q. robur* (4+2) *A. glutinosa* (6+0)	*C. avellana* (2830+1038) *C. sanguinea* (1611+306) *C. betulus* (144+37) *E. europaea* (89+6) *P. avium* (44+22) *A. pseudoplatanus* (14+0) *A. glutinosa* (6+0) *S. nigra* (6+0)
i	*F. excelsior* (91+12) *A. glutinosa* (84+4) *B. pendula* (15+2) *Q. robur* (8+2) *B. pubescens* (2+0) *U. laevis* (3+0)	*A. glutinosa* (97+11) *C. betulus* (32+0) *A. pseudoplatanus* (12+0) *B. pendula* (3+3) *U. laevis* (2+0)	*C. avellana* (3118+857) *C. sanguinea* (1701+127) *P. avium* (145+120) *A. pseudoplatanus* (170+2) *F. excelsior* (12+53) *S. nigra* (35+0) *E. europaea* (21+3) *P. abies* (6+4) *U. laevis* (8+2) *C. betulus* (7+0) *S. aucuparia* (2+2) *A. glutinosa* (0+4) *P. sylvestris* (0+2)
j	*F. excelsior* (200+8) *Q. robur* (20+4) *A. pseudoplatanus* (4+0) *A. glutinosa* (4+0) *C. betulus* (4+0)	*C. betulus* (80+0) *A. pseudoplatanus* (36+0)	*C. avellana* (3744+620) *C. sanguinea* (560+68) *P. avium* (216+56) *C. betulus* (196+0) *A. pseudoplatanus* (80+4) *F. excelsior* (60+40) *A. glutinosa* (8+0)
k (excluding artificial gaps) (z wyłączeniem gniazd)	*P. sylvestris* (303+0) *B. pendula* (118+0) *C. betulus* (53+0) *A. pseudoplatanus* (13+0)	*C. betulus* (118+0) *A. pseudoplatanus* (13+0) *B. pendula* (13+0) *P. sylvestris* (0+13)	*C. avellana* (4368+1724) *A. pseudoplatanus* (368+0) *C. sanguinea* (303+79) *C. betulus* (13+0)

In sub-compartment 92 a, a poplar plantation was identified. The tree layer is formed, primarily, by *Populus canadensis* (97% of all trees), with *Fraxinus excelsior* occurring as an admixture species (Table 2). DBHs of poplars range from 27.0 to 44.5 cm (mean – 35.4 cm) and the highest of these trees reach the height of 27.8 m (mean – 24.5 m). The total stand basal area ($G_{1.3m}$) amounts to 30.6 $m^2 \cdot ha^{-1}$, of which 14.1% falls on dead trees (Table 3). Dead poplar trees constitute 23% of all recorded specimens in the upper storey. The total density of trees and shrubs in the layer of undergrowth and shrubs amounts to 13 335 specimens per 1 ha. The undergrowth and the developing lower storey is made up, primarily, of: *F. excelsior* (mean height – 12 m), *Fagus sylvatica* (9.5 m) and *Carpinus betulus* (10.5 m). Moreover, *Quercus robur*, *Alnus glutinosa* and *Ulmus laevis* were recorded sporadically. In 1993, underplantings of ash, oak and beech were carried out in this sub-compartment in order to replace dying poplar trees (PLAN OCHRONY... 2006). Consequently, part of trees in this layer (with the exception of hornbeam, alder and elm) is of artificial origin. Mean DBH of live *F. excelsior* amounts to 8.7 cm (range – 3.9-14.8 cm), *C. betulus* – 7.3 cm (3.7-12.4 cm), *F. sylvatica* – 6.3 cm (3.4-11.7 cm) and *Q. robur* – 7.1 cm (5.6-9.6 cm). A considerable proportion of trees in the undergrowth layer and of the developing lower storey comprises dead trees, e.g. dead ash trees constitute 37% of all trees of this species recorded in this layer. Dead hornbeam and beech trees as well as shrubs were observed less frequently (Table 2).

Table 3. Basal area at tree breast height (live + dead) in two stand storeys for particular sub-compartments of the reserve ($m^2 \cdot ha^{-1}$)
Tabela 3. Pole powierzchni przekroju pierśnicowego drzew (żywe + suche) w dwóch warstwach lasu w poszczególnych wydzieleniach rezerwatu ($m^2 \cdot ha^{-1}$)

Sub-compartment Pododdział	Upper storey Warstwa wysoka	Lower storey Warstwa niska	Total Suma
1	2	3	4
a	*P. canadensis* (22.1+4.3) *F. excelsior* (4.2+0)		26.3+4.3
b	*A. glutinosa* (34.8+1.8)		34.8+1.8
c	*F. excelsior* (8.5+5.3) *B. pendula* (6.4+1.0) *A. glutinosa* (0.7+0)	*C. betulus* (1.9+0) *A. pseudoplatanus* (1.4+0) *T. cordata* (0.5+0) *U. glabra* (0.4+0) *A. platanoides* (0.2+0) *F. excelsior* (0.1+0.4)	20.1+6.7
d	*Q. robur* (13.8+0.2) *F. excelsior* (2.3+0) *C. betulus* (1.7+0) *P. abies* (0.2+0) *A. pseudoplatanus* (0.1+0)	*C. betulus* (14.9+0.2) *A. pseudoplatanus* (0.5+0) *Q. robur* (0.1+0) *T. cordata* (0.1+0)	33.7+0.4

Table 3 – cont. / Tabela 3 – cd.

1	2	3	4
f (excluding artificial gaps) (z wyłączeniem gniazd)	*P. sylvestris* (30.1+0.4) *P. abies* (0.6+0) *B. pendula* (0.6+0) *Q. robur* (2.5+0) *A. pseudoplatanus* (0.2+0) *C. betulus* (0.3+0) *F. excelsior* (0.1+0) *U. laevis* (0+0.3)	*C. betulus* (3.0+0) *P. sylvestris* (1.8+0.4) *A. pseudoplatanus* (0.9+0) *Q. robur* (2.1+0) *F. excelsior* (0.4+0.1) *B. pendula* (0.1+0) *P. avium* (0.1+0) *U. laevis* (0+0.2)	42.8+1.4
g	*B. pendula* (12.3+0.2) *P. sylvestris* (9.3+0.2) *A. pseudoplatanus* (2.8+0) *Q. robur* (2.4+0) *A. glutinosa* (0.3+0) *B. pubescens* (0.2+0)	*C. betulus* (4.1+0) *P. sylvestris* (0.4+0.3) *A. pseudoplatanus* (0.8+0) *B. pendula* (0.3+0.1) *A. glutinosa* (0.2+0) *Q. robur* (0.3+0) *B. pubescens* (0.2+0) *U. laevis* (0.1+0)	33.7+0.8
h	*Q. robur* (34.8+0) *B. pendula* (0.5+0.1) *P. sylvestris* (0.3+0) *F. excelsior* (0.4+0)	*C. betulus* (6.9+0.1) *Q. robur* (0.1+0) *A. glutinosa* (0.2+0)	43.2+0.2
i	*F. excelsior* (7.9+0.8) *A. glutinosa* (7.5+0.2) *B. pendula* (1.8+0.1) *Q. robur* (1.1+0.1) *B. pubescens* (0.1+0) *U. laevis* (0.6+0)	*A. glutinosa* (4.8+0.2) *C. betulus* (1.5+0) *A. pseudoplatanus* (0.6+0) *B. pendula* (0.1+0.2)	26.0+1.6
j	*F. excelsior* (19.2+0.6) *Q. robur* (3.9+1.4) *A. pseudoplatanus* (0.6+0) *A. glutinosa* (0.3+0) *C. betulus* (0.7+0)	*C. betulus* (1.7+0) *A. pseudoplatanus* (1.5+0)	27.9+2.0
k (excluding artificial gaps) (z wyłączeniem gniazd)	*P. sylvestris* (21.4+0) *B. pendula* (10.3+0) *C. betulus* (2.8+0) *A. pseudoplatanus* (0.9+0)	*C. betulus* (3.4+0) *A. pseudoplatanus* (0.3+0) *B. pendula* (0.4+0) *P. sylvestris* (0+0.2)	39.5+0.2

In the case of sub-compartment 92 b situated on the ash-alder riparian forest site on a former meadow, alder forest occurs (PLAN OCHRONY... 2006). The upper storey is formed by *A. glutinosa* (Table 2). The tallest alders reach the height of 23.0 m. Live alder DBHs range from 14.0 to 38.5 cm (mean – 20.0 cm), while the total $G_{1.3m}$ amounts to 36.6 $m^2 \cdot ha^{-1}$ (Table 3). Sporadically, dead trees were observed (6% of alders). The density of trees and shrubs in the layer of shrubs, undergrowth and the developing lower storey was determined at 6236 specimens per 1 ha. Riparian and oak-hornbeam forest species can be found in this layer, mainly: *A. glutinosa*, *C. betulus* and *F. excelsior*. Sporadically, *Acer pseudoplatanus* trees were also found. Mean DBHs of live *A. glutinosa* trees in this layer amount to 11.0 cm (range: 6.6-14.0 cm), of *A. pseudoplatanus* – 8.1 cm (one specimen on the study plots) and *C. betulus* – 6.4 cm (the only hornbeam on the study plots). In the shrub and undergrowth layer, dead specimens constitute 14.5% of all trees and shrubs occurring here. These are mainly shrubs but also alder and ash trees (Table 2). At the edge of this sub-compartment, from the side of the field, a strip of silver birch occurs which are higher than the alders surrounding them. The tallest of these birches reached the height of 28 m.

Elm-ash riparian forest occurs in the sub-compartment 92 c and in this sub-compartment of the reserve, actual vegetation corresponds to the potential natural vegetation (PLAN OCHRONY... 2006). The density in the upper tree layer amounts to 367 specimens per 1 ha and the stand consists of: *F. excelsior* (61%), *Betula pendula* (36%) and *A. glutinosa* (3%) (Table 2). The tallest trees are ashes reaching the height of 27.3 m (mean – 24.1 m). DBHs of live ashes range from 16.9 to 47.2 cm (mean – 29.7 cm), DBHs of birches – from 15.2 to 40.5 cm (26.3 cm), while those of alders – from 23.9 to 29.8 cm (26.9 cm). In the upper tree layer, dead ashes and birches were found (35% of all trees). In the case of ash, 48% of trees are dead, while in the case of birch – 17%. Mainly *C. betulus* forms the poorly developed lower tree storey (47%) (mean height – 14.3 m). *Acer pseudoplatanus* (22.2 m), *Tilia cordata* (15.4 m), *Ulmus glabra* (15.7 m), *Acer platanoides* and *F. excelsior* occur in the admixture. DBHs of live hornbeams range from 11.0 to 21.7 cm (mean – 15.1 cm). The total $G_{1.3m}$ of trees amounts to 26.8 $m^2 \cdot ha^{-1}$, of which 25% are dead trees (Table 3). The density of trees and shrubs in the undergrowth and shrub layer as well as in the developing lower storey was found to be 4398 specimens per 1 ha. The dominant trees in this layer are the following oak-hornbeam forest species: *A. pseudoplatanus*, *C. betulus* and sporadically *F. excelsior*, *U. laevis*, *A. platanoides*, *B. pendula* and *T. cordata*. Dead specimens constitute 23% of all trees and shrubs of the discussed layer (Table 2). In the c sub-compartment (outside experimental plots), a tree with the biggest diameter at breast height in the nature reserve was found – a pedunculate oak growing by the road (DBH – 120 cm). In the same sub-compartment, the largest sycamore maple tree in the reserve can also be found with the DBH of 64.6 cm (Table 4).

In sub-compartment 92 d, in compliance with the potential natural vegetation, oak-hornbeam forest (*Galio sylvatici-Carpinetum betuli*) is growing (PLAN OCHRONY... 2006) with mainly *Q. robur* forming the upper tree storey (65%) and *F. excelsior* (19%), *C. betulus* (11%), *Picea abies* (4%) and *A. pseudoplatanus* (1%) occurring in the admixture (Table 2). In this part of the nature reserve, oaks reach the height of 32.1 m (mean height – 26.8 m). Dead trees were recorded only sporadically and constituted 1% of all trees. DBHs of live oaks ranged from 31.0 to 89.4 cm (mean – 52.7 cm),

Table 4. Largest circumferences and DBHs of trees in 'Czmoń' reserve (cm)
Tabela 4. Obwody i pierśnice najgrubszych drzew w rezerwacie „Czmoń" (cm)

Sub-compartment Pododdział	Species Gatunek	Circumference Obwód	DBH Pierśnica
c	*Q. robur*	377	120.0
d	*Q. robur*	322	102.5
d	*Q. robur*	313	99.6
j	*Q. robur*	293	93.3
d	*Q. robur*	281	89.5
d	*Q. robur*	277	88.2
f	*Q. robur*	276	87.9
d	*Q. robur*	274	87.2
f	*Q. robur*	259	82.4
d	*Q. robur*	238	75.9
g	*F. excelsior*	238	75.8
d	*Q. robur*	230	73.2
j	*C. betulus*	218	69.4
c	*A. pseudoplatanus*	203	64.6
i	*P. abies*	157	50.1
i	*B. pendula*	157	50.1
j	*P. sylvestris*	154	49.0

of ashes – from 20.8 to 60.0 cm (40.0 cm), hornbeams – from 42.0 to 52.5 cm (46.7 cm) and of spruce trees – from 15.8 to 33.3 cm (24.2 cm). The diameter at breast height of the only sycamore maple tree growing on this study plots is 41.3 cm. *Carpinus betulus* (96%; mean height – 22.1 m) dominates in the lower tree storey with *A. pseudoplatanus*, *Q. robur*, *F. excelsior* and *T. cordata* occurring sporadically. Dead trees constitute 2% of all trees (Table 2). DBHs of live hornbeams found in this layer range from 20.0 to 25.1 cm (mean – 23.1 cm), of sycamore maples – from 10.0 to 39.0 cm (27.7 cm) and of oaks – from 20.2 to 28.3 cm (24.2 cm). The DBH of the only ash found here amounts to 13.8 cm and of a lime – 28.0 cm. The total $G_{1.3m}$ of the upper tree storey amounts to 18.3 $m^2 \cdot ha^{-1}$ and that of the lower tree storey – 15.8 $m^2 \cdot ha^{-1}$ (Table 3). Tree and shrub density in the undergrowth and shrub layer amounts to 1286 specimens per 1 ha and can be attributed, primarily, to oak-hornbeam forest species: *A. pseudoplatanus* (64%) and *C. betulus* (18%). In addition, *F. excelsior* was reported sporadically. The mean DBH of live *A. pseudoplatanus* in this layer was found to be 4.9 cm (range – 3.3-8.4 cm) and of *C. betulus* – 7.8 cm (3.5-14.6 cm). Dead trees and shrubs make up 12% of the undergrowth and shrub layer. Dead sycamore maples, hornbeams, hazels, ashes and dogwoods were recorded (Table 2). Sub-compartment 92 d constitutes a fragment of the

reserve in which oaks of magnificent circumferences were recorded most numerously (Table 4).

Diameters at breast height of trees from the upper and lower tree storey in sub-compartment 92 d are ranged from 11 to 51 cm with much smaller numbers of specimens growing to greater dimensions. In the case of oak, the distribution of DBHs is distinctly shifted to the right side. No specimens with DBHs ranged from 11 to 21 cm are found and majority of oak trees attain DBHs ranging from 29 to 77 cm. In the case of hornbeam, the DBH distribution is clearly shifted to the left. Specimens with diameters at breast height ranging from 11 to 43 cm are most numerous. Single hornbeam trees exceed this limit reaching dimensions up to 53 cm (Fig. 2).

There is a land depression in the south-eastern part of the sub-compartment 92 d in which a stand of a different structure was recorded (study plot No. 2; Fig. 1). *Alnus glutinosa* (220 specimens per 1 ha) is dominant in the upper tree storey with *F. excelsior*, *C. betulus*, *B. pendula* and *Q. robur* occurring in the admixture. In the case of the lower tree storey, *C. betulus* (55 specimens per 1 ha) was dominant accompanied by *A. pseudoplatanus* (25 specimens per 1 ha) and *U. laevis* (5 specimens per 1 ha). The $G_{1.3m}$ of the upper tree storey in this fragment of the forest reaches 35.0 $m^2 \cdot ha^{-1}$ of which 73% fall on alders, while the $G_{1.3m}$ of the lower tree storey amounts to 4.5 $m^2 \cdot ha^{-1}$. The density of trees and shrubs in the undergrowth and shrub layer amounts to 2040 specimens per 1 ha. In the undergrowth, *A. pseudoplatanus* (705 individuals per 1 ha), *A. glutinosa* (65 individuals per 1 ha), *C. betulus* (20 individuals per 1 ha) and, sporadically *F. excelsior*, *A. platanoides* and *Q. robur*, were recorded.

In the case of sub-compartment 92 f, Scots pine stand grows on an oak-hornbeam site type (PLAN OCHRONY... 2006). The upper tree storey is made up mainly of *Pinus sylvestris* (93%; mean height – 22.1 m), while *B. pendula*, *P. abies*, *Q. robur*, *A. pseudoplatanus*, *C. betulus*, *F. excelsior* and *U. laevis* are found in the admixture (Table 2). The tallest trees in sub-compartment 92 f are those of *B. pendula* (27.3 m). DBHs of live pines vary from 18.6 to 40.4 cm (mean – 28.1 cm), of spruce trees – from 22.6 to 42.0 cm (28.4 cm), birches – from 23.1 to 34.9 cm (30.0 cm), oaks – from 32.5 to 87.9 cm (67.6 cm) and of sycamore maples – from 22.6 to 23.2 cm (22.9 cm). The diameters at breast height of the only ash growing on the experimental plot amounts to 21.2 cm and of the only hornbeam found in this layer – 39.2 cm. The total $G_{1.3m}$ of the upper tree storey reaches 35.1 $m^2 \cdot ha^{-1}$ (Table 3). Dead trees in this area (*P. sylvestris*, *U. laevis*) constitute 3% of all trees. The lower tree storey is made up of: *C. betulus* (37%), *P. sylvestris* (28%), *A. pseudoplatanus* (10%) and *Q. robur* (16%) trees with *F. excelsior*, *B. pendula*, *Prunus avium* and *U. laevis* also occurring sporadically (Table 2). Hornbeam diameters at breast height vary from 13.1 to 34.7 cm (mean – 17.0 cm), sycamore maple – from 12.1 to 30.9 cm (17.8 cm), oak – from 12.1 to 31.0 cm (21.3 cm) and of ash – from 16.1 to 20.5 cm (18.2 cm). The mean total $G_{1.3m}$ in the lower tree storey is 9.1 $m^2 \cdot ha^{-1}$. As was in the case of the upper tree storey, dead trees constitute 3% of all trees. Dead *U. laevis*, *B. pendula* and *F. excelsior* trees were recorded. Density of trees and shrubs in the undergrowth and shrub layer, as well as in the developing lower storey amounts to 2682 specimens per 1 ha. It is dominated by such oak-hornbeam forests' species as *C. betulus* and *A. pseudoplatanus*. In addition, *U. laevis*, *F. excelsior*, *Q. robur* and *P. sylvestris* were reported sporadically (Table 2). The mean DBH of live *C. betulus* amounts to 6.1 cm (range – 3.4-11.7 cm), *A. pseudoplatanus* – 6.6 cm (3.7-

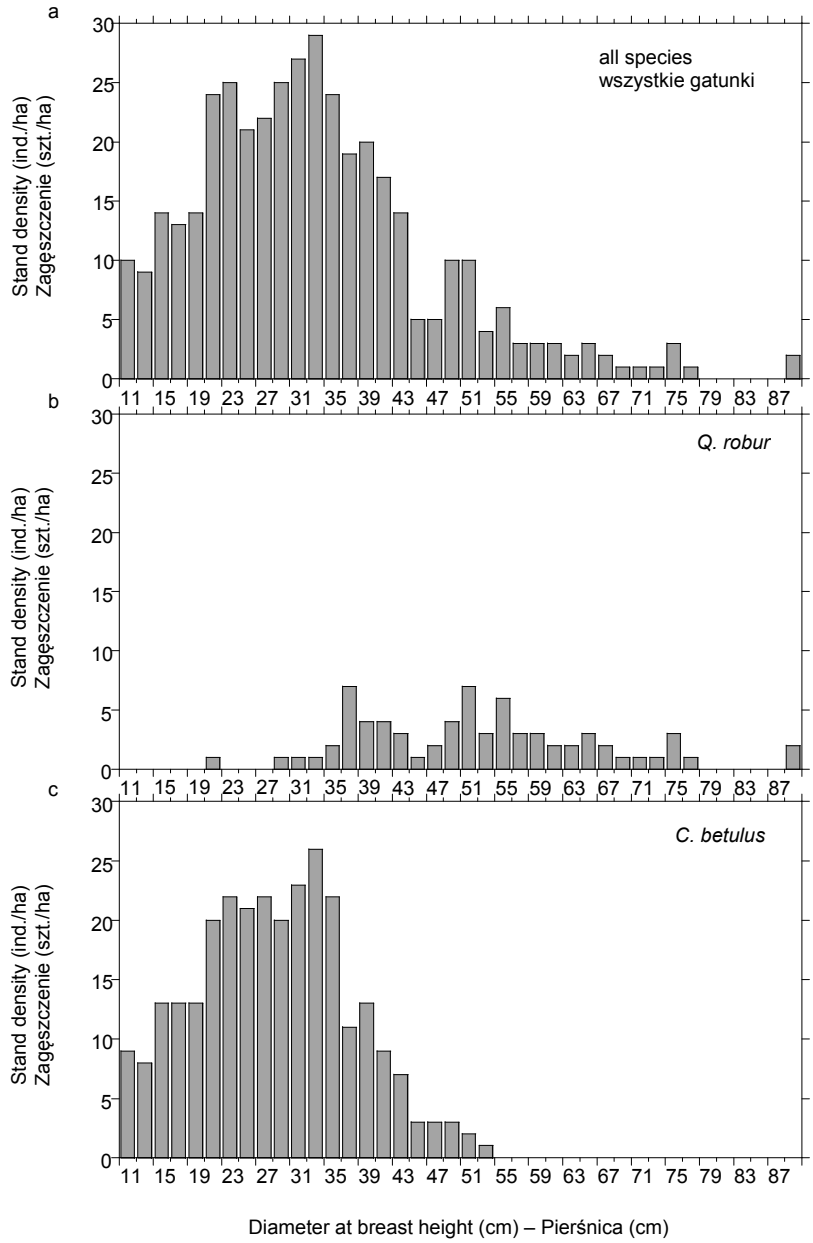

Fig. 2. DBH structure of the stand in upper and lower storeys in 92 d sub-compartment of the 'Czmoń' nature reserve
Rys. 2. Struktura grubości drzewostanu w warstwach wysokiej i niskiej w wydzieleniu 92 d rezerwatu przyrody „Czmoń"

-11.3 cm), *U. laevis* – 6.3 cm (6.0-6.6 cm), *F. excelsior* – 10.1 cm (9.0-11.2 cm) and of *Q. robur* – 9.9 cm (8.5-11.3 cm). Dead trees make up 21% of inventoried trees and shrubs in the discussed layer (*Corylus avellana*, *C. betulus*, *A. pseudoplatanus*, *U. laevis*). All pines recorded in this layer are dead (Table 2).

DBHs of trees from upper and lower tree storeys in the 92 f sub-compartment are ranged from 13 to 43 cm. Two oak trees reach greater dimensions. DBH distribution of pine trees in both storeys is similar to the normal distribution and, in the case of hornbeam, it is distinctly shifted to the left. Specimens with DBHs varying from 13 to 23 cm are the most numerous (Fig. 3).

Within the boundaries of the 92 f sub-compartment, two gaps can be found with artificial regenerations of pedunculate and sessile oaks, lime, sycamore maple and ash. Each of these gaps occupies the area of 0.3 ha. Within confines of the first gap, only one tree growing in it was measured – *B. pendula* of 22.5 cm DBH, whereas within boundaries of the second gap, no trees of diameter at breast height exceeding 3.5 cm were found. Two oak trees of substantial sizes were found growing at the border with sub-compartment 92 d (Table 4).

In sub-compartment 92 g, the upper tree storey is made up of *B. pendula* (42%), *P. sylvestris* (37%), *A. pseudoplatanus* (12%), *Q. robur* (7%), *A. glutinosa* (1%) and *Betula pubescens* (1%) (Table 2). The greatest height is achieved by *B. pendula* (31.8 m). DBHs of live birches vary from 21.5 to 46.6 cm (mean – 31.3 cm), of pines – from 19.2 to 47.5 cm (29.1 cm), of sycamore maples – from 21.5 to 37.3 cm (27.7 cm) and of oaks – from 27.1 to 41.2 cm (33.0 cm). The total $G_{1,3m}$ of the upper tree layer amounts to 27.7 $m^2 \cdot ha^{-1}$ (Table 3). Dead specimens were found sporadically (3% of all trees) among birches and pines. The lower tree storey was dominated by *C. betulus* (59%). *P. sylvestris* (13%), *A. pseudoplatanus* (8%), *B. pendula* (6%), *A. glutinosa* (5%), *Q. robur* (4%), *B. pubescens* (3%) and *U. laevis* (1%) were also noted in this layer. DBHs of live hornbeams ranged from 12.1 to 39.0 cm (mean – 19.2 cm), of sycamore maples – from 16.0 to 33.5 cm (23.3 cm), of pines – from 15.8 to 17.8 cm (17.2 cm), of silver birches – from 18.0 to 19.6 cm (19.0 cm), of oaks – from 16.0 to 22.1 cm (19.9 cm), of alders – from 17.4 to 19.2 cm (18.2 cm) and of downy birches – from 16.9 to 17.9 cm (17.4 cm). The diameter at breast height of the only elm tree amounts to 23.8 cm. The total $G_{1.3m}$ in the lower tree storey amounts to 6.8 $m^2 \cdot ha^{-1}$ (Table 3). The density of trees and shrubs in the undergrowth and shrub layer as well as in the developing lower storey amounts to 4755 specimens per 1 ha (Table 2). The oak-hornbeam forest and riparian forest species are dominant in this layer: *A. pseudoplatanus* (28%), *C. betulus* (4%) and *U. laevis* (1%). Moreover, also *F. excelsior*, *B. pendula* and *Q. robur* are found sporadically. The mean DBHs of live *A. pseudoplatanus* specimens in this layer amount to 7.8 cm (range – 4.0-14.9 cm), of *C. betulus* – 10.2 cm (3.7-14.9 cm) and of *U. laevis* – 10.9 cm (6.7-13.8 cm). In addition, one *B. pendula* of 13.2 cm DBH was recorded. Dead specimens constitute 18% of trees and shrubs in this layer. Presence of dead hazels, sycamore maples, dogwoods, hornbeams and oaks was also noted (Table 2).

In the sub-compartment 92 h, oak-hornbeam forest occurs on the Central-European oak-hornbeam site (PLAN OCHRONY... 2006). The upper tree storey here is dominated by *Q. robur* (91%) with *B. pendula* (4%), *F. excelsior* (3%) and *P. sylvestris* (2%) found sporadically (Table 2). Oaks predominate over trees of other species reaching heights of up to 29.8 m (mean height – 25.1 m). DBHs of oaks ranged from 32.0 to 77.3 cm (mean

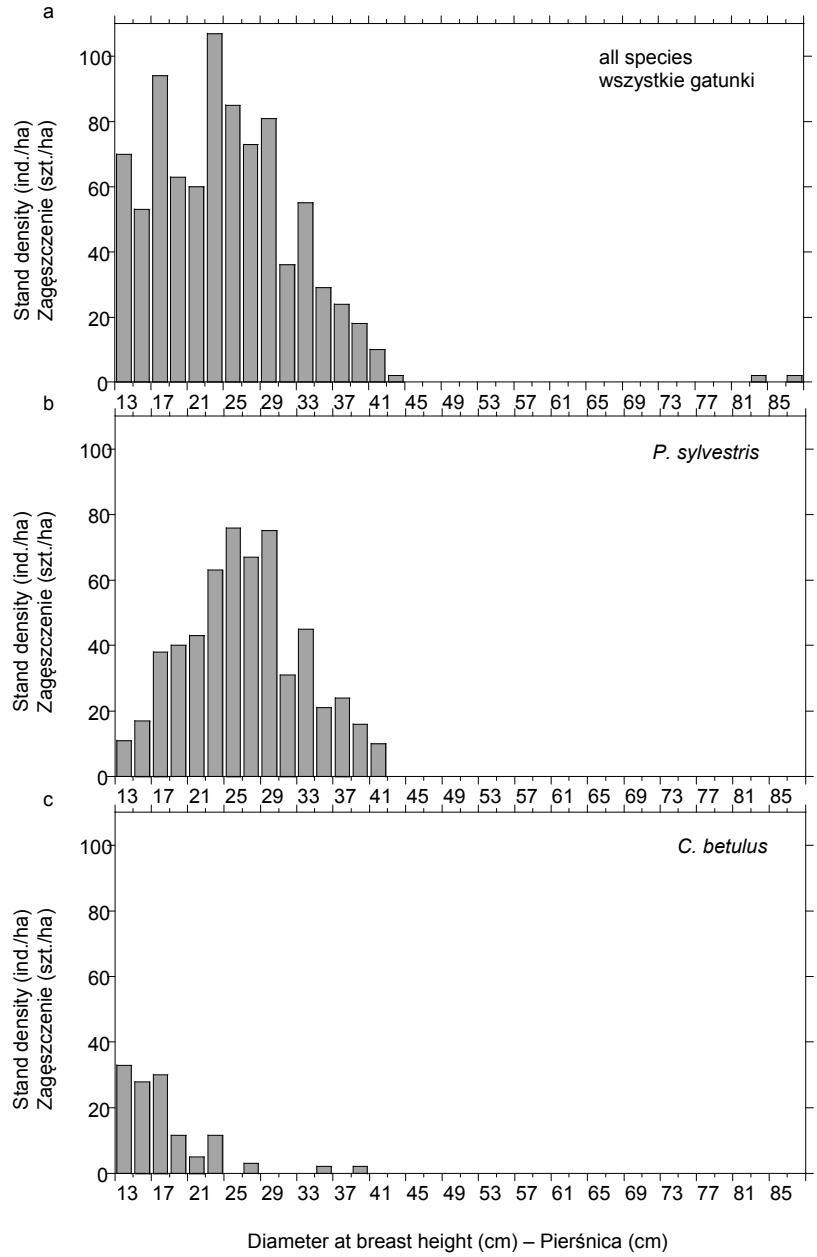

Fig. 3. DBH structure of the stand in upper and lower storeys in 92 f sub-compartment of 'Czmoń' nature reserve
Rys. 3. Struktura grubości drzewostanu w warstwach wysokiej i niskiej w wydzieleniu 92 f rezerwatu przyrody „Czmoń"

– 48.9 cm), while those of pines – from 25.8 to 29.9 cm (27.9 cm). The DBH of the only live birch found on the experimental plots amounts to 32.0 cm and of ash – 30.0 cm. The total $G_{1.3m}$ in the tall tree layer amounts to 36.1 $m^2 \cdot ha^{-1}$ (Table 3). The main species in the lower tree storey is *C. betulus* (96%) with a small admixture of *Q. robur* (2%) and *A. glutinosa* (2%) (Table 2). The DBHs of live hornbeams vary from 9.0 to 31.8 cm (mean – 16.0 cm), whereas those of oaks – from 12.2 to 13.2 cm (12.7 cm). The DBH of a single recorded alder amounts to 19.6 cm. The total $G_{1.3m}$ in the lower tree storey amounts to 7.3 $m^2 \cdot ha^{-1}$ (Table 3). Dead trees constitute 1% of specimens both in the upper as well as lower tree storey (Table 2). The total tree and shrub density in the undergrowth and shrub layer as well as in the developing lower storey amounts to 6153 specimens per 1 ha. This layer is dominated by shrubs, although *C. betulus* (3%), *A. pseudoplatanus* and *A. glutinosa* were recorded sporadically. The mean *C. betulus* DBH in this layer amounts to 6.5 cm (range – 3.5-11.2 cm) and of a single recorded specimen of *A. glutinosa* – to 12.3 cm. DBHs of all *A. pseudoplatanus* occurring on this experimental plot were smaller than 3.5 cm. Dead specimens make up 23% of all trees and shrubs recorded in the undergrowth and shrub layer. Dead hazels, dogwoods, hornbeams, European spindles and bird cherries were noted (Table 2).

In sub-compartment 92 i, a regeneration form of riparian forest was found on an elm-oak riparian forest site (PLAN OCHRONY... 2006). The upper tree storey is made up mainly of *F. excelsior* (46%) and *A. glutinosa* (39%) with *B. pendula*, *Q. robur*, *B. pubescens* and *U. laevis* found in the admixture (Table 2). The greatest heights in this stand are attained by ashes (maximum height – 33.1 m, mean – 28 m). Dead trees constitute 9% of specimens in this layer; majority of them are ashes (60%). DBHs of live ashes vary from 17.8 to 46.8 cm (mean – 32.5 cm), of alders – from 22.3 to 45.0 cm (32.9 cm), of silver birches – from 26.8 to 50.0 cm (38.5 cm) and of oaks – from 23.3 to 51.5 cm (40.6 cm). The DBH of the only downy birch found within experimental plots of this sub-compartment amounts to 29.9 cm and of the elm – 53.2 cm. The total $G_{1.3m}$ in the upper tree layer amounts to 20.2 $m^2 \cdot ha^{-1}$ (Table 3). The lower tree storey is dominated by *A. glutinosa* (68%) with *C. betulus* (20%), *A. pseudoplatanus* (8%), *B. pendula* (4%) and *U. laevis* (1%) occurring in the admixture. Dead trees constitute 9% of specimens in this layer; dead alders and birches were also recorded. Diameters at breast height of live alders range from 11.9 to 34.9 cm (mean – 24.1 cm), of hornbeams – from 12.7 to 34.8 cm (22.9 cm) and of sycamore maples – from 16.7 to 30.5 cm (24.2 cm). The DBH of a single recorded live birch amounts to 24.6 cm and of elm – 15.4 cm. The total $G_{1.3m}$ in the lower tree storey amounts to 7.4 $m^2 \cdot ha^{-1}$ (Table 3). The density of trees and shrubs in the undergrowth and shrub layer as well as the developing lower storey amounts to 6401 specimens per 1 ha (Table 2). Majority of them are shrubs. *A. pseudoplatanus* (3%) was recorded in the undergrowth layer with *F. excelsior*, *P. abies*, *U. laevis*, *C. betulus*, *A. glutinosa* and *P. sylvestris* occurring sporadically. Dead trees and shrubs in the discussed layer constitute 18% of the total number of specimens. Dead specimens of *A. pseudoplatanus*, *F. excelsior*, *P. abies*, *U. laevis*, *A. glutinosa* and *P. sylvestris* were found in this layer (Table 2). The mean DBH of *A. pseudoplatanus* in this layer reaches 8.9 cm (range – 5.9-13.8 cm), of *F. excelsior* – 12.7 cm (10.7-14.9 cm), of *U. laevis* – 5.3 cm (3.5-7 cm), of *C. betulus* – 7.2 cm (5.9-8.5 cm) and of *P. abies* – 9.3 cm (9.1-9.5 cm).

In sub-compartment 92 j, the elm-ash riparian forest was found to occur in compliance with the site potential (PLAN OCHRONY... 2006). The upper tree storey is formed by: *F. excelsior* (85%), *Q. robur* (10%), *A. pseudoplatanus* (2%), *A. glutinosa* (2%) and *C. betulus* (2%) (Table 2). Ashes reached the maximum height of 31.8 m (mean height – 28.1 m). Dead ashes and oaks were observed (5% of all trees in this layer). DBHs of live ashes vary from 24.5 to 57.0 cm (mean – 34.2 cm) and of oaks – from 33.0 to 74.6 cm (47.6 cm). Diameters at breast heights of single sycamore maple, alder and hornbeam amounted to: 42.1, 29.5 and 46.8 cm, respectively. The total $G_{1.3m}$ (live and dead trees) amounts to 26.7 $m^2 \cdot ha^{-1}$ of which 78% falls on the ash (Table 3). The lower tree storey is made up of *C. betulus* (69%) and *A. pseudoplatanus* (31%). Hornbeam DBHs vary from 10.5 to 22.4 cm (mean – 16.1 cm) and of the sycamore maple – from 11.5 to 33.2 cm (21.6 cm). The total $G_{1.3m}$ of the lower tree storey amounts to 3.2 $m^2 \cdot ha^{-1}$ (Table 3). The density of trees and shrubs in the undergrowth and shrub layer reaches 5652 specimens per 1 ha (Table 2). Majority of them are representatives of shrub species. *Carpinus betulus*, *A. pseudoplatanus*, *F. excelsior* and *A. glutinosa* species were recorded sporadically. The mean *C. betulus* DBH in this layer was found to be 6.7 cm (range – 4.2-9.8 cm), of *A. pseudoplatanus* – 9.7 cm (9.7-9.7 cm), while that of *F. excelsior* – 15.1 cm (5.4-23.6 cm). Dead trees and shrubs in the undergrowth and shrub layer constituted 14% of all specimens. Dead *C. avellana*, *C. sanguinea*, *P. avium* and *F. excelsior* were noted. Sporadically, dead *A. pseudoplatanus* occurred in this layer (Table 2). Oaks and a hornbeam tree, with diameters at breast height among the greatest in the reserve, were recorded in sub-compartment 92 j. The recorded hornbeam specimen was the only tree in the reserve of monumental dimensions (Table 4). In addition, presence of several specimens of an alien species of ash – *Fraxinus pennsylvanica* was recorded here.

In sub-compartment 92 k, a pine-dominated stand growing on oak-hornbeam forest site was found (PLAN OCHRONY... 2006). The upper tree storey here is made up of: *P. sylvestris* (62%), *B. pendula* (24%), *C. betulus* (11%) and *A. pseudoplatanus* (3%) (Table 2). The highest pines in this stand reach the maximum height of 26.5 m. Pine DBHs vary from 20.0 to 40.2 cm (mean – 29.5 cm), of birches – from 26.4 to 42.4 cm (33.0 cm) and of hornbeams – from 21.9 to 33.6 cm (25.4 cm). The DBH of the only sycamore maple tree amounts to 29.7 cm. The total $G_{1.3m}$ of trees forming this layer is 35.4 $m^2 \cdot ha^{-1}$ of which 60.5% falls on pine (Table 3). The lower tree storey is dominated by *C. betulus* (75%) with *A. pseudoplatanus* (8%), *B. pendula* (8%) and *P. sylvestris* (8%) recorded sporadically. Hornbeam DBHs in this layer vary from 15.4 to 28.9 cm (mean – 18.8 cm). The DBH of the only sycamore maple amounts to 17.3 cm and that of birch – 19.3 cm. All pine trees occurring in this layer are dead. The total tree and shrub density in the undergrowth and shrub layer amounts to 6855 specimens per 1 ha. *Acer pseudoplatanus* is dominant in the undergrowth (5%) with *C. betulus* found sporadically. DBHs of all *A. pseudoplatanus* specimens did not exceed 4 cm. Dead trees and shrubs constitute 26% of specimens in the undergrowth and shrub layer. Dead hazels and dogwoods were recorded (Table 2). Two artificial gaps of 0.3 ha each are situated within sub-compartment 92 k. Within the boundaries of these gaps, no stands occur and only scattered, single or grouped older trees can be found. The total of 19 trees was inventoried in gap No. 1: seven specimens of *C. betulus* of mean DBH of 18.3 cm (range – 15.5-24.3 cm), five specimens of *U. laevis* of mean DBH of 27.4 cm (23.1-32.5 cm),

three *Q. robur* specimens of mean DBH of 35 cm (34.5-35.8 cm), two *A. pseudoplatanus* specimens of mean DBH of 40.8 cm (38.3-43.3 cm) and single specimens of *A. platanoides* (18.6 cm) and *F. excelsior* (33.5 cm). One of the elms is dying. Thirty four trees were found in the gap No. 2. Twenty five of these specimens are *C. betulus* of mean DBH of 19.5 cm (range – 10.5-26.9 cm), five – *Q. robur* of mean DBH of 24.8 cm (19.5-32.7 cm) and four – *A. pseudoplatanus* of mean DBH 31.6 cm (24.6-39.1 cm).

Within entire nature reserve (with the exception of artificial stand gaps and the sub-compartment 92 a which were artificially regenerated), oak-hornbeam species dominate in the undergrowth. *Acer pseudoplatanus* and *C. betulus*, on average, constitute 83% of all recorded specimens in this layer. Apart from the above species, oak-hornbeam forest species are represented by less numerous ones, namely: *T. cordata*, *Q. robur* and *A. platanoides*. On the other hand, more numerous are species typical for riparian forests, e.g. *A. glutinosa* and *F. excelsior* which constitute 15% of specimens identified in the undergrowth (Fig. 4).

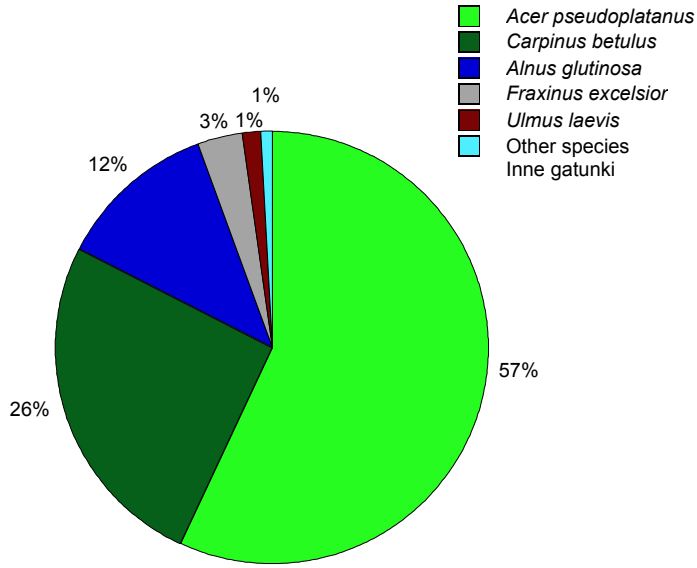

Fig. 4. Mean share of particular tree species in the shrub and undergrowth storeys of the 'Czmoń' nature reserve
Rys. 4. Średni udział poszczególnych gatunków drzew w podszycie i podroście rezerwatu przyrody „Czmoń"

The species represented most numerously in the group of dead trees in the entire reserve is *F. excelsior* but this group of trees is also represented by *P. canadensis*, *P. sylvestris*, *B. pendula* and *A. glutinosa* (Fig. 5).

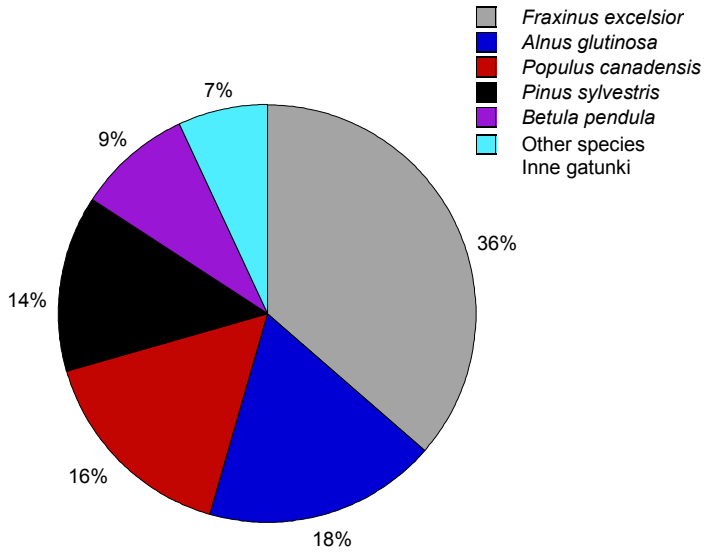

Fig. 5. Mean share of particular tree species in dead trees group in upper and lower storeys of the 'Czmoń' nature reserve
Rys. 5. Średni udział poszczególnych gatunków w grupie drzew martwych w warstwach wysokiej i niskiej rezerwatu przyrody „Czmoń"

Discussion

Stand structure is not a permanent feature but undergoes changes and transformations under the influence of natural factors and processes taking place in forest ecosystems (BONCINA 1999). In addition, forest management carried out in a given area may be treated, in ecological sense, as a disturbance (VAN MIEGROET 1986). In the described nature reserve, an unambiguous influence of forest management conducted in the not-so-distant past on the vertical and horizontal forest structure and stand species composition is apparent. At the moment of nature reserve establishment, it was estimated that the performed forest management did not exert a negative influence on forest condition on 75% of its area but on the remaining areas, it led to degeneration of natural communities (PLAN OCHRONY... 2006). However, the results of this research project make it possible to infer that a regeneration of forest communities is already under way in the entire reserve towards potential vegetation (15 years after its establishment). Trees of site- (*P. sylvestris*) or geographically-alien (*P. canadensis*, *F. sylvatica*) species constitute a considerable percentage of dead trees. The highest proportion of ash trees among the dead ones is alarming. Dry ashes can be found in all stand layers. This fact is disturbing in view of reports of ash-tree disease recorded in Poland since 1995 (PRZYBYŁ 2002) caused by a pathogen described as *Chalara fraxinea* (KOWALSKI 2006). Within the boundaries of the entire nature reserve, *A. pseudoplatanus* and *C. betulus* dominate in the undergrowth layer. They are present in this layer both in the well preserved fragments of oak-hornbeam and riparian forests as well as in pine-

-dominated stands (sub-compartments 92 f and 92 k). Presence of hornbeam in pine stands growing on oak-hornbeam sites was reported earlier in different regions of the country (e.g. FALIŃSKI and PAWLACZYK 1993, DOBROWOLSKA 2006). It is associated with a considerable ability of hornbeam to colonise interiors of artificial pine stands on fertile sites (FALIŃSKI and PAWLACZYK 1993). Hornbeam also forms the second storey of stands resulting in the development of a *Pinus-Carpinus* combination described by JAKUBOWSKA-GABARA (1991). In the case of well-developed oak-hornbeam forests, the presence of abundant sycamore maple and hornbeam undergrowth is associated with the ecological strategy of these species. They develop profuse undergrowth of slow expansion filling gaps developed as a result of death of older trees (FALIŃSKI and PAWLACZYK 1993, BORATYŃSKI and FILIPIAK 1999).

The comparison of the research results of this study with the data available in the "Plan of protection of the 'Czmoń' reserve for 2006-2025" (PLAN OCHRONY... 2006) (Table 1) makes it possible to draw conclusions regarding changes that took place in the structure of stands in the reserve during the past six years. Already then, attention was drawn to dying off of alien species: hybrid black poplar and Scots pine. Dying of ashes was also noticed six years ago (PLAN OCHRONY... 2006). At the moment, the proportion of dead specimens increased considerably in sub-compartment 92 c. Dead trees also appeared in sub-compartment 92 b. In the case of the remaining sub-compartments, the proportion of dead trees did not undergo significant change. However, the absence of oak in the undergrowth continues to pose a challenge.

Within the sub-compartment 92 d, one of the best-preserved fragments of oak-hornbeam forest in Wielkopolska region can be found. The recorded stand species composition is considered as characteristic for well-developed oak-hornbeam forests (MATUSZKIEWICZ 2001, 2006, LASY... 2012). Nevertheless, quantitative relationships between the recorded species differ significantly from those described by BERNADZKI et AL. (1998) from the area of Białowieża Primeval Forest. The results of the above-quoted study indicate domination of hornbeam, lime and spruce in communities of *Tilio-Carpinetum stachyetosum* and *Tilio-Carpinetum typicum* sub-associations. Ash, oak, Norway maple, alder and birch occur in smaller quantities. The observed differences can be attributed to geographical variability of oak-hornbeams forests (MATUSZKIEWICZ 2001, 2006, LASY... 2012).

Considerable effectiveness of natural regeneration of forest is confirmed by the DBH distribution in the discussed fragment of the reserve. In general, it reminds the curve described in the self-regenerating natural forests or re-naturalised commercial forests (BERNADZKI et AL. 1998, BONCINA 1999, BOBIEC et AL. 2000, PIOVESAN et AL. 2005) (Fig. 2). A similar course of the curve is characteristic for the hornbeam population from the 'Czmoń' reserve. In the case of oak, the DBH distribution indicates aging of the population, as well as a distinct absence of natural regeneration. Lack of oak regeneration in European forests was earlier indicated by BERNADZKI et AL. (1998), EMBORG et AL. (2000), BRZEZIECKI et AL. (2012) and MIŚCICKI (2012).

Conclusions

The objective of the establishment of the 'Czmoń' nature reserve was the protection of one of the best-preserved fragments of the Central-European oak-hornbeam forest in the Wielkopolska region (PLAN OCHRONY... 2006, LISIEWSKA and KRÓL 2007). In fact, it is situated in sub-compartment 92 d. The results of the presented study let us conclude that it remains in a good condition. Within boundaries of the rest of the sub-compartments, oak-hornbeam and riparian communities can be found which are in different degrees of degeneration. It appears that a natural process of regeneration is taking place there leading to communities complying with potential vegetation. Symptoms of oak population aging and dying off of ash are worrying.

The area of the 'Czmoń' nature reserve remains an exceptionally interesting scientific object. The results of this research project allowed characterisation of the structure of its stands at the present time – 15 years after its establishment. Repetition of the research in future will make it possible to trace the dynamics of forest systems following the cessation of any forest management and to assess the effectiveness of the selected methods of protection.

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STRUKTURA DRZEWOSTANÓW I SKŁAD GATUNKOWY W REZERWACIE PRZYRODY „CZMOŃ"

Streszczenie. Rezerwat przyrody „Czmoń" został utworzony w 1998 roku ze względu na występujący tu grąd środkowoeuropejski (*Galio sylvatici-Carpinetum betuli*) – rzadkie na terenie Wielkopolski zbiorowisko roślinne. Ochroną objęto 23,65 ha lasu, w którym występują również inne zbiorowiska rzadkich na tym terenie zespołów (*Querco-Ulmetum minoris* i *Fraxino-Alnetum*). W rezerwacie występują zarówno zbiorowiska o charakterze naturalnym, jak i zbiorowiska zdegenerowane, co można łączyć z prowadzoną tu wcześniej gospodarką leśną. Celem pracy było scharakteryzowanie struktury drzewostanów w rezerwacie, ich składu gatunkowego oraz prześledzenie potencjalnych zmian w drzewostanach wynikających z zaprzestania prowadzenia zabiegów związanych z gospodarką leśną. Na potencjalnych siedliskach grądu środkowoeuropejskiego, łęgu wiązowo-dębowego i łęgu jesionowo-olszowego występują zbiorowiska leśne w różnych fazach rozwoju i formach degeneracji. Na podstawie analizy składu gatunkowego podrostu, ilości martwych drzew i krzewów oraz rozkładu stopni grubości drzew stwierdzono proces regeneracji postępujący w kierunku zbiorowisk zgodnych z roślinnością potencjalną. Największy udział drzew obumarłych stwierdzono wśród rosnących w rezerwacie gatunków drzew obcych siedliskowo (*Pinus sylvestris*) oraz geograficznie (*Populus canadensis*, *Fagus sylvatica*). W warstwie podrostu zanotowano dominację gatunków grądowych i łęgowych (przede wszystkim *Carpinus betulus* i *Acer pseudoplatanus*). Niepokojący jest brak w podroście dębu szypułkowego (*Quercus robur*) oraz masowe zamieranie jesionu (*Fraxinus excelsior*).

Słowa kluczowe: grąd środkowoeuropejski, *Galio-Carpinetum*, ochrona przyrody, Wielkopolska, skład gatunkowy, drzewa martwe

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