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THE HEALTH STATUS OF ENDANGERED OAK STANDS IN POLAND*

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Abstract. This paper reports a country wide study on the health condition and its short term dynamics in the most threatened middle-aged-to-old-growth oak stands. The field measurements and observations were carried out in the period 2001-2004, covering 52 stands in 18 forest districts. Except of the complete survey of each stand, a total of 1560 permanently marked trees were subject to detailed measurements and assessment, both conducted during the growing season and at the leafless stage, in order to comprehensively describe the variety of tree vitality aspects. It is concluded that the health status of the majority of stands covered by the present study are threatened, both in terms of their development and stability.

Key words: crown architecture, decline, defoliation, dynamics, monitoring, pedunculate oak, permanent plots, vitality

INTRODUCTION

While rapidly-progressing socioeconomic development, especially in the 20th century, has brought undeniable civilisational achievements, it has at the same time been a cause of environmental degradation in many regions of the globe. This has been particularly the case for forest ecosystems, and has manifested itself in recent years in a widely-observed deterioration in the health status of many forest-forming tree species. Locally, whole stands of both coniferous and broadleaved species may even be afflicted by a dieback or dieoff process, with pathogenic and damage-causing organisms present and trees ageing prematurely.

Oak stands have been particularly affected by the above problems. The phenomenon of the mass decline and dieoff of oaks (*Quercus* spp.) has been found to occur periodically in different Northern Hemisphere countries since the mid 18th century [Oak decline... 1991, Delatour 1983, Recent advances... 2000, Thomas et al. 2002].

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The extensive literature on the problem includes a series of concepts accounting for it by reference to the role of different biotic, abiotic and anthropogenic factors in the emergence of the disease process in oaks. The prevalent view today is that the damage-causing factors and agents have a combined influence of the occurrence simultaneously in the same place and time, serving to predispose, initiate or co-participate, as in the model of the "multi-factor disease spiral" [Manion 1991]. Recently, the inter-dependence of the occurrence of abiotic and biotic factors as causes of oak decline in Central Europe has been discussed by Thomas et al. [2002].

Oaks are among Europe's most important forest tree species from both the economic and ecological points of view. In Poland, the pedunculate and sessile oaks (*Quercus robur*, *Q. petraea*) are the main forest-forming broadleaved trees. Oak stands occupy almost 500 000 ha, or 7.2% of the country's forest, and about 30% of its broadleaved forest. Around 6.6% of standing timber is in the form of oak, putting the species third only to Scots pine and Norway spruce [Leśnictwo 2004].

The stand conversion being carried out in the State Forests and reafforestation within the framework of the National Programme for the Augmentation of Forest Cover both anticipate an increase in the share of oak within the species composition of Poland's forests [Puchniarski 2000 a, b]. The importance of oak may increase still further with the forecast climatic warming and eutrophication of habitats that will favour broadleaved species. However, it will at the same time be necessary to count on an increase in the vulnerability of this genus of tree to diseases, pests and anomalies of temperature [Sadowski 1994, Ryszkowski et al. 1995, Rykowski 2003].

Poland's first documented case of the mass dieoff of pedunculate oaks (aged 70-100 years) was noted in the Krotoszyn oakwoods in the years 1942-1943 [Krahl-Urban 1943]. A renewed decline in the state of health of oak stands – and an onset of dieoff on a scale not met with in Poland hitherto – characterised the mid 1980's. The dieoff of trees at that time was really something in the nature of a disaster, taking in a total of 145 000 ha of stands [Oszako 1996], or some 2% of the then forest area of Poland. The last decade (1995-2004) has seen annual inventorying of the condition of oak stands, and this has shown areas characterised by symptoms of dieback covering between 15 000 ha in 1998 and 1999, and around 44 000 ha in 1995. The last three years in turn brought a near doubling of the affected area to around 35 000 ha [Sierota et al. 2005].

The widespread presence of forest dieback has inclined many states to conduct systematic inventories of the health of (level of damage to) tree stands. In Poland, the level of damage to stands (including oak stands) was assessed in the period from the late 1980's onwards using a bioindicative method concerning the loss of assimilatory apparatus. This is in line with European standards [Jaszczak 1999].

However, the considerable temporal variability to the level of defoliation of trees creates major difficulties with interpretation and raises doubts as to whether the use of this feature as the only criterion by which to assess trees and stands is justifiable. As a result it is more and more common for other, or additional, assessment criteria to be applied, e.g. the vitality method from Roloff [1989], as based on changes in the morphological structure of crowns. Dmyterko [1998] proposed a method combining structural and defoliation methods in the assessment of oak stands, with an equal weighting of the above criteria being applied.

The aim of the work described here has been to assess the state of health of oak stands threatened with dieback, in areas representative of the Polish population of the species. The fieldwork was done in areas exposed to unfavourable phenomena of a local or regional nature, in forest complexes found in the past to display symptoms of dieoff. The analysis was carried out repeatedly on permanent plots wherein individual trees had been identified. Observations were made in both the growing season and the period of dormancy, the aim being to describe all of the symptoms of a debilitated condition, in relation to both the assimilatory apparatus (i.e. defoliation) and crown architecture. To allow conclusions to be drawn regarding the causes of the observed phenomena, a detailed inventory of the state of tree stems was carried out, in the form of an assessment of both phytopathological condition and technical quality. Entomofaunas were described, along with fungal pathogens, and notes were taken of historical information of all kinds (e.g. the occurrence of severe defoliation episodes, gales, lowerings of the water table, longer-lasting droughts, cattle-grazing, past land-use, etc.) that might potentially be of use in interpreting results.

METHODS

The work analysed 52 oak stands in 18 Forest Districts distributed across all parts of Poland in which the species occur (Fig. 1). Fieldwork was done in the years 2001-2003, in those Districts in which long-term symptoms of oak-decline phenomena were observed,

Fig. 1. Distribution of oak (*Quercus*) stands subjected to health status study conducted in years 2001-2003
Rys. 1. Lokalizacja nadleśnictw, w których prowadzono badania stanu zdrowotnego drzewostanów dębowych w latach 2001-2003

or had been observed in the not-too-distant past. The areas to be studied were selected by means of a multi-stage procedure, in which the principle was to choose (at least) a pair of stands in each object that were "healthy" (in line with criteria for the overall local condition of stands) and damaged (as distinctly as possible). The stands in a given District had in common, not only their state of health, but also other fundamental assessment parameters. Sometimes two or more weakened stands within a single Forest District were chosen (as in Mircze, Miękinia, Jabłonna, Świerczyna, Połczyn, Czarna Białostocka and Radziwiłłów FDs), in line with the history of the stand or the presence of diversified symptoms of damage. The Krotoszyn Forest District was particularly well-represented (with 10 stands).

The stands made subject to detailed repeat measurements and observations over a 3-year period are distributed across 6 natural-forest provinces in Poland, with 6 Districts representing Province I (Baltic) (14 stands assigned numbers 1-14), 1 District Province II (Mazury-Podlasie) (with 4 stands numbered 15 to 18 inclusive), 1 District Province III (Wielkopolska-Pomerania) (10 stands given numbers between 19 and 28 inclusive), 5 Districts Province IV (Mazowsze-Podlasie) (the 14 stands numbers 29 to 42 inclusive), 4 Districts Province V (Silesia) (8 stands numbered 43 to 50) and 1 District Province VIII (Carpathian) (the 2 stands numbered 51 and 52).

The four stands numbered 17, 45, 49 and 50 serve as plus seed stands. One stand (no. 23) enjoys the Nature Reserve status. Stands affected by the unprecedented flooding of 1997 are those numbered 45, 46 and 47 (in Miękinia FD), as well as numbers 48 and 49 (in Wołów FD). Pre-cutting and older stands were selected, it having been reported that oak stands at younger developmental stages show less-intensified symptoms of debilitation.

Defoliation was determined (in relation to 5% intervals across the range 0-100%) in the case of 30 numbered trees from each main stand, along with crown vitality with intervals of 0.1, as assessed by reference to the Roloff method [1989]. The arithmetic means of vitality measures for summer and winter were determined.

The following degrees of damage were adopted, in relation to intervals for the percentage loss of the assimilatory apparatus at tree and stand level:

0 – undamaged (0-10% defoliation),

1 – slight damage (11-25% defoliation),

2 – moderate damage (26-60% defoliation),

3 – severe damage (over 60% defoliation).

In the case of each stand, a mean value for the evaluated trees was calculated, the result obtained being use to assign a stand to one or other of the above degrees of damage.

Also determined was the level of damage to the stems of the 30 aforementioned trees, in line with a phytopathological classification system adopted to meet the needs of the research in question. The two classification systems are presented below. A total of 1560 trees were measured and assessed.

The aforementioned phytopathological classification of damage to oak stems was as follows:

0 – stem undamaged: no disease or damage symptoms,

1 – stem slightly damaged: a small number of small-scale cracks in bark healed over, and perhaps some dark patches,

2 – stem moderately damaged: wounds and cracks up to 5 cm long not healed over, possibly also dark patches and discharge, frost or lightning wounds, etiological signs of the presence of wood-rotting fungi and the presence of early stages of actual tree-rotting,

3 – stem severely damaged: unhealed wounds and cracks more than 5 cm long, frost and lightning damage, indications of the presence of decay, fruiting bodies and formations of wood-rotting fungi with bark beginning to separate and fall off,

4 – stem very severely damaged: extensive wounds and necrotic tissue, severe and extensive rotting, branches lost and tree-holes present, numerous fruiting bodies and formations of wood-rotting fungi, patches of detaching bark.

Each stem was described in detail from the point of view of the type and origin of damage, as well as disease symptoms (dark patches on bark, rotting of wood and the presence of fungus species, etc.).

The technical quality of tree stems was estimated using a three-point scale:

1 – stem with no visible flaws to lower its utilitarian value (potentially assortments WA and WB),

2 – stem with significant flaws, e.g. twisting thick branches, etc. (potentially WC),

3 – stem with flaws that disqualify the timber from the valuable and sawmill grades (potentially class D or S4 for stacked wood).

Each stand had a mean technical quality determined for its trees, and this was then the subject of analysis, and of comparisons between different sites.

Use was made of the synthetic index of damage proposed by Dmyterko [1998], known as *Syn*, this combining measures of tree defoliation and vitality, with the degree of damage to individual assessed trees and stands being described through formulae (1) and (2) respectively:

$$Syn = \frac{0.03 \cdot Def + Wit}{2} \quad (1)$$

$$Syn = \frac{0.03 \sum Def + \sum Wit}{2 \cdot n} \quad (2)$$

where: *Def* – % crown defoliation,
Wit – degree of vitality of tree,
n – number of sample trees.

Rounding-off of the value of the *Syn* index allowed for assignment to four categories of damage, i.e. 0 – healthy, 1 – weakened, 2 – damaged, 3 – dying.

The identification of uniform groups was achieved using a multiple comparisons test plus the 95% LSD method.

Measurements made in each of the stands studied (over sampling areas of 2500 m^2 or more) served in the determination of stand-quality parameters. The rate at which trees had died off was reconstructed on the basis of the amount of timber harvested annually via sanitation and incidental felling.

RESULTS

The studied stands represented 4 forest habitat types: Lśw – fresh broadleaved forest (36), LMśw – fresh mixed forest (9), Lł – floodplain forest (5) and Lwyż – upland forest

(2). Almost half of the stands assessed (21) were pure oakwoods; 12 stands were 90% oak, 7 – 80%, 8 – 70%, 2 – 60% and 2 – 30%. The youngest stand studied was 60 years old and the oldest more than 200. Most (44) of the stands were evenaged structure, while the remaining 8 had oaks of various ages. A majority (28) of the stands were also characterised by average growth quality (a value of 2 or 2.5). Higher growth quality (values 1.0 or 1.5) was reported in 15 stands and lower (3-4) in 9. The highest elevation of any of the stands studied was the 350 m a.s.l. in the Kańczuga Forest District.

The mean rates of defoliation in the stands assessed were of between 20.3 and 89.0% (Table 1). In analysing this feature, it is possible to distinguish between three groups of stands: the slightly damaged (with defoliation of between 11 and 25%) – 7 sites; the moderately damaged (defoliation of 26-60%) – 35 sites; and the highly damaged (defoliation over 60%) – 10 sites. Assimilatory apparatus in the best state was reported from the following stands: Świerczyna 2, Radziwiłłów 34, Świerczyna 1, Wejherowo 8, Czarna Białostocka 16, 17 and Radziwiłłów 33. The most intensive defoliation was in turn recorded in the Zaporowo 13, Mircze 40, Zaporowo 14, Chełm 37, Strzelce 39 and Młynary 11 and 12 stands (Table 1).

The mean proportions of trees in different defoliation classes, considering all stands together, were: class 0 – 1.0%, 1 – 22.0%, 2 – 53.0%, 3 – 24.0% (Table 2).

Mean vitality of stands varied across the range 1.3 to 2.4 (Table 3). Values determined both when trees were without leaves and when they had full foliage were almost identical and ranged between 1.2 and 2.5. Analysis allowed for the identification of two groups: of weakened stands (vitality 0.5 to 1.5) – 9 sites; and of damaged ones (vitality 1.6 to 2.5) – 43 sites. The stands showing the highest level of vitality are: Jabłonna 31, Radziwiłłów 34, Miękinia 45, Świerczyna 2 and Zaporowo 14, while those most severely damaged were Strzelce 39, Krotoszyn 23, 19, 24 and 28 and Wejherowo 7 (Table 3).

The values of the synthetic index of damage (*Syn*) for the stands studied ranged from 0.96 to 2.46 (Table 4). On the basis of this feature, it is possible to distinguish between two groups of stands (as in the case of crown vitality). There is a prevalence of damaged stands (*Syn* in the range 1.6 to 2.5) – 28 sites, while the remaining 24 reflect stands that are weakened (*Syn* from 0.5 to 1.5). The healthiest stands are: Radziwiłłów 34, Świerczyna 2, Jabłonna 31, Świerczyna 1 and Czarna Białostocka 16, while the most damaged are in Strzelce FD 39, as well as in Mircze 40, Zaporowo 13 and Młynary 11 (Table 4).

The index of damage to oak stems assumed mean values of between 0.13 and 1.30 (Table 5). Analysis of the mean degree of damage to trunks allowed for two groups of sites to be discerned. Stems in a majority of stands (35) were classified as slightly damaged (degree 1 – value for feature between 0.5-1.5). 17 stands had undamaged trunks (degree 0 – value for feature below 0.5). The least damaged oak stems were present at: Kańczuga 51, Henryków 43, Świerczyna 3, Wejherowo 7 and Miękinia 45, while the most damaged ones were in Młynary 12 and 11, Jabłonna 30, Krotoszyn 19 and Zaporowo 13 (Table 5).

The overall proportion of trees with stems showing disease and damage symptoms was high (at around 60%). Around 43% of all assessed trees had splits, wounds or stains indicative of discharge at different degrees of intensity and advancement. 128 trees (or 8.3% of the total) were found to have dark patches and/or discharges at various heights up their stems (between the root collar and a height of several metres above the ground). This type of symptom occurred most frequently at plots 30 (Jabłonna), 46 (Miękinia) and 15 (Czarna Białostocka). The share of trees displaying symptoms of rotting was 6.8%.

Table 1. Average defoliation index of oak trees in years 2001-2003 (%) and homogeneous groups of objects
Tabela 1. Średnia defoliacja dębów w latach 2001-2003 (%) i grupy jednorodne obiektów

Forest district Nadleśnictwo	Plot no. Nr pow.	Mean defoliation, % Średna defoliacja, %	Homogeneous groups Grupy jednorodne
Świerczyna	2	20.3	x
Radziwiłłów	34	21.5	xx
Świerczyna	1	22.0	xx
Wejherowo	8	24.8	xxx
Czarna Białostocka	16	25.2	xxx
Czarna Białostocka	17	25.2	xxx
Radziwiłłów	33	25.3	xxx
Elbląg	10	26.2	xxxx
Kańczuga	51	27.3	xxxx
Jabłonna	31	28.0	xxxx
Czarna Białostocka	18	29.8	xxxx
Kańczuga	52	31.3	xxxxx
Połczyn	6	31.7	xxxxxx
Połczyn	5	31.7	xxxxxx
Połczyn	4	31.7	xxxxxx
Radziwiłłów	32	32.7	xxxxxx
Krotoszyn	25	33.0	xxxxxx
Radziwiłłów	35	33.3	xxxxx
Elbląg	9	36.0	xxxxx
Czarna Białostocka	15	36.5	xxxxx
Krotoszyn	24	37.2	xxxx
Krotoszyn	22	37.5	xxxx
Krotoszyn	20	38.5	xxxx
Krotoszyn	28	38.7	xxx
Miękinia	47	40.5	xxx
Krotoszyn	21	41.0	xxx
Henryków	43	42.2	xxx
Świerczyna	3	42.3	xxx
Miękinia	45	42.7	xxx
Krotoszyn	27	42.7	xxx
Wejherowo	7	44.8	xxx
Wołów	49	45.7	xxx
Krotoszyn	26	45.8	xxx
Milicz	50	46.8	xxx
Miękinia	46	47.3	xxx
Krotoszyn	19	49.7	xxx
Strzelce	38	52.0	xxx
Chełm	36	52.2	xxx
Krotoszyn	23	55.8	xxx
Wołów	48	56.3	xxx
Henryków	44	58.0	xxx
Jabłonna	29	58.5	xxx
Mircze	42	61.0	xx
Mircze	41	63.8	x
Jabłonna	30	76.7	x
Młynary	12	82.7	xx
Młynary	11	84.2	x
Strzelce	39	84.2	x
Chełm	37	84.2	x
Zaporowo	14	85.7	x
Mircze	40	86.3	x
Zaporowo	13	89.0	x

Table 2. Defoliation structure of oak trees in period 2001-2003 study, %
Tabela 2. Udział dębów w klasach defoliacji w latach 2001-2003, %

Forest district Nadleśnictwo	Plot no. Nr pow.	Defoliation class – Klasa defoliacji				
		0	1	2	3	2 + 3
Chełm	36	0.0	6.6	66.7	26.7	93.3
Chełm	37	0.0	0.0	0.0	100.0	100.0
Strzelce	38	0.0	0.0	66.7	33.3	100.0
Strzelce	39	0.0	0.0	3.3	96.7	100.0
Mircze	40	0.0	0.0	6.7	93.3	100.0
Mircze	41	0.0	3.3	43.3	53.4	96.7
Mircze	42	0.0	3.3	53.4	43.3	96.7
Henryków	43	0.0	13.3	76.7	10.0	86.7
Henryków	44	0.0	0.0	63.3	36.7	100.0
Miękinia	45	0.0	6.7	90.0	3.3	93.3
Miękinia	46	0.0	6.7	80.0	13.3	93.3
Miękinia	47	3.3	10.0	83.4	3.3	86.7
Wołów	48	0.0	3.3	53.4	43.3	96.7
Wołów	49	0.0	3.3	83.4	13.3	96.7
Milicz	50	0.0	0.0	96.7	3.3	100.0
Świerczyna	1	6.7	76.7	16.6	0.0	16.6
Świerczyna	2	16.7	66.7	16.6	0.0	16.7
Świerczyna	3	0.0	3.3	83.4	13.3	96.7
Połczyn	4	3.3	43.4	50.0	3.3	53.3
Połczyn	5	0.0	50.0	43.3	6.7	50.0
Połczyn	6	0.0	33.3	66.7	0.0	66.7
Wejherowo	7	0.0	0.0	86.7	13.3	100.0
Wejherowo	8	3.3	56.7	40.0	0.0	40.0
Elbląg	9	0.0	23.4	73.3	3.3	76.6
Elbląg	10	0.0	66.7	33.3	0.0	33.3
Kańczuga	51	0.0	56.7	43.3	0.0	43.3
Kańczuga	52	3.3	50.0	40.0	6.7	46.7
Czarna Białostocka	15	0.0	36.6	46.7	16.7	63.4
Czarna Białostocka	16	6.7	60.0	33.3	0.0	33.3
Czarna Białostocka	17	0.0	73.3	26.7	0.0	26.7
Czarna Białostocka	18	3.3	33.3	63.4	0.0	63.4
Młynary	11	0.0	0.0	10.0	90.0	100.0
Młynary	12	0.0	0.0	6.7	93.3	100.0
Zaporowo	13	0.0	0.0	6.7	93.3	100.0
Zaporowo	14	0.0	0.0	14.3	85.7	100.0
Krotoszyn	19	0.0	6.7	70.0	23.3	93.3
Krotoszyn	20	0.0	16.6	76.7	6.7	83.3
Krotoszyn	21	0.0	10.0	76.7	13.3	90.0
Krotoszyn	22	0.0	16.7	83.3	0.0	83.3
Krotoszyn	23	0.0	3.5	65.5	31.0	96.5
Krotoszyn	24	0.0	6.7	93.3	0.0	93.3
Krotoszyn	25	0.0	40.0	56.7	3.3	60.0
Krotoszyn	26	0.0	0.0	86.7	13.3	100.0
Krotoszyn	27	0.0	3.3	86.7	10.0	96.7
Krotoszyn	28	0.0	16.6	76.7	6.7	83.4
Radziwiłłów	32	3.3	26.7	66.7	3.3	70.0
Radziwiłłów	33	0.0	63.3	36.7	0.0	36.7
Radziwiłłów	34	0.0	83.3	16.7	0.0	16.7
Radziwiłłów	35	0.0	30.0	66.7	3.3	70.0
Jabłonna	29	0.0	0.0	53.3	46.7	100.0
Jabłonna	30	3.3	0.0	23.3	73.4	96.7
Jabłonna	31	6.7	40.0	53.3	0.0	53.3
Mean – Średnia		1.0	22.0	53.0	24.0	77.0

Table 3. Average vitality index of oak trees in years 2001-2003 and homogeneous groups of objects
Tabela 3. Średnia witalność dębów w latach 2001-2003 i grupy jednorodne obiektów

Forest district Nadleśnictwo	Plot no. Nr pow.	Mean vitality Średnia witalność	Homogeneous groups Grupy jednorodne
Jabłonna	31	1.3	x
Radziwiłłów	34	1.3	x
Miękinia	45	1.3	x
Świerczyna	2	1.4	xx
Zaporowo	14	1.4	xxx
Jabłonna	30	1.5	xx
Czarna Białostocka	16	1.5	xx
Młynary	12	1.5	xx
Świerczyna	1	1.5	xxx
Wołów	49	1.6	xxx
Miękinia	47	1.6	xxx
Chełm	37	1.6	xxxx
Milicz	50	1.6	xxxx
Połczyn	4	1.6	xxxx
Kańczuga	51	1.6	xxxxx
Elbląg	10	1.6	xxxxx
Świerczyna	3	1.7	xxxx
Jabłonna	29	1.7	xxxxx
Połczyn	5	1.7	xxxxxx
Połczyn	6	1.7	xxxxxx
Wejherowo	8	1.7	xxxxxx
Czarna Białostocka	18	1.7	xxxxxx
Miękinia	46	1.8	xxxxx
Czarna Białostocka	17	1.8	xxxxx
Kańczuga	52	1.8	xxxx
Wołów	48	1.8	xxxx
Elbląg	9	1.8	xxxx
Zaporowo	13	1.8	xxxxx
Radziwiłłów	32	1.8	xxxxxx
Radziwiłłów	33	1.8	xxxxx
Henryków	43	1.8	xxxx
Młynary	11	1.9	xxxx
Mircze	40	1.9	xxxx
Radziwiłłów	35	2.0	xxxx
Mircze	42	2.0	xxxx
Czarna Białostocka	15	2.0	xxxxx
Chełm	36	2.0	xxxxx
Strzelce	38	2.1	xxxxxx
Krotoszyn	20	2.1	xxxxxx
Krotoszyn	21	2.2	xxxxxx
Mircze	41	2.2	xxxxx
Krotoszyn	25	2.2	xxxx
Henryków	44	2.2	xxx
Krotoszyn	26	2.2	xxx
Krotoszyn	22	2.2	xxx
Krotoszyn	27	2.2	xxx
Wejherowo	7	2.3	xxx
Krotoszyn	28	2.3	xxx
Krotoszyn	24	2.3	xxx
Krotoszyn	19	2.3	xxx
Strzelce	39	2.4	xx
Krotoszyn	23	2.4	x
Mean – Średnia		1.8	

Table 4. Mean values of the synthetic damage index of oak trees *Syn* in the period 2001-2003 and homogeneous groups of objects
Tabela 4. Średnie wartości syntetycznego wskaźnika uszkodzenia dębów *Syn* w latach 2001-2003 i grupy jednorodne obiektów

Forest district Nadleśnictwo	Plot no. Nr pow.	Synthetic damage index Syntetyczny wskaźnik	Homogeneous groups Grupy jednorodne
Radziwiłłów	34	0.96	x
Świerczyna	2	0.99	x
Jabłonna	31	1.05	x
Świerczyna	1	1.09	xx
Czarna Białostocka	16	1.12	xxx
Elbląg	10	1.21	xxx
Kańczuga	51	1.23	xxxx
Wejherowo	8	1.24	xxxx
Czarna Białostocka	17	1.27	xxxx
Połczyn	4	1.28	xxx
Miękinia	45	1.29	xxxx
Radziwiłłów	33	1.30	xxxxx
Czarna Białostocka	18	1.31	xxxxx
Połczyn	5	1.32	xxxxx
Połczyn	6	1.34	xxxxxx
Kańczuga	52	1.38	xxxxxx
Radziwiłłów	32	1.40	xxxxxx
Miękinia	47	1.41	xxxxxx
Elbląg	9	1.45	xxxxxx
Świerczyna	3	1.46	xxxxx
Wołów	49	1.48	xxxx
Radziwiłłów	35	1.50	xxxxx
Milicz	50	1.51	xxxx
Czarna Białostocka	15	1.54	xxxx
Henryków	43	1.56	xxxxx
Krotoszyn	25	1.57	xxxxx
Miękinia	46	1.59	xxxxx
Krotoszyn	20	1.64	xxxxx
Krotoszyn	22	1.67	xxxxx
Krotoszyn	21	1.69	xxxxx
Krotoszyn	24	1.69	xxxxx
Krotoszyn	28	1.71	xxxx
Jabłonna	29	1.72	xxx
Wołów	48	1.75	xxx
Krotoszyn	27	1.76	xxx
Krotoszyn	26	1.79	xxx
Chełm	36	1.80	xxx
Wejherowo	7	1.80	xxx
Strzelce	38	1.82	xxx
Jabłonna	30	1.89	xxx
Krotoszyn	19	1.90	xxx
Mircze	42	1.91	xxxx
Henryków	44	1.97	xxx
Zaporowo	14	1.97	xxx
Młynary	12	1.98	xx
Mircze	41	2.04	xx
Krotoszyn	23	2.06	xx
Chełm	37	2.07	xx
Młynary	11	2.20	xx
Zaporowo	13	2.25	x
Mircze	40	2.26	x
Strzelce	39	2.46	x
Mean – Średnia		1.61	

Table 5. Average index of the stem damage in oak trees in years 2001-2003 and homogeneous groups of objects
Tabela 5. Średni stopień uszkodzenia pnia dębów w latach 2001-2003 i grupy jednorodne obiektów

Forest district Nadleśnictwo	Plot no. Nr pow.	Mean index of the damage Średni stopień uszkodzenia	Homogeneous groups Grupy jednorodne
Kańczuga	51	0.13	x
Henryków	43	0.23	xx
Świerczyna	3	0.30	xxx
Wejherowo	7	0.33	xxxx
Miękinia	45	0.33	xxxx
Świerczyna	1	0.33	xxxx
Wołów	49	0.37	xxxxx
Jabłonna	29	0.40	xxxxxx
Radziwiłłów	34	0.40	xxxxxx
Mircze	42	0.40	xxxxxx
Czarna Białostocka	17	0.40	xxxxxx
Krotoszyn	27	0.43	xxxxxxx
Świerczyna	2	0.43	xxxxxxx
Strzelce	39	0.43	xxxxxxx
Krotoszyn	24	0.47	xxxxxxxx
Czarna Białostocka	16	0.47	xxxxxxxx
Krotoszyn	28	0.47	xxxxxxxx
Strzelce	38	0.50	xxxxxxx
Henryków	44	0.50	xxxxxxx
Radziwiłłów	32	0.53	xxxxxxx
Kańczuga	52	0.53	xxxxxxx
Zaporowo	14	0.53	xxxxxxx
Czarna Białostocka	15	0.63	xxxxxxx
Radziwiłłów	33	0.63	xxxxxxx
Miękinia	46	0.63	xxxxxxx
Wołów	48	0.67	xxxxxx
Radziwiłłów	35	0.67	xxxxxx
Krotoszyn	26	0.67	xxxxxx
Chełm	37	0.67	xxxxxx
Milicz	50	0.70	xxxxxx
Krotoszyn	25	0.70	xxxxxx
Krotoszyn	23	0.70	xxxxxx
Połczyn	4	0.73	xxxxxx
Mircze	40	0.73	xxxxxx
Połczyn	6	0.73	xxxxxx
Chełm	36	0.77	xxxxxx
Czarna Białostocka	18	0.80	xxxxxx
Miękinia	47	0.80	xxxxxx
Połczyn	5	0.80	xxxxxx
Krotoszyn	20	0.90	xxxxxx
Krotoszyn	21	0.93	xxxxxxx
Jabłonna	31	0.97	xxxxxxxx
Mircze	41	0.97	xxxxxxxx
Krotoszyn	22	1.03	xxxxxxx
Elbląg	10	1.07	xxxxxx
Wejherowo	8	1.10	xxxxx
Elbląg	9	1.13	xxxx
Zaporowo	13	1.13	xxxx
Krotoszyn	19	1.17	xxx
Młynary	11	1.27	xx
Jabłonna	30	1.27	xx
Młynary	12	1.30	x

Table 6. Average index of the stem technical quality in oak trees in years 2001-2003 and homogeneous groups of objects
Tabela 6. Średnia jakość techniczna pnia dębów w latach 2001-2003 i grupy jednorodne obiektów

Forest district Nadleśnictwo	Plot no. Nr pow.	Mean index of the stem technical quality Średnia jakość techniczna pni	Homogeneous groups Grupy jednorodne
Miękinia	45	1.0	x
Henryków	44	1.1	xx
Wołów	49	1.1	xxx
Wołów	48	1.3	xxx
Krotoszyn	28	1.3	xxx
Henryków	43	1.3	xxx
Miękinia	46	1.4	xxx
Czarna Białostocka	17	1.4	xxx
Świerczyna	2	1.4	xxxx
Krotoszyn	27	1.4	xxxx
Krotoszyn	19	1.5	xxxx
Krotoszyn	24	1.5	xxxx
Zaporowo	14	1.5	xxxxx
Kańczuga	51	1.6	xxxxx
Połczyn	4	1.6	xxxxx
Krotoszyn	21	1.6	xxxxx
Krotoszyn	20	1.6	xxxxx
Zaporowo	13	1.7	xxxxx
Radziwiłłów	34	1.7	xxxxx
Krotoszyn	23	1.7	xxxxx
Czarna Białostocka	16	1.7	xxxxx
Radziwiłłów	32	1.8	xxxxx
Elbląg	10	1.8	xxxxx
Połczyn	6	1.8	xxxxx
Radziwiłłów	33	1.8	xxxxx
Krotoszyn	25	1.8	xxxxx
Radziwiłłów	35	1.9	xxxxxx
Świerczyna	1	1.9	xxxxxx
Mircze	40	1.9	xxxxxxx
Kańczuga	52	1.9	xxxxxxx
Krotoszyn	22	1.9	xxxxxxx
Czarna Białostocka	15	1.9	xxxxxxx
Młynary	11	2.0	xxxxxxx
Jabłonna	31	2.0	xxxxxxx
Elbląg	9	2.0	xxxxxxx
Krotoszyn	26	2.0	xxxxxxx
Strzelce	39	2.0	xxxxxxx
Strzelce	38	2.0	xxxxxxx
Świerczyna	3	2.0	xxxxxxx
Czarna Białostocka	18	2.0	xxxxxx
Połczyn	5	2.0	xxxxxxx
Wejherowo	8	2.1	xxxxxxxx
Chełm	37	2.1	xxxxxxx
Młynary	12	2.1	xxxxxx
Mircze	42	2.1	xxxxx
Mircze	41	2.1	xxxxx
Chełm	36	2.2	xxxx
Jabłonna	30	2.2	xxxx
Milicz	50	2.3	xxx
Jabłonna	29	2.3	xx
Miękinia	47	2.4	x
Wejherowo	7	2.8	x

Fruiting bodies or other structures of fungi giving rise to rotting of timber were reported from 2.1% of trees. The species posing a more serious threat that occurred most frequently were *Armillaria* spp., *Phellinus robustus*, *Laetiporus sulphurous*, *Stereum hirsutum*, *S. gausapatum*, *Hymenochaete rubiginosa* and *Daedalea quercina*. A considerable proportion (about 10%) displayed mechanical damage reflecting harvesting or extracting/skidding work. This kind of damage was most prevalent at the Krotoszyn 25, Połczyn 4 and Miękinia 46 sites.

The mean technical quality of stems varied across a narrow range from the 1.0 noted at Miękinia (stand no. 45) to the 2.8 noted in Wejherowo (stand no. 7). Analysis of the mean level of technical quality of stems allowed three groups of stands to be distinguished. The best represented group (with 41 sites) comprises stands with flawed stems, with values in the range 1.5 to 2.5. Ten stands have trees with no obvious trunk flaws at all (mean value for the stand below 1.5). There was also one stand in which the stems were of such flawed material that they are disqualified from being used as a good-quality raw material (Table 6).

The mean volume of timber from sanitation or incidental cutting over the last 10 years offers a supplementary characterisation of the threat to stands. The value was estimated on the basis of documentation of the measures taken in different Forest Districts. The mean annual level of incidental felling varied from 0 to almost 12 $m^3 \cdot ha^{-1}$. It did not exceed 2 $m^3 \cdot ha^{-1}$ in most (33) of the stands, though the values were of 2-5 $m^3 \cdot ha^{-1}$ in 9 stands and 5-10 $m^3 \cdot ha^{-1}$ in 7 (Henryków 43, Miękinia 45, Czarna Białostocka 15 and 16 and Krotoszyn 19, 20 and 24). The highest figures of all (over 10 $m^3 \cdot ha^{-1}$) were noted at the Krotoszyn 21 and 23 and Elbląg 9 stands.

DISCUSSION

The research into the state of health of Polish oak stands threatened with dieoff was in fact a part of a large project pursued between 2001 and 2004 at the Faculty of Forestry of Warsaw Agricultural University (SGGW). The aim was to devise principles by which to proceed with silvicultural and protective measures in stands showing symptoms of tree dieback or dieoff. As it happens, the period in question was one of variable weather conditions. Prolonged periods of drought were interspersed with violent downpours often themselves accompanied by gale-force winds. The winter months brought alternate periods of freezing and thawing. Such weather anomalies – and most notably the longer periods of drought in the growing season and rather sudden changes of temperature – are considered important underpinning factors when it comes to initiation of the disease process in Central Europe's oak stands [Siwecki and Ufnalski 1998, Recent advances... 2000, Sierota 2001, Thomas et al. 2002].

Analysis of the defoliation of oaks in Poland over the last 10 years points to a stable incidence of undamaged trees (defoliated by 10% or less) within the range 2-7% of the total, in contrast to the markedly variable share of trees most severely damaged (with more than 25% defoliation) – between 41 and 62% [Leśnictwo 2004]. The assessment of damage to oak stands in National Parks that was carried out in the mid 1990s revealed the following percentages of trees in the different damage classes, i.e. 0 – 5%, 1 – 30%, 2 – 60% and 3 – 5% [Borecki et al. 1995].

In comparison with data for oaks obtained from nationwide monitoring of damage [Leśnictwo 2004], those in the stands researched were far less likely to have under 10% defoliation, while there were 50% more trees in the category with over 25% loss of the assimilatory apparatus. This is understandable when the methodology applied in choosing stands is born in mind.

The high degree of damage to the assimilatory apparatus recorded in some of the stands was associated with the mass occurrence of foliophages during the research period. The species in question were *Tortrix viridana* and *Operophtera* spp. in the Krotoszyn, Zaporowo, Młynary, Chełm, Mircze, Strzelce, Jabłonna, Wołów and Miękinia Forest Districts; *Euproctis chrysorrhoea* in Mircze, Strzelce and Chełm FDs; and *Melolontha* spp. in Czarna Białostocka and Chełm FDs. Additionally, these stands were afflicted – sometimes seriously afflicted – by oak mildew *Erysiphe* (*Microsphaera*) *alphitoides*, which had infected the second set of leaves in particular.

According to Roloff [1989], oaks assigned to vitality class 2 or the stagnation phase (damaged trees) are not in a position to regenerate and return to a higher level of vitality, even when conditions for growth improve. This means that as many as 43 out of 52 stands assessed in the course of the research may in the nearest future pass through to the resignation phase (i.e. dieoff). Such a state of oak stands often results from the advanced age of those in question, as well as from the methods selected to choose study objects. However, it first and foremost reflects the occurrence in recent years of conditions unfavourable to the growth of oaks (which is to say a drought of some years' standing and associated lack of rainfall (especially in the growing season)), combined with low or high temperatures, a fall in the water table and local subsidence floods.

The attention is drawn to disparities between assessments of the states of certain stands made using the two different aforementioned measures. For example, the Zaporowo 13 and 14 and Strzelce 39 sites are at quite opposite ends of the scale in the two assessments. This attests to the differing suitability of the measures involved. Defoliation can give nothing more than an insight into the state of tree crowns in a given growing season (in which all 3 stands had in fact been subject to attack by an outbreak of foliophagous pests). In contrast, vitality offers a reflection of long-term trends.

The use of a method of assessing the damage to oak stands that is based on a synthetic index thereof [after Dmyterko 1998] results in the assigning of a majority (28) of the stands to the damaged categories, leaving only 24 to be regarded as weakened. According to the work by Dmyterko and Bruchwald [1998], which assessed 1355 trees from 132 stands, the domestic oak woods are characterised by a "quite marked degree of damage". In the case of Polish oak stands, the vitality index assumed a mean value of 1.3, cf. a value for damage of 1.2. The research presented here revealed much higher values for these indices – of 1.8 and 1.6 respectively – understandable in the light of the methods adopted in the choice of stand.

The unfavourable abiotic and biotic factors reported in the course of the work promoted growth in the populations of cambio- and xylophages (*Agrilus* spp., *Scolytus intricatus*, *Xyleborus* spp., *Plagionotus* spp., *Rhagium* spp., *Leiopus nebulosus*, *Phymatodes* spp., and *Saperda scalaris*), as well as the activation of honey fungus (*Armillaria* spp.). These represent the last link in the chain leading to the dieoff of weakened oaks. In many areas, species characteristic of xerothermic habitats and stands with high levels of illumination were noted, an example being *Rhagium sycophantha*. Ocurring frequently in Poland *Agrilus biguttatus* was nevertheless recorded in just three

Forest Districts. It was very abundant in all 10 assessed stands within the Krotoszyn FD, where it was the main cause of an accelerated thinning of trees [Tarasiuk et al. 2003 a, b]. The last few years have brought a variation in the amount of raw timber harvested by way of sanitation and incidental felling in the stands of the Krotoszyn FD, between 1 $m^3 \cdot ha^{-1}$ in plot 26 and 12 $m^3 \cdot ha^{-1}$ in plot 21. The large volume of wood harvested from plot 9 within the Elbląg FD was in turn a result of the carrying out of sanitary and selective felling in this stand (GDN).

Forestry management has no influence on the course of the meteorological phenomena that initiate disease in oak woodlands. However, damage and losses resulting from the disease processes in oak stands may be confined, if appropriate silvicultural and protective measures are applied [Tarasiuk and Szczepkowski 2004].

CONCLUSION

1. A distinct impairment of the state of health of most of the assessed stands was reported, to the extent that fears are in many cases raised about the prospects for their future survival.
2. The debilitation processes involved are long-lasting, while their presumed causes are such as to limit possibilities for the adoption of active counter-measures.
3. The leaving in place of numbered trees on demarcated key trial plots will allow for future repeat observations and assessments of dynamics to the state of health of oaks over the longer term.

REFERENCES

Borecki T., Miścicki S., Nowakowska J., Wójcik R., 1995. Stan drzewostanów parków narodowych. PIOŚ, Bibl. Monit. Środ. Warszawa.
Delatour C., 1983. Les dépérissements de chênes en Europe. Rev. For. Fr. 35, 265-282.
Dmyterko E., 1998. Metody określania uszkodzenia drzewostanów dębowych. Sylwan 10, 29-38.
Dmyterko E., Bruchwald A., 1998. Weryfikacja metod określania uszkodzenia drzewostanów dębowych. Sylwan 12, 11-21.
Jaszczak R., 1999. Monitoring lasów. Wyd. AR Poznań.
Krahl-Urban J., 1943. Die Eiche im Reichsgang Wartheland. Verlag J. Neumann-Neudamm.
Leśnictwo 2004. Informacje i opracowania statystyczne. GUS Warszawa [oraz opracowania z lat 1995-2003].
Manion P.D., 1991. Tree disease concepts. Prentice Hall Career and Technology New Jersey.
Oak decline in Europe. 1991. Eds R. Siwecki, W. Liese. PWRiL Poznań.
Oszako T., 1996. Choroby dębów. Bibl. Leśn. 59.
Puchniarski T., 2000 a. Przebudowa drzewostanów. PWRiL Warszawa.
Puchniarski T., 2000 b. Krajowy Program Zwiększenia Lesistości. Zalesienia porolne. PWRiL Warszawa.
Recent advances on oak health in Europe. Eds T. Oszako, C. Delatour. For. Res. Inst. Warsaw.
Roloff A., 1989. Kronenentwicklung und Vitalitätsbeurteilung ausgewählter Baumarten der gemässigten Breiten. Schriften aus der Forstlichen Fakultät der Universität Goettingen und der Niedersächsischen Forstlichen Versuchsanstalt. Frankfurt am Main.

Rykowski K., 2003. Wpływ zmian klimatycznych na gospodarkę leśną. In: Czy Polsce grożą katastrofy klimatyczne? Komitet Prognoz "Polska 2000 Plus" PKN IGBP – Global Change PAN. Wyd. Dom Wydawniczy ELIPSA, 82-94.

Ryszkowski L., Kędziora A., Bałazy S., 1995. Przewidywane zmiany globalne klimatu a lasy i zadrzewienia krajobrazu rolniczego. Sylwan 2, 19-32.

Sadowski M., 1994. Zagrożenie lasów wynikające z przewidywanych zmian klimatycznych oraz potrzeby zmian w polityce kompleksowej ochrony zasobów leśnych. In: Polska polityka kompleksowej ochrony zasobów leśnych. Ed. A. Grzywacz. Fundacja "Rozwój SGGW" Warszawa, 34-43.

Sierota Z., 2001. Choroby lasu. Centrum Informacji Lasów Państwowych Warszawa.

Sierota Z., Małecka M., Stocka T., 2005. Choroby infekcyjne. In: Krótkoterminowa prognoza występowania ważniejszych szkodników i chorób infekcyjnych drzew leśnych w Polsce w 2005 roku. IBL, Analizy i raporty 4, 102-119 [oraz opracowania z lat 1995-2004].

Siwecki R., Ufnalski K., 1998. Review of oak stand decline with special reference to the role of drought in Poland. Eur. J. For. Path. 28, 99-112.

Tarasiuk S., Szczepkowski A., Borowski J., 2003 a. Zamieranie dębów w Polsce. Cz. 1. Las Pol. 6, 24-25.

Tarasiuk S., Szczepkowski A., Borowski J., 2003 b. Zamieranie dębów w Polsce. Cz. 2. Las Pol. 7, 24-25.

Tarasiuk S., Szczepkowski A., 2004. Postępowanie hodowlano-ochronne w drzewostanach dębowych z objawami zamierania drzew. Przegl. Leśn. 5 (155/14), 26-27.

Thomas F.M., Blank R., Hartmann G., 2002. Abiotic and biotic factors and their interactions as causes of oak decline in Central Europe. For. Path. 32, 277-307.

STAN ZDROWOTNY ZAGROŻONYCH ZAMIERANIEM DRZEWOSTANÓW DĘBOWYCH W POLSCE

Streszczenie. Badania przeprowadzono w latach 2001-2004, w 52 drzewostanach na terenie administrowanym przez 18 nadleśnictw. Na powierzchniach próbnych wielkości co najmniej 2500 m^2 wykonano inwentaryzację drzewostanu. W celu dokonania pełnego opisu różnorodnych aspektów żywotności dębu wybrano 1560 trwale oznakowanych drzew, reprezentujących 6 krain przyrodniczo-leśnych. Szczegółowe pomiary i ocenę przeprowadzono w fazie ulistnionej i bezlistnej. Stwierdzono, że stan zdrowotny większości badanych drzewostanów dębowych budzi obawy dotyczące ich trwałości.

Słowa kluczowe: architektura koron, dąb szypułkowy, defoliacja, dynamika, monitoring, stałe powierzchnie obserwacyjne, witalność, zamieranie

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