

## APPLICATION OF A SYNTHETIC TREE DAMAGE INDEX TO ASSESS CHANGES IN THE HEALTH CONDITION OF SELECTED OAK STANDS IN THE WŁOSZAKOWICE FOREST DIVISION

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**Abstract.** The paper presents an evaluation of health condition of selected oak stands in the Włoszakowice Forest Division based on a synthetic tree damage index. Field work was conducted in 2007-2008. In order to perform this task seven experimental sites were established, with 25 trees from Kraft's age classes I-III evaluated in each. It was found that the overall health condition of most stands deteriorated in 2008 in comparison to 2007.

**Key words:** health condition of stands, defoliation, oak, the Włoszakowice Forest Division, oak die-back, insect pests, tree damage index

### INTRODUCTION

Tree die-back has been a phenomenon known for several centuries. It affects many deciduous tree species, including oak. In Europe the first information on this subject dates back to the 18<sup>th</sup> century [Oszako 2002]. Causes include abiotic factors such as prolonged drought, very low sub-zero temperatures in the winter, early or late frost, as well as damage to the assimilating organ caused by insects and fungi [Houston 1987, Oszako 2000, 2002]. One of the causes may also be related with inappropriate silvicultural practices in the past [Oszako 2002].

A significant role among defoliators is played by insects. They are the factor, which within a short time may cause a complete loss of the assimilating organ. They have an effect on the condition of trees and their physiological status. Although a single extensive defoliation as a rule does not lead to tree die-back, a repeated defoliation within successive years may be a significant factor accelerating thinning of the stand. This is true particularly in the case of trees in commercial stands, which have relatively small crowns and each reduction of foliage affects their health condition. Feeding by leaf-

feeding pests affects the condition of trees not only directly, but also through their weakening, while changes in light conditions in the stand promote their colonisation by secondary pests, of which some (e.g. *Plagionotus* sp., *Lyctus* sp., *Bostrichus* sp., *Lymexylon Navale* (L.) or *Clytus arietis* (L.) are directly connected with light availability [Dominik 1968].

Although defoliation may be a highly variable factor in individual years, due to its significant effect on health condition it is relatively often used in evaluation of both deciduous and coniferous stands [e.g. Beker 1993, Staszewski et al. 2009, Szewczyk and Czeryba 2010, Szewczyk et al. 2011, Szczerba and Robakowski 2013]. Moreover, defoliation of tree crowns constitutes one of the basic criteria in forest monitoring both in Poland and elsewhere in Europe [Jaszczak 2008 a].

In this study the condition of trees and directions in occurring changes in health status were assessed also based on losses in the assimilating organs, which has a significant effect on the value of the synthetic health status index of trees. Results recorded in successive years of the study made it possible to observe potential directions of changes in health status of both stands and individual trees, as well as the volume of these changes, which was the objective of this study.

## METHODS

Investigations were conducted in 2007-2008 in the Włoszakowice Forest Division in oak stands of age class III and older.

In the Wschowa working circles (compartments 302c, 303b, 303c and 307a) and the Włoszakowice working circles (compartments 100a, 101a and 110a) plots representative for a given subcompartment were selected and marked. In each of these plots 25 trees were selected (solely from Kraft's classes I, II and III) and numbered. Each tree was examined twice to assess its condition. Analysed characteristics included first of all the condition of the tree crown (e.g. defoliation rate, the number of withered limbs and branches) and the condition of stems (the presence of spots, water sprouts, bracket fungi, cracks, tree hollows). Moreover, vitality of each tree was determined. In 2007 the initial inspection was performed and next in 2008 a repeated inspection was conducted in order to observe possible changes in the health condition of the analysed trees.

The condition of stands was assessed and compared in the analysed years based on a synthetic tree damage index [Dmyterko and Bruchwald 1998]. This index for each tree on the established plots was calculated according to the following formula:

$$Syn = \frac{0.03 \cdot Def + Wit}{2}$$

where:

- Syn* – synthetic tree damage index,
- Def* – tree defoliation (%),
- Wit* – vitality.

Vitality was determined following the definition presented by Roloff [1989] using the scale where:

- 0 – undamaged tree (vital)

- 1 – weakened tree
- 2 – damaged tree
- 3 – dying tree (strongly damaged).

The index *Syn* may take values from 0 to 3. An increase in the index value indicates a decrease in tree vitality, while its reduction shows its improvement. Individual values of the synthetic index correspond to respective degrees of tree damage [Dmyterko 1998]: 0 – a healthy tree, 1 – a weakened tree, 2 – a damaged tree, 3 – a dying tree.

## RESULTS

According to the adopted method trees were evaluated in the selected plots in 2007 and then in 2008. Recorded results made it possible to calculate the synthetic index for individual years and plots (Figs 1-2).

Generally both in the Wschowa and Włoszakowice working circles the average value of index *Syn* was lower in the first year of the study, which indicates a general deterioration of their condition caused by a greater loss of their assimilating organs in the following year. Specifically, when analysing individual plots, it can be stated that the condition of trees in some of the plots changed slightly. All the experimental plots are analysed in detail below.

### The Wschowa working circle

In plot no. 1 (compartment 307a; Fig. 1) after rounding the values of the synthetic tree damage index to integers and referring them to the scale it was found that a significant change in the index showing a change in the health condition category occurred only in three trees. All of them shifted from the category of undamaged trees to the category of weakened trees. The condition of the other trees did not change. The total value of synthetic indexes for all trees in that plot in 2008 remained identical to that in the previous year. Similarly the mean for one trees did not change and fluctuated around 1.2 (weakened trees).

In plot no. 2 (Fig. 1) an increase was observed in the values of synthetic tree damage indexes for seven trees. Four trees shifted from category 0 (no damage) to category 1 (weakened trees), while three from category 1 to 2, i.e. the group of damaged trees. The total of values of the synthetic indexes for this plot in 2008 increased in comparison to the year 2007, although the average value of index *Syn* for the plot after rounding to integer and referring them to the scale still indicates the group of weakened trees.

Plot no. 3 (Fig. 1) is characterised by the smallest change in this index. All trees maintained their original health condition. Generally the average health condition of trees in plot no. 3 determined using the synthetic damage index did not change.

In plot no. 4 (Fig. 1) values of the synthetic indexes increased for five trees, which indicates a deterioration of their health condition. Apart from one specimen, all these trees shifted from category 1 to category 2. The total value of the synthetic indexes for this plot in 2008 increased in comparison to 2007, which indicates a general deterioration of the health condition of trees. The average value of index *Syn* classifies this plot to the group of damaged trees (previously – weakened trees).

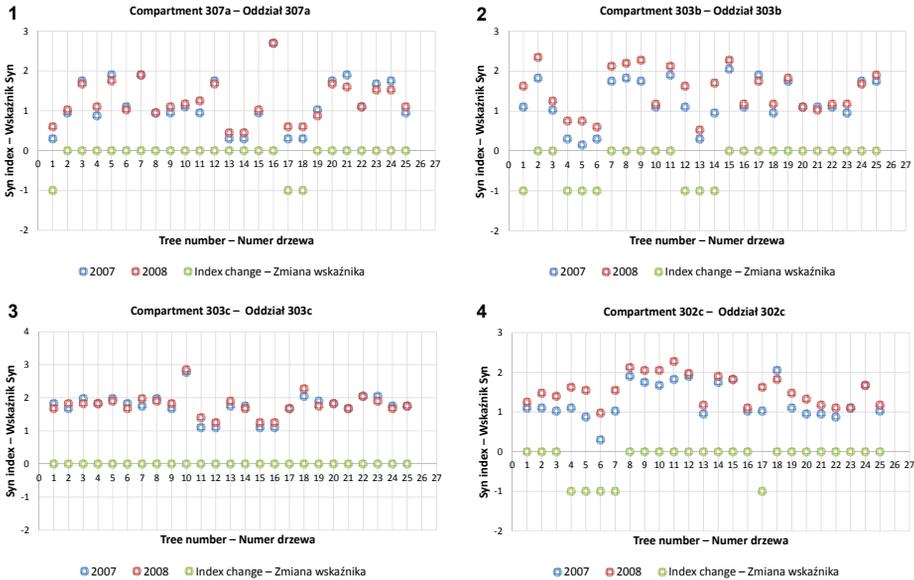


Fig. 1. List of synthetic tree damage indexes for experimental plots in the Wschowa working circle in 2007-2008

Rys. 1. Zestawienie syntetycznych wskaźników uszkodzenia drzew dla powierzchni badawczych w obrębie Wschowa w latach 2007-2008

In the plots established in the Wschowa working circle a significant deterioration of health condition was found in 15% trees selected in the control plots. No improvement in health condition was observed in any tree. It was found that the overall value of the synthetic index for the Wschowa working circle increased in 2008 in comparison to 2007. This indicates a deterioration of health condition of examined trees, as shown in Figure 3. The averaged value of index *Syn* for a single tree in this working circle increased from 1.361 to 1.511, resulting in a change in the health condition category from weakened to damaged trees. This resulted from a greater defoliation in plot no. 4 (Fig. 3). The other trees maintained their previous health condition categories.

Figure 1 present the synthetic index determined for individual trees in the experimental plots in the successive years of the study. The red and blue colours denote the value of index *Syn* in a year of the study. The green colour was used to indicate a change in the index (when rounded to the integer), where the zero value denotes these trees, which health condition did not change. Positive values 1 and 2 indicate an improvement in tree condition, while negative values show a deterioration of tree condition.

### The Włoszakowice working circle

In the Włoszakowice working circle the health condition of trees was evaluated in three selected plots (compartments 100a, 101a, 110a). Results are presented in Figure 2. In plot no. 5 (Fig. 2) values of synthetic indexes increased, while a reduction in the health condition by one category was found only for one tree (no. 1). Thus the total

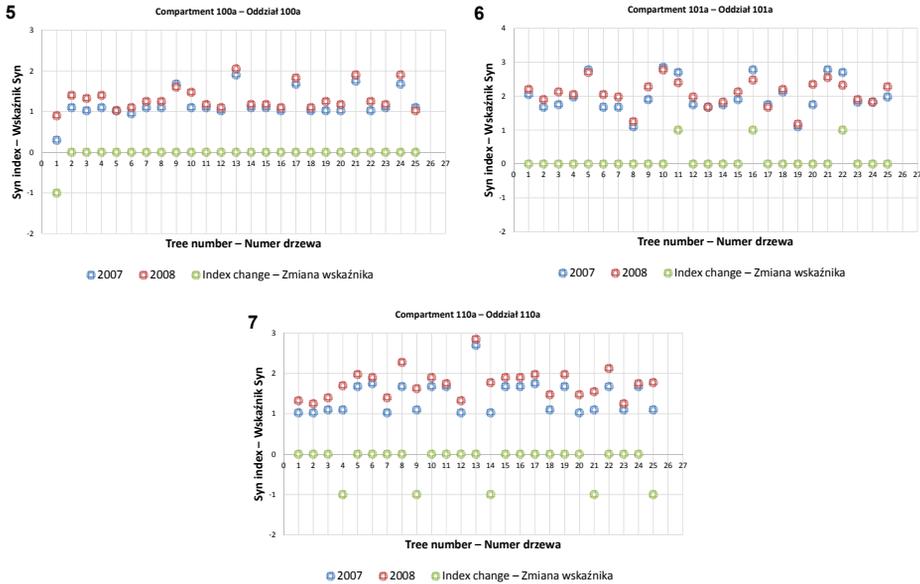


Fig. 2. List of synthetic tree damage indexes for experimental plots in the Włoszakowice working circle in 2007-2008

Rys. 2. Zestawienie syntetycznych wskaźników uszkodzenia drzew dla powierzchni badawczych w obrębie Włoszakowice w latach 2007-2008

value of the synthetic index for this plot practically did not change, which indicates maintenance of the health condition by that stand.

In plot no. 6 (Fig. 2) a slight increase was recorded for the average values of index *Syn* for the stand. However, a significant change may be observed only in three cases. The health condition improved, resulting in the transfer of these trees to the group of damaged trees. Generally despite a slightly greater defoliation in 2008, trees in this compartment maintained their health condition.

In plot no. 7 (Fig. 2) for five trees the values of their synthetic indexes increased significantly. Also the mean value of the index for this plot in 2008 increased greatly, which indicates a general deterioration of health condition of the trees, resulting in the classification of the plot to the group of damaged trees (previously weakened trees).

In the Włoszakowice working district it was found that health condition deteriorated in 8% trees. Improvement of health condition was recorded in 4% trees selected in the experimental plots. The overall value of the synthetic index for the Włoszakowice working circle increased in 2008 in comparison to the year 2007 (Fig. 3). This was primarily influenced by the greater defoliation in plot no. 3 (2007 – weakened trees; 2008 – damaged trees). However, the average value of index *Syn* still classifies the plots in this working circle to the group of damaged trees.

When comparing values of synthetic tree damage indexes a greater share of trees, which health condition deteriorated, was found in the Włoszakowice Forest Division. Generally the value of index *Syn* increased in 2008 in comparison to 2007 in each of the analysed plots.

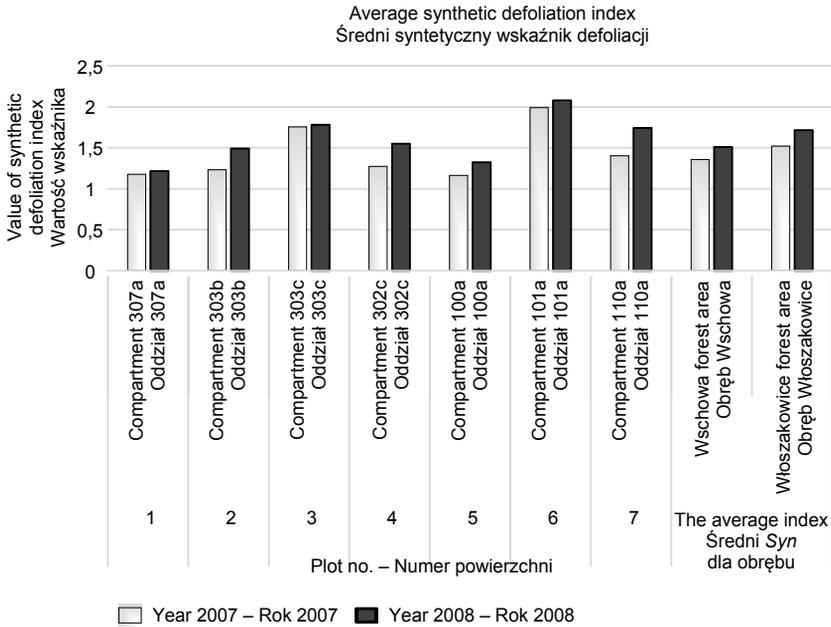


Fig. 3. Average values of the synthetic index  $S_{yn}$  for experimental plots in 2007-2008  
Rys. 3. Przeciętna wartość wskaźnika syntetycznego  $S_{yn}$  dla powierzchni badawczych w latach 2007-2008

For most of them the change was non-significant, although in plots nos. 4 and 7 a greater loss of foliage was observed in comparison to the base year, which resulted in the change of the health condition category of the plots. While in the first year (2007) five plots were classified as weakened stands and only two as damaged stands, in 2008 as many as four plots were classified to the damaged category.

## DISCUSSION

Die-back of oak stands is a disease complex, comprising both abiotic and biotic factors. Some of them cause a reduction of the assimilating organ. The primary defoliators include insects, which next to drought and frost damage play the role of a factor initiating the die-back process. Reduction of foliage results in a deterioration of tree health. Thomas et al. [Tulik 2012 after Thomas et al. 2002] suggested that it is defoliation that weakens oaks to the greatest degree, making them more susceptible to the effect of other stress factors. The loss of the assimilating organ is reflected in the production of assimilates and disorders in transpiration. At the same time it limits the synthesis of enzymes (glucanase and chitinase) serving an important function in the defence system of trees [Oszako 2007 after Wargo 1975, 1976]. Acute defoliation results also in the reduction of root biomass, which makes the trees more sensitive to other factors [Tulik 2012 after Kozłowski et al. 1991]. Moreover, it affects overall thermal and light conditions in the stand. This means that on the one hand the loss of the assimilating organ

will directly weaken trees, while on the other hand it will create advantageous conditions for the development of certain secondary pests, first of all *Agrius* spp.

For this reason defoliation, as a factor significantly influencing tree condition, frequently is the basis for the determination of health condition of stands. In forest monitoring it illustrates the scale and scope of the effect of external factors on the forest environment [Jaszczak 2008 b]. Its evaluation is based on a gradual scale following the guidelines of the Forest Protection Manual [Instrukcja... 2012] or the EU classification [Wyrzykowski and Zajaczkowski 1995]. However, although defoliation provides a suitable tool, it is highly variable in time. It is the considerable fluctuations in this factor that raise doubts for the establishment of this parameter as the only criterion in the evaluation of damage status of trees [Dmyterko 1998]. It is proposed to evaluate health condition of stands using the method based both on defoliation and additionally on tree vitality understood as a potential for growth or the power to compete and regenerate [Dmyterko 1998]. This method is referred to as the structural defoliation method.

These investigations were planned specifically to cover two successive vegetation periods in order to verify the practical applicability of this method. A description of trees prepared in the base year made it possible to verify their condition in the following season. It turned out that at the maintenance of the original vitality the health condition was determined only by defoliation. Similarly as Dmyterko [1998], it may be stated that defoliation reflects only the condition of trees in the year of evaluation, which is highly variable and does not necessarily result in the actual change in the health condition of trees. The method based on two criteria is more reliable. Changes in the health condition are practically possible (apart from 100% leaf loss) by only one health category, while according to both the Forest Protection Manual [Instrukcja... 2012] and the EU scales they are not so stable.

We need to consider whether the evaluation of trees vitality should, in the future, include the condition of their stem, or rather the presence of secondary pests and fungal pathogens. Occurrence of fungal fruiting bodies and feeding holes of e.g. *Agrius* spp. should result in a reduction of vitality to the lowest category, irrespective of the condition of the crown. Moreover, additional criteria may be provided by the presence of spots or water sprouts on stems.

Based on the conducted analyses it can be stated that the structural defoliation method seems to be a relatively reliable tool, which may be used not only to evaluate health condition of oak stands in a given year, but first of all it facilitates monitoring of individual trees and stands in successive years. At the same time it is less dependent on such a variable criterion as defoliation alone, since at the reliance only on the latter we may obtain in successive years greatly different health condition categories for the same tree.

## CONCLUSIONS

The synthetic tree damage index is a suitable and reliable tool in the monitoring of health condition of trees and stands. This facilitates observations not only of the direction, but also the volume of the occurring changes.

In order to record occurring changes it is necessary to perform a detailed evaluation of trees in the first experimental year based on the condition of both their crowns and stems.

Conducted investigations generally showed a deteriorating health condition of oak stands in the Włoszakowice Forest Division caused by greater defoliation. However,

a significant change resulting in the deterioration of health condition category was found only in the case of two plots.

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## WYKORZYSTANIE SYNTETYCZNEGO WSKAŹNIKA USZKODZENIA DRZEW DO OCENY ZMIAN STANU ZDROWOTNEGO WYBRANYCH DRZEWOSTANÓW DĘBOWYCH NADLEŚNICTWA WŁOSZAKOWICE

**Streszczenie.** Obserwowane od wielu lat pogorszenie stanu zdrowotnego drzewostanów dębowych stwarza konieczność monitorowania tego zjawiska. W ocenie drzewostanów powszechnie wykorzystywana jest wielkość defoliacji. Jednak jako czynnik bardzo zmienny w czasie, uzyskiwane wyniki mogą nie w pełni oddawać stan faktyczny. Dlatego proponuje się wykorzystać metodę opartą na vitalności drzew i procentowym ubytku aparatu asymilacyjnego do oceny stanu zdrowotnego drzew i drzewostanów [Dmyterko i Bruchwald 1998]. Celem pracy było zbadanie przydatności proponowanej metody do oceny stanu zdrowotnego drzewostanów dębowych i określenia wielkości tych zmian. Praca została zrealizowana na terenie Nadleśnictwa Włoszakowice w latach 2007-2008. Stwierdzono, że ogólny stan zdrowotny większości drzewostanów pogorszył się w 2008 roku w porównaniu z 2007 rokiem. Dla większości z nich zmiana nie była istotna, na dwóch powierzchniach stwierdzono jednak większy ubytek aparatu asymilacyjnego niż w roku bazowym – co skutkowało obniżeniem kategorii zdrowotności. Z przeprowadzonych badań wynika, że syntetyczny wskaźnik uszkodzenia drzew jest wygodnym narzędziem do monitorowania stanu zdrowotnego drzew i drzewostanów. Jest bardziej stabilny, niż sam czynnik defoliacji i pozwala obserwować wielkość i kierunek zachodzących zmian.

**Słowa kluczowe:** zdrowotność drzewostanów, defoliacja, dąb, Nadleśnictwo Włoszakowice, zamieranie dębów, szkodliwe owady, wskaźnik uszkodzenia drzew

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