# Relationship between diameter increment and damage status of pedunculate oak (Quercus robur L.)

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UDK 630*585+561+469 (Quercus robur L.)

# RELATIONSHIP BETWEEN DIAMETER INCREMENT AND DAMAGE STATUS OF PEDUNCULATE OAK (*Quercus robur* L.)

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The research of the relationship of diameter increment and the damage status of Slavonian oak (pedunculate oak - *Quercus robur* L.) was carried out on colour infrared (CIR) aerial photographs (APs) in the famous lowland forests in the Sava Valley. For the assessment of the relationship between the increment and damage status of pedunculate oak, the increment cores were taken on the ground, using colour infrared (CIR) aerial photographs (APs) for the identification of a particular tree. 247 cores were taken. The width of the annual rings in the year of obtaining the colour infrared (CIR) aerial photographs (APs) were measured on the cores and compared with the damage status of particular oak trees. The relationship between 5-years current annual diameter increment ($i_{d5}$) and the damage status at the end of the period was also investigated.

The increased damage of pedunculate oak trees reduces their growth. The diameter increment is a very good indicator of damage status since, even in the case of minor vitality decrease, it is reduced considerably. This was proved by the correlation analysis.

The correlation between the damage stage in percentages assessed on color infrared aerial photographs and the width of annual rings in the year in which the aerial photographing was made is very strong ($r = -0.9430$).

The correlation between 5-years current annual diameter increment and the damage stage in percentages at the end of the 5-year period is also strong ($r = -0.8475$).

The damage status was determined along natural and man-made communication lines in the forest. The analysis of stand damage status was performed within 100 and 200 metre zones along linear infrastructures. Along meliorated marshes, public roads and channels the damage is high; along natural streams and simple forest roads it is much smaller. These results showed that the stability and health of oak stands are highly dependent on the disturbance of the natural water regime.

Key words: pedunculate oak, colour infrared (CIR) aerial photographs (APs), diameter increment, damage status, natural and man-made linear infrastructure

## INTRODUCTION

Pedunculate oak is the most important species in the lowland forests of Croatia in terms of its economic value. For a number of years forests of pedunculate oak have suffered changes affecting their stability, which is directly linked to their productivity. These changes are most frequently reflected in a physiological weakening of individual oak trees and stands and in a reduced increment. The increment of damaged trees and stands has been studied by a number of authors (Athari and Kramer 1983, Kenneweg and Nagel 1983, Kenk et al. 1984, Kalafadžić 1987, Hočevar and Hladnik 1988, Kalafadžić and Kušan 1989, Pranjić and Lukić 1989, Pernar 1994, and others). They all observed a reduction in the tree diameter increment resulting from an increased damage status. Diameter increment is a good indicator of damage status, as it decreases considerably even when the vitality is only slightly weakened. Individual or joint action of all positive and negative factors in a site affects the width of annual rings, or diameter increment. The result of their action is always cumulatively expressed in the width of an annual ring. This is a measurable, stable function that does not change after formation (Pranjić and Lukić 1989). The paper examines the rate of pedunculate oak (*Quercus robur* L) increment at various extents of damage.

## AIM OF RESEARCH

The main aim of this work is to find out the extent to which the increment of pedunculate oak decreases if the damage status increases. In order to achieve the set goal, several concrete tasks had to be accomplished, including:

- establishing the damage status of pedunculate oak with colour infrared (CIR) aerial photographs according to the existing photointerpretative key (Pernar 1994)
- determining the increment of pedunculate oak according to the degree of damage
- comparing the obtained results.

## RESEARCH AREA

The relationship between the increment and the damage status of pedunculate oak was studied using the CIR aerial photographs of lowland pedunculate oak forests in Slavonian Posavina. Samples of aerial photographs were taken in the form of strips in the forest basin "Spačva" in 1989. Two strips of 49.08 km in total were recorded in a north-south direction and one in an east-west direction (Figure 1). The 157 compartments were recorded partially or completely in 99 aerial photographs on a scale of 1: 6123.


Figure 1. Map of area covered by aerial photographs in strips

## METHODS OF WORK

The cores used for the increment analyses were taken in the field with the help of aerial photographs. Oak trees with dbh ranging from 40 to 50 cm (which was the range of the mean diameter at breast height of these stands) were found with aerial photographs in stands of about 100 years of age (95 - 110 years). The cores, used for the ring width analysis, were taken from the selected trees with Pressler's drill. The damage status of every tree was assessed in the CIR aerial photographs applying the valid photointerpretation key for pedunculate oak (Pernar 1994). A total of 247 cores were taken, and the widths of annual rings were measured on the cores. The measurement was done with special measuring instruments, where cores were observed with a binocular microscope with 3x, 8x and 10x magnification. The widths of rings were measured with a vernier scale of m = 0.05 mm.

As the studied area is abundantly intersected with natural streams, channels and man-made communication lines, the CIR photographs also determined the damage status along these facilities. The extent of individual damage status was determined within 100 and 200 m along these facilities. Forest areas along the so-called forest highways (asphalt road with deep side ditches), forest roads, natural streams, meliorated marches, man-made canals, and the Zagreb - Lipovac motorway were analysed.

## RESULTS OF RESEARCH

The ring width from 1989 was compared with the damage status of pedunculate oak determined by the CIR photographs (Table 1, Figure 2).

Table1. Annual ring width and damage status

| Percentage of damage (%) | Number of trees | Annual ring width (mm) |
|---|---|---|
| 10 | 1 | 2.00 |
| 15 | 3 | 1.63 |
| 20 | 60 | 1.66 |
| 25 | 82 | 1.57 |
| 30 | 35 | 1.20 |
| 35 | 30 | 1.16 |
| 40 | 20 | 1.05 |
| 45 | 8 | 1.09 |
| 55 | 3 | 0.83 |
| 60 | 2 | 0.80 |
| 65 | 1 | 0.35 |
| 70 | 2 | 0.40 |

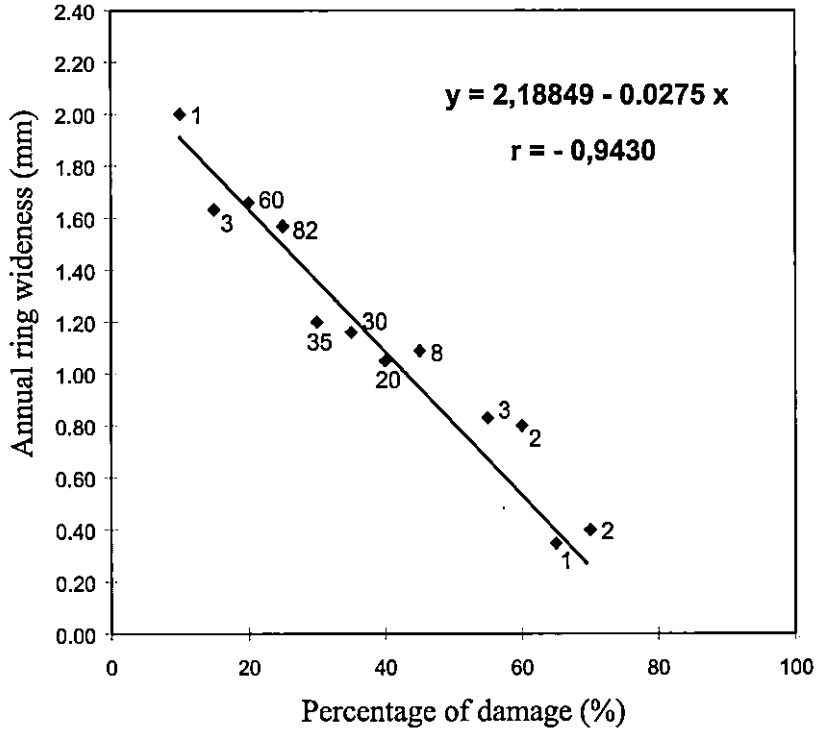


Figure 2. Relationship between annual ring width and damage status

The relationship between the current annual diameter increment for the period 1985. - 1989 and the damage status of trees at the end of this period was also analysed (Table 2, Figure 3).

Table 2. Diameter increment ($i_{d5}$) and damage status

| Percentage of damage (%) | Number of trees | Diameter increment ($i_{d5}$) (mm) |
|---|---|---|
| 10 | 1 | 4.28 |
| 15 | 3 | 3.68 |
| 20 | 60 | 3.54 |
| 25 | 82 | 3.45 |
| 30 | 35 | 3.16 |
| 35 | 30 | 2.99 |
| 40 | 20 | 2.92 |
| 45 | 8 | 3.07 |
| 55 | 3 | 2.03 |
| 60 | 2 | 3.87 |
| 65 | 1 | 1.14 |
| 70 | 2 | 1.50 |

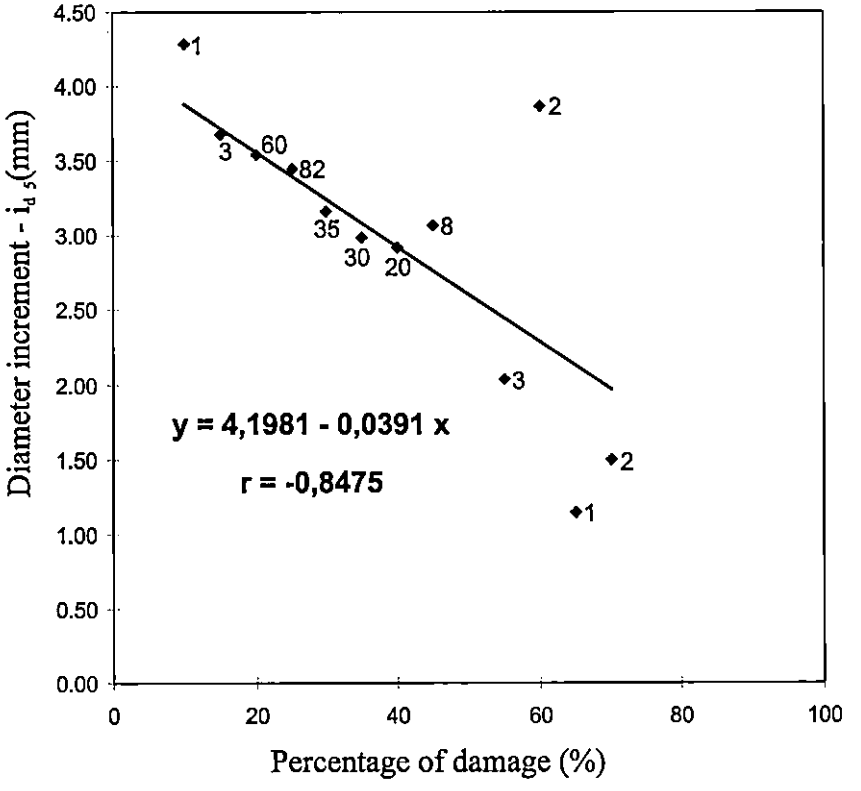


Figure 3. Relationship between diameter increment ($i_{d5}$) and damage status

The cores taken with Pressler's drill were analysed and the following was established: there is a strong negative correlation (r = - 0.9430) between the damage rate of pedunculate oak selected in aerial photographs and the annual width at breast height in the year of recording.

This relationship is linear, and can be expressed with a regression equation:

$$Y = 2.18849 - 0.0275X \text{ where}$$

X = percentage of damage determined by aerial photographs, and
Y = ring width in the year of recording (1989).

There is also a very strong negative correlation (r = - 0.8475) between the damage percentages of pedunculate oak determined in the aerial photographs and the current annual diameter increment for the period 1985 – 1989:

$$Y = 4.1981 - 0.0319X \text{ where}$$

X = percentage of damage determined by aerial photographs, and
Y = current annual diameter increment for the period 1985 - 1989.

The measured data can follow the fitted line up to 45% of the damage status, which is shown in Figure 3. This means that these trees have not displayed any significant oscillations in increment in the last five years, which is decreasing linearly.

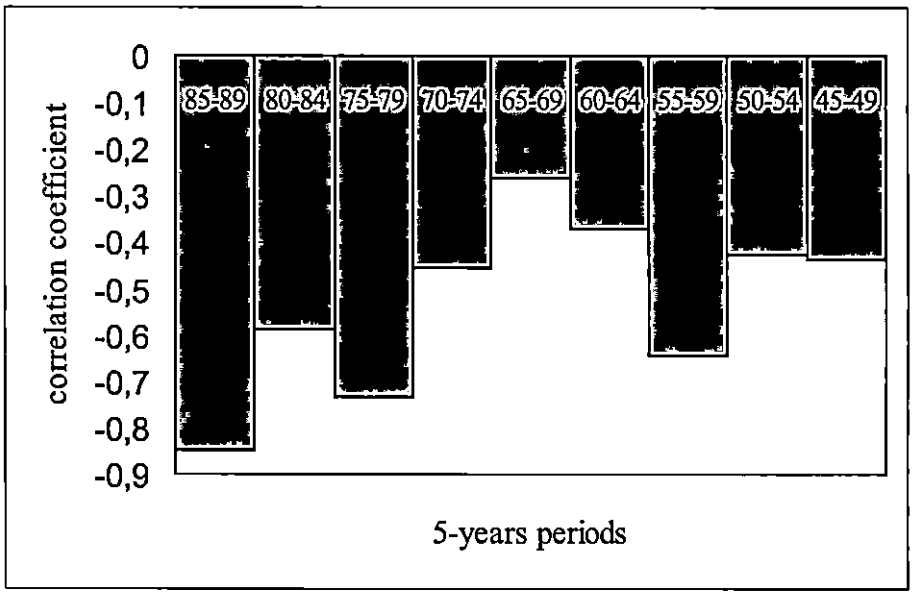


Figure 4. The changes in correlation coefficients between 5-year diameter increment and damage statuses in the period from 1945 to 1990

Significant deviations from the fitted line for more severely damaged trees are an indication of cases of acute dieback, because these deviations were not present in the ring widths in the year of aerial recording.

The analysis of the changes in correlation coefficients between 5-year increments and the damage status of pedunculate oak in the period from 1945 to 1990 shows that there has been a continuous increase (Figure 4). This growing trend of correlation coefficients points to changes in the site occurring in the past 45 years.

A link between the degree of stand damage and the kinds of natural or man-made infrastructure was also established (Table 3, Figure 5). The extent of damage was the highest along meliorated marches, asphalt roads with deep side ditches, and man-made canals. The areas along forest roads and natural streams, as well as along the motorway, are less damaged.

Table 3. The area share of damage statuses along the linear communication

| Linear communications | Interpreted | | Stand damage class | |
|---|---|---|---|---|
| | | | 1 | 2.1 |
| | | | 11-25% | 26-40% |
| | km | ha | area percentage | |
| 1. Ameliorated marshes | 1.9 | 38 | 9.0 | 91.0 |
| 2. Public roads | 9.2 | 92 | 28.3 | 71.7 |
| 3. Channels | 12.2 | 244 | 32.3 | 67.7 |
| 4. Motorway | 16.5 | 330 | 54.5 | 45.5 |
| 5. Natural streams | 29.5 | 590 | 62.1 | 37.9 |
| 6. Forest roads | 26.6 | 532 | 64.1 | 35.9 |

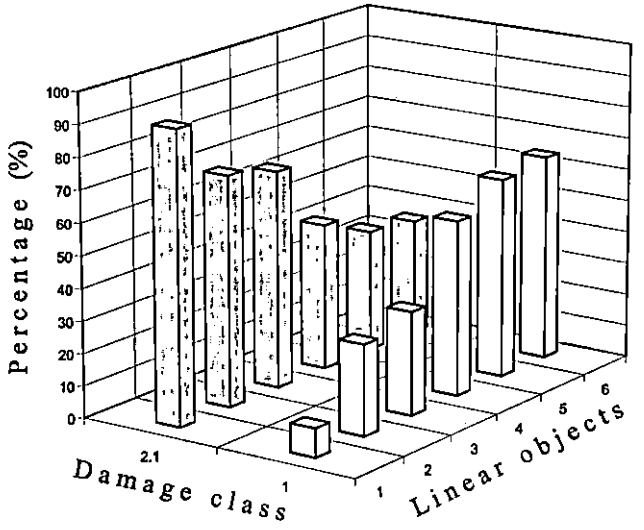


Figure 5. Stand damage near natural and built linear communication in the forest basin "Spačva"

## INTERPRETATION OF RESULTS

The analysis shows that an increase in the damage status of pedunculate oak has resulted in a lowered increment. Diameter increment is a good indicator of damage, as it decreases even at a slight weakening of vitality, which was confirmed with the correlation analysis. A negative correlation ($r = - 0.9430$) was established when the ring width in the year of the recording was compared with the damage observed in the aerial photographs. A current annual diameter increment in the 5-year period (1985-1989) also shows a negative correlation ($r = - 0.8475$) with the damage percentage determined in the aerial photographs.

The correlation coefficient trend points to significant changes taking place around 1970. According to some earlier research, important changes adversely affecting pedunculate oak occurred in 1977/78, resulting in a constant decreasing of ring widths. The strong impact of highly adverse short-lasting factors induced stress in the pedunculate oak in 1982/83, the result of which was a more pronounced dieback of its trees (Pranjić and Lukić 1989).

The dependence of forest damage on the conditions in the field is exemplified with a link between the damage status and natural and man-made linear communications in the forests. Damage depends on the intensity of interventions in natural hydrological conditions. Damage is more extensive along meliorated marshes, asphalt roads with deep side ditches and man-made canals than along natural streams, simple forest roads and the motorway. Low-scale damage along the Zagreb - Lipovac motorway can be explained either by the fact that a better-quality design and execution of the work did not unduly disrupt natural conditions or by the fact that 50-year-old stands of that time have adapted to the new conditions. This assertion is confirmed by earlier research in the area (Kalafadžić et al. 1993).

## CONCLUSION

The relationship between the diameter increment and damage status of pedunculate oak (*Quercus robur* L.) assessed in colour infrared (CIR) aerial photographs was studied in the lowland forests of pedunculate oak in Slavonska Posavina.

The research and the obtained results point to the conclusion that an increase in the damage status of pedunculate oaks has resulted in a decrease in the increment. Accordingly, diameter increment is a good indicator, as it decreases considerably even when the vitality is only slightly weakened. Severely damaged trees react poorly to changes in their surrounding, which in turn leads to a decrease in the diameter increment variability at a higher damage status. According to research results, pedunculate oaks with a degree of damage over 45% have not displayed any major oscillations in increment in the last 5 years, but have a long-term decrease instead. A continuous growth was observed in the correlation coefficients between 5-year increments and the extent of damage of pedunculate oak in the period 1945

- 1990. Dendrochronological research should also be included into the problem of increment in those trees suffering from varying degrees of damage.

The relationship between the damage status of pedunculate oak and the kinds of natural or artificial communications in the forests was also established. The size of damage depends on the intensity of interventions in natural hydrological conditions. Expert teams from various scientific fields should join forces to study these phenomena further.

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# ODNOS IZMEĐU DEBLJINSKOGA PRIRASTA I STUPNJA OŠTEĆENOSTI HRASTA LUŽNJAKA (*Quercus robur* L.)

Istraživanje odnosa prirasta i oštećenosti hrasta lužnjaka provedeno je na infracrvenim kolornim aerosnimkama (ICK) u nizinskim šumama hrasta lužnjaka u slavonskoj Posavini. Radi utvrđivanja odnosa prirasta i stupnjeva oštećenosti hrasta lužnjaka na terenu su uzimani izvrci. Uz pomoć aerosnimaka pronađeno je 247 hrastovih stabala različitih stupnjeva oštećenosti. Na izvrcima su izmjerene širine godova.

Uspoređena je širina goda u godini aerosnimanja i stupnja oštećenosti stabala hrasta lužnjaka određenoga na infracrvenim kolornim aerosnimkama. Usto je analiziran i odnos tečajnoga godišnjega debljinskoga prirasta za petogodišnje razdoblje ($i_{d5}$) i stupnja oštećenosti stabala na kraju toga razdoblja (godina aerosnimanja).

Analizom izvrtaka izbušenih Presslerovim svrdlom ustanovljeno je da se s povećanjem oštećenosti stabala hrasta lužnjaka smanjuje njihov prirast. Pri tome je debljinski prirast dobar indikator oštećenosti, jer se i pri manjem slabljenju vitalnosti on znatno smanjuje. To je potvrđeno korelacijskom analizom. Usporedbom između postotaka oštećenosti stabala hrasta lužnjaka određenih na aerosnimkama i širine goda u prsnoj visini u godini aerosnimanja postoji jaka negativna korelacijska veza ($r = -0{,}9430$). Postoji također i jaka negativna korelacijska veza ($r = -0{,}8475$) između tečajnoga godišnjega debljinskoga prirasta u posljednjih 5 godina i postotka oštećenosti stabala hrasta lužnjaka u godini aerosnimanja.

Također je uočena povezanost stupnja oštećenosti šume i vrste prirodnih ili ljudskom rodu načinjenih linijskih objekata uz koje se te šume nalaze. Određen je površinski udio pojedinih stupnjeva oštećenosti na širini od 100 i 200 m s obje strane tih objekata. Na taj se način nastojao ustanoviti utjecaj tih objekata na stupanj oštećenosti i pad prirasta okolnih šumskih sastojina.

Analizirane šumske površine uz isušene bare, asfaltirane ceste s dubokim postranim kanalima, te uz prokopane kanale pokazuju vrlo velika oštećenja. Uz šumske ceste i prirodne vodotoke oštećenost je manja, iz čega se može zaključiti da stupanj oštećenosti ovisi o intenzitetu zahvata u prirodne hidrološke uvjete.

Ključne riječi: hrast lužnjak, infracrvene kolorne aerosnimke, debljinski prirast, stupanj oštećenosti, prirodni i izgrađeni linijski objekti, slavonska Posavina