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DENDROECOLOGICAL INVESTIGATIONS ON THE OAK
DECLINE ON THE KROTSZYN PLATEAU, POLAND

ABSTRACT

The dendroecological studies conducted on 36 cores representing four oak stands (90-155 years old) of the Krotoszyn Plateau, show for oak decline a high dependence from the climatic factors. Abrupt growth depressions during past years can be explained by low precipitation in May and June as well as low temperature in winters. Special in the years 1957/70, 1973, 1975/76 and 1978-82 growth reduction of oaks corresponds to a high degree with a period of below-average precipitation in May and June.

INTRODUCTION

Oaks on the Krotoszyn Plateau show serious decline symptoms since long. The disease has first been described by Krahl-Urban et al. (1944) and since then was regularly observed by the foresters working in these areas and by scientists from the Institute of Dendrology in Kórnik (Siwecki et al., 1987). Reasons for this oak decline were recently analysed with respect to various biological and non-biological causes (Siwecki, 1990, Woźniak et al., 1989). These long-term observations provide useful information which should enable a detailed study on the relationships between past environmental conditions stored in tree-rings and
the present status of the oaks. Consequently, a tree rings analysis has been undertaken with the aim to find possible stressors in the past and their phenological expression.

MATERIAL AND METHODS

From 56 pedunculate oaks (Quercus robur L.) on the Krotoszyn Plateau cores have been taken on four sites and dendrooeologically analysed. The trees have the following age distribution:

Krotoszyn Stands: 1. 150-155 years, 2. 100-105 years, 3. 95-130 years (mainly 100-105 years) and 4. 90-100 years.

The climatic data expressed as monthly mean temperature and monthly sum of precipitation were supplied by the weather stations in Krotoszyn and Smolice. These records were supplemented by data from the station in Kalisz so that in total the period 1931-86 is covered. For comparison, regional climatic data of west Poland were used representing the situation in Great Poland and in the Silesian Lowland.

The oak samples from the Krotoszyn oaks were taken with an increment borer, two from each tree, and the tree-ring widths measured with an accuracy of 0.01 mm. The tree-ring series were grouped according to the four sites and visually evaluated regarding their main growth changes and severe growth reductions. The data were checked with the computer program COFECHA (Holmes, 1983). In order to remove the age influence and other non-climatic influences, the tree-ring series were standardized by the program ARSTAN (Cook and Holmes, 1986), and averaged to chronologies. These chronologies fluctuate around the value 1. The relations between climate and growth were determined using response-function calculation as well as simple correlations by program RESPO (Lough, unpubl.). For a detailed description of the methods see Fritts (1976) and Briffa and Cook (1990).

RESULTS

First information about the growth conditions can be obtained from the raw tree-ring series. They are shown in their cross-dated order for each stand in figure 1. In the following, a preliminary interpretation is given.

According to the tree-ring series the stands 2, 3 and 4 can be regarded as homogenous whereas the trees from stand 1 represent a more heterogeneous group. The growth of all oaks appears unstable with time and sensitive and shows numerous depressions. Note worthy are phases of depression, which occur in addition to many negative signature years.

The first long-lasting depression occurred from 1912 (1914) up to 1917, in some cases up to 1918. It was followed by a growth reduction period from 1940 (1942) up to 1945 (1946). The last depression, which was most severe and long-lasting, started in many trees in 1972. Later on, a smaller depression occurred 1968-70, which was totally due to climatic influences as proven by comparison with healthy oaks. Indeed, nearly all trees exhibit a somewhat broader ring in 1975, but from 1976 onwards a significant growth depression took place. This becomes especially evident for the stands 3 and 4. In 1984 a recovery started on all four sites with differences between trees. The growth patterns of the oaks for the last two years - 1987 and 1988 - appear quite irregular. These years belong for some trees still to their recreation phase, whereas for others a forthcoming reduction is indicated.

A comparison with the tree-ring series from oaks in the Nationalpark of Greatpoland and in the surrounding of Wrocław reveals that all growth changes correspond with a normal, climatically conditioned course of growth increment, except in the periods 1912-17 and 1975-83. The trigger years for these two periods, viz. 1912/1914 and 1972/1976, were also negative for other oaks in western Poland. Special reference has to be paid to climatic factors and, above all, water stress. This assumption may be verified by comparison with climatic data and considering extreme climatic events.

Climate-growth relationships were analysed for the periods of 1932-67 and 1932-76. The years 1977-86 were excluded because of their abrupt growth reduction. As independent variables temperature and precipitation from previous October until September of the current year were used. The climatic influence of the prior growth season was regarded less significant (Figs. 2 and 3).

The influence of the monthly climatic variables on the four groups of trees was of different intensity, but most obvious for the period 1932-67. The proportion of variance explained by climate was shown for the oaks at stand 4: $r^2 = 80.5\%$. In contrast, the tree-ring variation of the oaks on stand 1 was only explainable by 53% due to climatic factors; similar values were found for stands 2 and 3 - about 63%.

Considering the period 1932-76 it is obvious that for stands 1 and 2 the non-climatic factors are more significant as expressed by an $r^2$ of 39% and 42% respectively.

The pattern of the response functions as well as the simple correlation coefficients indicate some similarity between the oaks from stand 1 and 2 as well as from 3 and 4. The trees of these pairs of sites responded to the same climatic factors. The connection between climatic conditions and tree-ring widths are shown in figures 5-6 with the following conclusions:

- The oaks in Krotoszyn stands 1 and 2 respond quite sensitive to winter temperature, especially in January. The regression weights of the response
functions are with 0.6 - 0.7 quite high. This indicates that up to half of the total variation (r^2 = 0.49) of the tree-ring widths can be explained by the January temperature. Besides mild winters, the trees prefer much precipitation in May and especially June.

- The oaks in Krotoszyn stands 3 and 4 also reveal a distinct sensitivity towards winter temperature. Equally, precipitation during winter indicates a good relation with the tree-ring width. The strongest reaction, however, exist between the annual growth and the precipitation in May and June.

CONCLUSIONS

1. The dendroecological analysis confirms for the oaks in Krotoszyn a high dependence from climatic factors.

2. Most important are precipitation in May and June as well as temperature in winter. Abrupt growth depressions during past years can be explained by these two factors. However, the temperature influence may be analysed in more detail using minima values and daily values.

3. The recent long-lasting growth reduction corresponds to a high degree with a period of below-average precipitation in May and June in the years 1969-70, 1973, 1975-76, 1978-82. The present analysis supports earlier assumptions that the oak decline on the Krotoszyn Plateau is preferably caused by water stress.

REFERENCES


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