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THE EFFECT OF THE PRECIPITATION ON THE TREE RING WIDTH

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Abstract. The increased frequency of drought observed since the early nineties drew the attention to analysing the role of precipitation in tree growth. We carried out a study in three areas in Transdanubia (Zselic, Bakony and Pilis mountains) on how the total precipitation of different periods influence tree-ring width of different tree-species (Turkey oak, pedunculated oak and beech) and different age classes. We have found significant correlation with the April, May and June precipitation. The intensive growth period (May-June) and the weighted total precipitation also play an important role in tree-growth. High Gleichlaufigkeit was found between the tree-ring and the drought indexes.

We studied the growth trends of middle-aged and mature trees in the same samples. The analysis of the last eighty years did not provide unquestionable evidence of increasing growth of trees in Hungary, although we observed this phenomenon in several cases, mainly for beech.

Keywords: tree-ring width, precipitation, climate change, increment, effect of damaging agents

1. INTRODUCTION

Analyses of meteoroligical data for long periods seem to prove that Earth's climate has changed in the last forty years. Mean air temperature has increased, the atmosphere has higher carbon-dioxide and nitrogen content and the amount of precipitation changed as well. The direction of the latter is not universal however, increase and decrease were equally observed depending on location and period, and there are changes in precipitation' intensity. It is highly probable that tree-growth responds to these changing external factors. In order to be able to forecast future growth tendencies we should understand the existing relations by analysing sufficiently long time-series of growth data. Although the most sensitive indicator of changing conditions is thought to be the height growth, annual tree-height data are hardly available. A more feasible method is the analysis of radial growth, which is permanently stored in the width of the tree-rings. These data are of high importance for several other areas of science since a data set of a minimum thirty years period are as much characteristic for a certain area as finger prints are for humans. For this reason tree-ring analysis could be an important means for archeological age determination as well as climatology. In forestry tree rings are used for describing growth trends, determining increment loss due to damaging agents as well as understanding the effect of changing site conditions.

2. METHODOLOGY

2.1 Factors influencing sampling

Sampling must be based on a clear definition of the purpose of the analysis, since tree-ring width depends on a large number of factors. The most precise answer to our question can be found by eliminating most of the variables as early as during sampling. For this reason the analyses are focused on the same tree-species, since different species produce very different responses to changing external factors. Tree-ring width is also dependent on age but this relationship can nicely be described by functions and therefore can be incorporated in the analyses. A more serious problem arises from the fact that the available space has a strong influence on radial growth but very little is known about its temporal changes. Information on silvicultural treatments is available only on stand level there which could suggests, that increased growth of the succeeding years can be ascribed to the intervention. But such information is unavailable on the level of individual trees, we don’t really know what happened in the immediate environment of a sample tree, whether trees were removed or died resulting in changes of available space. Such developments could only be estimated through comparing the behaviour of several trees. For this reason several analyses, especially determination of age consider only the tree-rings from years with low and very low growth intensity. Sampling is restricted to dominant and co-dominant trees where it is highly likely that these trees had enough space throughout their life.

Site conditions have strong effects on tree growth, since they largely influence the intensity and length of the assimilation period. There are factors of permanent nature such as geographical and topographical location, soil – at least within the life span of a tree, except on areas with quick erosion or heavy pollution. The fluctuation of hydrological and meteorological conditions is clearly reflected by the tree-ring widths. Every year with low photo-synthesis due to lack of water, too low or too high temperature or reduced amount of light produces a narrow tree-ring. There are other detectable effects, such as the fire, late frost, other biotic and abiotic damages, as well as the increasing CO_2 content and the volume of nitrogen compounds.

2.2 Sampling and measurements

Sample ares were selected in the hilly and montenous regions of Transdanubia: Balaton-felvidék, Bakony, Somogyi-dombság, Vasi-hát and Pilis. Three tree-species in two age-classes wer selected on these areas: Turkey oak, pedunculated oak and beech, but in one case sessile oak was also selected. Younger stands were 55-70 years old, the older stands were 95-110 years old. Ten dominant or co-dominant sample trees with healthy and regular stem and crown were selected from each sample plots. Sampling itself was made by increment borer at breast height either from North and South or parallel to the slope.

Tree-ring width was measured by LINTAB4 device supported by TSAP software. In order to eliminate the effect of age as described above, tree-ring widths were converted to indexes. With this mathematical transformation we obtained relative values expressing the difference between the measured value for year **x** and the value for the same year derived from a function generated for the whole data set. Using these relative data made subsequent calculations.

3. RESULTS

3.1. Analysis of the relation between tree-ring index and precipitation

It seems to be evidence that precipitation considerably influences tree growth. But we know far less about which periods' precipitation play a really important role and which do not. To find an answer the correlation between tree-ring indexes and the monthly total precipitation was evaluated. We found that, in general and in reverse order of frequency, June, April and May precipitation showed correlation with growth, although coefficient was often on the margin. But we often found exceptions to this. April-June seemed to play a more important role for Turkey oak and beech, but in case of pedunculated oak this period was June-July.

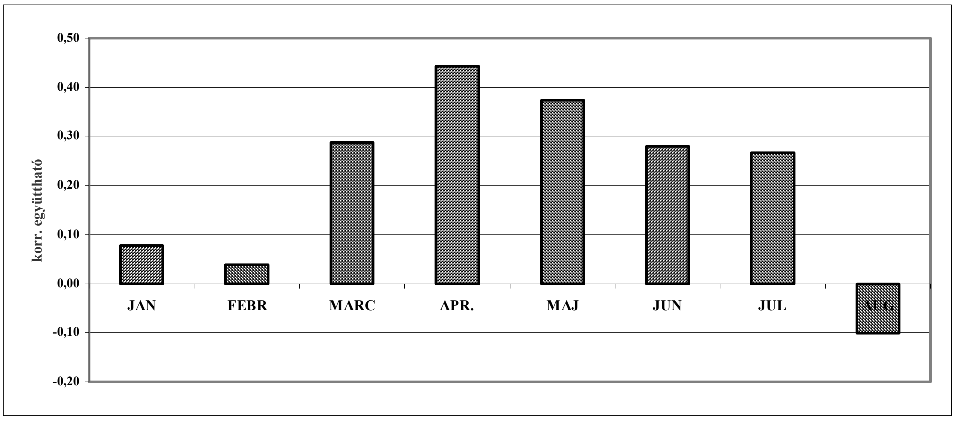

Fig. 1. Correlation between tree-ring indexes and precipitation

Another analysis was carried out on the correlation between precipitation of longer periods and tree-ring indexes. As it was expected, we found the strongest correlation with the total precipitation of the intensive growth period (May-July). The precipitation of these three months can influence the annual radial growth in as much as 36%. Similarly high correlation was found with the weighted total precipitation. Weighted total precipitation is calculated for the hydrological year (October-August) where the monthly precipitation is weighted by the water demand of the plants in the respective months. Although the weights were originally determined for agricultural plants, they are well applicable for trees as well. One may find surprising that the precipitation of the vegetation period showed the weakest influence on growth. The explanation for this is that although the precipitation of the April-June or April-July period is crucial, but the August and September precipitation is not at all important. (We often found negative correlation for August and September, which obviously does not mean that precipitation in these months decreases radial growth, it rather means that this relation is not worthwhile to analyse.) Since these two months are also included in the vegetation period, they decrease the correlation.

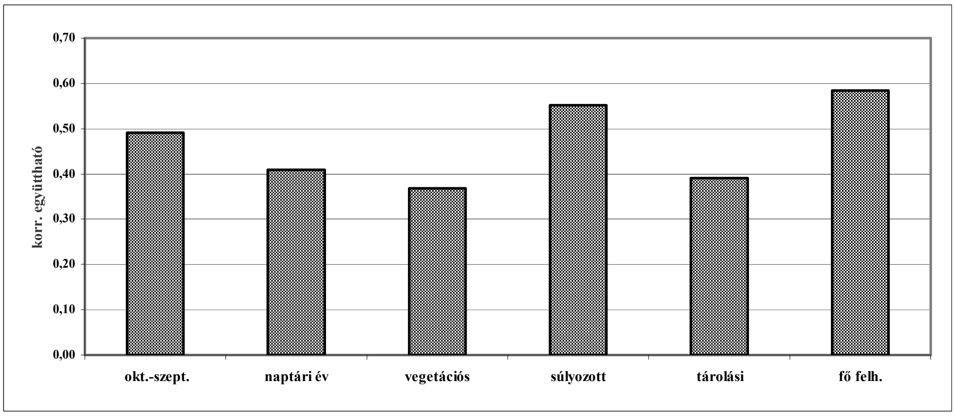

Fig. 2 Correlation between tree-ring index and total precipitation of different periods

Annual climate can well be described by different drought indexes, which comprise the temperature and precipitation conditions. We have selected the Pálfai drought index (PAI) which is available since 1930 in high spatial resolution. Correlation between tree ring indexes and drought indexes was hardly found significant, but the tree-ring and drought indexes were found synchronous. Synchronous means that when drought intensifies tree-rings get narrower and when drought is less intense the ring gets wider. We found this synchrony (Gleichlaufigkeit) in about 70%. There could be two reasons for the low correlation: firstly because drought was experienced mostly in July-August when radial growth is already close to its termination, secondly because the influence of the summer drought often appears in the following year only.

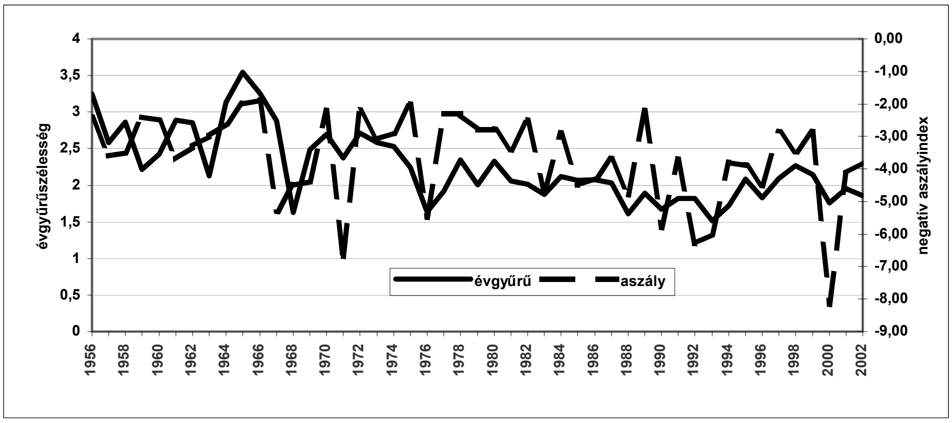

Fig. 3. Synchrony of tree-ring and drought (PAI) indexes

3.2 The influence of changing climate on tree growth

The analyses were focused on stands of same tree-species on identical sites but with 35-40 years of age difference. Beside the initial and juvenal periods the two stands were expected to show similar growth patterns in the identical age classes. Differences in the growth patterns can be ascribed to changing environmental conditions. If we aggregate the tree-ring widths starting from the centre we get a special curve showing the radial growth as a function of age. These curves well illustrate the periods with increased growth and the growth differences (Fig. 4).

The results vary depending on location, age and tree-species. We found that Turkey oak grew faster in the last 42 years than in the preceding 42 years. We found similar pattern in case of beech.

Surprisingly, old beech trees grew very intensively over the last 40 years, surpassing even the growth of younger beech stands. There were no differences found between the two period in case of pedunculated oak We found different patterns in case of Turkey oak in the Balaton-felvidék, where radial growth has considerable decreased in the most recent period, younger stands grow much slower now than their predecessors did 40 years ago.

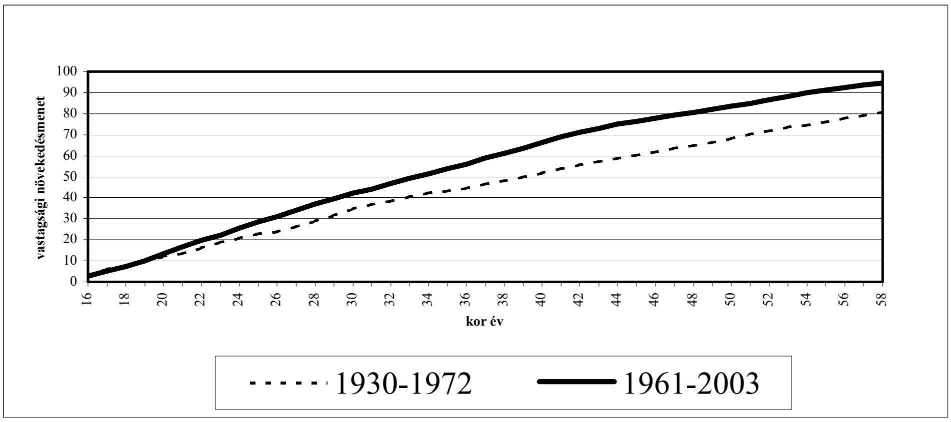

Fig. 4 Growth curves of two Turkey oak stands, similar life period but 40 years apart, in Zselic, Humgary

4. CONCLUSIONS

Tree-ring growth of different tree-species in different age-classes responded differently to the amount of precipitation. The temporal distribution of precipitation is also important, firts of all the April-July period plays a crucial role in tree growth. By developing scenarios for the precipitation of this period in the coming decades we can estimate the future borderlines of the abundance of different tree-species as well as their expected growth. Due to the changing climate the mean annual temperature has increased over the last 40 years while the amount of precipitation decreased. In addition to this, the amount of CO_2 and the deposition of nitrogen also increased. As a result of these changes we measured increased growth in the last 40 years compared to the preceding 40 years in the sample stands, these findings support the idea of accelerating growth on best quality sites. There is a need for further measurements however to fully prove this statement.

5. ACKNOWLEDGEMENT

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BIBLIOGRAPHY

Babos, K. 1983: *A csertölgy és néhány más fafaj évgyűrűszélessége és az éves csapadék összefüggés-vizsgálata.* Botanikai Közleméynek. 70. 1-2. 83-90.

Fritts H.C. 1976: *Tree ring and climate*. Academic Press, London, New York

Hajósy, F., Kakas, J., Kéri, M. 1975: *A csapadék havi és évi összegei Magyarországon*. OMSZ Budapest

Manninger, M.2004:*Erdei fák éves és korszaki növekedésmenete és kapcsolódása egyes ökológiai tényezőkhöz*. Erdő és Klíma IV. Sopron 152-162.p.

Májer, A.1972: *Évgyűrű-kronológia*. Az erdő.21:164-171

Mátyás, Cs. 2006: *VAHAVA Zárókonferencia*. MTA Budapest

Pálfai, I. 1991: *Az 1990. évi aszály Magyarországon*. Vízügyi Közlemények, LXXIII: 2

Schuck A., Karjalainen, T., Hunter, I.2000: *Erforschung des gesteigerten Waldwachstum in Europa.* AFZ 11. 571-572 p.

Spiecker, H., Mielikainen, K., Köhl, M., Skovsgaard, J.P.,1996: *Growth trend in European Forests*. Springer Berlin Heidelberg

Szabados, I. 2003: *A kocsánytalantölgy évgyűrűszélessége és a különféle csapadékösszegek kapcsolata*. Erdészeti Kutatások. ERTI Budapest.

* * * *OMSZ havi meteorológiai jelentései* [Monthly Reports of the National Meteorological Service]

- * * *Vízrajzi Évkönyvek* [Hydological Annual Reports] 1970-1995

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