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Dendroecological Analysis of Growth Anomalies in Walnut Forests in Southern Kyrgyzstan

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Introduction

Kyrgyzsian walnut forests are characterized by a remarkable biodiversity and a worldwide exceptional volume expansion. Beside the walnut (*Juglans regia*), the forests consist of various fruit species, which contribute to the enormous genetical diversity.

Due to the political circumstances since the beginning of the nineties the ecological balance of the forests is endangered. The political breakdown of the Sovjet Union 1991 leads to various socio-economical changes. One of the consequences is an increase of human influence on walnut forests. The local population depends on the agricultural sector; the forest regions are intensively farmed. Walnuts are harvested, firewood is lumbered and large areas are changed into pasture for cattle. The ecological consequences are a loss of forest area, a decrease of forest stand density, a loss of the genetical diversity and a loss of generative regeneration which leads to an ageing of the forests. Additionally, the forests lose their function as a shelter which leads to soil erosion, debris flows and floods. Further increase of utilisation pressure can end up in a breakdown of the ecosystem (Gottschling et al. 2005).

How the human activities in this region influence the forests is analysed within the research project "The Impact of the Transformation Process on Human-Environmental Interactions in Southern Kyrgyzstan" supported by the VW-foundation. Dendroecological analyses are made to find out how Kyrgyzsian walnut trees naturally grow, to what extend the climatological forcings influence tree-ring growth and how the anthropogenic utilisation changes the tree growth. Up to now the natural growth dynamics are investigated. The main subjects are:

- Age distribution: How old are Kyrgyzsian walnut forests?
- Analysis of growth variability i) internal site investigation ii) comparison of the sites

Material

For the dendroecological analyses tree cores from 20 sampling sites were taken.

The study sites are located in Southern Kyrgyzstan and belong to the Tien Shan Mountains, Fergana Range. The ecological conditions of the sampling sites differ in topographic characteristics such as elevation, exposition, inclination, and micro-relief, as well as in composition of species. Additionally, the degree of human influence varies between the sites, from non-utilised natural sites to completely farmed forests. In order to analyse the natural growth variabilities, four sampling sites are selected. The ecological settings are listed in table 1. In all sites *Juglans regia* is the dominant tree species. The selected sites differ mainly in elevation.

Figure 1: map of Kyrgyzstan; with research area, Source: Microsoft Encarta

The Sary Tasch sites and Arpa Tökty belong to the lower forest step (1000-1400m.a.s.l.) and Daschman belongs to the middle forest step (1400-1750m a.s.l.). Further details about the classification of walnut forests depending on elevation can be found in Gan 1992 and Kolov 1997.

Table 1: Settings of investigated sites

Site location	Geogr. Coordinates	Elevation	Exposition	Inclination
Daschman	41.3409 N 73.0237 E	1730m a.s.l.	N	26°
Arpa Tökty	41.4049 N 73.0791 E	1370m a.s.l.	NNO	17°
Sary Tasch (1)	41.3124 N 73.1020 E	1260m a.s.l.	N	26°
Sary Tasch (2)	41.3138 N 73.1048 E	1160m a.s.l.	NNW	4°

In total, 81 walnut trees were sampled: 15 trees in Daschman, 18 in Arpa, 20 in Sary 1 and 28 in Sary 2.

Methods

The dendroecological analysis and interpretation follows conventional procedures. Ring width measurement was made by using a LINTAB measuring device including the program TSAP (Rinn 1996). Synchronisation of the tree-ring curves was carried out with TSAP and COFECHA software (Holmes 1999). Mean Gleichläufigkeit (GLK) (Schweingruber 1983),

interseries correlation r_{xy} (Bahrenberg et al. 1992) and NET (Esper et al. 2001) were calculated to describe the internal site homogeneity. NET characterises the signal strength by calculating the coefficients of variation and Gegenläufigkeit. Due to the low number of sample depth before 1900, the time interval chosen for the comparison of the sites comprises the period between1900 and 2003. Some cores which consist of less than 50 rings were eliminated from the dataset.
The raw series (in mm) were standardized by a 5-year moving average and ratios were calculated to investigate the interannual signal. Event and pointer years were analysed following the method outlined by Schweingruber et al. (1990). Comparisons to further analyses in Kyrgyzstan and Pakistan (Esper 2000) were made to find out teleconnections. The 25-year moving average was calculated to search for the common signal between the four sites on a decadal to multi-decadal scale.

Results and Interpretation

Age distribution:

Daschman represents the longest cores going back to AD 1746 (Fig. 2). The mean segment length is 166 years, with a variation between 25 to 258 years. In contrast Arpa, whose longest core goes back to AD 1769, is characterized by the lowest mean segment length of all sites which is only 86 years. Sary 1 can be described by going back to AD 1866 and a mean segment length of 92 years. Sary 2, which has the highest sample depth, goes back to 1850 and has a mean segment length of 107 years.

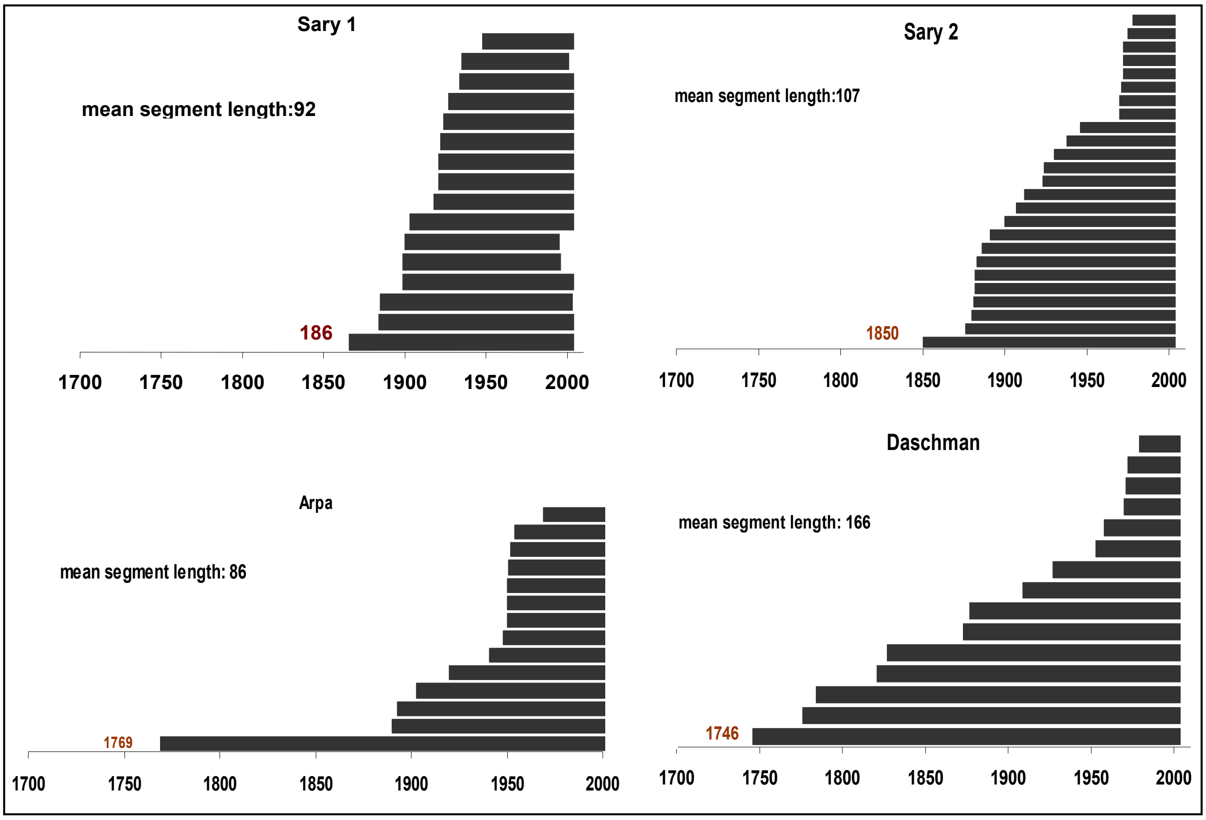

Figure 2: Age distribution and mean segment length of each site

Analysis of growth variability:

The internal site comparisons demonstrate a high level of similarity. The calculated statistical parameters are shown in Table 2. The mean GLK is very high and the significance in each site lies above the 95% level. Each NET value represents high signal strength, being below the defined threshold 0.8 (Esper et al. 2001).

Table 2: Statistical internal site comparison

Site	Mean GLK	Interseries correlation r_{xy}	NET
Daschman	80	0.50*	0.73
Arpa	77	0.41*	0.71
Sary 1	79	0.52*	0.70
Sary 2	80	0.45*	0.66

The mean tree-ring growth of Daschman, Sary1 and Sary2 is close to 1.5 mm/y. This value is very similar to European mean tree-ring growth which is described (defined) by 1.4 mm/y (Neuwirth 2005). In contrast to the other sites, Arpa has an exceptional high mean tree-ring growth of 2.4 mm/y. Thus, ring growth does not decrease with raising elevation. The ecological conditions in Arpa seem to be best for tree-ring growth in this region.

Comparing the different sites a site specific growth depression in Daschman for the period between 1917 and 1941 can be found. Ring growth of all individual series decreased during this strong depression (Fig. 3); the vertical ring growth dispersion is very low. The following increase of growth is not made by each series. To get detailed information about the interannual signal contained in the data, the 5-year moving average is calculated. Describing the ratios from the moving average, the dispersion of the values during the growth depression does not differ from the rest.

The years 1917/1918 can be defined as the beginning of the growth depression in Daschman. Regarding the increments of these years in all sites, they are characterised by small values and are therefore defined as pointer years. Other site overlapping negative pointer years are: 1912, 1931, 1932, 1947, 1965 and 1986. Positive pointer years are: 1972, 1995 and 2000. Comparison with further tree-ring analyses (*Juniperus spec.*) in Kyrgyzstan and Pakistan made by Esper (2000) confirm teleconnections. The years 1917 and 1965 in his data are defined as strong negative pointer years. Additionally, a one-year shift to our data exists in the years 1911, 1946 and 1948, which will be analysed in later investigations.

The 25-year moving average is calculated to find out the similarities in the decadal to multi-decadal scale. Apart from the influence of the growth depression on the moving average in Daschman, Arpa, which has no growth anomaly in the described time period, shows the same curve depression (Fig. 4).

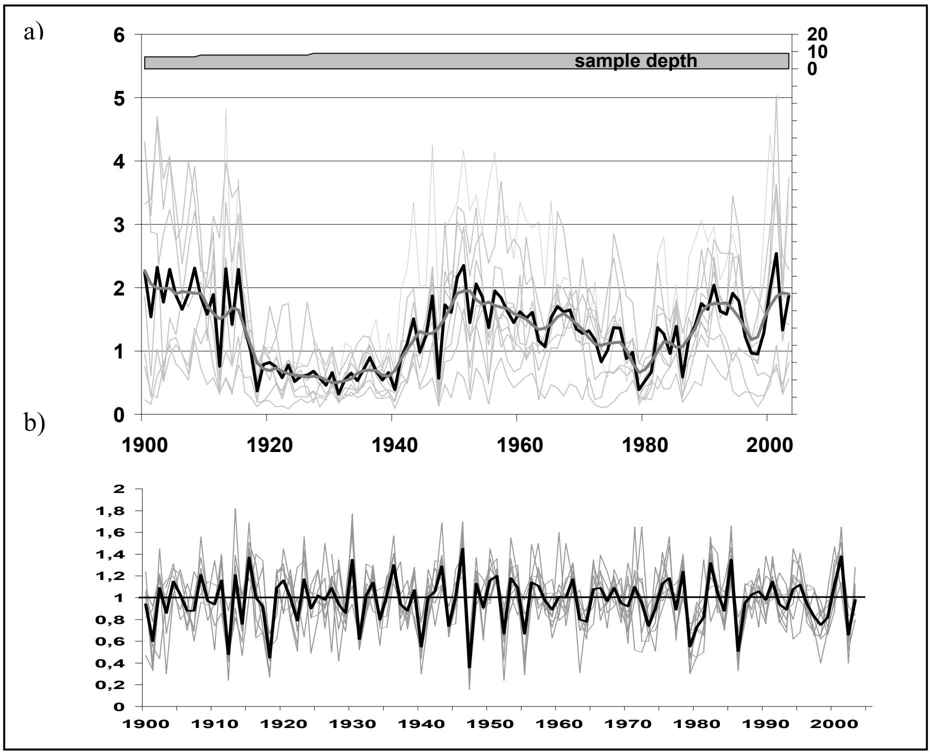

Figure 3: a) Daschman: grey: raw series, black: mean curve, dark grey: 5-year moving average; b) ratios from the 5-year moving average, grey: each series, black: mean curve

The whole curve progressions of Daschman and Arpa are very similar, but on a different level. Sary 1 and Sary 2 have similar curve progressions, too, whereas their behaviour in the time interval 1917-1941 differs from the other curves. All curves have an increase in the fifties ending up in peaks which vary in time. Since the end of the sixties, the curves rise temporally delayed.

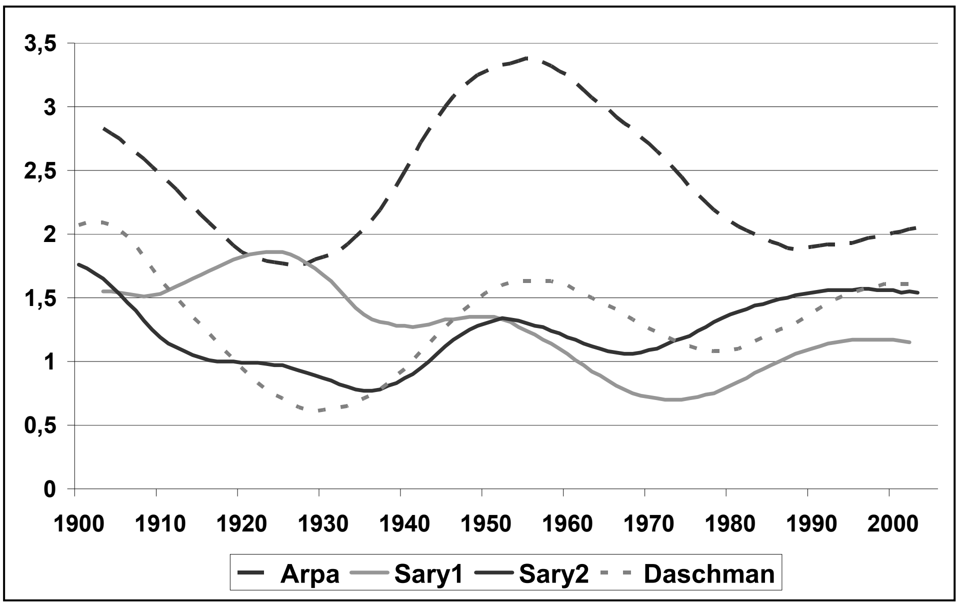

Figure 4: Calculated 25-year moving averages from the different sites

Conclusions and outlook

Our first results of dendroecological analyses in walnut forests in southern Kyrgyzstan confirm natural growth similarities between the different sites. Two groups of especially high similarities were found: Arpa – Daschman and Sary1 – Sary2. This grouping occurs due to the different levels of elevation. Arpa belongs to the lower forest step but due to its location in a v-valley, special climatological conditions are caused which are typical for the middle forest step. Hence, from a climatological point of view Arpa and Daschman belong to the middle forest step, whereas Sary1 and Sary2 belong to the lower forest step. The dividing line of elevation lies at the border of these elevation steps, which means at approximately 1400m a.s.l.. Therefore, we can interpret that elevation is more important for growth variabilities than exposition and inclination.

In later investigations, climate data will be used to estimate the influence of different climate forcings on tree-ring growth. These analyses will deliver further information for interpreting the growth depression in Daschman and the shift in time of the pointer years 1911/1912 and 1946/1947/1948. Additionally, tree-ring growth under anthropogenic influence will be investigated and compared with different natural growth behaviours in order to extract the ecological consequences of the increased utilisation pressure. These further analyses must be carried out under consideration of the above described different levels of elevation.

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