STSM Report: COST Action FP 1301
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Dendroecological study of sessile oak (*Quercus petraea* (M.) Liebl.) growth in stands with different forest management systems

Backgound:

Annual growth rings occur in trees in the mid- and high latitudes environments where there are distinct wet and dry seasons or where there is marked seasonality in temperature (Fritts 1976). Variations in tree-ring widths are related to age and size of a tree, climate, individual tree growth characteristics, stand disturbance and unexplained variability unrelated to any of the above factors (Nowacki and Abrams 1997). When a tree trunk is viewed in a cross-section or in cores, tree rings are visible. Every ring corresponds to a weather parameters variations during the growth season. The science of dendrochronology analyses tree rings to establish dates for these rings (Fritts 1976). Samples from a number of trees from a site are cross-dated and measured. This process provides reliable, accurate and exact dating.
Recently forest ecosystems have faced many problems regarding climate changes. Atmospheric warming and reduced precipitation are expected to exacerbate drought conditions and strongly influence regional water balances (Mariotti et al. 2008). Water shortage in forest ecosystems is not only the most likely cause of inter-annual changes in net primary productivity, but may also compromise tree health and survival (Bréda et al. 2006). If forest ecosystems become affected by climatic shifts, their services and economic values may be at risk (Schröter et al. 2005). When data from permanent plot data are lacking, forest growth dynamics and its controlling factors can be analysed using a dendroecological approach (Biondi 1999).

Purpose of the STSM:

The main goal of the short term scientific mission (STSM) was to apply dendroecological principles and methods to see what was the reaction of trees on a longer time scale (from the establishment of the forest) to the climate changes, especially the response of radial growth to climatic parameters such as precipitation and temperature. It is likely that the future extreme events would increase and affect vulnerable oak ecosystems which already showed unbalanced condition. Defining differences between high and coppice stands would highlight the important benefits and weaknesses of both systems and give possible answers to adapt management in the future.

Research site and methodology:

This dendroecological study was performed in coppice and high sessile oak stands of comparable age (100-120 years). The sites are located in a mixed *Carpineto-Quercetum* forest, north of the city of Brno in South Moravia, Czech Republic (Figure 1). The localities are very close to each other (3,1 km apart). High forest is managed by shelter wood system and was never coppiced. On the other hand, the coppice forest in this research was managed by clear cut after year 1920 (Figure 2). After resprouting it was abandoned and that is the reason why it is older than usual sessile oak coppices with rotation of max 30-40 years. The area is situated at an altitude of 360 m above sea level and the soil is covered with loess to a depth of 30-40 cm. The subsoil is an illimerized forest soil on loamy aluvium and granodiorite with an inaccessible ground water table. The long-term mean annual temperature is 7.5 ^{0}C and the mean annual precipitation is 550–650 mm (360 mm over the growing season) (Vasícek, 1984). Brno is classified by the Köppen Climate Classification as moist climate with mild winters and precipitation in all seasons (CMHI, 2014). Sessile oak (Quercus petraea (Matt.) Liebl.) is a dominant tree species in this forest district.

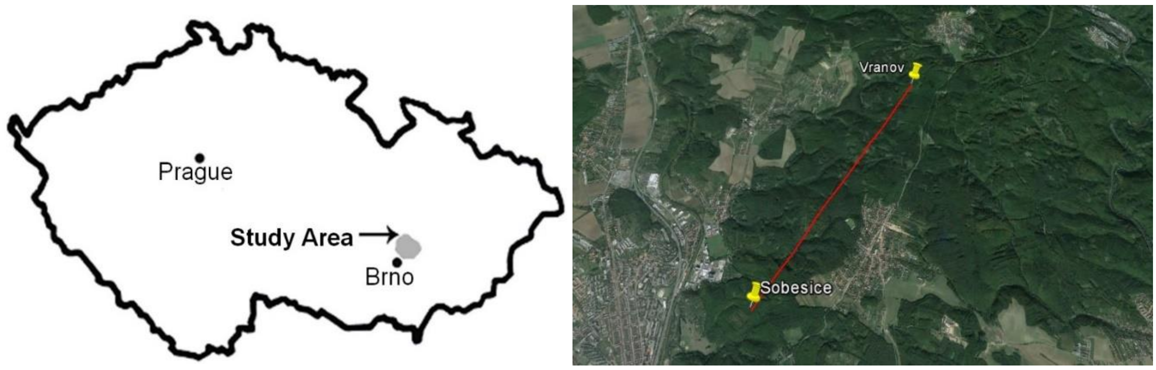

Figure 1: Study area were sampling was conducted

In total the 21 trees were sampled on each of the locations. Trees were cored with a 5 mm diameter Swedish increment borer, perpendicular to the stem axis, two cores per each tree. The core samples were inserted into straws, labelled, and allowed to dry for approximately 2 weeks. After drying the cores were mounted in a wooden blocks. This work was finished at the Faculty of Forestry and Wood Technology in Brno, Czech Republic. Other phases of samples processing which are described below were done at the Slovenian Forestry institute.

Figure 2: Localities were research was conducted, high forest (right), coppice forest (left)

Samples were sanded and polished with progressively finer sandpaper until a high polish surface were achieved. Core samples were used for tree-ring width measurements. Samples were scanned in high resolution using ATRICS system (Levanič, 2007) and measured using WinDENDRO software (Figure 3 and 4). The widths of the rings were measured to the nearest 0.01 mm.

Figure 3: Prepared and scanned core sample, ready to be measured using WinDENDRO software

Chronologies were cross-dated using PAST-4™ software (www.sciem.com) by using visual on-screen comparisons as well as statistical parameters, such are the t-value after Baillie and Pilcher (tBP) (Baillie and Pilcher, 1973) and Gleichläufigkeit coefficient (GLK%) (Eckstein and Bauch, 1969). Quality control were performed by COFECHA program, which is used for checking for the measurement errors (Holmes, 1983). Individual tree-ring width (TRW) series were standardized to remove long-term trends (Cook, 1985). Basic statistical parameters of TRW were calculated using ARSTAN for Windows (Cook and Holmes 1999) and advanced statistical analysis were performed using BootRes package (Zang, 2010).

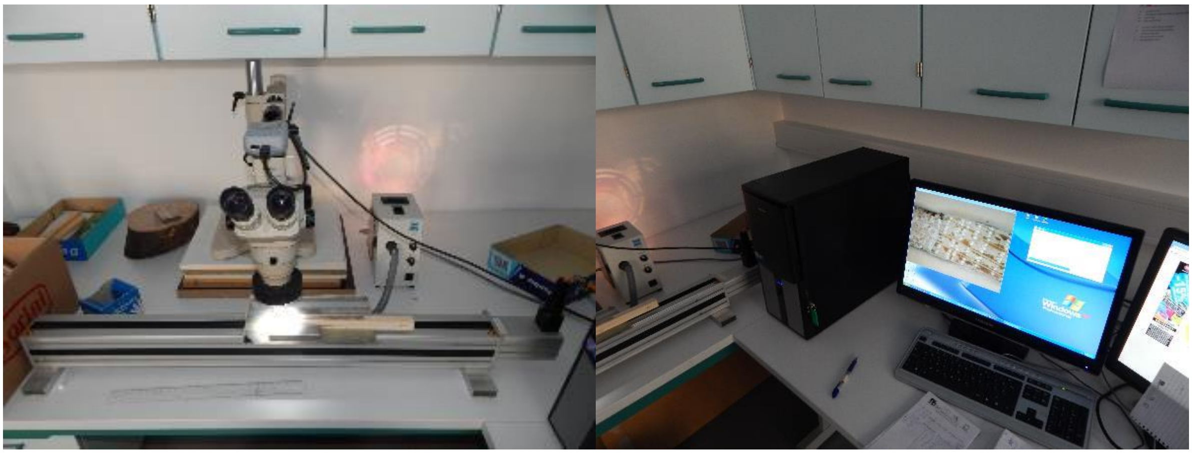

Figure 4: ATRICS device in the laboratory were samples were processed

Description of preliminary results obtained:

To test the historical origin and the effects of climate drivers, twenty-one trees were sampled at both locations with two cores per tree. Tree-ring width data were converted to basal area increment, and used for accurate quantification of wood production due to a continuously increasing diameter of a growing tree (Biondi and Qaedan, 2008).

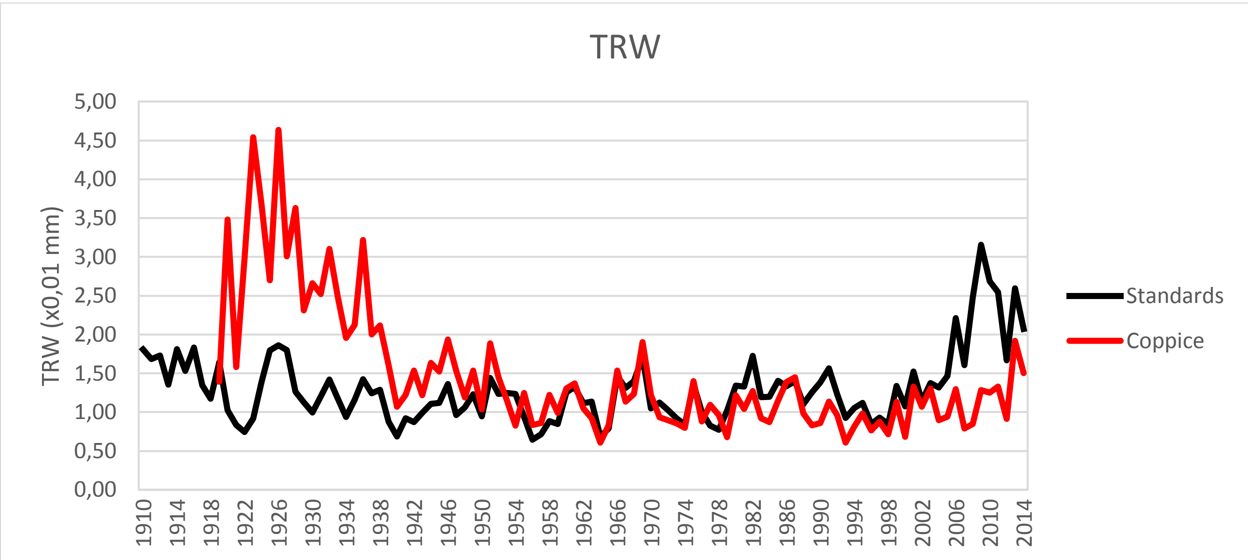

Figure 5: Tree-ring mean chronologies

From mean tree-ring width chronologies it is visible that coppice trees in young stages showed better performance, while high forest performed much better in older stages (Figure 5).

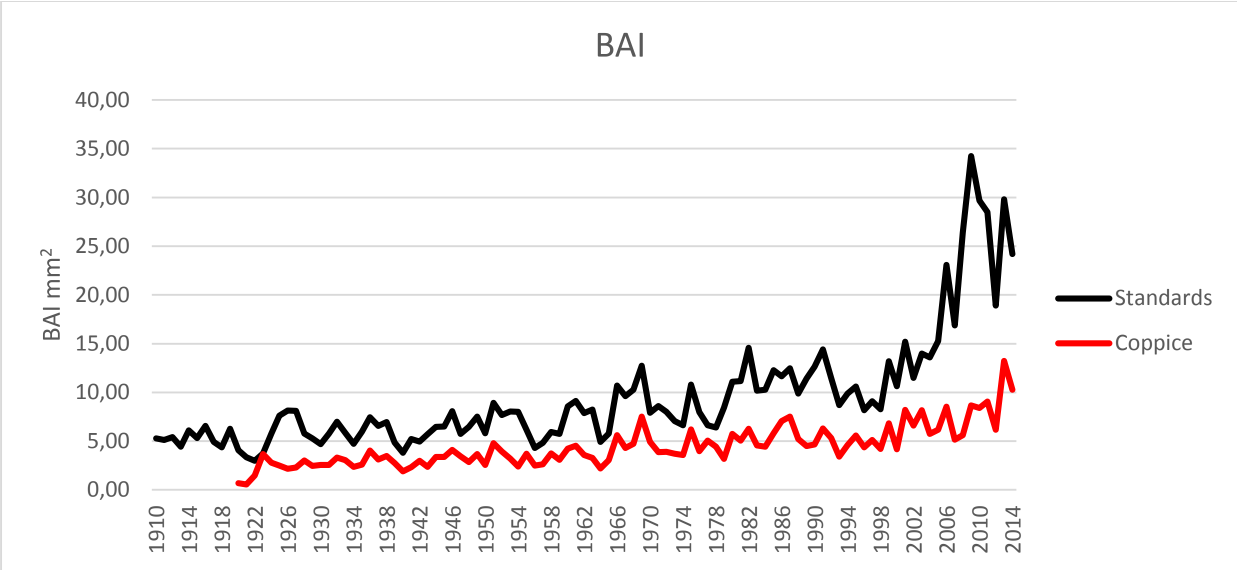

Figure 6: Tree-ring widths converted to basal area increment (BAI)

Basal Area increment of two stands showed much higher production of high sessile oak forest comparing to coppice forest (Figure 6).

The extremely dry years throughout the period 1919-2013 in the South Moravian region were recognized and their impacts on growth were evaluated using bootstrapped Pearson's correlation coefficient (Figure 7 and 8).

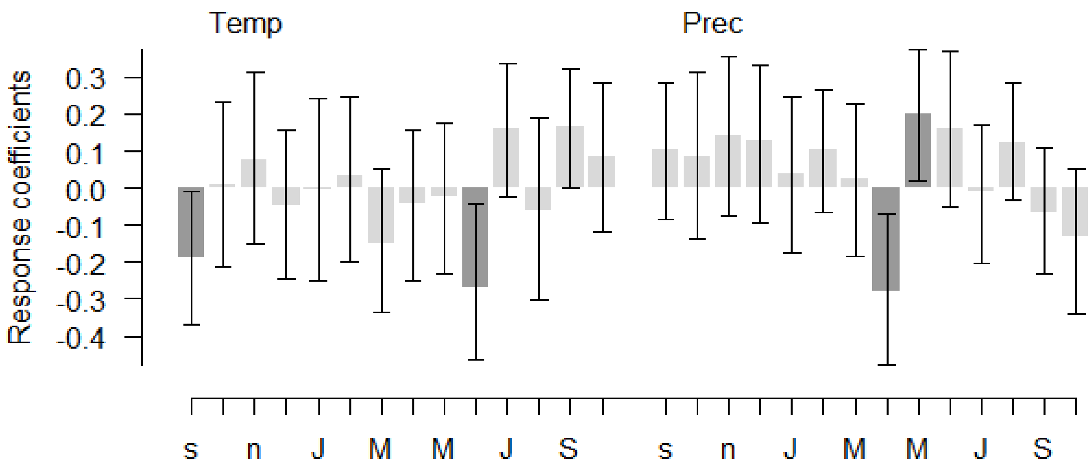

Figure 7: Pearson's correlations between radial increment, temperature and precipitation for coppice forest

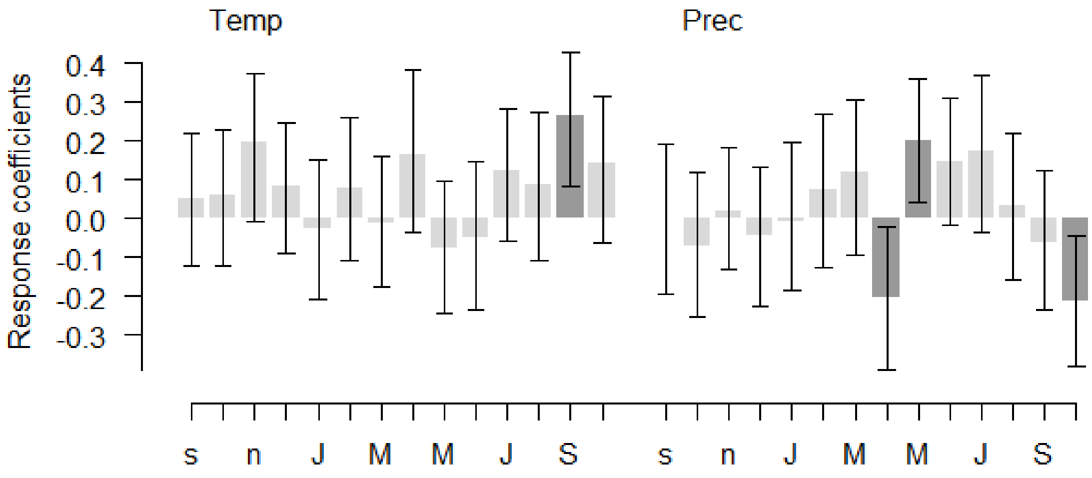

Figure 8: Pearson's correlations between radial increment, temperature and precipitation for high forest

The correlations between radial increment and precipitation for April (negative) and May (positive) were significant for both stands – higher in coppice than in high oak forests. Previous autumn temperature and current June mean temperature have significant negative correlation in coppice forests, however we found only positive effects of current September temperature in high stands (Mérian et al., 2011).

Preliminary conclusions obtained:

Coppice regeneration has an advantage over seedlings because of supplies of carbohydrates which are available from the parent stump and its root system, so new shoots grow very vigorously from the start. However, coppice shoots of most species rarely grow to the dimensions of trees grown from seed, so the system should be used to produce small-sized material. Our results confirm better performances of coppice in young stages and point their importance in traditional and historical management. Due to better performance in young stages the system should be used on extreme sites. Regarding site depletion, long-term stability and production sessile oak high forest proved more efficient.
Competition and growth reduction of drought-prone coppice oak populations will threat their future persistence under the forecasted warmer and drier conditions. Contrastingly, warmer winter conditions could enhance growth of high populations.

Future collaboration with the host institution:

I would like to express special gratitude to the dr Tom Levanič, dr Matjaž Čater and Jernej Jevšenak for the support in defining the research methods and all the help provided during the mission. Further cooperation on publishing the results of the research with the hosts is planned.

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