Introduction and purpose of the STSM

Provenance studies of larch (*Larix decidua* Mill.) in Poland have indicated variability with regard to their adaptation, morphology and resistance features [Kulej 1983, 1985, 1989, 1995, 2001, 2002, 2004, 2006, 2007; Rzeźnik 1980, 1992; Andrzejczyk 1989, 1992; Matras et al. 1995, 2006; Andrzejczyk, Bellon 1999; Socha, Kulej 2007; Szeligowski, Bolibok 2008; Szeligowski et al. 2010]. However, there is still incomplete knowledge of variability of larch in Poland with regard to sensitivity to climatic factors [Szeligowski 2001; Wilczyński, Kulej 2013]. Therefore, the aim of STSM was attempt at classifying larch provenances growing in the Polish Provenance Experiment 1967 according to their specific features of short-term radial increment rhythm. The task of this STSM was to i) measure tree-ring parameters, ii) collect and pre-analyse data to future analysis of climate-increment relationships.

The studied larches grew at 3 provenance experiments located in lowland (Sękocin), upland (Biżyń) and mountain (Krynica) in Poland (Fig. 1). The experiments contained collection of 20 the same larch provenances. Furthermore, the experiment in Biżyń and Sękocin contained 3 additionally the same provenances. 20-23 larch provenances were planted on each experiment in 1 (Sękocin), 2-3 (Biżyń), 5 (Krynica) repetitions (plots). The larch populations examined were subjected to high stresses induced by the different local climatic conditions. I assumed the size of tree rings is a fundamental measurement of the larches’ responses to climatic conditions, which influence their vitality. In this year, when the larches were 50 years old, 20 trees were selected from each provenances in the experiments and cored to take one sample. In the experiment in Biżyń (only provenance no. 2 and 5) and
Sękocin, 2 increment cores from the all trees on provenance plots were taken with regard to lower number of trees (7-14). In total 1368 cores were collected. The cores were scanned using optical scanner with a resolution 1800 DPI.

![Provenances number and name:
1 -Myśliboż, 2-Pelplin, 4-Płonne, 5-Góra Modrzejewowa,
6-Tomkowo, 7-Czerniejewo, 8-Trębaczew, 9-Grójec,
10-Marcule, 11-Skarżysko, 12-Bliżyn, 13-Góra Chelmowa, 14-Moskorzew, 15-Dąbrowki, 16-Holubla,
17-Dukla, 18-Krościenko, 19-Pilica, 20-Prószków,
21-Henryków, 22-Kłodzko, 23-Szczytna Śląska,
24-Kowary

![Fig. 1. The natural distribution range of European larch and the locations of larch provenances (dots) and the provenance experiments (triangles) in Poland]

**Description of the work carried out during the STSM**

The activities were divided into 4 parts: measurements, cross-dating, synchronisation tree-ring widths series, statistical analyses and preparing data to analysis of climate-increment relationships.

In the beginning of study, tree-ring, earlywood and latewood widths were measured on images of cores using the CooRecorder 7.8 + CDendro program. The cross-dating and synchronisation of the tree-ring widths (TRW) were done and verified using COFECHA [Holmes 1986], additionally the dplR package in RStudio. Each 2 cores from tree were averaged. The larch provenances in the experiment in Bliżyn and Krynica was represented by 20 TRW series and in Bliżyn (provenance nr 2 and 5) and Sękocin by 7-14 TRW series. The interval trend indices (IT) chronology was then calculated for each larch provenances using the formula: IT<sub>i</sub> = N<sub>ri</sub> · N<sub>trs</sub><sup>-1</sup>, where IT<sub>i</sub> - interval trend in the year <i>i</i>, N<sub>ri</sub> - number of rising intervals in the year <i>i</i>, N<sub>trs</sub> - number of TRW series; the interval length is one year [Meyer 1998-1999]. A IT value shows the relative number of trees which increased their ring widths in given year compared to the previous years. A value 1 indicates all trees increased radial growth, a value 0 shows all trees decreased radial growth. Pointer years were also detected.
using IT\textsubscript{i} formula. Positive and negative pointer years demand for threshold values of IT\textsubscript{i}. The values IT\textsubscript{i} > 0.8 are defined as positive pointer years and the values IT\textsubscript{i} < 0.2 are defined as negative pointer years. In the end of study, hierarchical cluster analysis for TRW and IT provenances chronologies and principal component analysis for IT provenances chronologies was carried out. Finally, the all collected data were prepared to future analysis of climate-increment relationships. The statistical analyses were done using STATISTICA and RStudio program.

**Description of the main results obtained**

The chronologies of TRW of individual provenances from each experiments showed a decreasing trend between 1970 and 2014, typical for ageing trees, and a similar medium-term variation.

Hierarchical cluster analysis produced a dendrograms where 3 main clusters were indentified. The TRW and IT chronologies were grouped primarily by the experiment and secondarily by the provenance. The first cluster includes TRW and IT chronologies from experiment in Sękocin, the second one includes TRW an IT chronologies from Bliżyn, the third one TRW and IT chronologies from Krynica. In forming the provenance groups, the lowland, upland and mountain provenances were mixed. The results showed that larch growing in experiments have different medium-term variation and short-term radial increment rhythm, which is determined by metrological conditions.

The results of principal component analysis (PCA) showed that in the individual experiments the percentage of the common variance of IT provenance chronologies explained by the first principal component (PC1) was higher than by the second principal component PC2. Therefore, the variations in the short-term increment rhythm of the larch were most effective described by PC1. In each experiment the IT provenance chronologies correlated positively with PC1. PC2 differentiated these IT chronologies into two groups with regard to sing of correlation. Each group included larch provenances from different regions of Poland. PC1 can be helpful in identification the climatic factors to which larches of different provenances shows similar sensitivity and PC2 can be useful in describe the climatic factors to which their shows different sensitivity.
The pointer years analysis show the highest number of common pointer years for the all provenances were found in experiment in Krynica. The lowest number of these years were recorded in Sękocin. The number of common negative pointer years in experiments in Bliżyn and Krynica was higher than the number of common positive pointer years. In Sękocin their number were equal. After taking common pointer years with the exception of one provenance into consideration, only one positive year and one negative year was indentified as common pointer year for the all experiments.

More details and analyses of climate-increment relationships will be contained in the publication which is being written.

**Description about how the results contribute to the Action aims**

The results of this STSM contribute to the STReESS action by completing still limited knowledge of the intra-species variability of larch in Poland which represents significant part of range of European larch in Europe. As results of this STSM were collected such fundamental stress response annual parameters as tree-ring, earlywood, latewood width larches of 23 provenances growing in 3 provenance trials in Poland, located in different climatic regions, in period 1970-2014. The provenance master TRW chronologies were created. The regional, local and provenance pointer years were indentified. The results also consist the dendrograms of cluster groupings provenances of larch based on similarity of their short-term radial increment rhythm and PCA groupings, which are being correlated with climate parameters (monthly sunshine duration, air temperature, precipitation etc.) to directly indicate which climate elements had a similar effect and which differentiated the annual incremental rhythm of the studied provenances. On the basis of collected data, hierarchical cluster analysis based on similarity of tree response to climatic parameters; bootstrap correlation between tree-ring series, provenances chronologies and climatic parameters; response function analysis for provenances chronologies and climatic parameters are being carried out, which are the second part of wider study about European larch in Poland. As result of above mentioned analyses, it will be possible to indicate the most limiting element of the climate, which had the strongest impact on the variation in the radial growth of larch in Poland. Such provenance research provide information about the variability of different features of the population of larch and their usefulness in the forestry industry. On the basis of data collected during this STSM a basic understanding of larch in respect of adaptation to
climatic conditions in different regions of Poland will be generated. Finally, the larch populations which may be suitable for reproduction in different climatic regions in Poland could be chosen.

**Projected publications to result from the STSM**

At the moment with the help of colleagues from University of Agriculture in Krakow are being prepared a manuscript based on part of the results of this STSM which will be submitted to the international journal.

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**Confirmation by the host institution of the successful execution of the STSM**

The confirmation letter by the host institution is attached separately.

**Authorization to post the report at the Action website**

I authorize to post this report at the Action website.

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