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Short-Term Scientific Mission Report

Recognition of coppice wood quality

Introduction

Black alder multiplies vegetatively through sprouts or generatively from seeds. Management of coppice stands is a traditional form of forest management. In Poland coppice stands mainly consist of black alder (*Alnus glutinosa* Gaertn.). This species covers around 122 M m^3 or 5.1% of the total national forested area.

Previous studies of the morphological and anatomical features and the properties of black alder wood published in literature do not distinguish between vegetative (sprout) and generative (from seeding or planting) stand origin. Coppice alder is attributed other morphological features and an increased occurrence of wood defects, e.g. sweep, buttresses, taper and rot. On the other hand, there is the lack of studies confirming this fact and documenting the size and incidence of the above-mentioned features.

A tree from vegetative multiplication is an organism biologically older by the age of previous generations. Taking the above into account, a hypothetic assumption was made that the main physical property of wood, its density, would be different in the case of alder from vegetative multiplication than that of alder from generative multiplication.

Purpose

The main objectives of the STSM were:

1) to start a co-operation between the Wood Technology Institute in Poznan and the Lab of Forest Utilization at the Aristotle University of Thessaloniki (AUTH),

2) learn how modern equipment can be used in wood density measurements,

3) carry out a comparative study on wood samples from coppice trees and high forest trees of black alder (from both countries),

4) prepare a common paper summing the obtained results to high quality journal (JCR list).

Methods, circumstances and locations

PART I. Preparatory work done in Poland.

Wood discs from a vegetative and generative propagation of black alder were sampled in Northern Poland in Zaporowo Forest District. Model trees (tab. 1) were cut from two stands:

1. Vegetative stand: 80 % Black alder 65-years-old (forest address 07-34-1-05-90-a-99), rich site, average dbh 30 cm, average height 23 m, standing volume 241 m^3/ha

Figure 1. Model tree from vegetative propagation

Figure 2. Coppice stand of black alder

2. Generative stand (fig. 1; fig. 2): 60 % Black alder 33-years-old (forest address 07-34-1-05-90-c-00), rich site, average dbh 18 cm, average height 18 m, standing volume 123 m^3/ha.

Figure 3. Generative stand of good quality

Figure 4. Preparation of wood samples from a generative stand

Table 1. Characteristics of model trees from vegetative and generative propagation

Type of propagation	Number of a tree	Number of discs	dbh [cm]	Height of a crown [m]	Height of a tree [m]
Vegetative	1	3	10.6	15.3	19.3
Vegetative	2	3	9.4	17.5	21.0
Generative	1	3	10.6	17.0	22.3
Generative	2	3	9.4	15.2	19.8

Wood discs from three heights of every trunk were selected as every stem was divided into three equal logs. Then discs of 9 cm in height were transported and dried in the Laboratory of Wood Technology Institute in Poznan (fig. 5). After drying, the discs were cut into two parts: 5 cm and 3 cm in height. Lower discs were taken to Greece, when higher discs were left for further analysis.

Figure 5. Wood discs from two propagations

PART II. Wood testing with Lignostation

LIGNOSTATION™ is a compact, high-resolution system for preparing wood surfaces and recording the tree ring parameters and the wood density. LIGNOSTATION™, developed in cooperation with the University of Freiburg, is based on an entirely novel concept (RinnTech 2015).

A precision mill prepares the measuring radii on the wood surface. Then, precise scans are obtained using a high-frequency probe. At the same time, optical scans of the surface can be made and analyzed in comparison with the image. The entire system is computer-controlled (RinnTech 2015). The method is based on the propagation of continuous electromagnetic waves in a high-frequency (HF) transmitter-receiver link of an extremely small electrode system, which is in direct contact with the wood surface investigated (Schinker et a. 2003).

The measurement of alder discs were taken on northern radius from bark to pith. When any abnormalities in wood appeared (anatomical disturbances as wood rays or structure defects as small knots or secondary defects as cracks, checks) the path was corrected and set in wood without defects.

All works in Laboratory were provided in premises of Aristotle University of Thessaloniki, School of Forestry and Natural Environment, Laboratory of Forest Utilisation. The Head of the Department is professor Ioanis Barboutis. Direct co-operation was established with dr Petros Tsioras and dr Dimitrios Koutsianitis. The latter was responsible for all operations of Lignostation.

Initially, a calibration of the machine was needed. It appeared that it had been done at the first start-up of the apparatus and the recalibration was necessary. Two of alder discs were already examined and the density values were too high. The service of RinnTech company did a remote calibration. Results from two first discs were recalculated automatically and there was no need to measure them again. Alder is a diffuse-porous species where borders of annual rings are not very distinct. For better annual ring recognition the additional mill tracks were established. So at the beginning we started with one milling path and then switched to 4 paths/repetitions which gave a better smoothness of discs (fig. 6).

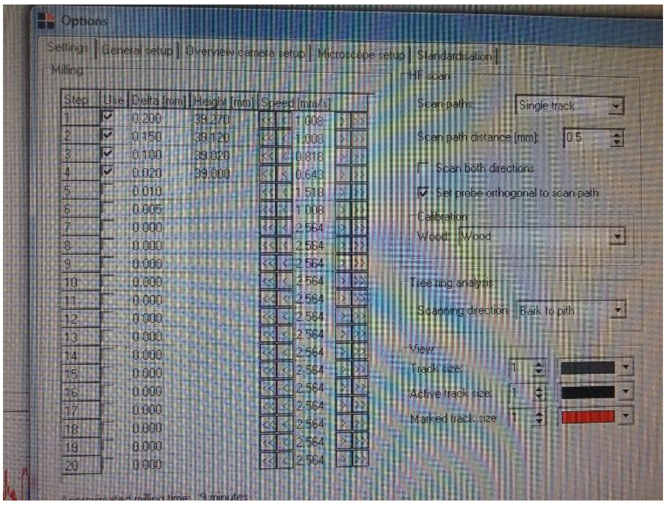

Figure 6. Set of milling paths

This gave a better image after a microscopic scanning and enhanced the accuracy of annual rings distinctions (fig. 7). Paths were set perpendicularly to the annual ring borders. When paths were set (usually 4-5 paths on each discs), the probe measured the density. The accuracy of measurement was 1/100 mm. The time of all operations done by Lignostation was about 35-45 minutes per sample, depending on the diameter of each wood disc.

At the beginning we started with discs from coppice trees (fig. 8). It appeared that automatic tree ring border detection must be corrected manually. This included, in most cases, the deleting of wrongly identified annual rings and the insertion of the actual annual ring borders. This correction was of substantial importance: For example, in sample C_1_1.3 (C – coppice, 1 – first tree, 1.3 – a height of disc) the disc automatic border detection calculated the age of the tree to be 104 years, while manual correction gave only 46 years. This fact justifies our choice to rely solely on manual marking of annual ring borders in all discs.

Figure 7. Microscopic scan of alder wood

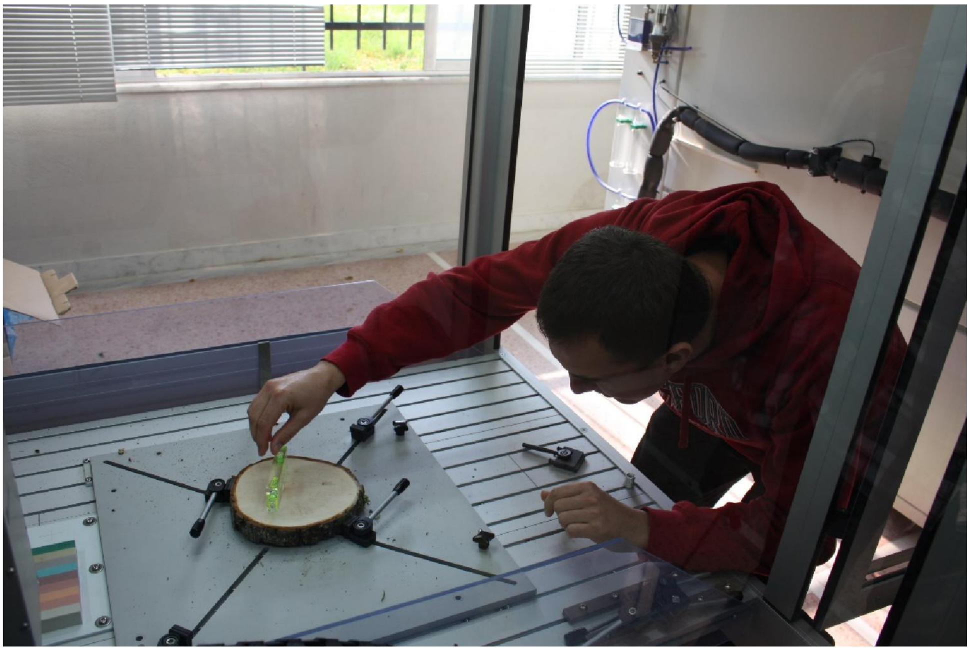

Figure 8. Attachment of a wood disc in Lignostation

Overview of collected data

For every examined disc a unique “project” was created in Lignostation software. After all operations the obtained results have been exported to csv file. For every ring the following data were gained:

- Ringwidth [1/100mm];
- Earlywood width [1/100mm];
- Latewood width [1/100mm];
- Minimum density [m^3/kg];
- Maximum density [m^3/kg];
- Mean earlywood density [m^3/kg];
- Mean latewood density [m^3/kg];
- Mean ring density [m^3/kg].

Table 2. Example of data set from the tree G_1_2

Ringwidth	Earlywood	Min density	Mean Earlywood Density	Latewood	Max density	Mean Latewood Density	Mean Ring Density
1/100mm	1/100mm	kg/m3	kg/m3	1/100mm	kg/m3	kg/m3	kg/m3
401	260	354	383	141	446	417	395
536	259	346	367	277	423	402	385
444	226	360	379	218	430	411	395
427	292	362	383	135	433	407	391
515	227	353	379	288	432	411	397
335	254	355	377	81	435	407	384
364	285	368	386	79	432	413	392
213	85	350	370	128	418	394	385
193	71	340	355	122	452	428	401
245	67	321	355	178	418	399	387
289	68	321	343	221	419	395	383
259	149	363	376	110	407	393	383
228	93	394	408	135	440	426	419
172	84	347	363	88	402	383	373
134	75	379	387	59	415	407	396
120	68	368	376	52	401	391	382
191	92	285	320	99	409	370	346
173	61	409	424	112	448	440	434
150	79	332	360	71	429	402	379

PART III. Field trip to University Forest of Taxiarchis

The University Forest spreads on the area of 5800 ha in the central part of Chalkidiki. This is a steep terrain 320-1625 m above sea level.

The Forest fulfills several functions. i.e provides and serves as: infrastructure for the practical training of students and for conducting the research, model forest for forest management and attractive are for touristic activity.

During field trip I visited a coppice oak forest with dr Petros A. Tsioras. The quality of the forest was good (fig. 9). There were stumps left after last early thinning with sprouts with signs of grazing done by game animals. Wood from the University Forest is mainly harvested and sold as a fuelwood.

Figure 9. Oak coppice forest

From this part of the Forest model trees for further wood density analysis will be selected.

Additional attraction of the field trip was a Forest Museum visiting, where specimens of the local flora and fauna are exhibited (fig. 10).

Figure 10. Wood samples of native tree species

Results based on the collected data

General results:

Density values ranged from 284 kg/m^3 to 447 kg/m^3 for coppice wood and from 303 kg/m^3 to 421 kg/m^3 for generative wood. At every examined height of a tree the mean density of coppice wood was lower than density of generative wood (tab. 3).

Table 3. Mean density values for coppice and generative wood

Propagation	Disc	Mean density [kg/m3]
Coppice	1	368
	2	362
	3	380
Generative	1	382
	2	385
	3	385

The biggest difference in density values in wood of two propagations have been on discs from the second log of trunks (discs no 2). The lowest difference in density has been identified in discs from top part of trunks – just 5 kg/m^3.

Mean density of coppice wood calculated from all discs was 370 kg/m^3, while from generative wood it was higher: 384 kg/m^3.

Detailed analysis of one coppice tree:

The density and the width of annual rings differed in 3 disc from a tree C_1 which has a vegetative propagation. The lower value of mean density was measured on the lowest wood disc which was cut from dbh height. The higher discs were cut from the stem, the bigger density values were (tab. 4).

The annual rings mean width from the tree C_1 ranged from 1.67 to 2.55 mm. The widest rings were calculated on the middle disc.

Table 4. Characteristics of the coppice tree C_1

Tree code	Disc code	Mean annual ring width [mm]	Mean density [kg/m^3]
C_1	C_1_1	184	360
	C_1_2	255	369
	C_1_3	167	395

The width of annual ring decreased in all discs from pith to bark as it was proved by regression analysis (fig. 11). For the discs following regression models were obtained:

C_1_1: Y= 269.562807 + 8.318016x - 0.691673 x^2 + 0.008875 x^3

Where:

Y is annual ring width,

x is a number of following annual ring from pith to bark.

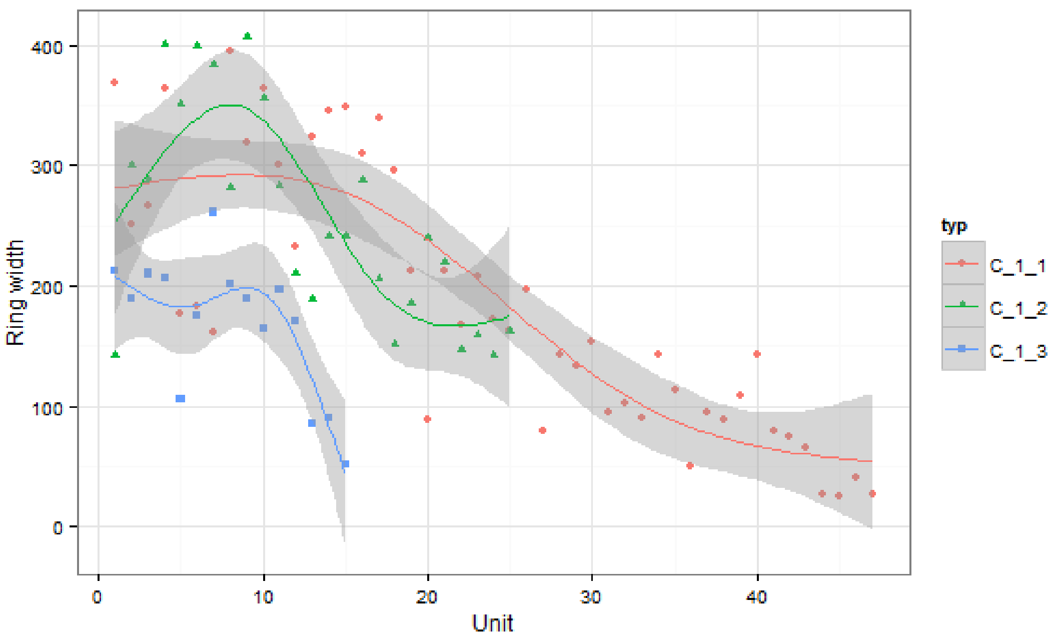

Figure 11. Change of annual rings width in time for three heights

Coefficient of determination for the model was R^2=0.7224.

C_1_2: Y= 175.29075 + 56.32679 x - 5.29883 x² + 0.12266 x³

Coefficient of determination for the model was R^2=0.6674.

C_1_3: Y= 232.2293 -26.8654 x + 4.8510 x² -0.2616 x³

Coefficient of determination for the model was R^2=0.6670.

Density values for C_1_1 differed at the whole wood section. For discs from upper heights a trend was observed: both rings near pith and rings near bark showed higher density, while wood from a middle zone was of lower density values (fig. 12).

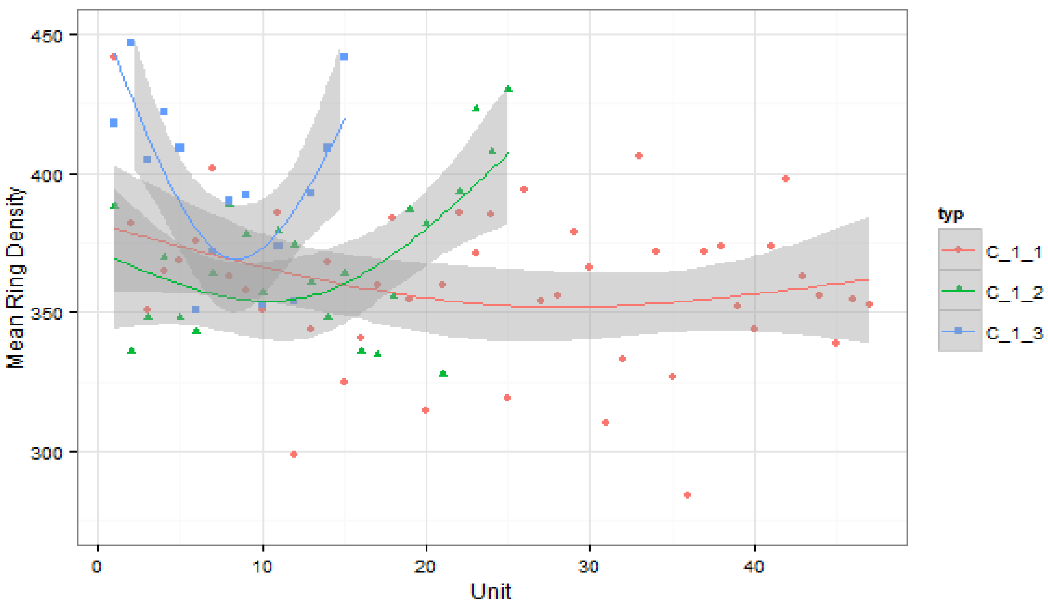

Figure 12. Ring density values from pith to bark

Conclusions

All aims of the STSM were gained. A collaboration with the Lab of Forest Utilisation and especially with Dr Petros A. Tsioras has been established. Additionally the visit gave me the opportunity to meet the facilities and other researchers from the Department and get informed about their scientific interests. There seems to be many common research fields of interest and it would be to the mutual benefits of our Institutes to continue and expand this cooperation in the future.

Learning the new method of density measurement with the Lignostation was a great experience. Advantages of the method in comparison with a well-known gravimetric method are as follows: higher accuracy of a measurement, it's a time saving method, a possibility of referring density results to annual rings, additional ring width data.

The obtained results are very promising. Their accuracy and interconnections of rings width with ring densities give a possibility for multiplied analysis. The preliminary data revealed different values of density in wood from two propagations. Wood from generative trees on the Northern radius of discs was more dense than wood from coppice trees. This observation was detected at all three heights which were taken into consideration during the STSM.

Detailed analyses of collected data will be discussed in the scientific paper to be submitted to Drewno Journal (www.drewno-wood.pl).

Recommendations

Lignostation will be used during a common research on Scots pine wood samples from different locations in the stand and during analysis of coppice wood from Greek forest (Tsioras – Karaszewski).

Literature

Schinker M., Hansen N., Spiecker H. 2003. High-frequency densitometry – a new method for the rapid evaluation of wood density variations. IAWA Journal 24: 231-239.

RINTECH.2015.online:29.11.2015.http://www.rinntech.de/content/view/30/51/lang,english/index.html

A declaration of acceptance of the report by the host institution (signature)

Herewith, I would like to verify and accept the report provided by Dr. Zbigniew Karaszewski. His STSM was a very fruitful one, with Dr Karaszewski as well the members of the Lab of Forest Utilisation AUTH cooperating in a very timely and precise manner, according to the initially submitted STSM work plan. His professional dedication and his exceptional human qualities make him a valuable candidate for future cooperation.

On behalf of the Host Institution

Dr Petros A. Tsioras

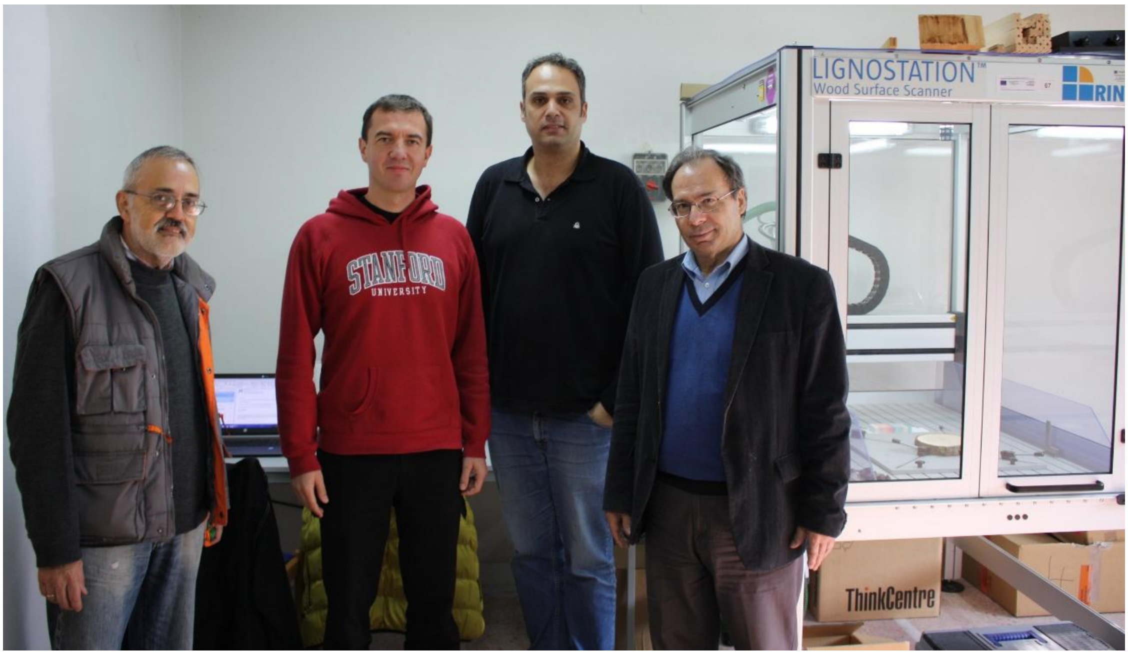

Figure 13. Representatives of Aristotle University and the STSM visitor.
From the left: prof. Ioanis Barboutis, dr Zbigniew Karaszewski, dr Petros A. Tsioras, prof. Elias Voulgaridis (fot. Dr Dimitrios Koutsianitis)