STSM under COST Action FP1203: European Non-Wood Forest Products (NWFPs)

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Purpose of the STSM;

The purpose of the RSTSM to Madrid was to carry out a first draft of a scientific paper dealing with methods to calculate leaf area in stone pine stands – from the leaf to the stand level. The main objective was to gather data in a database that would allow obtaining realistic estimates of leaf area by combining the dataset from Portuguese and Spanish field experiments using different approaches (harvesting, hemispherical photography, cone production).

Description of the work carried out during the RSTSM;

I started with a presentation of Portuguese data to INIA team members (Sven Mutke, Rafael Calama, Miren Del Rio and RicardoRuiz-Peinado) providing a description of the STSM objectives and a discussion of potential comparable data. In the following days the draft of the scientific paper was developed throughout meetings with the INIA supervisor (Sven Mutke). The Introduction and Material and Methods sections were partially written and some preliminary results were presented.

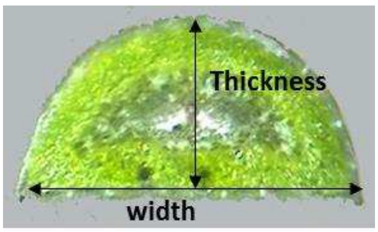
Description of the main results obtained;

Leaf area index (LAI) is an important ecophysiological parameter closely related with canopy photosynthesis and transpiration and therefore with vegetation gross primary productivity (GPP). LAI varies among years and seasons reflecting drought conditions and phenological events. Therefore, adequate estimation of LAI is essential as key input parameter in process-based ecosystem models such as 3PG and pipe-model based models. LAI can also bridge ground base productivity measurements with estimations from remotely sensed indexes (such as NDVI or greenness indexes) from satellite images, aerial photography's or LiDAR. There is a research gap in this subject for stone pine.

Management of stone pine stand requires successive thinning and pruning during stand life cycle in order to allow crown development free from neighbourhood tress competition and without light limitations. The goal is to achieve optimum growth and cone yield. The ecophysiological bases of this empirical knowledge must be investigated. This papers intends to model LAI from ground-based measurements and to study its relation to growth and cone productivity.

A short description of the preliminary results are presented below:

1) Specific leaf area in stone pine



We collected needles in different crown positions in a 10 years old stone pine stand. We found significant differences in needle morphology between needles according with their position in the crown, namely in widths, thickness and length. Sun exposed needles are thicker, wider and longer than shade needles ($p<0.001$). Needle geometry is important for accurate estimates of specific leaf area (SLA) calculations. SLA is defined as the ratio between needle surface area and needle dry biomass and is used to convert needle biomass in needle area. SLA was higher in the base and shaded needles with values of 121.1 ± 4 $cm^2.g^{-1}$ and lower in the top crown in sun exposed needles with 87.2 ± 2.2 $cm^2.g^{-1}$. Needles in the inner crown, either in the top or in the base, showed no differences for SLA with

107.1 ± 2.5 and 104.0 ± 2.8 $cm^2.g^{-1}$, respectively. Needle surface area can be accurately predicted using a simple formula described below. This method was compared with geometrically detailed-based measurements of needle surface area, with an error of less than 6%.

Needle surface area (mm) = $0.762*(W_{50\%}+W_{80\%})*l$, where $W_{50\%}$ is needle width at 50% and 80%($W_{80\%}$) of needle length (l) (all in mm).

2) Needle biomass equations

We gathered a database with 103 stone pine trees with information regarding needle biomass measured trough tree harvesting. The trees were collected in Portuguese stands near Lisbon and in Spanish stands in Valladolid region. A preliminary analysis shows that stone pine needle biomass can be predicted by a non linear model using diameter at breast height (d) as an independent variable (R^2=0.81) (Fig. 1). Portuguese trees showed higher needle biomass heterogeneity within the same d class. This may be related with management and its influence in tree competition status within the stand. It was also found a high variability between trees from lower diameter classes which is related with sampled trees that were never pruned. This case requires specific analysis.

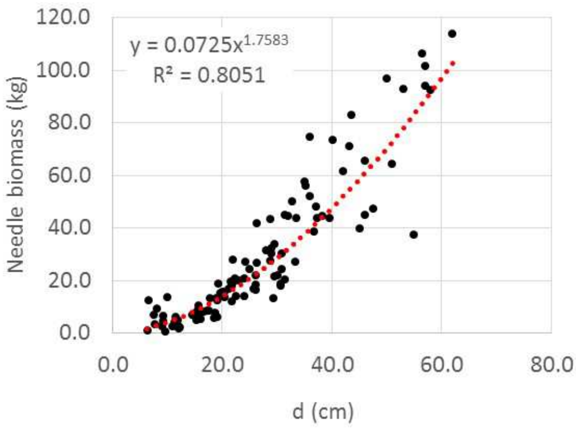


Figure 1 – Needle biomass plotted with diameter at breast height (d). The trend line represents the non-linear correlation between d and needle biomass with an R^2 of 0.81.

Additional 15 trees from Portuguese stands will be added to this database as a result of an ongoing collaboration. Preliminary results highlight that: 1) there is a biomass alometric homogeneity in stone pine trees from contrasting ecological regions, 2) a set of biomass models for stone pine can be built in a broad regional scale (e.g. Iberian).

3) Hemispherical photography

We used a compact camera Nikon CoolPix 4500, equipped with the FC-E8 fish-eye lens converter to take pictures of individual stone pine crowns. A total of 10 trees with d between 7.4 and 20.4 cm were used in this analysis. Two pictures per tree were taken in the base of the crown under uniform overcast sky conditions which were then processed in a image software to delete woody tissues (trunk and big branches) from the analysis. The Hemiview software package was used for pictures processing and for leaf area estimation at the tree level. Preliminary results show that Leaf area estimated indirectly with Hemiview is positive and statistically coorelated with the leaf area measured by destructive sampling. Hemispherical photography´s can be used to estimate tree-level leaf area (Fig. 3) but with some precautions: 1) the tree crown needs to be clearly distinguished from the neighborhood trees, 2) a correction function needs to be applied due to leaf area underestimations from hemispherical photography's.

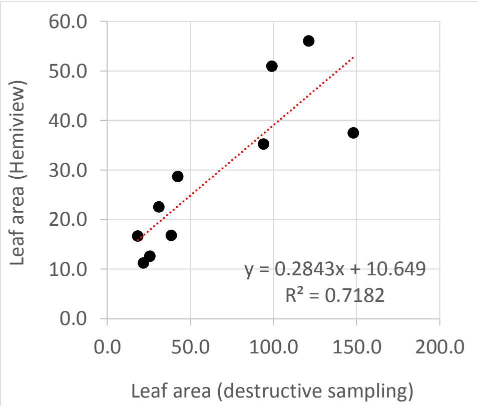


Figure 3 – Leaf area estimated with Hemiview versus leaf area measured trough destructive sampling. The trend line represents the linear correlation between the variables.

4) Leaf area index (LAI) and cone production

Leaf area index (LAI), that is the ratio between total tree leaf area and stand area, was plotted with average stand cone production (in kg DM/tree) for Portuguese stands. We observed that maximum cone production occurs within a LAI threshold between 0.4 and 0.6 irrespective of the crop year (Fig. 3). There is an optimum boundary tree density for cone production inferred by leaf area index. This result is somewhat consistent with previous findings for maximum cone production occurring at a basal area of 12 m^2/ m^2. We conclude that there is the potential to use remotely sensed indexes like NDVI or LIDAR as a supplementary tool for tracking stand productivity changes at a higher temporal scale over large regional areas. This research field can eventually help in the management decision process of stone pine stands.

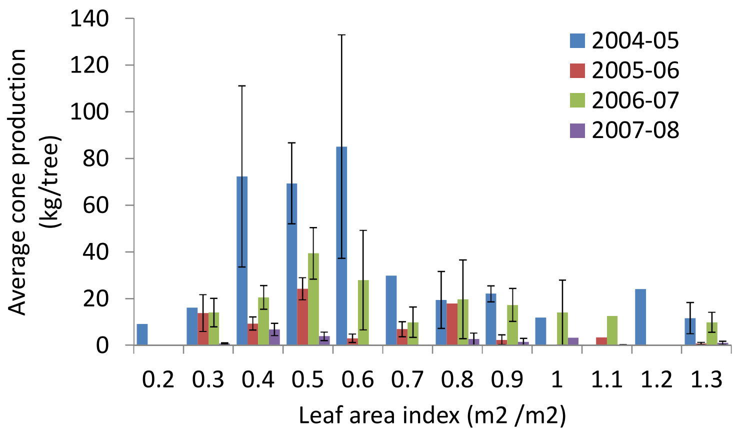


Figure 3 – Leaf area index estimated at the stand area using cone production from Portuguese stands.

Future collaboration with the host institution (if applicable);

The goal is to publish this paper by the end of 2014 and also to submit a presentation (oral or poster) in the Medpine conference in September (http://medpine5.ctfc.es/) with the work developed (already submitted as a preliminary version).