Portuguese Maple Syrup? Assess the theoretical conditions and installing experimental plots for the production of Tree Sap from the natives Maple (*Acer pseudoplatanus*) and Birch (*Betula pubescens*) species

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Motivation

Tree Sap, a Non-Wood Forest Product yet to be explored in Portugal, is a sweet liquid consumed either raw, as syrup or fermented that can exude from certain trees. Two commonly reported species for production are native in Portugal – *Betula pubescens* and *Acer pseudoplatanus* (Svanberg et al. 2012). Sap exudation is a complex mechanism that requires a daily inversion of night-time negative air temperature to daytime air temperature (Cirelli et al. 2008), therefore is more common on northern latitudes and higher elevation quotas. Sap exudation resembles resin tapping, as it requires incisions or holes carved on the tree trunk.

If viable, tree sap could raise the silvicultural interest for these two species in mountainous areas; both are deciduous, therefore favoured for reforestation by law (DL No. 82/2021, Art. 44(5)).

To assess its productivity, the climate conditions must be carefully analyzed to understand the patterns of a sap season in Portugal. Additionally, Species Distribution Models (SDM) will be developed to compare the current and potential distribution ranges of each species. This knowledge is crucial to succeed in the next step: experimental trials of tree sap production in Portugal in 2024/2025.

Materials and Methods

To evaluate the climate suitability, satellite data will be used to analyze the time periods where the right conditions are met for sap production to, according to the literature: 24h of production after a day with minimum temperature (Tmin) < -1.1 ºC and maximum temperature (Tmax) > 2.2 ºC (Skinner, DeGaetano and Chabot, 2010); to prevent spoiling and sap hole clogging, no periods of Tmax < 15.6 ºC should occur (Perkins *et al.*, 2022). In a given area and during a given year, it is not problematic if Tmin fluctuates above the threshold (-1.1. ºC), but it is critical not to be hit by high Tmax (> 15.6 ºC), as it may cease the production altogether.

The satellite data from ERA5-Land Reanalysis is available hourly for the period 1950-2024, and we plan to process the data first to daily data, then generate new variables according to the thresholds, and verify the time of the year that these occur. The data is available through Climate Data Store's API, to be downloaded using Python, along with subsequent processing. The final results will be visualized using QGIS.

For the Species Distribution Models, current populations will be assessed through both GBIF and National Forest Inventory's data. In combination with abiotic variables, a Species Distribution Model (SDM) will be fit to each species, using a similar methodology from (Roces-Díaz *et al.*, 2014), which developed General Linear Models and selected the most parcimonious using Wald's backward stepwise method; this will be performed using RStudio's package 'maxnet' (Phillips *et al.*, 2017).

The climate analysis, along with the current and potential species' distributions will be essential to select populations for the experimental trials, as well as to increase the chances of positive trial results, as correctly timing the climate conditions is very important.

Early Results

Using a portion of the ERA5-Land data for 2016-2020 readily available in the form of raster and as weekly, some early results were achieved. The summary results were separated in two periods: 'Sap Season 1' is from October 1st to January 15th, and 'Sap Season 2' is from January 15th to May 1st (Figure 1).

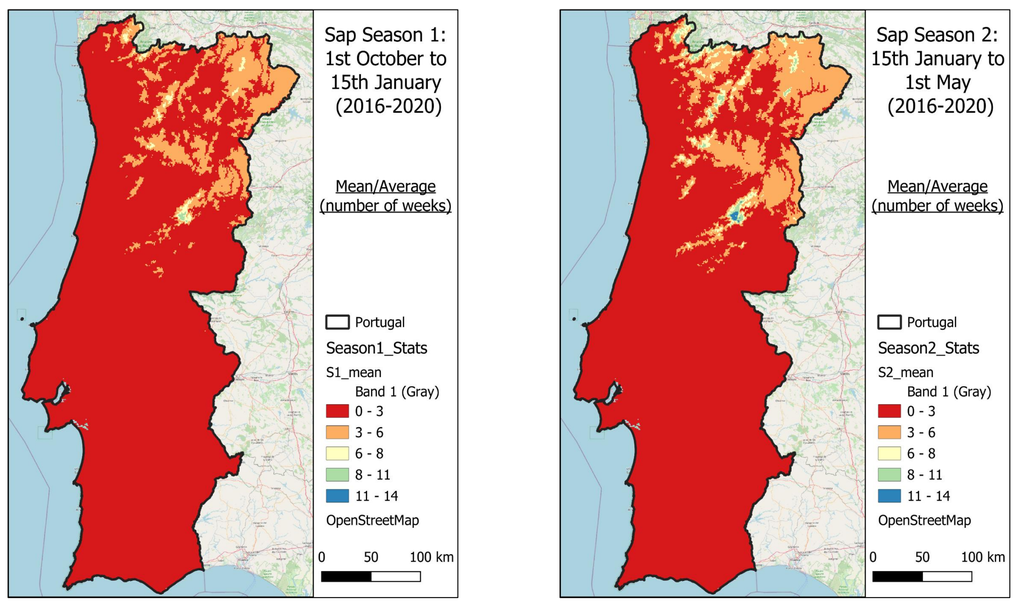

Figure 1 – Maps representing the number of weeks, in the period 2016-2020 in which the weekly minimum and maximum temperature (from ERA5-Land) surpassed the thresholds for sap production, on average. The map on the left represents the weeks between 1st October to 15th January (Sap Season 1) and the map on the right represents the weeks between 15th January to 1st May.

The number of weeks is overall higher in the 'Sap Season 2'. With some areas having above 8 annual weeks of compatible weather – the literature reports an expect window of production of 4-8 weeks (Perkins et al., 2022). However, the corresponding amplitude and standard deviation is very high (Figure 2), which represents a challenge for the experimentation trial.

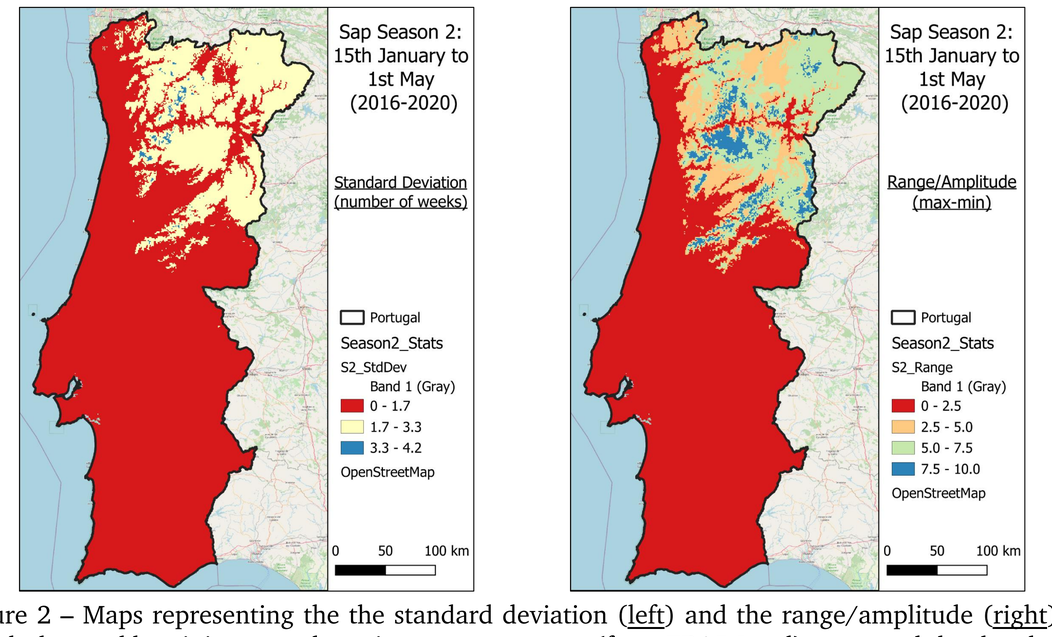

Figure 2 – Maps representing the the standard deviation (left) and the range/amplitude (right) in which the weekly minimum and maximum temperature (from ERA5-Land) surpassed the thresholds for sap production, on average, during the 'Sap Season 2' (January 15th-May 1st).

Drawn Conclusions

The early results of the climate analysis for the period of 2016-2020 show that some areas on northern Portugal (in mountain ranges) have a higher number of weeks with compatible climate conditions. However, these conditions seem to highly vary interannually, which will prove to be a challenge for the experimental trials. Further analysis is required to analyze this pattern on a longer time-frame (at most 1950-2024, per data available).

As a side note: Two forestry entities with mature stands of the selected species – which are uncommon – have shown their openness to set experimental plots: i) Agrupamento de Baldios Estrela Sul, a common's land association in Serra da Estrela; ii) Laboratório Rural, a project in Paredes de Coura with a network of communities and several iberian universities, including my host institution – Instituto Superior de Agronomia.

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