

**THE EFFECT OF ALTITUDE ON THE STRUCTURE OF
ALEPPO PINE TREES IN THE CHETTABA FOREST
(ALGERIA)**

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ABSTRACT

Knowledge of vegetation characteristics is necessary for the management of disturbed areas. The aim of this study was to investigate the effect of elevation on tree structure in Aleppo pine spatial systems in the Chettaba forest, located in northeastern Algeria. An inventory of trees of *P. halepensis* forest formations was conducted based on dendrometric parameters (tree diameter and height) which were measured on 4 plots (30 m × 30 m). The results obtained showed that the average height varies from 7.79 cm to 9.71 cm, while the average diameter appears from 24.39 cm to 30.61 cm, respectively. The height-diameter relationship of the trees varies with the altitude horizons (774 m to 1023 m). The Weibull theoretical distribution was used to characterize stand structure, due to its flexibility and the wide variability of distribution shapes it produces. Management measures, such as full protection of forest relics, will have to be implemented.

Keywords: *Structure, Altitude, Aleppo pine, Dendrometric characteristics*

INTRODUCTION

Among the useful forest species recorded in Algeria, *Pinus halepensis* has a very wide geographical distribution, covering more than 850.000 hectares [1]. This species, which is present in all bioclimatic stages from the coast to the Saharan Atlas, finds its optimum growth mainly in semi-arid zones [2]. Its plasticity and robust temperament enable it to withstand drought and high temperatures. Thus, its great capacity for survival on poor and much-degraded soils permits a very heterogeneous spatial distribution according to bioclimatic stages. The spatial structure of tree species appears to be a determining factor in their regeneration, growth, resource use, and mortality processes [3]. Indeed, it helps to detect the local environment of each individual and consequently, through the processes of competition, its capacity to develop and grow, or its probability of exclusion [4]. Stand structure and biodiversity are two important and interrelated ecological and functional features of the forest ecosystem [5]. Tree diameter structure, density, basal area and height are influenced by environmental factors, such as altitude, slope, light [6], land use types or vegetation formations [7]. Therefore, the analysis of vegetation structure and variability are indicators for testing the ecological theory of ecosystem functioning [8] and understanding its dynamics.

The target of this research is to characterize the effect of altitude variation on structure of *Pinus halepensis* populations of Chettaba forest.

MATERIAL AND METHODS

Presentation of the study area

Forest of Chettaba is located southwest of Constantine (Algeria). The estimated terrain elevation above sea level is 865 meters. The study area is located on the map topographic Constantine Scale 1/200 000 sheet N° 17 and located between the coordinates 36°19'4" north latitude and 6°28'36" East longitude. The forest of Chettaba spreads over an area of 2398 ha and 94a, and is perfectly limited and divided into six districts. Extreme altitudes of the forest is about 1104 m (maximum altitude) and 652 m (minimum altitude), corresponding to each of them respectively following map coordinates: (x = 839, y = 344), (x ' = 839.9, y' = 340.3). Its bioclimatic is semi-arid to sub-humid. The average annual rainfall is estimated between 670 and 800 mm and the mean annual temperature of the region is 18°C, with an average of the warmest month above 35°C and the coldest month varies between 1.25 and 3.05°C. A large plant grouping as the forest of Chettaba can be studied in its entirety, especially when it concerns hundreds of acres to be treated in the detail (Fig. 1).

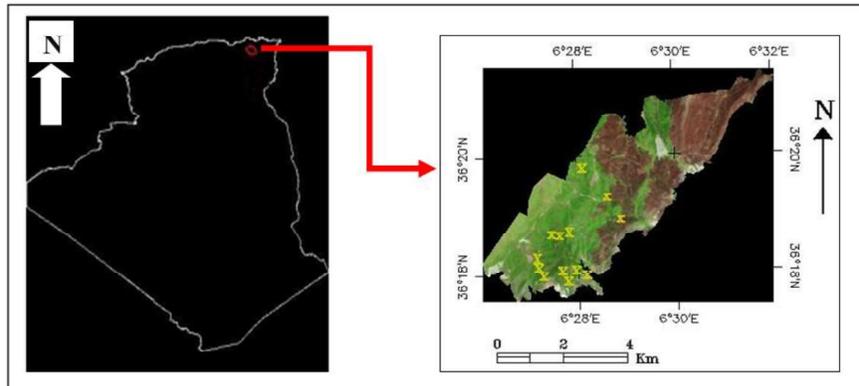


Fig. 1. The map of study area.

Dendrometric parameters

Dendrometric data collection inventory and description of the stands are a prerequisite for any successful forest management and silvicultural planning. We are interested in achieving this inventory to highlight the structure. The structure of the stand is defined as the manner in which these are arranged dendrometric variables. The tree inventory was conducted in each plot. Dendrometric measurements are:

- The circumference (C) at 1.30 m is estimated with a tape measure.
- The total tree height (H) measured with the "Smartphone".

Data processing and analysis

The data obtained were entered into the Excel spreadsheet, which allowed us to determine the ecological characteristics and structure of the natural of Aleppo pine population.

- The density (N) or number of individuals per hectare.
- Basal area (G in m²/ha).
- The total volume (V) depends on the basal area and the height of the individuals.

RESULTS AND DISCUSSION

In general, the dendrometric parameters of *P. halepensis* vary significantly ($P < 0.0001$) with the altitudinal gradient. The relative density of the stand is too high in plot P4 with 267 individuals/ha, whereas plot P1 shows a very low abundance with 78 individuals/ha. The basal area and total volume of *P. halepensis* are significantly different between the four plots; plot P2 has the highest average of 1.35m²/ha and 12.53m³/ha respectively. The smallest diameter is observed in plot P2 (25.65cm) (Tab. 1).

Table1. *Principal dendrometric characteristics.*

Altitude (m)	N/ha	D (cm)	H (m)	G (m ²)	V (m ³)
P1 (774)	78	30.61	9.03	0.76	6.86
P2 (834)	267	25.65	9.28	1.35	12.53
P3 (959)	167	28.68	7.79	1.02	7.79
P4 (1023)	267	24.39	9.71	1.24	12.04

The distribution of trees in diameter classes shows a different situation depending on the altitudes (Fig. 2). For each stand and each population concerned, tree diameter or height data were used to estimate the parameters a, b and c using the maximum likelihood method available in MINITAB (2018). The Weibull distribution can take several forms depending on the value of the shape parameter c. A very highly significant difference between the diameter classes in terms of their frequencies is noted in the diameter structure of different plots. This is quite obvious since in such a structure young individuals are clearly more frequent than mature ones [9]. In Figure 2, the distribution is right asymmetric or positive asymmetric, characteristic of monospecific stands with a predominance of young or small diameter individuals in plots 2 and 4; whereas the distribution is left asymmetric or negative asymmetric, characteristic of monospecific stands with a predominance of old or large diameter individuals in plots 1 and 3.

By analysing the height structure of 4 forest plots, it can be seen that the height distribution is in the form of an "inverted J", characteristic of multispecies or uneven-aged stands in plot 2. The shape parameter varies from 1.40 in plot 4 to 2.53 in plot 3; the diameter distribution for *P. halepensis* shows a negative exponential shape (Fig. 3), an "inverted J" and a straight skewness. The negative or left-skewed distribution in plot 1 is characteristic of monospecific stands with a predominance

of older individuals. Trees with a height of 4 to 8 m are the most numerous per hectare. Trees taller than 36 m are poorly represented in the different plots.

Fig. 2. Diameter structure of Aleppo pine stands.

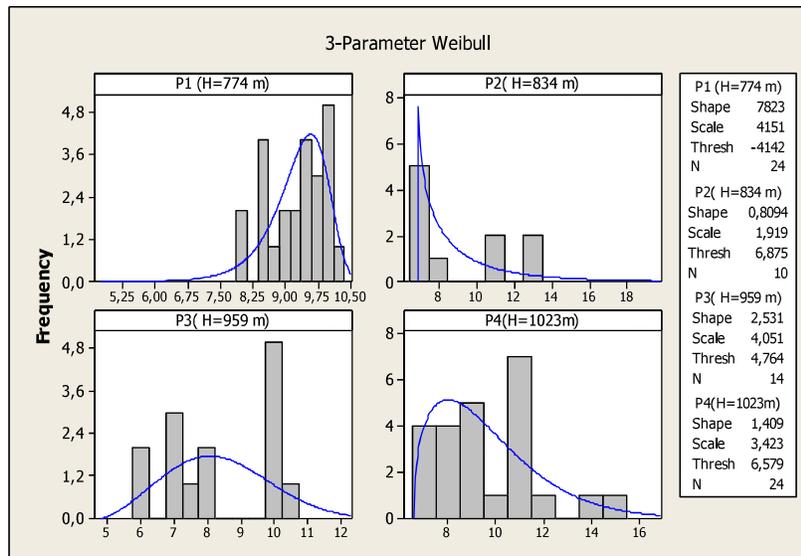
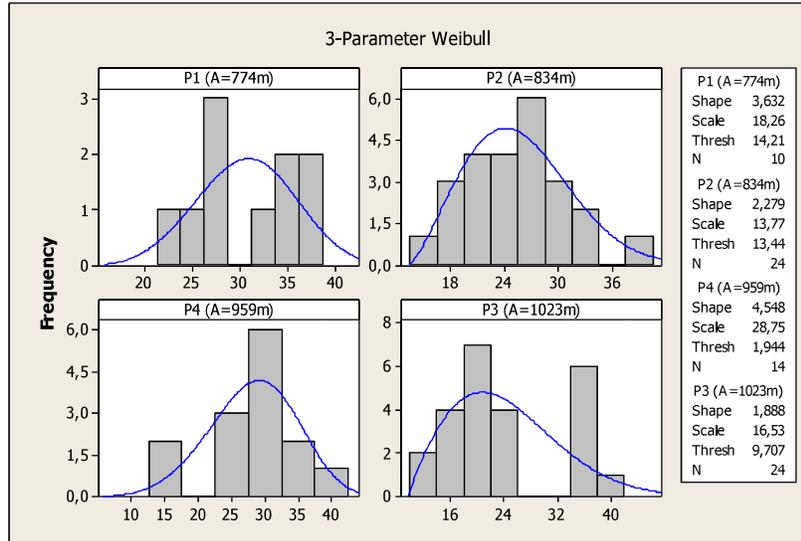


Fig. 3. Height structure of Aleppo pine stands.

CONCLUSION

The present study allowed for the structural characterisation of Aleppo pine in relation to the altitude of the Chettaba forest. The results revealed that the forest is still in an evolutionary dynamic but is under some selective pressure, especially from anthropic action and summer fires. This means that conservation strategies should be more oriented towards target species groups to ensure the conservation of the biological diversity of this forest. The structural variability of the vegetation of the Chettaba forest is evident and becomes more and more pronounced with increasing altitude. This variability should be taken into account when trying to understand the functioning of this ecosystem, especially its role in the accumulation of above-ground woody biomass, in order to mitigate the negative effects of climate change. But also with the aim of improving their management and development system.

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