Structure and Biophysical Variable of Mediterranean Aleppo Pine Forest: Case of Boutaleb Forest (North East of Algeria)

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ABSTRACT— Boutaleb forest is one of mediterranean forest which located in the North east of Algeria in the province of Setif, and characterize by a very important specific diversity belongs to three types of formations: Aleppo pine, Holm oak and Atlas cedar. The objective of this work is to study the sanitary state, describe the structure and biophysical characteristics of the trees of *Pinus halepensis* Mill in their naturel and wooded states. The dendrometric measurements and the DEPEFEU protocol, on two sample plots of 900m² of Aleppo pine were carried out. The results obtained show that this species is more developed in the wooded state than in the natural state and some signs of deterioration were presents which requires a silvicultural intervention to improve the health status of the damaged species.

KEYWORDS: Boutaleb forest, dendrometric, sanitary state, *Pinus halepensis* Mill, DEPEFEU protocol.

1. Introduction

Aleppo Pine is one of the most characteristic species of the Mediterranean Basin, particularly the western part [1]. In eastern Mediterranean, populations often are scattered and relic [2], with a total forest cover estimated to attain 2.5 million ha [3]. The diversity in climate conditions and ecological settings across the Mediterranean Basin could favor growth plasticity in response to the climate of widespread tree species such as Aleppo Pine (*Pinus halepensis* Mill.). However, the Mediterranean basin is a climate-warming hotspot where aridification trends have increased since 1980s, and has a negative impact on forest productivity and radial growth of some tree species [4].

In Algeria, *Pinus halepensis* Mill represents the first forest species in terms of area with 881,000 ha corresponding to 21% of the principal forest types [5]. It is found both in coastal and inland areas. Its plasticity has been reported for various aspects including warming-induced drought stress [6]. This species is located largely in the eastern and central regions of the country, mainly on the Tellian and Saharan Atlas. The main forests are distributed on the ridges of the Saharan Atlas between 1000 and 1500 m altitude [7].

Boutaleb forest has experienced an increase by 32 % in the wooded area of Aleppo pine, to the detriment of

those of holm oak (*Quercus rotundifolia* Lam) and Atlas cedar (*Cedrus atlantica* Mannetti). This can be explained by the fact that the Aleppo pine is a colonizing species [8]. The vegetation of this massif is very noticeable by the imprint of man, his daily and seasonal activities and also fire. Aleppo pine is a flammable species, frequently affected by wildfires, characterized by a high stand density and a continuous presence of branches along the stem [9]. Pine forests have a high resilience to fire, but their regeneration process might fail when fire recurrence is high. However, the characterization of Aleppo pine forest in Boutaleb forest has been less analyse. In this case our study is to estimate the dendrological variables at Aleppo pine forest in both of the natural state and the wooded state, by studying the biophysical characteristics (diameter, total height, diameter of the crown...) and to make a precise diagnosis which aims at drawing up and evaluating the sanitary state of this plant formation.

2. Material and methods

2.1 Study area

Boutaleb forest is located between the Setif high plains and the Hodna bassin [10], constituting a link between them. It belongs administratively to the district of Ain Oulmene, and occupies the djebel Boutaleb, one of the principal mountains of the Eastern slope of the chains of Hodna [11]. It covers 28,427 ha and peaks at 1886 m [10]. Three main plant formations are found in the massif: the cedar forest, the holm oak and the Aleppo pine forests with their different states depending on their history in the region [12].

From a climatic point of view, this region is characterized, at low altitudes, by a semi-arid bioclimatic stage (with cool winter in the north and cold in the south) and, at high altitudes, sub-humid (with very cold winter). The dry season is longer at lower altitudes, where it can last five months; on the other hand, at high altitudes, it does not exceed three months [11].

The state forest of Boutaleb is located between six communes of Setif: Rasfa, Ain Azel, Boutaleb, Al Hamma and Saleh Bey, and also the commune of Gosbet of the province of Batna, as well as the commune of Magra of the province of M'Sila (fig. 1)
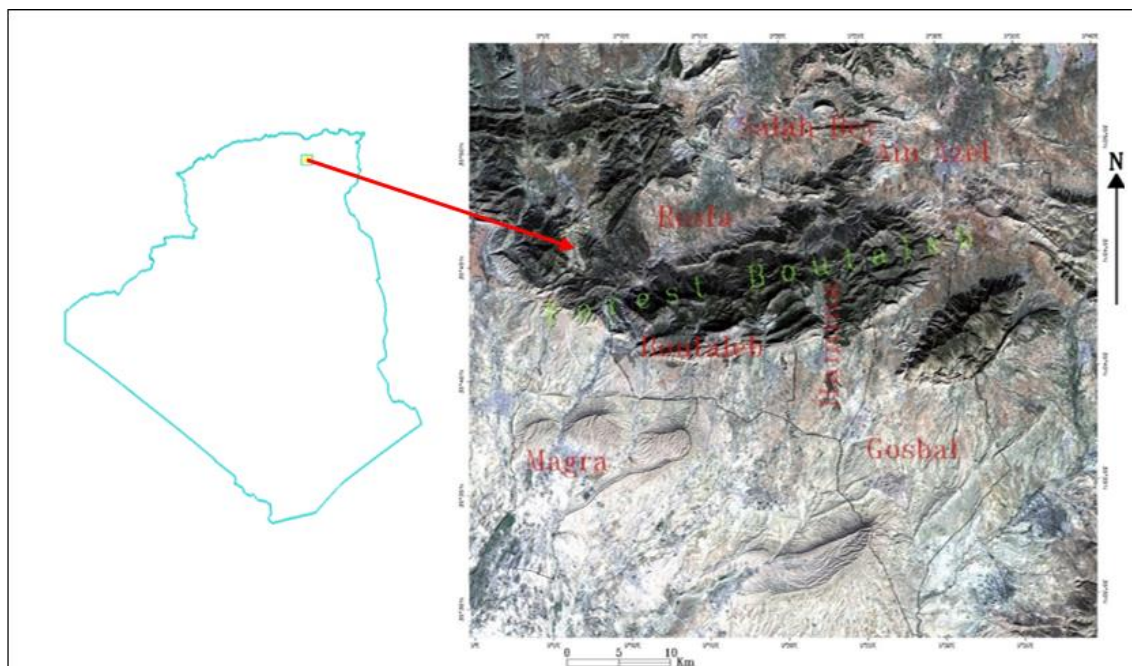
Figure 1: Study area location over natural color composition map obtained from Landsat 8 satellite

processed with ENVI 5.1 software.

2.2 Methodology

A measurement of the dendrometric parameters (circumference at 1.30 m from the ground, the height of the trees, the width of the crown) and a diagnosis of the sanitary state of the trees, by applying the DEPEFEU method [13], were carried out in Boutaleb forest on June 2022.

The diagnosis of the sanitary state of the trees consists of:
- A visual inspection, from the foot of the tree, of the different structures (root a visual inspection, from the foot of the tree, of the different structures (root starts and visible roots, collar, carpenters, crown).
- Identification of parasites or pathogens infesting the tree.
- Evaluation of the risk (fall, breakage) and the expectation of maintaining in safe condition.
Two plots with an equivalent area of 900m² were chosen (tab. 01)

Table 1. Plots localization

Plot	Geographic coordinates	
	Latitude	Longitude
P1 Efssir	N : 35° 43' 57.97 "	E : 5° 21' 41.11"
P2 Dar el baida	N : 35° 41' 10.57"	E : 5° 10' 6.04 "

3. Results and discussion

Aleppo pine formation in Boutaleb forest is located at 900 m and can go up to 1400-1600 m. It is in two forms: natural and wooded formation

3.1 Trees density distribution

The comparison between the two plots shows that the number trees of Aleppo pine is more important in the wooded plot than in natural state (fig. 2).
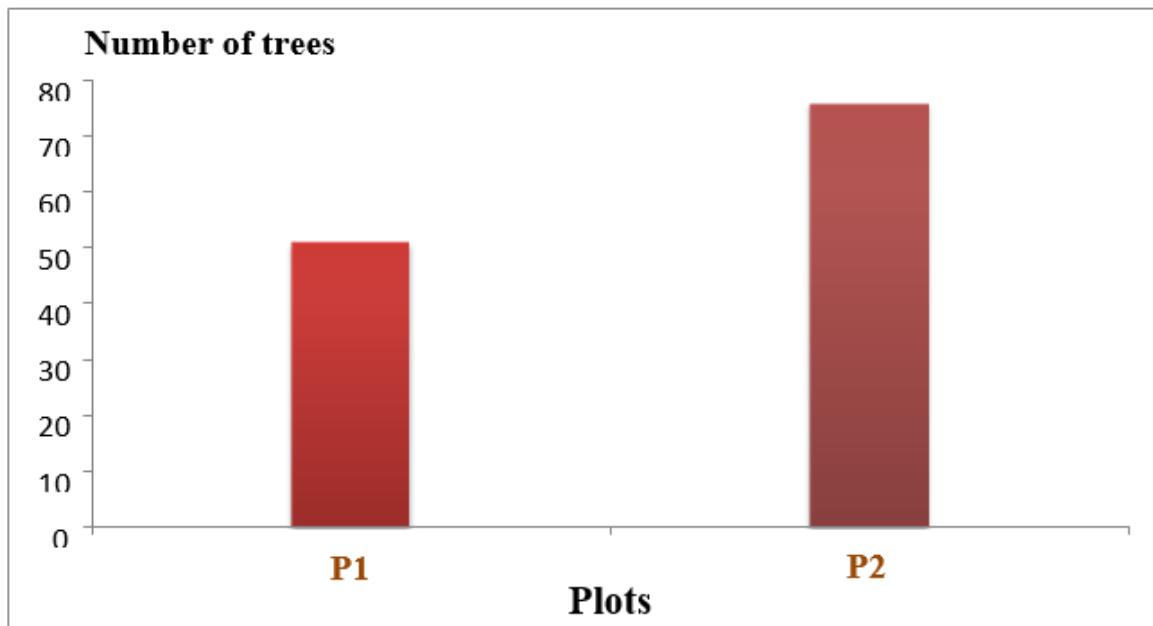
Figure 2: Distribution of the number of Aleppo pine trees according to the stations in the Boutaleb forest.

The average density is higher in the second station, due to the location and the type of forest (mono species), while the first station is a natural mixed forest (*Pinus halepinsis*, *Quercus suber* and *Juniperus oxycedrus*).

3.2 Analysis of the dendrometric characteristics of Aleppo pine trees
3.2.1 Distribution of tree circumferences
The knowledge of the distribution of stems by circumference classes constitutes for the forest manager a very precious tool, which facilitates the forecasting of the different silvicultural interventions as well as the harvested volumes [14].

The comparison between the two plots allows us to note that the diameters of the trees feet of the wooded plot is more important compared to the natural plot. This is justified by the competition of the other species (fig. 3).
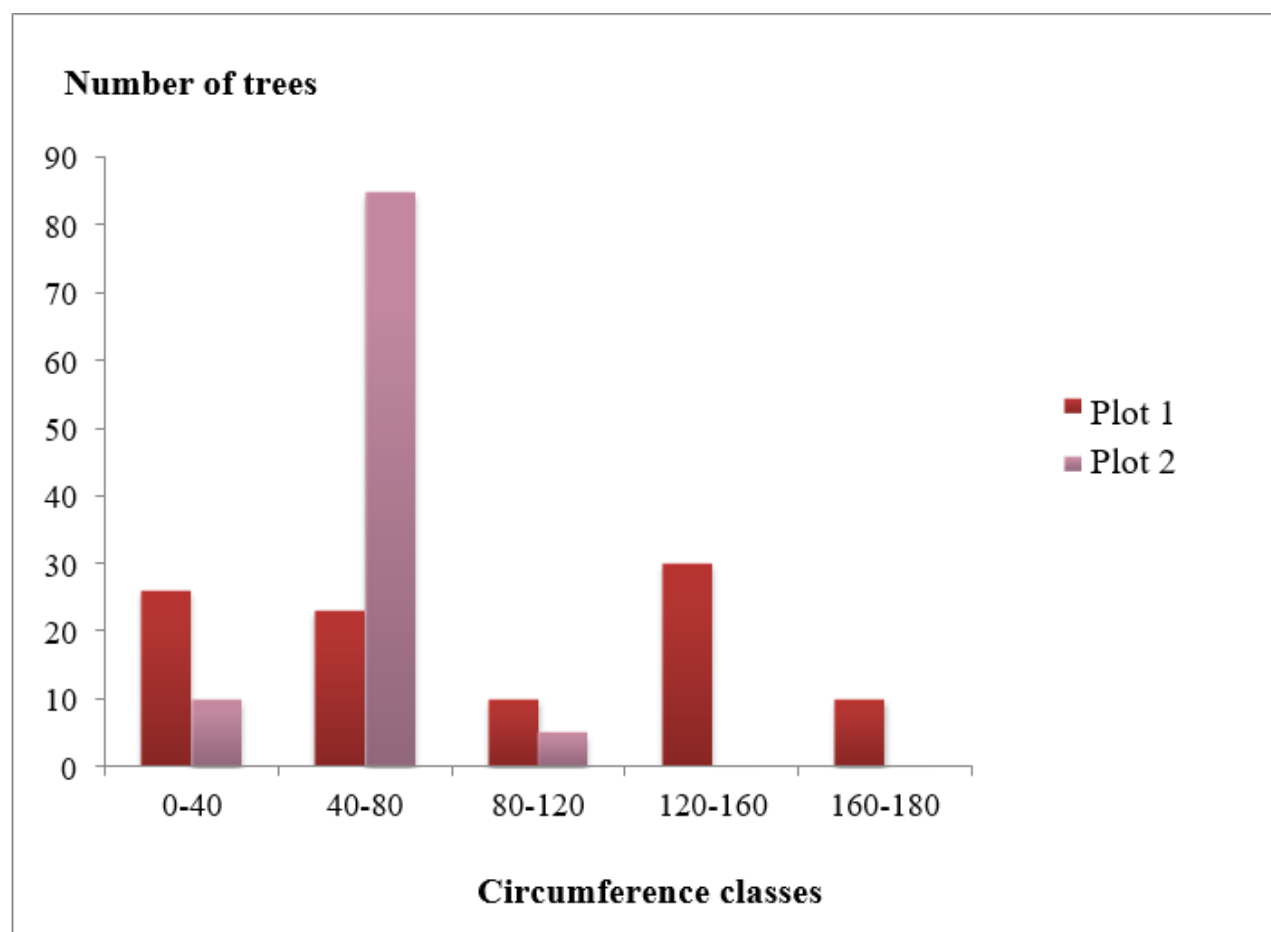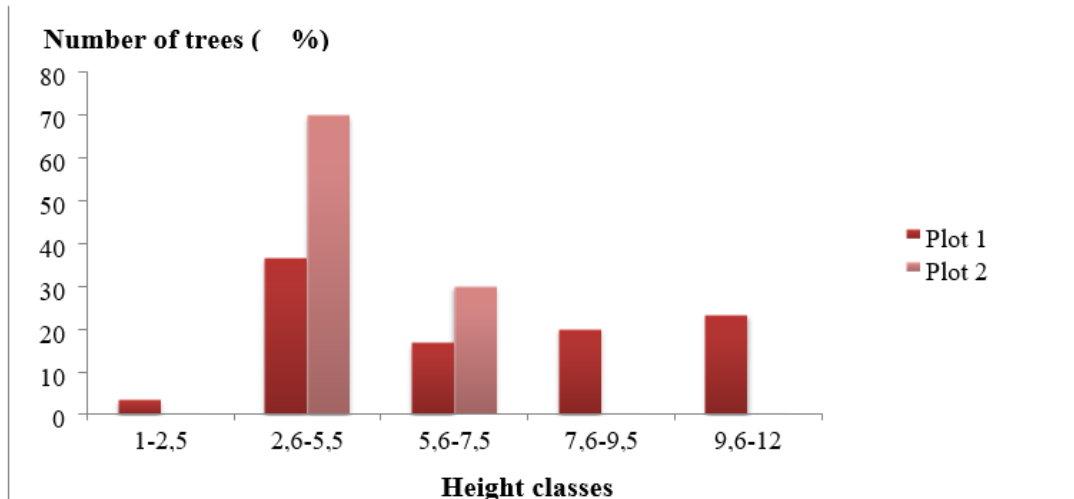

Figure 2: Frequency distribution of the number of trees by circumference class in the Boutaleb forest.

3.2.2 Height distribution of Aleppo pine trees
The height is one of the most important parameters used to estimate the growth of species.

The results obtained on the measurements of the average total height of the trees in the two plots studied show that class 2 (2.6 -5.5 m) is the dominant class with a rate varying between 36.66 % and 70 %. The first plot shows the dominance of the highest heights (23.33%) up to 12 m (fig. 3).

Number of trees (%)

Figure 3: Frequency distribution of the number of trees by height class of Boutaleb forest.

3.2.3 Characteristics of the crown of Aleppo pine trees

Tree crowns and their leaf traits are the engines of tree growth [15]. Determining the biological potential for crown width is needed for estimating stand-level metrics of density, such as crown competition factor (CCF), it can also be used to calculate stand canopy closure, which is important for assessing wildlife habitat suitability, fire risk, and understory light conditions for regeneration [16].

From the help of the shadow projection of the crown on the ground, the crown width of the trees in both plots is determined. The measurement results indicate that the second plot is marked by the dominance of the crown width class between 2.1 and 3.8 m (75%), while the highest values (class of 7.4-9m) are recorded in the first plot with a rate of 16.66% (fig. 4).
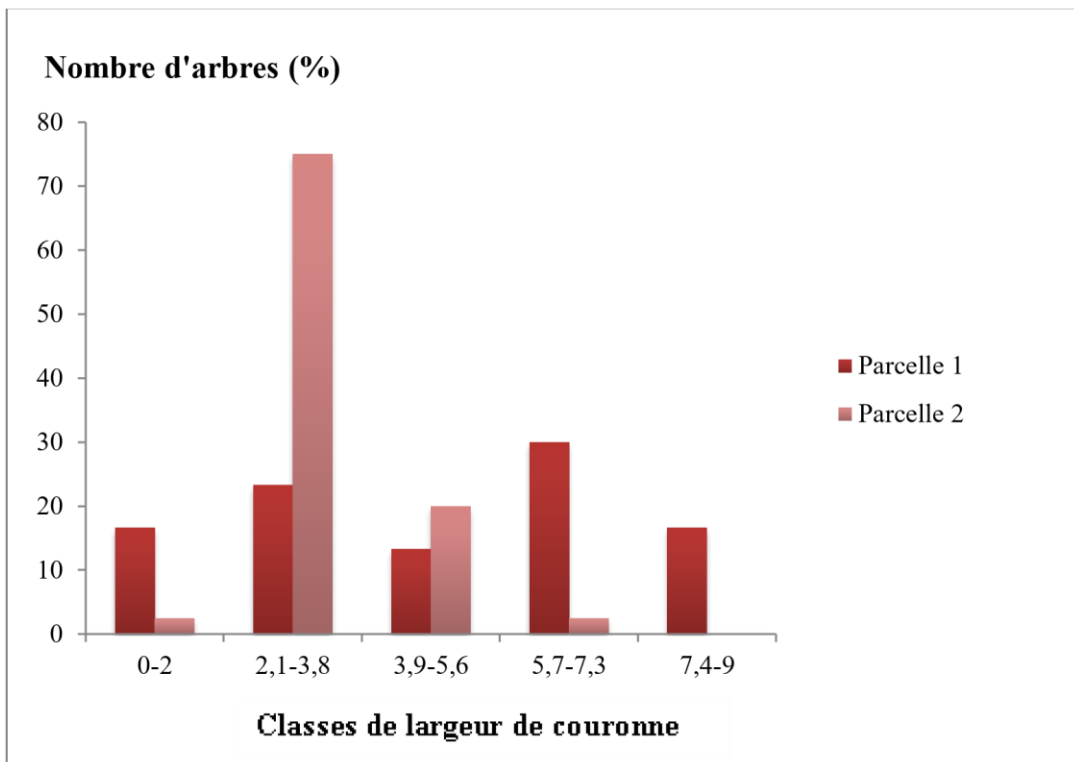
Figure 4: Distribution of the width classes of the crown of Aleppo pine trees according to the plots in the
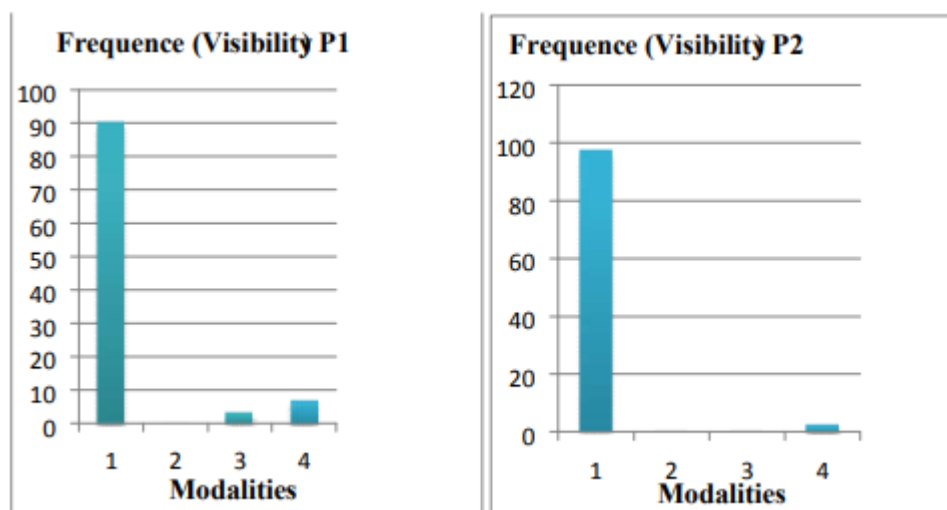
Boutaleb forest.

3.2.4 Evaluation of the sanitary state of Aleppo pine trees

Diagnostic method of the sanitary state is based on visual observations; the result is strongly influenced by the appreciation and the experience of the observer. The objective is to evaluate different criteria such as defoliation, discoloration, fruiting, damage and symptoms in order to estimate the vitality of the tree.

Visibility

Visibility is a limiting factor and a source of error for the characterization of the crown. In fact, when the visibility of the crown is reduced because of competing, the observable portion is extrapolated to the whole crown. In some cases of non-visibility, observers refrained from making any ratings defoliation, discoloration and observable fruiting [17].

Our observations showed that 90% of the trees at the first station have a fully visible crown (class 1), followed by class 4 and finally class 3. For the second site, it was observed that 97.5% of the trees have fully visible crowns and only one tree has a non-visible crown (2.5%).
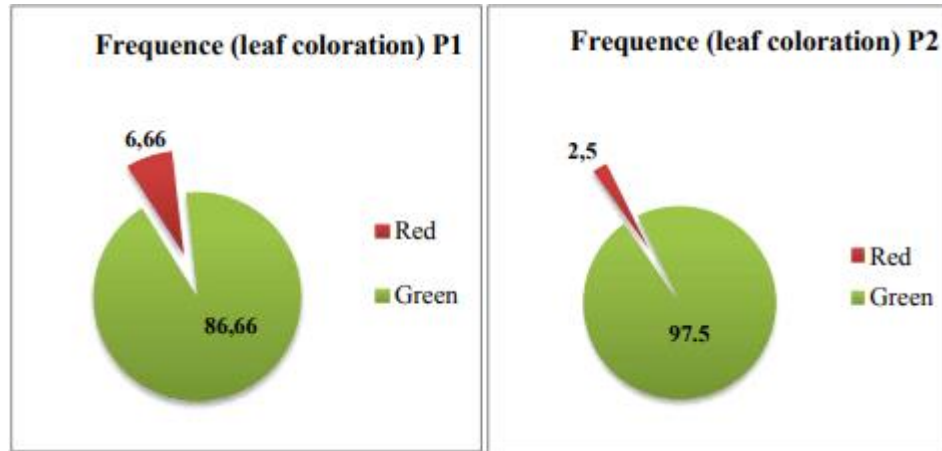

Figure 5: Distributions of Aleppo pine trees according to the level of visibility in the forest of Boutaleb

Leaf coloration

Discoloration is defined in the protocol as any alteration of the normal color of the foliage. This criterion is noted in percent and corresponds to the proportion of the foliage affected in relation to the total observable crown [17].

The analysis of the obtained results shows that the majority of the trees having a normal green color in both stations with a rate varies between 86.66% and 97.5%, the rest of the trees have a red color 6.66 % for the first station and 2.5 % for the second station (fig. 6).
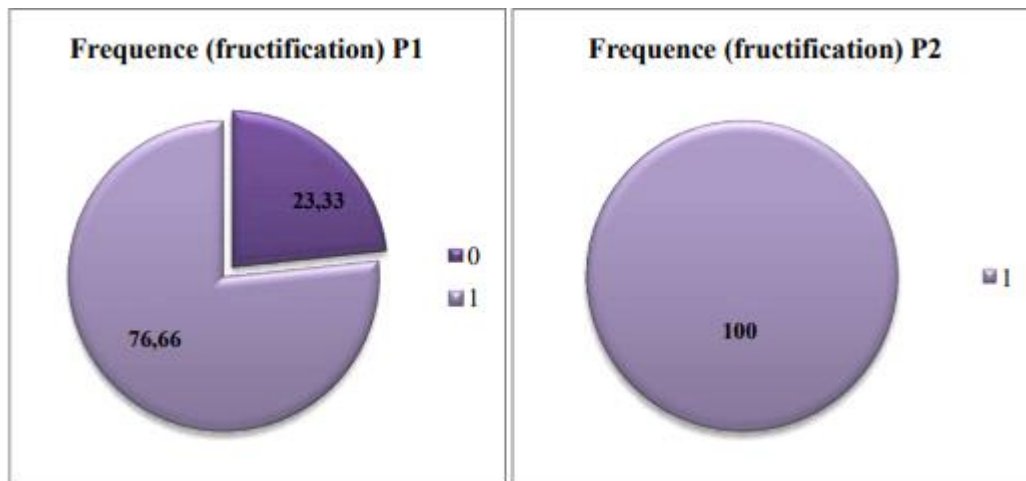
Figure 6: Spectrum of the distribution of Aleppo pine trees according to the color of leaves in the forest of Boutaleb

Fructification

Fructification is the biological process of fruit development. It is controlled by many factors (photoperiod, humidity, temperature, pollination, etc.). The standardized protocol foresees to estimate the volume of fruits in the upper part of the crown [18].

Figure 7 shows a presence of fruits in the majority of the trees of the first station (76.66%) and in the second station all the trees have fruits (100%).

Figure 7: Distribution spectrum of Aleppo pine trees according to fruiting

4. Conclusion

This study located in Boutaleb forest (Northeast of Algeria) allowed the structure and biophysical characterization of *Pinus halepensis* Mill in both natural and planted forests. The results obtained through dendrometric measurements during our work at the level of the study site allowed us to identify the sanitary state of this forest. It emerges that the density of the feet of trees in a planted forest is more important compared to the natural state. The results obtained from the different dendrometric parameters of each station: height, diameter at breast height indicate that the growth is more significant and strongly related to the quality of the station. The analysis of the health status of the crowns of both stations is generally healthy and well developed. The observation of the color of the leaves of the Aleppo pine subjects indicates us that

there were signs of dieback from where it is necessary to deepen the research of the causes in order to safeguard this pine forest.

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