The estimation of dendrometric characteristics of cork oak crown: a tool for sustainable management of Hafir forest (western Algeria)

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ABSTRACT

The study of the descriptive parameters of the cork oak crown in Hafir forest (western Algeria) was carried out on 14 sample plots of 10 ares. Projection area, diameter, volume, maximum area, vital spacing quotient, crown competition factor, and ideal density were determined for each plot. The results obtained show that the studied settlements were composed mainly of small wood whose diameter varies between 7.5 and 22.5 cm. The cork oak crown is characterized by a diameter ranging from 1.85 m to 5.08 m, a projection surface ranging between 4.77 m² and 35.28 m², a volume of 3.50 m³ to 45.08 m³ and a maximum surface ranging from 4.48 m² to 32.88 m². Plots 7, 11 and 12 represent respectively 37%, 36% and 40% span scales, which results in a very strong competition between crowns. The ideal densities calculated for plots 1, 2, 3, 4, 5, 6, 8, 9, 10, 13 and 14 are higher than the current densities, so it is essential to practice reforestation operations. The opposite case is recorded for plots 7, 11 and 12 which have an excess of stems, hence the interest of starting thinning work.

Keywords: Cork oak, Hafir forest, crown, thinning, reforestation

INTRODUCTION

The cork oak is a species of the western Mediterranean and Atlantic sides. It is found spontaneously on the western perimeter of the Mediterranean from the Strait of Messina to Gibraltar: Sicily, Italian Peninsula, Sardinia, Corsica, France (Alpes-Maritimes, Var and Eastern Pyrenees), Spain (Catalonia, Andalusia) and along the Mediterranean coast of North Africa. In addition, the most extensive stands are located in Algeria and Tunisia (Saccardy 1938; Quezel and Medail 2003). The cork oak, calcifuge species, it structures an original ecosystem, recognized of community interest by the "European directive habitat" (Amandier 2006). The forest formations of the Algerian cork oak extend over all the north of the country between the littoral in the north and the telliens chains in the south. In 2008, the area of cork oak stands is estimated at 357,582 ha (D.G.F 2008; Bouchaour-Djabeur 2013). Actually this area is under constant threat mainly related topests, fire, illegal grazing and woody cuts.In western Algeria, the area occupied by cork oak forests was estimated at 9,400 ha (Thinton 1948), but in 2003 this zone was regressed at only 6,500 ha (Bouhraoua 2003).

In addition to the factors contributing to the regression of cork oak forests, the occupation of airspace can be considered as a factor limiting the growth of this species. An effect exerted on cork oak by the associated shrubs and trees has an action that results to space competition. In this context, we are interested to estimate the dendrometric characteristics of the cork oak crown in order to evaluate the air competition between crowns and to provide the best densities for a balanced airspace in the Hafir forest located in Tlemcen national park in western Algeria.

MATERIALS AND METHODS

Study area

Hafir forest covers an area of 9872 ha; it is an essential part of Tlemcen national park in western Algeria (Figure1). The forest rests on a massif dating from the upper Jurassic, mainly composed of sequanian sandstones and quaternary alluvial deposits (Letreuch-Belarouci 2009). This forest massif is located at an altitude ranging from 1000
The slopes vary from 12.5 to 25% (Gaouar 1998; Letreuch-Belarouci and al. 2010). The hydrographic network is relatively dense but characterized by low flow (Otmami 2013). The climate is Mediterranean, marked by its summer drought which manifests itself as early as June. Annual rainfall ranges from 650 mm to 1000 mm (Medjahdi 2010).

The forest massif of Hafir as a whole offers a quite remarkable floristic diversity, directly related to the climate, soil and terrain conditions (Bouchaour-Djabeur 2001). It is mainly composed by Quercus suber on siliceous substratum, sometimes associated with Quercus ilex, while Quercus faginea is found in ravines (Valbuena and al. 2014; Letreuch-Belarouci et al. 2009; Mahboubi 1995). The shrub layer is composed by Arbutus unedo, Erica arborea, Phyllarea angustifolia, Crataegus oxyacantha, Juniperus oxycedrus, Rosa canina, Genista tricuspidata, Calycotome spinosa, Cistus monspeliensis, Chamerops humilis ... (Belgherbi and al. 2015).

Fieldwork

Random sampling that takes into account the variability of cork oak stands has been carried out in a few cantons that make up the Hafir forest. The experimental plan we have put in place involves the following steps:

- Installation of circular plots of 10 ares of surfaces, and 17.84 m of radius.
- Measurement of total height and diameter at 1.30 m of all trees in the plot.
- Horizontal projection of the crowns which consists according to Parde and Bouchon (1988) and Rondeux (1993) to locate a point most often close to the foot of the tree, on the side where the summit with the greatest amplitude, this point will be considered as radiation center. The radii should then be measured in cardinal directions (Figure 2).

Data analysis

After compiling the field data on a total of 348 cork oaks trees, calculation of dendrometric parameters relating to competition between crowns was carried out according to Rondeux, 1993 (Table 1):

| Dendrometric parameters | Formula |
|------------------------|---------|
| Crown projection area  | $S_p = \pi \cdot \sum_{i=1}^{n} r_i^2 / n$ |
| Crown diameter         | $d_{h0} = \sqrt{\frac{4}{\pi} \cdot s_p}$ |
| Crown Volume           | $V_{h0} = \frac{1}{6} \cdot \pi \cdot d_{h0}^3 / 2$ |
| Vital spacing quotient | $TAR = \sum_{i=1}^{N} (S_p)$ |
| Maximum crown area     | $MCA = \left(\frac{\pi(a + a d)}{4}\right)$ |
| Competition factor crowns | $FCC = \frac{1}{S} \cdot \left(\sum_{i=1}^{n} MCA\right) \cdot 100$ |
| Ideal density of cork oak | $D_i = \frac{5000}{S_m}$ |
|                        | $D_i = \frac{(5000 \times 4)}{(3.14 \times d_{h0}^2)}$ |
RESULTS AND DISCUSSION

Diameter structure of cork oak trees

Given the high number of trees sampled (348 trees), the cork oak was grouped into 5 diametric classes (Figure 3):

- Ø < 7.5 cm: Perchs (PER).
- 7.5 < Ø < 22.5 cm: Small woods (SW)
- 22.5 < Ø < 42.5 cm: Medium woods (MW)
- 42.5 < Ø < 67.5 cm: Big woods (BW)
- > 62.5 cm: Very big woods (VBW)

Figure 3. Diametric structure of cork oak in Hafir forest.

It appears clearly (Figure 3), that the studied stand is young, since the majority of this stand is composed by small woods. This structure results from post fire consequence, it produces for the moment very little reproduction cork. Regeneration by stump reject is ubiquitous in Hafir forest, this is largely due to the passage of fire. However, it seems difficult to rely solely on stump rejects to guarantee the regeneration of this forest (Letreuch-Belarouci and al. 2010). The ability of the species to reject strains decreases with age. Regeneration by stump reject is only a palliative; the maintenance of this forest will be ensured only by the assisted regeneration (Belghazi and al. 2001).

Vertical structure of cork oak trees

Figure 4 revealed the dominance of the heights of the first, second and third classes. The fourth class is moderately represented, while the fifth and sixth classes are composed of a relatively low number of trees.

Description of the dendrometric characteristics of the crown

The descriptive parameters of the calculated cork oak crown constitute a basic model established specifically for our forest. The results obtained highlight (Table 2):

- Crown diameter ranging from 1.85 m to 5.08 m
- Crown projection area oscillating between 4.77 m2 and 35.28 m2
- Crown volume ranging from 3.50 m3 to 45.08 m3
- Maximum crown area ranging from 4.48 m2 to 32.88 m2

Figure 4. Vertical structure of cork oak in Hafir forest

The span degree of crown that corresponds to the ratio expressed as a percentage between the crown diameter and the total height of the tree, is an effective parameter for measuring stem competition (Lemaire 2010). The author estimates that the aerial competition between cork oak is very high when the diameter of their crown is less than one third of their total height. The optimum is to maintain a large crown whose crown diameter is half the total height, which means 50% crown span.

Table 2. Descriptive parameters of 6 cork oak in Hafir forest (average values)

| Plots | Ht (m) | dh0 (m) | dh0/Ht (%) | Sp (m²) | Vh0 (m³) | MCA (m²) |
|-------|--------|---------|------------|--------|----------|----------|
| 1     | 6.35   | 4.58    | 72         | 20.14  | 42.23    | 15.06    |
| 2     | 5.07   | 3.60    | 70         | 17.38  | 21.86    | 11.47    |
| 3     | 4.32   | 3.92    | 90         | 13.93  | 23.20    | 12.97    |
| 4     | 4.15   | 3.15    | 75         | 9.75   | 15.03    | 8.26     |
| 5     | 5.37   | 3.54    | 65         | 10.94  | 16.39    | 9.39     |
| 6     | 3.85   | 2.35    | 61         | 4.77   | 4.39     | 4.48     |
| 7     | 5.15   | 1.85    | 37         | 32.98  | 21.42    | 11.83    |
| 8     | 4.52   | 2.96    | 65         | 8.31   | 3.50     | 7.26     |
| 9     | 5.2    | 3.8     | 73         | 16.68  | 33.82    | 15.73    |
| 10    | 7.46   | 5.07    | 68         | 22.59  | 45.08    | 21.78    |
| 11    | 7.63   | 2.82    | 36         | 35.28  | 25.89    | 25.67    |
| 12    | 6.75   | 2.75    | 40         | 33.82  | 44.20    | 32.88    |
| 13    | 4.90   | 3.75    | 76         | 13.95  | 24.36    | 11.16    |
| 14    | 7.14   | 5.08    | 71         | 22.04  | 43.96    | 20.77    |

In our case, we find that the competition between cork oak crowns is practically very high in plots 7, 11 and 12 which respectively represent a span degree of crown of 37%, 36% and 40%. The trees of the other plots are developing without competition.
Vital spacing Quotient and Crown Competition Factor

Plots 1, 2, 3, 5, 6, 9, 10, 13 and 14 have a crown competition factor approaching to 100 (Table 3). These trees are developing without much competition and have reached the stage of complete closure of the canopy (medium and big wood). We believe that cork oak seedlings need sufficient light forest ablishment and growth. This assumes that crown cover competition is moderate and that cover is open or clear. These results are consistent with those reported by Letreuch-Belaruci (2002). Thus these plots are most likely in the near future to a progressive competition and to a very limited natural regeneration if the stand is allowed natural grow.

Table 3. Vital spacing Quotient and Crown Competition Factor

| Plots | TAR | FCC % |
|-------|-----|-------|
| 1     | 0.94 | 84    |
| 2     | 1.04 | 79    |
| 3     | 0.92 | 77    |
| 4     | 0.95 | 71    |
| 5     | 0.96 | 81    |
| 6     | 0.98 | 64    |
| 7     | 0.93 | 115   |
| 8     | 1.13 | 65    |
| 9     | 1.12 | 93    |
| 10    | 0.91 | 95    |
| 11    | 1.07 | 122   |
| 12    | 0.95 | 105   |
| 13    | 1.11 | 93    |
| 14    | 1.08 | 97    |

Strong crown competition was found in plots 7, 11 and 12 with present a crown competition factor exceeding 100.

Ideal density of cork oak in Hafir forest

Table 4 demonstrated the percentage of trees to be conserved and / or possibly to be thinning in the silvicultural management of the forest.

As an example (Figure 5), for plot 7, it seems to us imperative in theory to conserve 73% of the standing trees and to thinning the 132 trees in excess. The same statement is made for the plots 11 and 12.

Moreover, for the rest of the plots namely 1, 2, 3, 4, 5, 6, 8, 9, 10, 13 and 14, it is obvious that the stand is in deficit of stems. It is essential then to practice artificial plantations or assisted regeneration in clearings spaces.

CONCLUSIONS

The results obtained in this study confirmed the effect of crown competition on cork oak growth in Hafir forest. The tool set up through the crown tables contains all the criteria for estimating or predicting the density or vital space ideal for stand growth. The interest in Hafir’s unmanaged forest is to have quantitative data available to determine the effect of improvement operations, including thinning on cork oak growth.

ACKNOWLEDGMENTS

This work was developed in collaboration with Tlemcen National Park (Algeria)

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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