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Thinning effect on stand structure of holm oak stand in northern Greece

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ABSTRACT: This paper is dealing with the influence of different intensity thinning on the structure of holm oak stands, 7 years after the silvicultural treatments. Sampling was done on two blocks of 0,5 ha in the study area, which is the forest area of Stavros, Thessaloniki. In each block, were defined four sample plots of 0,1 ha, one as control plot and the other three for thinning of different intensities (light: removal of 10% of basal area; moderate: removal of 20% of basal area; heavy: removal of 30% of basal area). The vitality, developmental tendency and stem quality of trees were relatively low because of the high stand density and the lack of any silvicultural treatment in the past. Seven years later, the results of thinning on structural characteristics showed that the quality and ecological stability of *Quercus ilex* stands were improved. As the "elite" trees were favored by the appropriate thinning intensity that took into account the special stand conditions. The research area is characterized by a Mediterranean – type climate with a mild sub-humid winter and a relative long xerothermic period. So, the Holm oak trees are stressed during the long dry period and the appropriate thinning improve the growing conditions of the stands.

1 INTRODUCTION

Greek forestry is in general environmental oriented forestry because all high forests are managed according to the principle of sustainability. Clear cuts are forbidden in these forests and the natural regeneration is the rule. One of the most important ecological and silvicultural problems in Greece is the coppice oak and beech forest. During the last decades some researches about the conversion of oak and beech stands have been realized (Dafis 1966, Hatzistathis et al 1996, Zagas et al 1998, Thanasis and Zagas 2001, Zagas et al 2003).

The first research about the conversion of the evergreen holm oak began in 1996 by the members of the Laboratory of Silviculture of A.U.Th. (Hatzistathis et al 1996, Zagas et al 1998).

In Greece, Holm oak (*Quercus ilex* L.) occurs in the lower mediterranean zone. It is an evergreen tree, of height of 5-15 m, thermophile, semi-shade-tolerant, fire resilient and it prefers moist and deep soils with a sufficient amount of nutrients (Athanasiadis 1986).

The Holm oak forests are under coppice management (the clear cutting system, and produce good quality fuel wood and charcoal.

Touristic development in Greece is responsible for the increase of aesthetic, protective and hydrological value of coastal forests (Tsitsoni and Zagas 1992, Hatzistathis et al 1996). Therefore coppice forests should be converted, through appropriate silvicultural treatments (Dafis 1966, 1990) into middle forests (mixed seedlings and sprout forests) or seedling origin uneven-aged high forests, they appear the following advantages (Matthews 1989, Zagas and Hatzistathis 1995, Thanasis and Zagas 2001):

- they increase the diversity and consequently the ecological stability and economical importance of these forests
- by maintaining a constant forest cover, soils' exposure is reduced and protection against erosion is provided
- they contribute to the mitigation of green house gases
- they increase proportion of timber having special qualities
- they provide better regulation of the quantity and quality of water supplies
- they provide better protection for the habitat of native fauna and flora
- aesthetically, they are considered to be attractive and this can bring benefits to the owner, to the region and to the general public.

All above-mentioned attributes, including bad quality of stumps because of inappropriate cuttings (by axe) in the past, are met in the study area (Stavros-Thessaloniki).

This research was a part of the project "Reclamation of the Mediterranean ecosystems affected by wildfires" which was financed by EE (Environment R.T.D. Programme 1994-95).

The objectives of this long-term experimental work are:

a. to study the stands condition from a silvicultural point of view
b. to increase the resistance against fires
c. to improve the quality of the stands
d. to estimate the impacts from thinning intensity (thinning grades) to stands structure
e. to determine the thinning intensities with respect to stand features.

2 MATERIAL AND METHODS

2.1 *Study area*

Seven years after the establishment of the experiment we have the opportunity to see the influence of the silvicultural treatments on the growth, stability and other characteristics of the stands. The area is located in Stavros, 80 Km east from the city of Thessaloniki. It is located in a site with elevation 40-120 m, NE aspect and the slope varies from 20 to 30%. The climate is thermo-mediterranean. Metamorphic rocks (gneisses, schists) prevail as geological substrates. Soils are medium deep, sandy-clay and light acid.

Phytosociologically the area belongs to the broadleaf evergreen zone (*Quercetalia ilicis*) and particularly to *Quercion ilicis* subzone (Dafis 1973, Athanasiadis 1986). The woody vegetation (trees and shrubs) consists of *Quercus ilex, Q. frainetto, Q. pubescens, Q. coccifera, Carpinus orientalis, Fraxinus ornus, Olea europaea var. sylvestris, Arbutus unedo, Phillyrea media, Erica arborea, Sorbus domestica, Laurus nobilis, Pistacia lentiscus, Juniperus oxycedrus, Pistacia terebinthus and Sorbus torminalis*

Three blocks of relatively uniform stand composition and site conditions, a size of 0.5 ha each, were established. Four plots, a size of 0.1 ha (40 m x 25 m), were selected in each block, three for thinning treatment and one as control. A belt at least 5 m in width is interpolated between two plots in each block. Two of these blocks have been used for the evaluation of thinning treatments.

In each plot all trees and shrubs were numbered and measured for their breast-height diameter (dbh), total height (h) and basal area (g) and classified according to IUFRO criteria (Dafis 1962, Ouellet and Zarnovican 1988).

The trees were numbered with metallic labels, which were put on the stems with a wired perimeter. The trunks were marked by the help of an unfading colour at the point and direction where their dbh was measured so that the next measurement will be read exactly at the same height and direction.

The IUFRO classification is based on recognition of two main aspects of trees, the biological (height class, vitality, developmental tendency) and the silvicultural or economic (stem quality).

Thinning from above is the selected thinning regime in order to improve the well-developed trees "elite-trees" by cutting the keen competitors. The selected thinning intensities are the light, moderate and the heavy ones and they focus on the dominant over-storey species (*Quercus ilex* L., *Quercus pubescens* and *Quercus frainetto* Ten*.).*

The thinning treatments (or thinning grades) are:

- Light: removal 10% of oaks basal area (b.a)
- Moderate: removal of 20% of oaks area (b.a.)
- Heavy: removal of 30% of oaks (b.a.).

3 RESULTS

The average stand density of all plots is high (seven years after the thinning treatments), ranging from 3,010 to 5,300 stems/ha.

Diameters over 10 cm represent the *Quercus frainetto* and *Q. pubescens* trees which they were manipulated as "standards" and some overstorey trees of *Q. ilex,* especially in the heavy and medium thinned plots (fig. 1, 3, 5, 7). Diameter classes less than 5 cm derived mainly from *Carpinus orientalis, Fraxinus ornus, Arbutus unedo, Phillyrea media, Erica arborea,* and suppressed coppice shoots of *Q. ilex* which constitute the under-storey and a part of the middle-storey.

The growth conditions have improved in the plots where moderate and heavy thinning were applied. The best improvement has succeeded in applying moderate thinning grade (20%). In this treatment the basal area increment has reached 5,95 m^3/ha seven years after thinning, while in the heavy thinning grade (30%), the basal area increment has reached 4,53 m^3/ha. The lowest increment 0,99 m^3/ha was observed in the treatment of light thinning grade (10%), (Table 1).

Table 1. Basal area (G) into the different treatments before and after thinning and 7 years later.

Treatment	G before thinning m^2/ha	Stand Removal m^2/ha	G after thinning m^2/ha	7 years later G increment	
				G m^2/ha	m^2/ha
Control	7.23	0	7.23	9.50	2.27
Thinning 10%	11.33	1.13	10.20	11.19	0.99
Thinning 20%	19.75	3.27	16.48	22.43	5.95
Thinning 30%	25.58	7.52	18.06	22.59	4.53

These results agree with the preliminary ones published a few years ago. Additionally, the moderate thinning treatment (thinning grade 20%) has been estimated as the most fire resistant treatment, because it combines relatively low production of dead organic material and ideal decomposition conditions for it (Zagas et al 1998).

The vitality in all treatments has been improved after thinning (Hatzistathis et al 1996). Seven years after thinning, vitality remains almost in the same levels, except for the moderate thinning treatment (Table 2). In this case, vitality has been improved and in combination with the above mentioned about fire resistance we can characterize it, as the thinning treatment, which has the most advantages.

The developmental tendency (DT) is slightly deteriorated in all treatments but the greatest deterioration is observed in the light thinning treatment. The best developmental tendency is observed in the moderate thinning treatment, despite of the high density of the stand (Table 2).

The stem quality (SQ) is better in all treatments in comparison to control plots. The best stem quality is observed in the heavy thinning treatment (Table 2).

The best height increment is observed in the heavy thinning treatment while the best breast height diameter increment in the moderate thinning (Table 2).

Table 2. Stand parameters and social classification values in the beginning of the experiment and 7 years later.

Thinning treatment	dbh_0	dbh_7	h_0	h_7	N/ha	Vt_0	Vt_7	DT_0	DT_7	SQ_0	SQ_7
Control	4.98	5.88	4.68	6.50	3010	22.40	22.49	2.20	2.33	55.96	57.03
Light	4.58	5.54	4.55	6.11	4040	23.43	23.49	2.19	2.56	55.74	54.88
Moderate	5.48	6.75	6.32	8.04	5300	22.39	21.28	2.10	2.24	54.13	54.75
Heavy	6.13	7.24	7.35	9.83	4320	23.00	23.06	2.20	2.35	53.50	54.55

dbh_0 = mean breast height diameter in the beginning of the experiment
dbh_7 = mean breast height diameter 7 years after the thinning
h_0 = mean height in the beginning of the experiment
h_7 = mean height 7 years after the thinning
Vt_0 = vitality in the beginning of the experiment
Vt_7 = vitality 7 years after the thinning
DT_0 = developmental tendency in the beginning of the experiment
DT_7 = developmental tendency, 7 years after the thinning
SQ_0 = stem quality in the beginning of the experiment
SQ_7 = stem quality 7 years after the thinning

The distribution of diameter classes in the light thinning treatment shows a high concentration of stems in the classes of 4 and 6 cm which belong mainly to a secondary stand and has not yet good differentiated (Fig. 1).

In the same treatment the height classes' distribution is the typical of the even aged stand (Fig. 2).

In the moderate thinning treatment the distribution of diameter classes shows a relatively good differentiated stand (Fig. 3). This differentiation is better depicted in the distribution of height classes (Fig. 4). It is clear that there are two storeys, an over-storey with a concentration of stems in the height class of 9 m and a middle-storey with a concentration of stems in the height class of 5 m.

In the heavy thinning treatment the distribution of diameter classes shows a better differentiation (Fig. 5). The differentiation of storeys is clearer in the height classes' distribution histogram (Fig. 6). There are two storeys, an over-storey with a concentration of stems in the height class of 13 m and a middle storey with a concentration of stems in the height class of 9 m.

In the control plots the picture is almost the same as in the light thinning treatments (Fig. 7, 8). The height classes' distribution is the typical of even aged coppice stands with standards, which belong to height classes of 10, 11 and 12 m (Fig. 8).

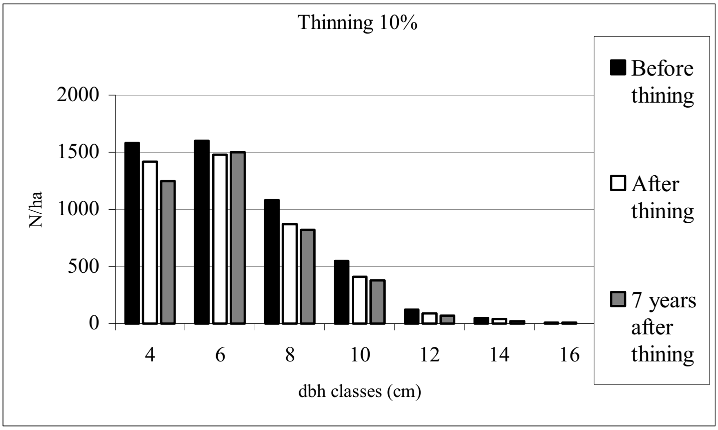

Figure 1. Distribution of dbh classes before and after thinning and 7 years after thinning, in the thinning grade treatment 10%.

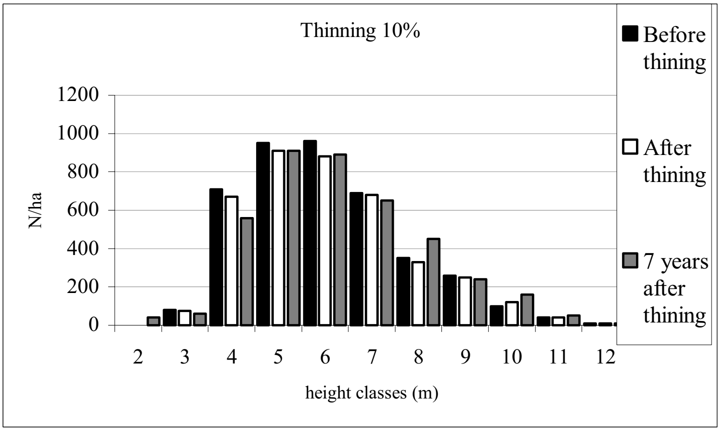

Figure 2. Height classes distribution before and after thinning and 7 years after thinning, in the thinning grade treatment 10%.

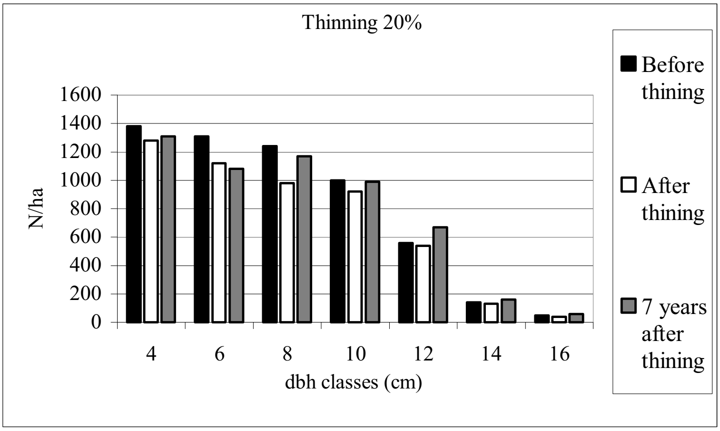

Figure 3. Distribution of dbh classes before and after thinning and 7 years after thinning, in the thinning grade treatment 20%.

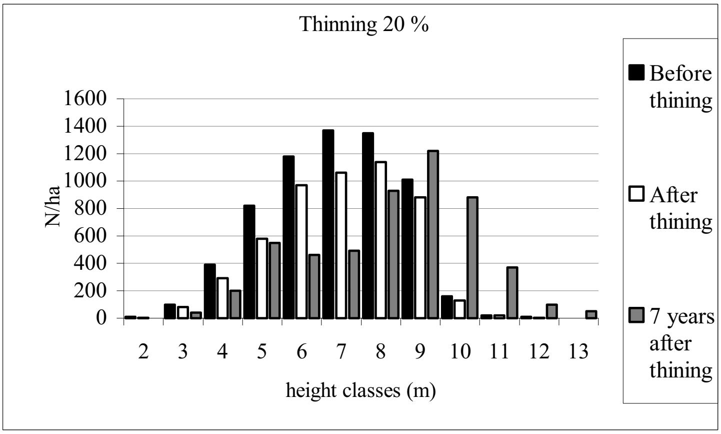

Figure 4. Height classes distribution before and after thinning and 7 years after thinning, in the thinning grade treatment 20%.

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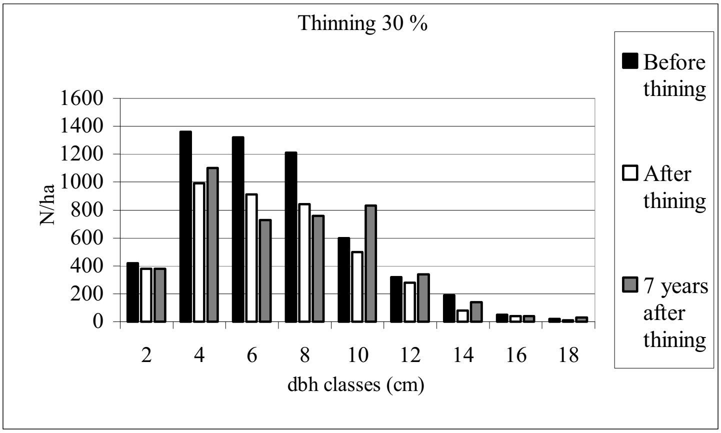

Figure 5. Distribution of dbh classes before and after thinning and 7 years after thinning, in the thinning grade treatment 30%.

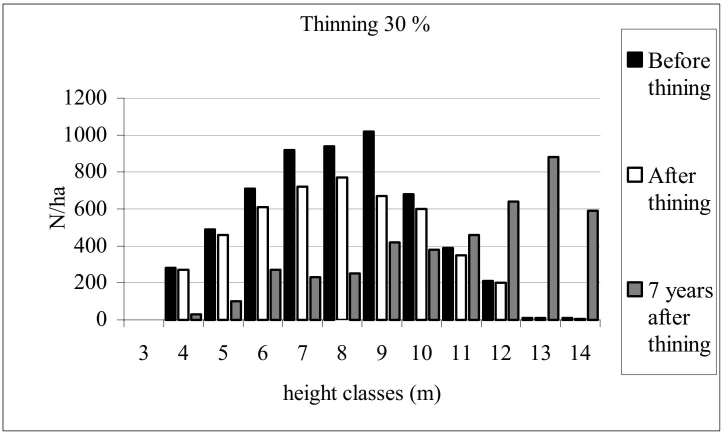

Figure 6. Height classes distribution before and after thinning and 7 years after thinning, in the thinning grade treatment 30%.

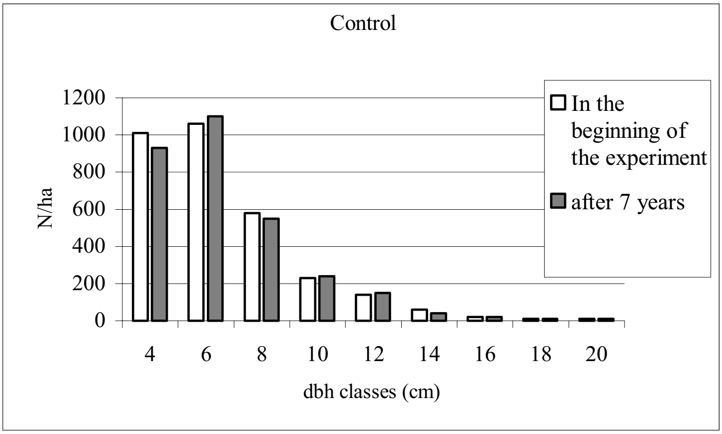

Figure 7. Distribution of dbh classes in the beginning of the experiment and 7 years later, in the control plots.

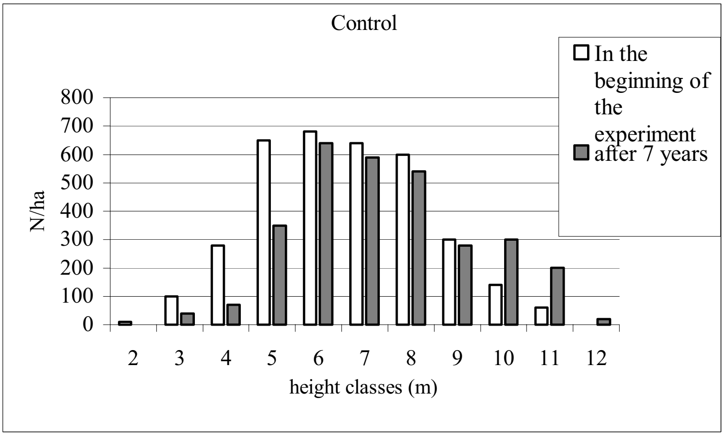

Figure 8. Height classes distribution in the beginning of the experiment and 7 years later, in the control plots.

4 CONCLUSIONS

a. The stands condition has improved from a biological and silvicultural point of view as following:

- the best growth conditions have succeeded in the moderate thinning treatment.
- the best vitality was observed in the moderate thinning treatment.
- the best stem quality is observed in the heavy thinning treatments. In all thinning treatments the stem quality is better in comparison to the control plots.

b. The fire resistance of stands can be increased by applying moderate thinning treatments, as they combine relatively low production of dead organic material and good decomposition conditions for it (Zagas et al 1998).

c. The quality of stands was improved in all treatments because the stem quality is better in the thinned plots. The moderate and heavy thinnings have contributed to a better differentiation of stands. The advantages of this differentiation are the improvement of stands stability against external pressures (snow and wind) and the enhancement of biodiversity (ecological stability) by improvement of growth conditions of all participating plant species and by giving life opportunities for more fauna species. The thinning treatments have contributed to an earlier and richer fructification of the dominant Holm oak trees. The oak acorns are the basis for a lot of food chains in the forest ecosystem.

d. The moderate and heavy thinning treatments contribute to an earlier differentiation and strengthening of Holm oak stands. The thinning treatments have mainly favored the “elite” trees, which are the most important capital of the stands.

e. Holm oak stand conditions are differentiated in a short distance and for this reason the thinning treatments must take this differentiation seriously into account. The moderate and heavy thinning have the best effect on the growth and structure of stands. The heavy thinning must be applied in high-density stands growing on good sites. The moderate thinning can be the rule as they present the best effect on growth and structure of Holm oak stands.

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