Structure and stem analysis of Pinus halepensis mill forests in the Kassandra Peninsula – Chalkidiki

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Abstract

The present study was conducted on the Kassandra Peninsula of Chalkidiki, for the research project : GR-Forest Fires NATO Science for stability programs. The structure analysis is determined in stands of different age classes. Moreover, the forest yield data in all age classes are given. In order to study the diameter and height growth, stem analysis in 30 trees were done.

The results of this research indicate all the silviculture treatments that should be carried out in Pinus halepensis forests, in order to fulfil the multifunctional management of forests.

Key words : *Structure analysis, Pinus halepensis, stem analysis, biodiversity, natural regeneration, forest management, reforestation, forest fire.*

1. Introduction

Pinus halepensis is considered to be a widespread species in Mediterranean forest ecosystems. It occupies a larger area than the other Mediterranean xerothermic conifers. It's a species of the evergreen broadleaves zone that spreads mostly in the west part of the Mediterranean area. In Greece, it's found in Sterea Hellas, Peloponnisos, Pilio, Chalikidiki, Euboia, Skopelos, Skiathos, Skyros and on some other islands of the Aegean and Ionian seas. It appears in sites with mean annual rainfall of 350-1000mm, mean summer rainfall not more than 40mm, relative humidity of 47-60%, mean air temperature of 20-26^{0}C and tolerates temperature up to -17^{0}C.

As stated by the soil conditions, it is a species that has a great adaptability, low demands in moisture and nutrition elements and it grows in soils of different origin (limestones, marls, schists, granites etc.). Aleppo pine forests occupy an area of 250,000 ha in regions with high temperatures and drought, usually found near urban and tourist areas. Under these circumstances, their value will become greater in the future. Biomass accumulation is observed in these forests due to the reduction of apiculture, resin, illegal loggings, grazing etc. At the same time, there are prolonged summer drought periods with high temperatures. These facts, in combination with the absence of scientific methods of prevention and control of forest fires increase the possibilities of forest fire disasters.

The aim of this paper is to present the structure analysis characteristics of Pinus halepensis, the height and diameter increase according to the silviculture treatments that were carried out and also to determine the silvicultural aim and the proper silviculture treatments in Pinus halepensis forests in Chalkidiki.

2. Study area

This research was conducted on the Kassandra peninsula of Chalkidiki, at 40^0 latitude and 25^{0}30' longitude. The area of the Kassandra peninsula is about 34,937 ha from which 14,002 ha are forests, 19,996 ha are cultivated fields and 970 ha are badlands. The Kassandra forests are one of the best representations of the structure and the soil conditions of Pinus halepensis forests.

2.1. Climatic conditions

The area has a Mediterranean type climate with mild winters and dry, warm summers (Flokas,1990), which is the same as the Greek Mediterranean bioclimate (Mauromatis,1980).The Kassandra peninsula, according to the bioclimatic diagram of Ellenberg (1962), belongs to the subhumid Mediterranean zone.

Figure 1 shows the ombrothermic diagram of the meteorological station of Kassandra, Chalkidiki and table 1 shows the mean monthly temperature and rainfall. The mean annual temperature is 16.2^{0}C, the rainfall is 569.1mm, the relative air humidity is 74.4% and the evaporation is 662.01mm.
The absolute minimum temperature is -10^{0}C (7/1/1978) and the absolute maximum temperature is 40^{0}C (25/6/1978 and 7/7/1978). The ecological dry period begins in the middle of April and ends in the middle of September.

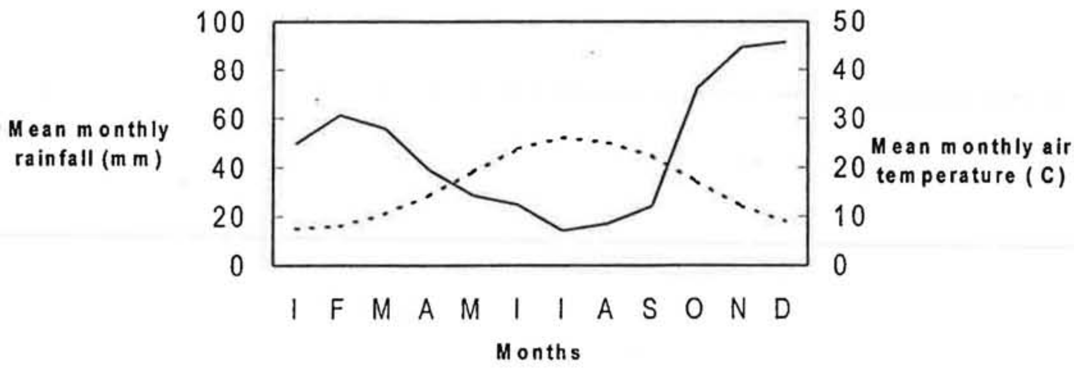

Figure 1. Ombrothermic diagram of meteorological station of Kassandra, Chalkidiki (period 1975-1993).

Table 1. Mean monthly values of temperature and rainfall from meteorological station of Kassandra, Chalkidiki (period 1975-1993)

Months	Climatic factors	
	Mean monthly rainfall(mm)	**Mean monthly air temperature (^{0}C)**
January	49.7	7.5
February	61.5	8.0
March	56.0	10.4
April	38.9	14.2
May	28.6	19.1
June	24.8	23.9
July	14.3	26.1
August	17.1	25.1
September	24.3	22.3
October	72.6	17.1
November	89.5	12.1
December	91.8	8.9
Year	**569.1**	**16.2**

2.2. Geological substrate - Soil

The Kassandra Peninsula geologically shows a relative homogenity since the dominant rocks are marls, conglomerates, sands and marl-limestones with marl as connected material. Apart from the conglomerates, there are also red soils on most parts of the peninsula. The coastal areas have alluvial, calcareous and sandstone deposits. Also, on a small part of the peninsula a tip is made of basic rocks. The soils in the north part of the peninsula are brown forest soils and rendzinas, in the south part, red Mediterranean soils and in a small part, are alluvial soils (FAO,1965).

2.3. Vegetation

The Kassandra Allepo pine forests belong to the evergreen broadleaves zone (Quercetalia ilicics). Pinus halepensis appears in the growth area of Oleo ceratonion and Quercion illicis (Dafis,1973 ; Athanasiadis,1986). According to Tsitsoni(1991), in the study area there are three site types. The second type occupies the largest part of the Kassandra peninsula. The most important species of understorey in the study area are : Quercus coccifera, Quercus ilex, Phillyrea media, Pistacia lentiscus, Erica arborea, Erica manipuliflora, Arbutus unedo, Cistus incanus, Cistus monspeliensis, Smilax aspera, Fraxinus ornus, etc.

2.4. Fauna

The most significant mammals are :Lepus europeus, Vulpes vulpes, Martes foina, Mustela nivalis, Meles meles, Apolemus sylvaticus, Erinaceus europaeus, Sus scrofa and Sciurus vulgaris. The most important reptiles are : Vipera ammodytes, Natrix tesselata, Natrix natrix, Laceta viridis and Testudo greca.

The most important birds are :Carduelis carduelis, Carduelis chloris, Coccthraustes vespertinus, Emberiza calandra, Erithacus rubeccila, Frihgilla coelebs, Garrulus grandarius, Hippolous olivetorus, Muscocapa stuafa, Parus major, Passer domesticus, Phoenicurus ochruros, Phoenicurus phoenicurus, Phylloscopus trochilus, Pegulus igni capillus, Sylvia africapilla, Sylvia melanocephala, Sylvia nisoria and Turdus merula (Kenneth, 1996).

3. Research method

For the stem analysis, 30 trees were cut according to the stratified random sampling method from stands with 23, 48, 70 and over 100 years of age classes. From each tree, cross-sectional discs were cut and removed from a 0.3m level, breast height, 2.0m level and at 3 meter intervals up to the bole. The last disc was collected from the bole diameter of 7.5cm. These discs were taken to the Forestry laboratory in order to measure the rings' width with the ADDO instrument (Kramer, Akca,1987).

In order to study the stand structure, fifteen sample plots of 25x40m were taken (5 sample plots from each 48, 70 and over 100 years age classes). From a 23 age class stand, 5 sample plots of 10x10m were taken. For every sample plot the following data were recorded :

-diameter in cm, for all trees with diameter over 4cm (breast height)

-height in meters

-crown length in meters

-vitality and development, according to the I.U.F.R.O. system

-in each age class, description of soil profile was made and samples of forest soil were collected in order to be analyzed in the laboratory

-the ring width measurement was taken in the laboratory with the ADDO instrument.

3.1. Stands of 23 years

These stands originated after a forest fire in mild slope areas. The stands soils are rendzinas, clay of medium depth.

Soil profile description

A_0 No decomposed plant residues of 2-3cm from Pinus halepensis needles and leaves of ground vegetation

A 0-3cm. Argilic horizon with 46.9% clay, 28.5% silt and 24.6% sand. The nitrogen (N) is 0.3%, the organic matter is 6.70%. The carbon (C) is 3.90% and the calcium carbonate is 5.50%, C/N 12.80 and pH 7.7. There are abundant short roots.

A/C 9-27cm. Argilic horizon with 44.3% clay, 29.6% silt and 26.1% sand. The nitrogen (N) is 0.14%, the organic matter is 2.60%, the carbon (C) is 1.50% and the calcium carbonate is 9.20%, C/N 10.50 and pH 7.82. There are many short roots.

C 27-60cm. Clay-loamy horizon with 39.7% clay, 41.1% silt and 19.2% sand. The nitrogen (N) is 0.05%, the organic matter is 0.95%, the carbon (C) is 0.55% and the calcium carbonate is 63.57%, C/N 17.88 and pH 7.82.

The basic characteristic of the soil profile is the high content of clay and the very low degree of C/N which is probably caused by forest fires, and the high rate of pH.

Structure analysis

In table 2 the most important forest yield data are shown. In this stage the main characteristic is the absence of Pinus halepensis understorey, due to the high competition in the overstorey and middlestorey of Pinus halepensis and also the competition in the evergreen broadleaves understorey. The number of trees per hectare is assumed to be very large, 3340 with a maximum height of 17m. The vitality is very good and the trend of development is going up due to the young age. The basal area is 17.10 m^2/ha and the wood volume is 66.87m^3/ha.

The bole distribution in diameter classes are given in figure 2. Even though the stand originated after a forest fire, we observe a vertical fall in the exponential distribution. The tree height distribution in height classes, which is given in figure 3, shows us a one-storey stand with the maximum massing in the 9 m height class.

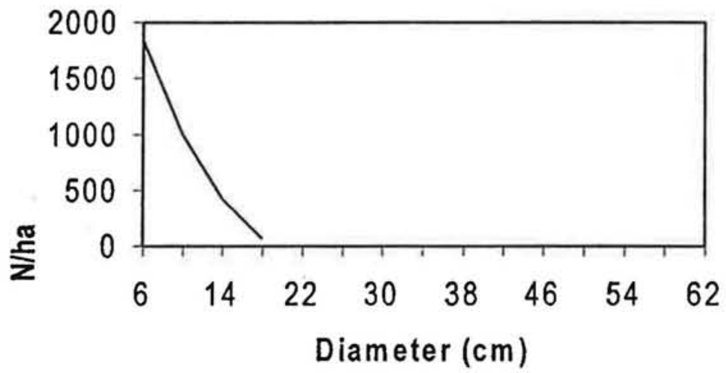

Figure 2. Structure analysis graph from diameter classes of 23 year old Pinus halepensis stands.

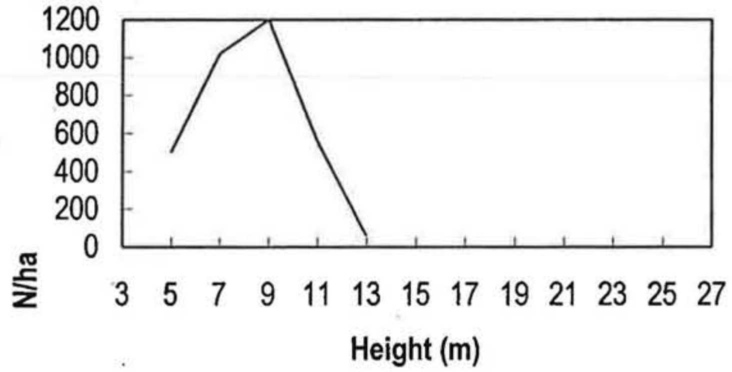

Figure 3. Structure analysis graph from height classes of 23 year old Pinus halepensis stands.

3.2. Stand of 48 years

These stands originated after a forest fire, in mild and medium slope areas.

Soil profile description

A_0 No decomposed plant residues of 2-3cm from Pinus halepensis needles and leaves of ground vegetation

A 0-14cm. Loamy horizon with 20.6% clay, 36.40% silt and 43.0% sand. The nitrogen (N) is 0.27%, the organic matter is 6.70%. The carbon (C) is 3.90% and the calcium carbonate is 26.05%, C/N 14.60 and pH 7.72. There are abundant thin roots.

A/C 14-30cm. Loamy horizon with 25.1% clay, 29.9% silt and 45.0% sand. The nitrogen (N) is 0.12%, the organic matter is 2.80%, the carbon (C) is 1.60% and the calcium carbonate is 54.17%, C/N 13.80 and pH 7.68. There are sufficient thin roots.

C 30-60cm. Sand-loamy horizon with 16.1% clay, 18.3% silt and 65.6% sand. The nitrogen (N) is 0.05%, the organic matter is 1.40%, the carbon (C) is 8.20% and the calcium carbonate is 66.0%, C/N 16.65 and pH 7.79.

Structure analysis

In this stage the characteristics are the intense competition of the trees, the reduction in the number of trees to 470 per hectare and the appearance of Pinus halepensis understorey which is caused by the intense species differentiation. The result is the creation of more favourable light conditions. The basal area is 20.66m^2/ha and the volume of the wood is 167,02m^3/ha. The vitality and development trends are at normal levels for this stage.
The stem distribution in diameter classes in figure 4 shows a normal distribution with intense differentiation. The height distribution in height classes in figure 5 shows a one-storey stand with the maximum massing in 19m height classes. The remaining structure data are given in table 2.

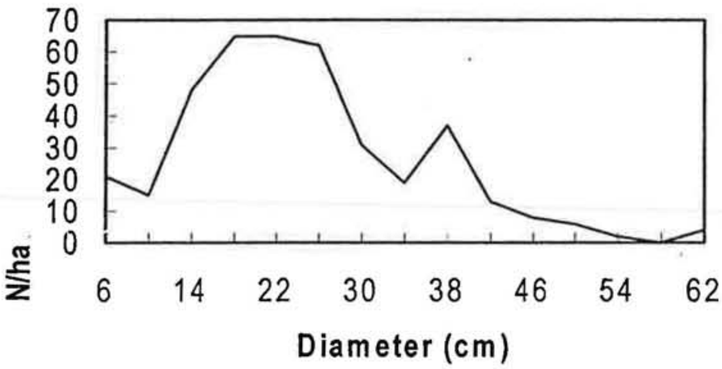

Figure 4. Structure analysis graph from diameter classes of 48 year old Pinus halepensis stands.

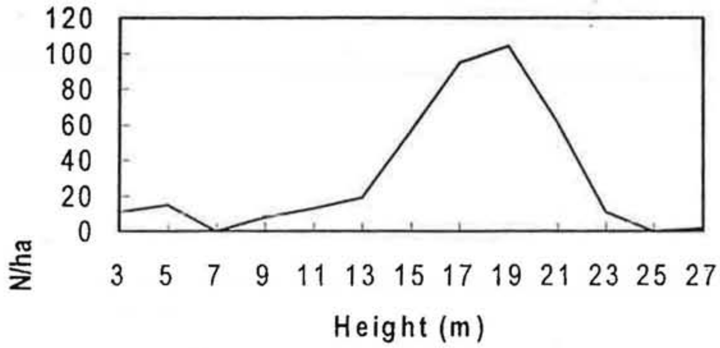

Figure 5. Structure analysis graph from height classes of 48 year old Pinus halepensis stands.

3.3. Stand of 70 years

These stands originated after a forest fire in small, medium and large slopes.

Soil profile description

A_0 No decomposed plant residues of 2-4cm from Pinus halepensis needles and leaves of understorey

A 0-10cm. Silt-loamy horizon with 14.6% clay, 54.3% silt and 31.1% sand. The nitrogen (N) is 0.23%, the organic matter is 9.20%. The carbon (C) is 5.32% and the calcium carbonate is 38.93% and pH 7.64. There are abundant thin roots.

A/C 10-40cm. Silt-loamy horizon with 20.1% clay, 54.2% silt and 24.9% sand. The nitrogen (N) is 0.07%, the organic matter is 1.93%, the carbon (C) is 1.12% and the calcium carbonate is 70.18% and pH 7.77. There are many thin roots.

C 40-60cm. Loamy horizon with 20.2% clay, 47.8% silt and 32.0% sand. The nitrogen (N) is 0.03%, the organic matter is 0.69%, the carbon (C) is 0.40% and the calcium carbonate is 84.50% and pH 7.83.

Structure analysis

In this stage the main characteristic is the excessive reduction in the number of trees, 260 trees per hectare, in order to prepare the stand for resin. The result of the intense thinning is the absolute absence of the middlestorey and understorey. The vitality and development trends are at normal levels. The remaining structure data are given in table 2. The maximum height is 24m and the minimum is 15m.The stem distribution in diameter classes in figure 6 shows a normal distribution with the maximum massing in 38cm diameter classes. The height distribution in height classes in figure 7 shows a one-storey stand with the maximum massing in 21m height classes. The basal area is $28.11m^2$/ha and the volume is $256.80m^3$/ha.

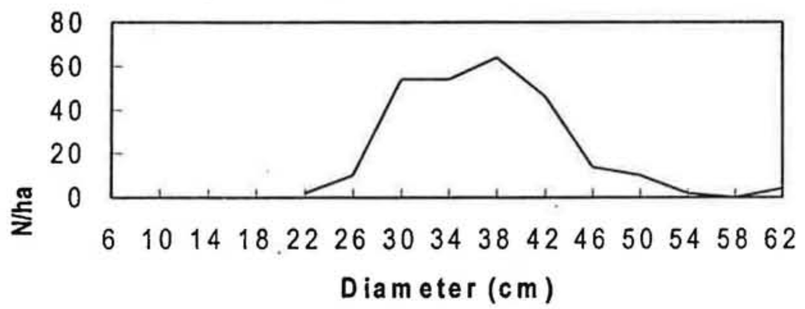

Figure 6. Structure analysis graph from diameter classes of 70 year old Pinus halepensis stands.

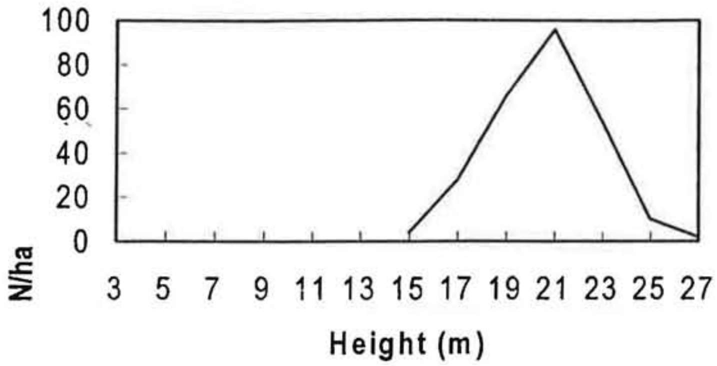

Figure 7. Structure analysis graph from height classes of 70 year old Pinus halepensis stands.

3.4. Stand over 100 year

These stands originated after a forest fire in mild and medium large slopes.

Soil profile description

A_0 No decomposed plant residues of 2-4cm from Pinus halepensis needles and leaves of understorey

A 0-7cm. Clay-loamy horizon with 34.0% clay, 33.4% silt and 32.6% sand. The nitrogen (N) is 0.26%, the organic matter is 8.78%. The carbon (C) is 5.0% and the calcium carbonate is 2.08%. There are abundant thin roots.

B 7-25cm. Clay-loamy horizon with 32.5% clay, 33.6% silt and 26.9% sand. The nitrogen (N) is 0.09%, the organic matter is 2.37%, the carbon (C) is 1.37% and the calcium carbonate is 8.96% and pH 7.48. There are many roots.

B/C 25-65cm. Clay-loamy horizon with 30.6% clay, 37.6% silt and 31.8% sand. The nitrogen (N) is 0.05%, the organic matter is 1.65%, the carbon (C) is 0.68% and the calcium carbonate is 36.89% C/N 12.84 and pH 7.77.There are many thin roots.

C 65-75cm. Clay-loamy horizon with 37.5% clay, 32.0% silt and 30.5% sand. The nitrogen (N) is 0.04%, the organic matter is 0.72%, the carbon (C) is 0.42% and the calcium carbonate is 54.15% and pH 7.86.

Structure analysis

In this stage the characteristics are the appearance of young trees in the understorey due to the light conditions. The vitality and development trends are at normal levels. The most important structure data are given in table 2. The basal area is 33.95m^2/ha and the wood volume is 302.70m^3/ha.The stem distribution in diameter classes is given in figure 8. We regard a normal distribution of trees from the old stand with maximum range and a second distribution of young trees in small diameters. The height distribution is given in figure 9 and shows a multi-storey stand.

Table 2a. Pinus halepensis structure analysis data of Kassandra Chalkidiki.

Stand		Overstorey		Middlestorey		Understorey		Total	
		Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
23 years	**Diameter (cm)**	9.21	2.7	5.45	1.7			7.5	3.0
	Height (m)	9.03	1.1	5.91	0.9			7.61	1.8
	Living crown base (m)	4.64	1.1	4.18	0.6			4.18	1.0
	Vitality	17.36	5.3	20.26	4.6			18.68	5.2
	Development trend	1.56	0.5	1.97	0.4			1.75	0.5
	Basal area (m^2/ha)	13.18		3.91				17.10	
	N/ha	1820		1520				3340	
48 years	**Diameter (cm)**	26.77	10.0	16.31	5.8	7.83	7.7	24.11	10.9
	Height (m)	17.87	2.0	11.73	1.8	3.63	0.9	16.11	4.3
	Living crown base (m)	13.31	2.6	8.37	2.8	3.04	5.4	11.97	4.0
	Vitality	19.93	4.0	25.39	4.3	18.33	3.8	20.59	4.8
	Development trend	1.85	0.4	2.35	0.5	1.58	0.5	1.90	0.5
	Basal area (m^2/ha)	19.22		1.22		0.22		20.66	
	N/ha	300		52		44		396	

Table 2b. Pinus halepensis structure analysis data of Kassandra Chalkidiki.

Stand		Overstorey		Middlestorey		Understorey		Total	
		Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
70 years	**Diameter (cm)**	36.53	6.6					36.53	6.6
	Height (m)	20.12	2.2					20.12	2.2
	Living crown base (m)	15.42	1.6					15.42	1.6
	Vitality	20.85	5.1					20.85	5.1
	Development trend	2.08	0.6					2.08	0.6
	Basal area (m^2/ha)	28.14						28.14	
	N/ha	260						260	
over 100 years	**Diameter (cm)**	43.19	8.0	34.23	8.2	7.57	3.8	35.10	14.5
	Height (m)	21.18	2.5	15.64	1.5	6.35	12	17.28	5.6
	Living crown base (m)	12.81	2.9	9.84	2.9	2.24	0.9	10.32	4.6
	Vitality	18.67	6.0	19.77	5.4	20.00	7.3	19.22	6.0
	Development trend	1.87	0.4	1.93	0.5	2.13	0.5	1.93	0.5
	Basal area (m^2/ha)	25.14		8.55		0.25		33.95	
	N/ha	166		88		46		300	

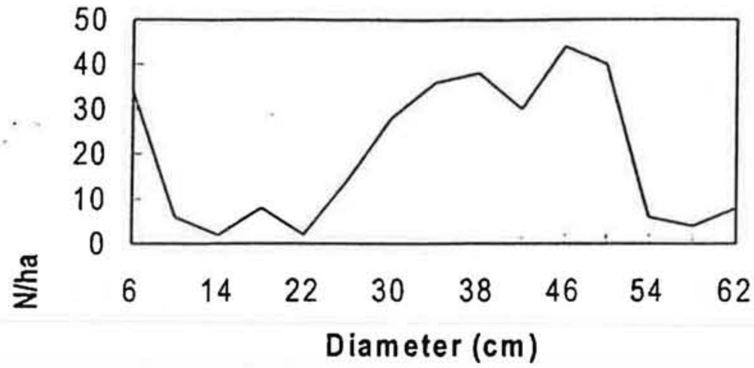

Figure 8. Structure analysis graph from diameter classes of over 100 year old Pinus halepensis stands.

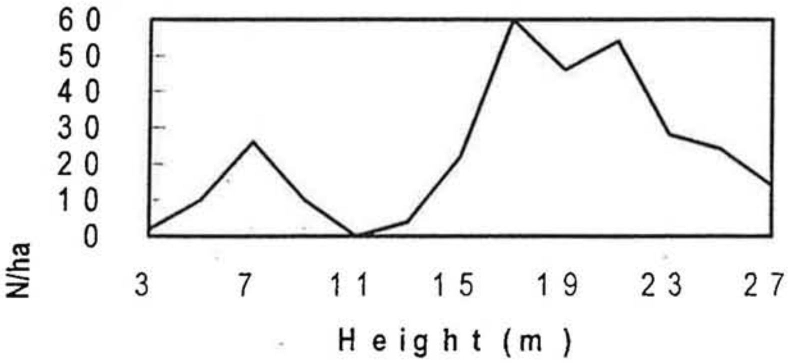

Figure 9. Structure analysis graph from height classes of over 100 year old Pinus halepensis stands.

Picture 1. Pinus halepensis 23 year old stand

Picture 2. Pinus halepensis 48 year old stand

Picture 3. Pinus halepensis 70 year old stand

Picture 4. Pinus halepensis over 100 year old stand

4. Stem analysis

The stem analysis results are given in table 3 and figure 10. It is observed that the annual rings' growth reaches the maximum value in the twenty group of the five. In the first 50 years (21 – 11 group of the five), there is a satisfactory growth of trees.
The stand resin collection begins at this age and despite the intense thinning of the stand that occurred, we observe an almost gradual and steady reduction of the annual rings' width.
Studying the annual rings' width per group of five in various heights, we observe a partial growth trend of the annual rings' width inside the crown until the age of 50 years.

At this age, as was mentioned, the resin collection begins, a fact which causes a suspension of the continuation of the intense growth trend inside the crown at greater ages.
These results are different from other species stem analysis data, in which the annual ring width growth with height becomes intense inside the crown (Smiris,1992, Smiris, Zagas,1994, Smiris, Ganatsas, Euthimiou,1992).
This fact is probably due on one hand, to the intense growth in the branchless part of a bole for healing scourges of resin collection and on the other, to the growth of new branches in this branchless part of bole due to the intense stand thinning.
Studying the height growth in relation to the age, it is observed that the maximum growth is at the age of 28-32 years, in which we have a 3m height increase in a 4 year period. At young ages, we have a small height growth due to intense competition in the understorey and among the Pinus halepensis trees.
At the age of 7years Pinus halepensis is 1,30m high, while at the age of 11 years it is 2m high. From the age of 11 years the stand needs a nine year period to reach the height of 5m. After the age of 50 years, we have a sudden reduction of height growth.

Table 3. Stem analysis data

Group of five	0,30m	1,30m	2,00m	5,00m	8,00m	11,00m	14,00m	16,50m (d=7,5cm)
1	0,471	0,493	0,427	0,419	0,448	0,479	0,510	0,626
2	0,562	0,563	0,582	0,486	0,600	0,655	0,693	0,643
3	0,547	0,549	0,480	0,449	0,516	0,593	0,602	0,579
4	0,542	0,531	0,459	0,432	0,525	0,554	0,572	0,503
5	0,623	0,615	0,536	0,570	0,717	0,739	0,769	0,532
6	0,723	0,697	0,664	0,726	0,782	0,861	0,746	0,543
7	0,711	0,754	0,695	0,722	0,739	0,699	0,618	0,422
8	0,794	0,785	0,834	0,845	0,840	0,971	0,644	0,662
9	0,826	0,931	0,830	0,834	0,974	0,739	0,701	
10	0,847	0,848	0,879	0,914	0,916	0,923	0,519	
11	1,008	0,897	0,942	0,905	0,981	0,799	0,758	
12	0,974	0,832	0,957	0,806	1,042	0,967	0,942	
13	0,873	0,843	0,895	0,918	1,130	0,902	1,339	
14	0,845	0,870	1,090	1,160	1,120	1,078	0,638	
15	1,009	1,137	1,217	1,017	0,693	1,270	0,592	
16	1,111	1,312	1,500	1,044	1,185	0,930		
17	1,056	1,255	1,244	0,802	0,868			
18	0,947	1,089	1,154	1,418	0,701			
19	1,093	1,116	0,833	1,426				
20	1,284	1,021	0,448					
21	1,084							
Rest	0,541	0,653	0,536	0,603	0,611	0,499	0,609	0,431

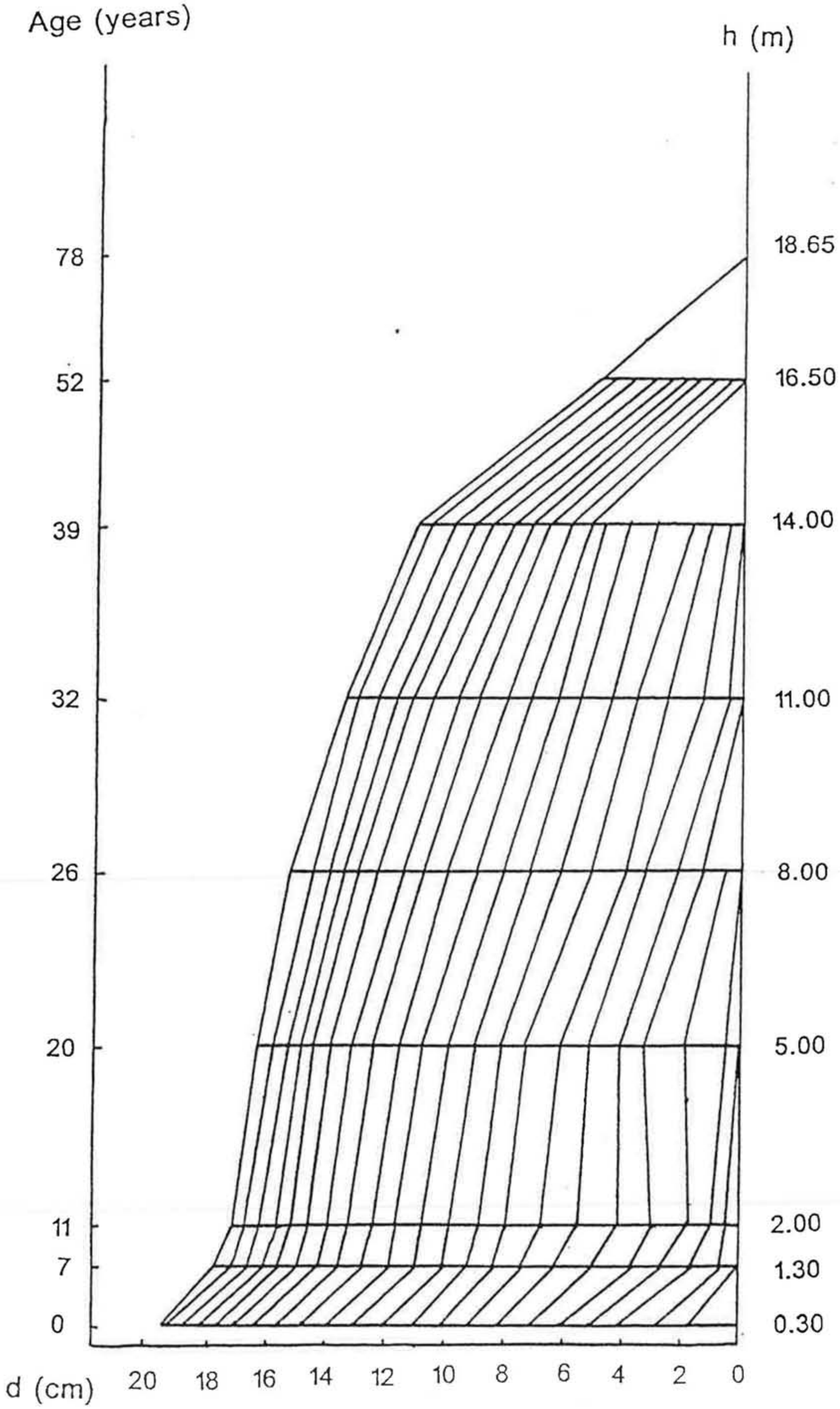

Figure 10. Stem analysis graph of Pinus halepensis.

5. Forest yield data

A height curve in relation to its age is given in figure 11 according to the equation $H=-2.841+0.46t-0.002t^2$ (R^2=97.8%). In this curve we observe a vertical growth of height until the first 40 years of age. Later this growth is gradually reduced.

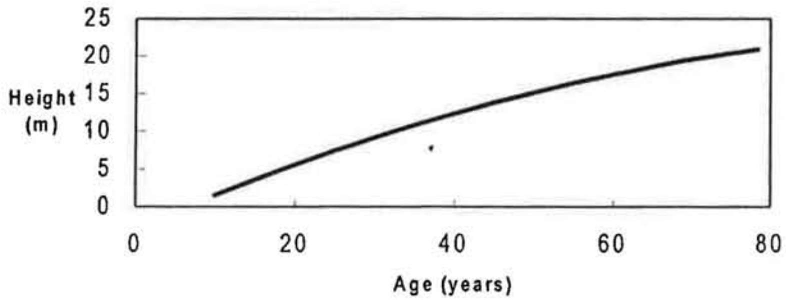

Figure 11. Height curve in relation to age $H= -2.841+0.46t-0.002t^2$ (r^2=97.8 %).

Figure 12 shows the curve of the mean annual height increase in relation to its age, in which is observed the sudden reduction of height growth after 40 years of age.

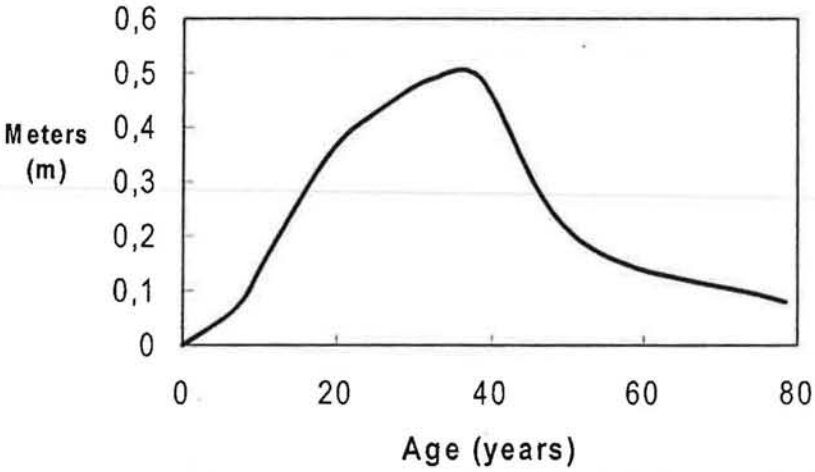

Figure 12. The curve of mean annual height increase in relation to the age.

A height curve in relation to its diameter is given in figure 13 according to the equation $H=0.9775+0.846d-0.0095d^2$ (R^2=90.3%). In this curve we observe a vertical growth of height up to the diameter of 30cm and then a complete fall of it.

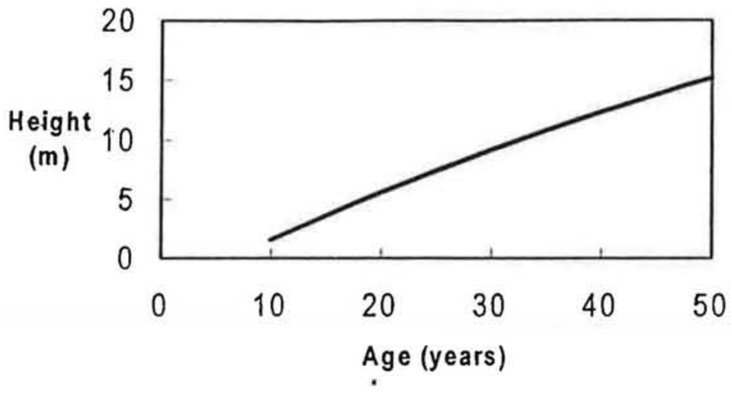

Figure 13. Height curve in relation to diameter $H=0.9775+0.846d-0.0095d^2$ ($r^2=90.3\%$).

Figure 14 shows the graph of Pinus halepensis rings' width. We observe that the mean width increases until the age of 10 years in which it reaches the maximum value. Afterwards, the mean width is reduced gradually until the age of 40 years, due to the absence of silvicultural treatments. When the stand was 50 years old, an intense thinning took place in order to prepare the stand for resin tapping. This thinning caused an increase of the mean ring width. These mean ring width fluctuations are due to thinnings or to environmental factors.

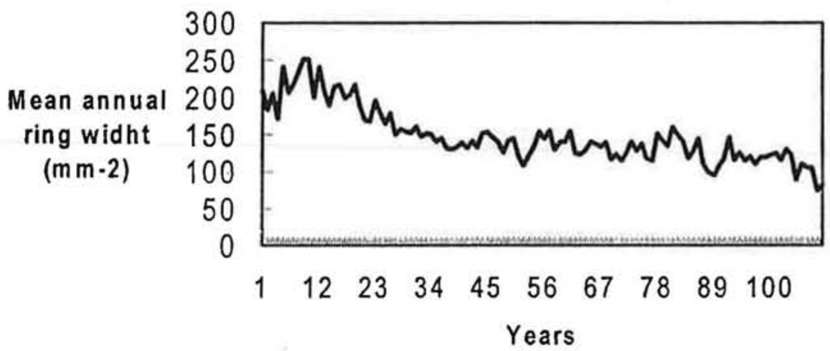

Figure 14. Mean annual ring width of Pinus halepensis.

Figure 15 shows the increase of basal area which agrees with the former graph.

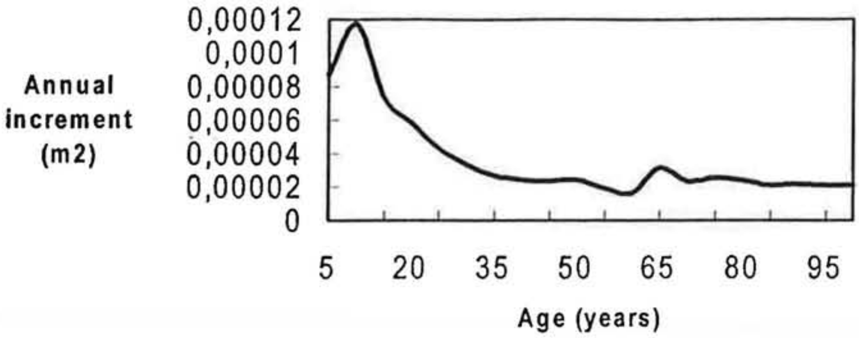

Figure 15. Curve of basal area increase in Pinus halepensis.

Finally, in figure 16 the course of volume increase of Pinus halepensis is shown. We observe that until the age of 70 years we have a linear relation of the volume increase (250m^3/ha) and then we notice a fall of growth (23 years-66.87 / 48 years –167.025 / 70 years –256.8 / over 100 years – 302.69).

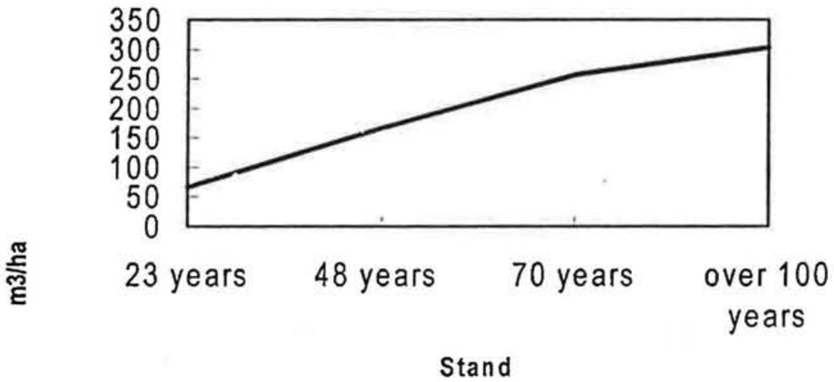

Figure 16. Growing stock of Pinus halepensis stands.

6. Results

Soil

The area soils can be delineated as renzinas or as soils of AC or ABC profile with heavy mechanical texture and basically as, clay-loamy soils with a high percentage of clay. These soils can be characterized from the high degree of pH (higher than 7.0) and high percentage of calcium carbonate. The A horizon sits over a calcium parent material (marl). The organic matter is between 0.69% and 9.2%. It's obvious that the soils are poor to medium in humus (Alexiadis,1962, Dafis,1969). The nitrogen is between 0.03 and 0.30% and the carbon is between 0.40 and 5.32%. The values of C/N are low due to the fires.

Structure

The stands under research originated from fires and are evenly aged. At the age of 23 years, there are 3340 trees, at the age of 48 years, there are 396 trees, at the age of 70 years, 260 trees and at the age of over 100 years, there are 300 trees per hectare. We observe a sudden fall of Pinus halepensis' number of trees due to the intense competition and heavy thinnings for the stand resin tapping preparation.

Tsitsoni (1991), for the equivalent site type, found 620 trees in the age of 10-20 years, 600 trees in the age of 25-35 years and 40-50years and 527 trees in the age of 60-80 age years.
Smiris (1987) found in Strofilia Achaias 2100 trees at the age of 25 years, 3200 trees at the age of 42 years, 972 trees at the age of 63 years, 561 trees at the age of 80 years and 489 trees at the age of 100 years.

The higher values recorded result from the fact that the stands, on one hand, have not suffered from resin tapping and strong interferences and on the other, this site is more favourable for the regeneration after fire. The mean diameter in the four age classes is 9.21cm, 26.77cm, 36.53cm, 43.19cm and depends on the silvicultural treatments applied in stands. These values are higher than those of Smiris (1987) due to the intense thinning and better quality of site. Tsitsoni (1991) found for the ages 10-20, 25-35, 40-50 and 60-80 the values 17.8-24.11-26.63-23.32cm respectively.

There are no substantial differences in the height values between Smiris (1987) and Tsitsoni (1991). The basal area for the respective ages 23-48-70 and over 100 years old are 17.10-20.66-35.10 and 33.95 m^2/ha.
The values which are found from Smiris (1987) are higher (due to light thinnings) than those from Tsitsoni (1991). Tsitsoni values for basal area for the respective ages 10-20, 25-35, 40-60, 60-80 are 18.56-33.47-41.29-50.98 m^2/ha.

From height distribution, it's obvious that we have one-stored stands expect for the 100 year old stage in which we have the appearance of the uderstorey due to disruption of stand canopy.

Stem analysis

From the stem analysis, it's obvious that the higher ring width is observed at the age of 10 years. Then the growth falls because of the absence of silvicultural treatments. After the age of 50 years, we have fluctuations in the annual rings' width because of the intense thinnings in the stands for the resin tapping preparation. The maximum height growth appears at the age of 28-32 years. After the first 40years of age, we have a valid fall of height increase.

7. Conclusions

-Pinus halepensis forests in the Kassandra Peninsula of Chalkidiki are more favourable for the regeneration after fires.

-Pinus halepensis stands are usually evenly aged.

-Till the age of 70 years, it's obvious that we have one-stored, homogeneous stands, which gradually become two-stored, heterogeneous or multistored stands.

-The maximum diameter growth is observed at the age of 10 years, and the maximum height growth appeared at the age of 28-32 years.

- Pinus halepensis forests in the Kassandra Peninsula are advisable for many forestry uses (aesthetic, protection, water production, financial and social uses).

-The multi-stored, heterogeneous stands at the age of over 100 years, are recommended for aesthetic aims.

-Kassandra forests can be characterized by the absence of silviculture treatments. These treatments need to be done early (till the age when canopy is connecting), when indicated, mechanical means should be used.

-The spacing degree depends on the management aim. Light thinnings are recommended for aesthetic and protection forests, regular thinnings for wood production forests and intense thinnings for resin production.

-In the burnt forests, which are not suitable for natural regeneration, (due to various reasons such as young age, high slope, or the absence of regeneration), it's obvious that in the reforestation many evergreen, native species need to be used, which increase the stability and the biodiversity of Pinus halepensis stands.

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