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Conditions determining natural regeneration after wildfires in the *Pinus halepensis* (Miller, 1768) forests of Kassandra Peninsula (North Greece)

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Abstract

Post-fire natural regeneration in Aleppo pine (*Pinus halepensis*) forests of Kassandra Peninsula (North Greece) was studied. The Kassandra Peninsula is characterized by a Mediterranean-type climate with a mild sub-humid winter and a long xerothermic period. Sampling was done on 74 plots in four different areas of the peninsula. The total mean regeneration indices were satisfactory in mature stands and varied between 0.60 and 14.26; they had their lowest values at the upper position and increased descending the hillside, showing statistically significant differences. The slope was also found to be an important factor determining natural regeneration, which was best in areas with a slope of 0–50%. A recurrence of fire in one of the areas studied, 4 years after the first fire, proved to be destructive for the natural regeneration.

Keywords: Natural regeneration; Wildfires; Aleppo pine forests; Mediterranean ecosystems

1. Introduction

Greece is a Mediterranean country in which the problem of fire is great, due to the climatic conditions prevailing in summer (high temperatures and drought). This problem is major in the zone of the evergreen broadleaves where mostly pyrophilic species of the genera *Pinus, Quercus, Erica* and *Cistus* appear. These species are known to be highly flammable and big areas are burnt every year. The wildfires are, however, an integral part of the Mediterranean-type environment, and this is justified by the high post-fire regeneration capacity of the burnt Mediterranean ecosystems (Naveh, 1974; Trabaud et al., 1985; Thanos et al., 1989; Thanos and Marcou, 1991). Due to the numerous adaptation mechanisms evolved by these species, they have been called 'fire-tolerant' (Le Houerou, 1974; Dafis, 1986). Especially the species *Pinus halepensis* and *Pinus brutia* maintain the germination capacity of their seeds long after fire (Dafis, 1986, 1987), a fact known in the ancient times as recorded by Theophrastus according to Thanos et al. (1989). A similar natural regeneration behaviour after fire has been observed in other species such as *Pinus banksiana* by Roe et al. (1971) and Beaufait et al. (1975).

In the present research, the natural regeneration of the Aleppo pine, after wildfire, is studied. It is a dominant forest species in the Mediterranean ecosystems and spreads from sea level up to 600–800 m in the Quercetalia ilicis vegetation zone and especially

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in the Adrachno-Quercetum ilicis plant formation where it has its optimal growth. In Greece it is found in Peloponnesos, Epirus, Sterea Hellada, Euboea, Chalkidiki, Pelio, Ionean and Aegean islands. From a silvicultural-biological point of view, Aleppo pine is a photophilic, dry-warm, frugal species preferring alkaline and neutral soils (Nahal, 1962; Quezel, 1986). Wildfires make the Aleppo pine more competitive against the rich shrubby vegetation of the exceptionally flammable species composing its understorey in relation to which it is less competitive under normal conditions (Dafis, 1986, 1987; Wagner, 1970).

The Aleppo pine forests in Kassandra Peninsula were selected for two reasons: (1) because this species reaches its optimal growth in this area (Dafis, 1969), and (2) because the existence and conservation of this species is very important for the already high touristic development of the area. However, the species is in danger due to the frequent fires occurring during summer.

The purpose of this research was: (1) to study the possibilities for natural regeneration of the Aleppo pine after fire, (2) to determine conditions favorable for natural regeneration after fire, and (3) to draw conclusions on forestry practice.

2. Study area

The research was conducted at the state and community forests of Kassandra Peninsula, which is the first of the three peninsulas of Chalkidiki from the west to the east; it occupies an area of about 35 000 ha (Fig. 1).

The climate of the area belongs to the Mediteranean type (Balafoutis, 1977) and, according to the bioclimatic diagram of Emberger (1959), to the sub-

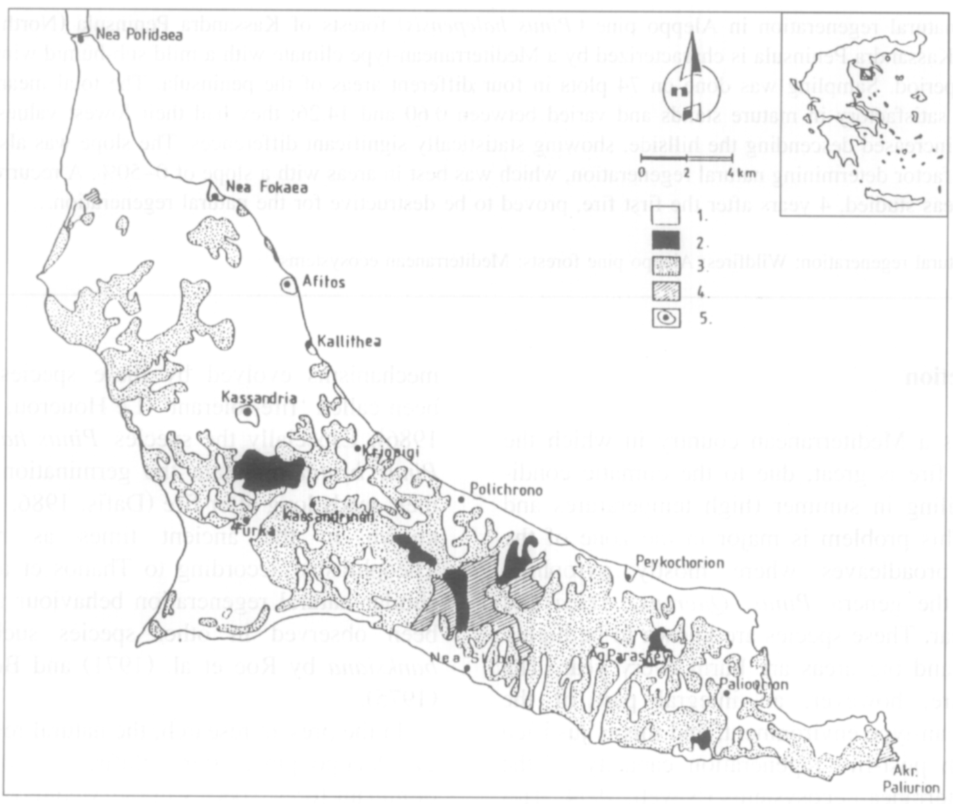

Fig. 1. Vegetation map in Kassandra Peninsula. 1, cultivated lands; 2, forests of *Pinus brutia* and *Pinus halepensis*; 3, forests of *Pinus halepensis*; 4, scrub of macquis (*Quercion ilicis*); 5, villages.

humid Mediterranean zone (Mavrommatis, 1980); this is also confirmed by the vegetation spectrum of the area (Tsitsoni and Karagiannakidou, 1992). The dry period has an average duration of 4.5 months, from the middle of April to the end of September, and the mean annual rainfall is 559.1 mm according to the data from the meteorogical station of Kassandria 1975–1990 (Tsitsoni, 1991).

The soils occupied by the Aleppo pine in Kassandra are loamy-clayey with a high content of loam, except for a few areas such as Polychrono (one of the four studied areas) where there was a relatively high content of sand. A characteristic feature of these soils is the high pH ranging from 7.0 to 8.4. The contents of organic matter in the burnt area is about 5–8%, while in other unburnt sites of Kassandra Peninsula it ranges from 2% to 4%. The total nitrogen of the local soils ranged from 0.02% to 0.3% (Tsitsoni, 1991).

The vegetation of the area consists of the characteristic Mediterannean floristic components, the Allepo pine dominating. The species prevailing in shrubby vegetation include *Pistacia lentiscus*, *Smilax aspera*, *Phillyrea media*, *Quercus coccifera*, *Asparagus acutifolius*, *Lonicera implexa*, *Cistus incanus*, *Myrtus communis*, *Arbutus unedo*, *Arbutus adrachne*, *Erica arborea* and *Erica manipuliflora*; those prevailing in herbaceous vegetation include *Rubia peregrina*, *Brachypodium retusum*, *Brachypodium pinnatum*, *Carduus pycnocephalus*, *Carex*

Table 1
Characteristics of natural regeneration in various sites of Aleppo pine forest at Nea Skioni, burnt on July 1977 (measurements were taken during July–September 1985)

Location on hillside	No.	RI (m^{-2})	Height (cm)			Age (years)	Exposure	Slope (%)	Mean RI (m^{-2})
			1–30	31–60	> 60				
Upper									
Prof. Hlias	1	2.8	0.4	0.3	2.1	7	E	25	
Livadakia	2	2.7	–	–	2.7	5	W	35	
Frama	3	2.4	–	0.3	2.1	8	SE	50	2.85
Nekrotafeio	4	3.5	–	2.9	0.6	7	S	40	
Trambala	5	0.6	0.2	0.2	0.2	2–5	SE	75	
Anemi (a)	6	1.3	–	–	1.3	7–8	W	75	0.83
Anemi (b)	7	0.6	–	–	0.6	7–8	S	75	
Total mean RI									1.99
Middle									
Prof. Hlias	8	6.2	0.6	–	5.6	7	E	25	
Livadakia	9	8.3	1.3	0.6	6.4	7	W	35	
Frama	10	2.8	–	–	2.8	5–8	SE	50	5.58
Nekrotafeio	11	5.0	–	–	5.0	8	S	40	
Trambala	12	0.7	–	0.7	–	5	SE	80	
Anemi (a)	13	0.7	–	–	0.7	8	W	80	0.63
Anemi (b)	14	0.5	–	–	0.5	7	S	80	
Total mean RI									3.45
Low									
Prof. Hlias	15	8.4	1.0	5.6	1.8	7	E	25	
Livadakia	16	5.6	0.2	0.3	5.1	7	W	35	
Frama	17	17.0	–	–	17.0	8	SE	50	9.0
Nekrotafeio	18	5.0	–	–	5.0	8	S	40	
Trambala	19	0.3	–	–	0.3	5	SE	80	
Anemi (a)	20	1.4	–	–	1.4	8	W	75	1.2
Anemi (b)	21	1.9	–	–	1.9	7–8	S	75	
Total mean RI									5.1

RI, regeneration index.

Table 2
Analysis of variance of the relationship between regeneration index and the parameters of position and the slope (Nea Skioni)

Source	d.f.	Mean square	*F*	*P*
Main effect	7	27.073	283.00	0.000
Position	2	23.899	249.81	0.000
Slope	5	28.343	296.27	0.000
Position × Slope	8	15.131	158.16	0.000
Explained	15	20.704	216.42	0.000
Residual	5	0.096		
Total	20	15.552		

flacca, *Asparagus monspesulanum*, *Brachypodium sylvaticum* and *Tammus communis* (Lavrediades, 1961; Tutin et al., 1964–1980; Tsitsoni, 1991).

3. Methods

The research on natural regeneration after fire was carried out from July to September of 1985, in four areas where fires had occurred in previous years. These areas were: (1) Nea Skioni (fire in June 1977); (2) Afitos (fire in July 1984); (3) Agia Paraskevi (fire in June 1977 and again in July 1981); (4) Polychrono (fire in July 1981).

In the above areas, 74 sample plots were taken on different slopes and at three positions on the hillside (upper, middle, low). The sample plots were squares of 10 m × 10 m. Each sample plot was divided into 100 squares of 1 m^2 and we randomly took ten squares, counting the number, age and height of seedlings in them. In each square the seedlings were classified into three classes according to their height: in the first, the seedlings measuring 1–30 cm were classified, in the second those measuring 31–60 cm and in the third class those higher than 60 cm. As regeneration index we defined the number of seedlings per square metre. For each position on the hillside, the total mean regeneration index was calculated in all areas. In all positions on the hillside, the mean regeneration index was calculated separately for slopes of 0–50% and slopes greater than 50%. The relationship between the regeration index, on the one hand, and the parameters of position on the hillside and the slope, on the other, were tested by analysis of variance (two-way ANOVA).

4. Results

The situation concerning natural regeneration in the studied areas is as follows.

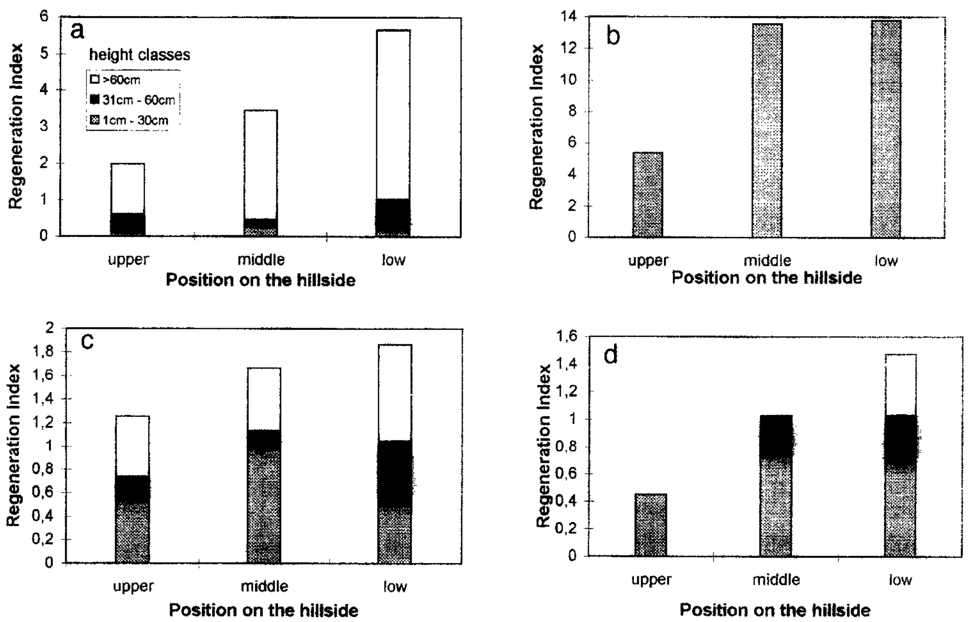

Fig. 2. Regeneration indices for all height classes and all positions on the hillside: a, Nea Skioni; b, Afitos; c, Agia Paraskevi; d, Polychrono area.

Table 3
Characteristics of natural regeneration in various sites of Aleppo pine forest at Afitos, burnt in July 1984 (measurements were taken in July–September 1985)

Location on hillside	No.	RI (m^{-2})	Height (cm)			Age (years)	Exposure	Slope (%)	Mean RI (m^{-2})
			1–30	31–60	> 60				
Upper									
Zoni Karakalou	1	11.1	11.1	–	–	1	E	5	
Giovanni Lakkos	2	9.3	9.3	–	–	1	S	3	
Baila	3	0.9	0.9	–	–	1	W	15	
Asimines	4	4.9	4.9	–	–	1	SE	15	
Pefkias	5	0.7	0.7	–	–	1	NE	10	
Total mean RI									5.58
Middle									
Zoni Karakalou	6	19.5	19.5	–	–	1	E	5	
Giovanni Lakkos	7	11.1	11.1	–	–	1	S	5	
Baila	8	4.3	4.3	–	–	1	W	15	
Asimines	9	22.2	22.2	–	–	1	SE	15	
Pefkias	10	10.7	10.7	–	–	1	NE	10	
Total mean RI									13.56
Low									
Zoni Karakalou	11	20.9	20.9	–	–	1	E	3	
Giovanni Lakkos	12	16.4	16.4	–	–	1	S	5	
Baila	13	8.1	8.1	–	–	1	W	5	
Asimines	14	9.7	9.7	–	–	1	SE	15	
Total mean RI									14.26

RI, regeneration index.

4.1. Nea Skioni

The general exposure of the area is western. Table 1 presents the characteristics of natural regeneration in various sites of the Aleppo pine forest in this area. As can be seen from Table 1, the regeneration index was considerably influenced by the degree of slope and position on the hillside. The statistical treatment of the data confirmed the observed differences, revealing statistically very significant differences among the regeneration indices in relation to the above two factors (Table 2). In the upper position on the slope, the total mean regeneration index was 1.99, in the middle position 3.45 and in the low position 5.61. The total mean regeneration index had its lowest value at the upper position and increased on descending the hillside. This is clearly shown in the histogram of Fig. 2(a) in which the regeneration indices for all height classes and all positions on the hillside are illustrated. In the low position of the hillside, the most numerous and the tallest seedlings are observed. The age of seedlings ranged from 2 to 8 years. A continuous enrichment of young seedlings occurred in the burnt area 8 years after fire, as can be seen from the age of the seedlings (Table 1).

4.2. Afitos

The general exposure of the area is eastern. Table 3, which gives the characteristics of natural regeneration in various sites of this area, shows that the

Table 4
Analysis of variance for the relationship between regeneration index and the parameter of position (Afitos)

Source	d.f.	Mean square	F	P
Main effect				
Position	2	111.718	3.001	0.091
Residual	11	37.232		
Total	13	48.691		

Table 5
Characteristics of natural regeneration in various sites of Aleppo pine forest at Agia Paraskevi, burnt in 1977 and 1981 (measurements were taken in July–September 1985)

Location on hillside	No.	RI (m^{-2})	Height (cm)			Age (years)	Exposure	Slope (%)	Mean RI (m^{-2})
			1–30	31–60	> 60				
Upper									
Ag. Thanasis	1	0.9	0.3	0.2	0.4	2–3	E	5	
Ag. Triada	2	2.9	–	1.2	1.7	4	SW	15	
Ag. George	3	1.8	–	–	1.8	3	NE	40	1.95
Palatia	4	2.2	2.1	0.1	–	4	W	20	
Mylos	5	1.5	1.5	–	–	2–4	W	80	
Mourkoutes	6	0.1	–	0.1	–	4	E	70	
Tzineria	7	0.9	–	0.1	0.8	2–4	N	70	0.72
Pigadaki (a)	8	0.1	–	0.1	–	2–4	N	60	
Pigadaki (b)	9	0.9	0.9	–	–	4	SE	70	
Total mean RI									1.27
Middle									
Ag. Thanasis	10	6.1	5.3	–	0.8	2–3	E	5	
Ag. Triada	11	3.7	0.6	0.8	2.3	4	SW	15	
Ag. George	12	0.5	–	0.3	0.2	3	NE	40	2.42
Palatia	13	1.5	–	–	1.5	4	W	20	
Mylos	14	0.3	0.1	0.2	–	4	W	50	
Mourkoutes	15	0.4	0.3	0.1	–	2–3	E	70	
Tzineria	16	1.0	1.0	–	–	2–3	N	80	0.70
Pigadaki (a)	17	0.5	0.5	–	–	2–3	N	70	
Pigadagi (b)	18	1.0	1.0	–	–	2–4	SE	70	
Total mean RI									1.65
Low									
Ag. Thanasis	19	61000	41000	20000	–	2–3	E	5	
Ag. Triada	20	22000	–	8000	14000	4	SW	4	
Ag. George	21	15000	–	8000	7000	3–4	NE	30	2.74
Palatia	22	32000	–	–	32000	4	W	20	
Mylos	23	7000	–	–	7000	3–4	W	50	
Mourkoutes	24	4000	–	3000	1000	4	E	70	
Tzineria	25	11000	2000	2000	7000	3–4	N	70	0.65
Pigadaki (a)	26	11000	–	3000	2000	4	N	70	
Pigadagi (b)	27	11000	1000	6000	4000	4	SE	70	
Total mean RI									1.81

RI, regeneration index.

slopes are very slight. At the upper position of the hillside, the mean total regeneration index is 5.58, at the middle 13.56 and at the low position 14.26. The analysis of variance (Table 4), which tested only the relationship between the regeneration index and the position on the hillside (since the slopes were very slight), revealed that there was no statistically significant difference. Fig. 2(b) shows that only seedlings of the height class 1–30 cm existed, since they were all 1 year old.

Table 6
Analysis of variance for the relationship between regeneration index and the parameters of position and the slope (Agia Paraskevi)

Source	d.f.	Mean square	*F*	*P*
Main effect	10	4.496	31.26	0.000
Position	2	1.049	7.34	0.019
Slope	8	5.324	37.24	0.000
Position × Slope	9	2.165	15.14	0.001
Explained	19	3.378	23.63	0.000
Residual	7	0.143		
Total	26	2.507		

Table 7
Characteristics of natural regeneration in various sites of Aleppo pine forest at Polychrono, burnt in 1981 (measurements were taken in July–September 1985)

Location on hillside	No.	RI (m^{-2})	Height (cm)			Age (years)	Exposure	Slope (%)	Mean RI (m^{-2})
			1–30	31–60	> 60				
Upper									
Vathylakos (a)	1	0.9	0.9	–	–	3	N	35	
Vathylakos (b)	2	0.6	0.6			3–4	S	35	
Sikalies (a)	3	0.35	0.35			3–4	E	40	
Sikalies (b)	4	0.3	0.3	–	–	3	W	40	
Total mean RI									0.60
Middle									
Vathylakos (a)	5	1.9	1.2	0.7	–	3–4	N	35	
Vathylakos (b)	6	1.5	1.0	0.5		3–4	S	35	
Sikalies (a)	7	0.4	0.4			3–4	E	40	
Sikalies (b)	8	0.3	0.3	–	–	3–4	W	40	
Total mean RI									1.10
Low									
Vathylakos (a)	9	1.9	1.4	0.5	1.5	3–4	N	35	
Vathylakos (b)	10	1.6	1.1	0.2	0.3	3–4	S	35	
Sikalies (a)	11	0.5	0.2	0.3		3–4	E	40	
Sikalies (b)	12	0.4	–	0.4	-3	3	W	40	
Total mean RI									1.90

RI, regeneration index.

4.3. *Agia Paraskevi*

The general exposure of the area is western. Table 5 shows that in this area very low regeneration indices were observed. The analysis of variance reveals statistically very significant differences among the tested parameters (Table 6). At the upper position of the hillside the total mean regeneration index was 1.27, at the middle 1.65 and at the low position 1.81. The seedlings were very young, 2–4 years old, which is a result of the second fire in the area. Fig. 2(c) shows the regeneration indices for each position on the hillside for all height classes.

Table 8
Analysis of variance on the relationship between the regeneration index and the parameters of position and the slope (Polychrono)

Source	d.f.	Mean square	*F*	*P*
Main effect	3	1.299	43.01	0.000
Position	2	0.373	12.35	0.007
Slope	1	3.152	107.134	0.000
Position × Slope	2	0.271	8.96	0.016
Explained	5	0.888	29.39	0.000
Residual	6	0.030		
Total	11	0.420		

4.4. *Polychrono*

The general exposure of the area is eastern. Table 7 shows that the area has moderate slopes and the total mean regeneration indices at the three positions on the hillside were: at the upper 0.60, at the middle 1.10, at the low 1.90. The analysis of variance showed that there was a statistically significant difference among the regeneration indices in relation to position on the hillside and the slope (Table 8). Fig. 2(d) shows that the short seedlings were the most numerous at all positions on the hillside, due to the young age of seedlings (2–4 years old).

5. Discussion and conclusions

The analysis of the results showed that the natural regeneration of the Aleppo pine in the studied area was satisfactory, a fact that can be attributed on one hand to the adaptation mechanisms evolved by this species, as mentioned in the Introduction and, on the other, to the favorable conditions prevailing in the area. The total mean regeneration indices varied between 0.60 and 14.26, during a period of 1–8 years after fire. These values are satisfactory in comparison with those reported by other authors for the species *P. halepensis*. Zagas (1987) studied Aleppo pine regeneration in Mount Pateras, Attiki (Central Greece), and found that the number of seedlings per square metre ranged from 8.7 to 18.5, 2 years after fire. Trabaud et al. (1985) found that, during the first 5 years after fire, the number of seedlings is rather stable, around 0.1 seedlings m^{-2}, while in 5–15 years it increases to a peak of 1 seedling m^{-2} and then decreases to a plateau value of 0.1 seedlng m^{-2} (15–30 years after fire). For the species *P. brutia*, Thanos et al. (1989) reported that 15 months after fire the average density of seedlings was 0.30 seedlings m^{-2}, a value which they considered high enough to result in complete natural regeneration for most of the area burnt.

Concerning the height of the seedlings in our study area, we should note that it reached 30 cm during the first post-fire year in Afitos. Thanos et al. (1989) measured the height of the 1-year-old *P. brutia* seedlings (5.9 cm) in burnt areas of Samos Island and found they were higher than those measured by Panetsos (1981) in nursery tests of four different provenances (values ranging from 4.45 to 4.85 cm). The height of the 1-year-old Allepo pine seedlings in Afitos ranged from 1 to 30 cm. The growth rates of *P. brutia* are clearly lower than those manifested by *P. halepensis*, at least during the first 4–5 years (Panetsos, 1981; Trabaud et al., 1985).

Furthermore, the natural regeneration of the Aleppo pine in our study area was satisfactory in spite of the high pH values (7.0–8.4) measured. This was also reported by other authors such as Magini (1955) and Giordano et al. (1984) for the same species in Italy, and Naveh (1974) in Israel (pH 7.5–7.7). The high value of organic matter of the burnt soil in our study area (5–8% versus 2–4% in unburnt neigbouring sites) was a favorable factor for natural regeneration.

As presented in the results, the analysis of variance showed that the position on the hillside was an important factor determining natural regeneration indices in all the four areas studied; the lowest values occur at the upper position and increase on descending the hillside, as seen in Tables 1, 3, 5 and 7. In the area of Afitos, although this general pattern is followed, no statistically significant differences were found due to the very slight slope of the area (see below). This increase of regeneration indices in the lowest parts of the hillside should be attributed to the fact that the seeds were being swept downwards by the rainwaters together with the ash and the soil, and accumulated in this position. Moreover, due to toposequence, in the low part of the hillside the soil is deeper with better conditions of humidity (Hatzistathis, 1975); however, the moisture of the soil was not high enough to favour the intense growth of the understorey, which could outcompete the Aleppo pine regeneration.

The slope is another very important factor which proved to determine natural regeneration, as resulted from the statistical analysis. In two of the examined areas (Nea Skioni and Agia Paraskevi), where various degrees of slope existed (5–80%), natural regeneration was satisfactory in sites having a slope of 0–50%, whereas on steeper slopes it was significantly reduced. Kailidis (1990) made similar observations in North Euboea and Attiki (Central Greece), and reported that, on the steepest slopes, poorer or non-existing natural regeneration appeared, sometimes resulting in bare rock. In the area of Afitos, where the slopes were very slight (3–15%), regeneration indices were extremely high (5.58–14.26). The low indices in the area of Polychrono, in comparison to those of the other areas, are possibly due to the composition of the soil, in which there was a relatively high percentage of sand, as mentioned above. In the area of Agia Paraskevi, lower regeneration indices in relation to the areas of Nea Skioni and Afitos were calculated due to the absence of mature stands because of the recurrence of fire 4 years after the first, and 4 years before our research. According to Dafis (1986, 1987)), the repetition of fire in a time period shorter than 10–15 years is catastrophic for natural regeneration because the Aleppo pine can not create new cones. Similar observations have been reported from the South of France and Sardinia by Duvernoy (1975) and in California by Biswell (1974).

From the above, it is clear that in Kassandra Peninsula a very satisfactory natural regeneration is taking place after wildfire, absolutely inexpensively. We should take advantage of this natural process and support it by various measures, such as: (1) declaring the burned area as being under reforestation, (2) controlling grazing, by restricting goats and sheep to rangelands which should be improved, (3) felling and removing outside the forest the burned logs until November and the latest until February of the next year, (4) protecting the area against fires by opening out firebreak strips and roads, and by removing the understory along the roads and in strips within the stand. In the event that natural regeneration does not appear 3 or 4 years after the fire, artificial planting should be made (Hatzistathis, 1975). Seedlings in patches should be planted in appropriate places and in a planting 2 m × 2 m. The seed used must be of the same origin as that of the burnt area (Hatzistathis and Dafis, 1989). In extreme situations special treatment of the soil is needed (Hatzistathis, 1972).

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References

Balafoutis, Ch., 1977. Contribution to the study of Macedonia and western Thrace climate. Ph.D. Thesis, Thessaloniki, 121 pp. (in Greek, with English abstract).

Beaufait, W.R., Hardy, C.E. and Fisher, W.C., 1975. Broadcast burning in Larch-fir clearcuts: the Miller Creek-Newman Ridge study. USDA Forest Service Research Paper, Interm. For. Rang. Exp. Stn. Res. Pap. INT-175, 53 pp.

Biswell, H., 1974. Effects of fire on chaparral. In: T.T. Kozlowski and C.E. Ahlgren (Editors), Fire and Ecosystems. Academic Press, New York, pp. 321–364.

Dafis, S., 1969. Site research in beech forests. Sci. Ann. Agric. For. Sch. Thessaloniki, 13: 1–48 (in Greek).

Dafis, S., 1986. Forest Ecology. Giahoudis-Giapoulis, Thessaloniki, 443 pp. (in Greek).

Dafis, S., 1987. Ecology of *Pinus halepensis* and *Pinus brutia* forests. Proceedings of the 1st Scientific Meeting of Hellenic Forestry Society on *Pinus halepensis* and *Pinus brutia* forests, Chalkida, 30 September–2 October 1987, Thessaloniki, 1: 17–25 (in Greek).

Duvernoy, M., 1975. On forest fires in the southern regions (of France). Foret Privee Francalse, 106: 75–76 (in French).

Emberger, L., 1959. Orientations actuelles au Servise de la C.G.V. de la ceuntographie phytosociologique appliquee. Bull. Serv. Carte Phytogeogr. Ser. B, IV: fasc. 2.

Giordano, E., Scarascia, G. and Schirone, B., 1984. Osservazioni sulla Rinnovozione Naturale del Pino d'Aleppo in Pulgia. Tuscia, Viterbo.

Hatzistathis, A., 1972. The influence of terracing and subsoiling on the soil moisture regime and soil fertility and its importance for reforestation work. Ph.D. Thesis, Thessaloniki, 106 pp. (in Greek).

Hatzistathis, A., 1975. Soil and Reforestations. Giahoudis-Giapoulis, Thessaloniki, 31 pp. (in Greek).

Hatzistathis, A. and Dafis, S., 1989. Reforestations–Forest Nurseries. Giahoudis-Giapoulis, Thessaloniki, 262 pp. (in Greek).

Kailidis, D., 1990. Forest Fires. Giahoudis-Giapoulis, Thessaloniki, 510 pp. (in Greek).

Le Houerou, H.N., 1974. Fire and vegetation in Mediterranean basin. In: Proceedings of the 13th Annual Tall Timbers Fire Ecology Conference, Rome, pp. 237–277.

Lavrediades, G., 1961. Floral plantgeographic and plantsociological research of Kassandra Peninsula. Sci. Ann. Sch. Phys. Math. Sci., 8: 1–157 (in Greek with English abstract).

Magini, E., 1955. Sulle condizioni di germinazione del pino d' Aleppo e del pino domestico. Italia Forestale e Montana, 40: 106–124.

Mavrommatis, G., 1980. The Bioclima of Greece, Relations of Climate and Natural Vegetation, Bioclimatic Maps. F.R.I., Athens (in Greek with English abstract).

Nahal, I., 1962. Le pin d'Alep (*Pinus halepensis* Mill). Etude Taxonomique, Phytogeographique Ecologique et Sylvicole. Annals Ecole Nationale Eaux et Forets, Nancy, 19: 1–207.

Naveh, Z., 1974. Effects of Fire in Mediterranean Region. In: T.T. Kozlowski and C.E. Ahlgren (Editors), Fire and Ecocystems. Academic Press, New York, pp. 401–434.

Panetsos, C. P., 1981. Monograph of *Pinus halepensis* and *Pinus brutia*. Ann. For. Zagreb, 9: 39–77.

Quezel, P., 1986. Les pins du group 'halepensis'. Ecologie, Vegetation, Ecophysiology. Options Mediterraneennes. C.I.H.A.N., 1986-1.

Roe, A.L., Beaufait, W. R., Lyon, L.J. and Oltman, J.L., 1971. Fire and forestry in the northern Rocky Mountains—a task force report. J. For., 69: 464–470.

Thanos, C.A. and Marcou, S., 1991. Post-fire regeneration in *Pinus brutia* forest ecosystems of Samos island (Greece); 6 years after. Acta Ecol., 12: 633–642.

Thanos, C.A., Marcou, S., Christodoulakis, D. and Yannitsaros, A., 1989. Early post-fire regeneration in *Pinus brutia* forest ecosystems of Samos island (Greece). Acta Ecol. Ecol. Plant., 10: 79–94.

Trabaud, L., Michels, C. and Grosman J., 1985. Recovery of burnt *Pinus halepensis* Mill. forests II. Pine reconstitution after wildfire. For. Ecol. Manage., 13: 167–173.

Tsitsoni, Th., 1991. Stand structure and conditions determining natural regeneration after fire in the Allepo pine forests of Kassandra Peninsula (Chalkidiki, Greece). Ph.D. Thesis, Thesssaloniki, 150 pp. (in Greek with English abstract).

Tsitsoni, Th. and Karagiannakidou, V., 1992. Phytogeographical analysis of the flora of *Pinus halepensis* forests in the peninsula of Kassandra-Chalkidiki, NE Greece. Feddes Repert., 103: 1–2, 41–47.

Tutin, T.G., Heywood, V.H., Burgers, N.A., Moore, D.M., Valentine, D.H., Walters, S.M. and Wedd, D.A., 1964–1980. Flora Europaea. Vols. I–V. Cambridge University Press, Cambridge.

Wagner, V., 1970. Proceedings of the 10th Annual Tall Timbers Fire Ecol. Conf. Fredericton, N. Brunswick, 10: 211–219.

Zagas, Th., 1987. Research on the natural regeneration of *Pinus halepensis* after a forest fire in the Mount Pateras area. Sci. Ann. Sch. For. Nat. Environ. Thessaloniki, 30: 7, 303–327 (in Greek, with English abstract).