

A PRELIMINARY ASSESSMENT OF THE USE OF BLACK PINE IN THE REFORESTATION OF MOUNTAIN PARNITHA NATIONAL PARK, GREECE

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Abstract

After the catastrophic fire of 2007 in Parnitha mountain, reforestation has taken place with greek fir (*Abies cephalonica*) in surfaces of the burned fir forest in the National Park. To assist the regeneration of fir, which under natural conditions depends on nurse plants for successful establishment, several sites were planted with black pine (*Pinus nigra*).

In the present study the development of this aspect of the reforestation project is investigated in five monitoring plots which were planted in 2009 and 2010. Black pine seedlings were surveyed in November 2011. Results show that black pine seedlings exhibit low survival rates. The differences among plots were statistically significant. Various other problems were also observed, such as browsed, broken or dead seedling top and dead needle occurrence. The average apical growth of seedlings was lower than in the growth period of 2010. Also in this case, there is a statistically significant difference of the median apical growth among plots.

Keywords: *pinus nigra*, mt. *parnitha*, national park, reforestation

1. INTRODUCTION

The forests of *Pinus nigra* and *Abies cephalonica* appertain to Mediterranean mountainous coniferous forests (Dafis S., 2008b). *Pinus nigra* Arnold var. *austriaca* has been widely used in reforestations in Greece (Dafis S., 2010). After the huge catastrophic fire of 2007 in Parnitha, reforestation has taken place with *Pinus nigra* in surfaces of the burned fir forest in the National Park in order to assist the regeneration of *Abies cephalonica*, which needs shade to grow (Efthimiou et.al. 2014). *Pinus nigra* does not compete with fir as the area lies outside the limits of its natural distribution and there is no risk of hybridization with local species (Geomelas et al. 2007, Latsoudi P. 2007). Thanks to its remarkable ecological flexibility, it is one of the most widely used species for reforestation purposes (Kakouros P., S. Dafis 2009). It had been introduced in Parnitha since the end of the 1950s and it was already growing well prior to the fire incidence (Karetsos G. 2008).

The purpose of this study is to present preliminary results (November 2011) on the reforestation with *Pinus nigra* in five plots, which were planted in 2009 and 2010. Specifically, a monitoring of the planted seedlings has taken place in order to establish their condition and to draw a first conclusion regarding this reforestation scheme.

1.1. Study area

The study site is located in the National Park of Parnitha mountain, a large part of which was burned in summer 2007. Parnitha is located in Central Greece, 36 km north of Athens and it is the highest mountain area of Attica. It extends over a large area with a variable topography. In 1961 the entire mountain (~25,000 hectares) was declared a National Park and it is of great importance for the wider Athens metropolitan area. The wildfire that occurred in June 2007 burned approximately 21800 hectares of *A. cephalonica* dominated vegetation out of a total of over 36000 hectares, about two thirds of the National Park area (Forestry Service of Parnitha).

Long term climatic data for this area are only available from the Dekelia meteorological station, which is located at the southern foothills of the mountain. The annual precipitation is approximately 430 mm and the average annual temperature 16.5°C, with a typical Mediterranean summer dry period. The microclimate of Parnitha is very variable. Climatic conditions vary along the north - south and east - west axes as well as along the altitude gradient (Geomelas et al. 2007). The mountain zone above 1000 m a.s.l. is reported to receive twice as much precipitation annually. Snowfall, fog and frost are common (Amorgianiotis 1997; Geomelas et al. 2007). Soils are developed on limestone and flysch and show signs of significant past erosion (Geomelas et al. 2007).

2. MATERIALS AND METHODS

Permanent monitoring plots were established for the needs of the study. An electronic micrometer and a wooden folding meter were used in order to measure the growth of the seedlings and their original height respectively. Survival, growth (cm), vitality (proportion of dead needles and degree of discoloration) and the condition of the top of each individual were being monitored in autumn 2011.

The values of descriptive statistical indexes were estimated for the monitored variables, such as growth, survival rate and vitality problems per area. In order to investigate the dependence of the survival rate of seedlings on the sample surface, the χ^2 test for independence was used. One-Sample Kolmogorov-Smirnov Test was used to test the distribution of the height growth values of *Pinus nigra* for normality. The differences in growth of seedlings between the surfaces were tested for significance by means of the Kruskal-Wallis because the variables do not follow a normal distribution. The statistical analyses were performed using EXCEL and SPSS (v.17.0).

Table 1 Environmental setting of monitoring plots with *Pinus nigra*. Data on the characteristics of reforestation surfaces retrieved from Chaitoglou (2009).

Plot	Reforestation surface	Altitude of planted area (m.)	Inclination
1	Z	700 – 1000	Medium 40-70% and mild <40%
2	H	1050 - 1240	Medium 40-70% and mild <40%
3	H	1050 - 1240	Medium 40-70% and mild <40%
4	H	1050 - 1240	Medium 40-70% and mild <40%
5	Z	700 – 1000	Medium 40-70% and mild <40%

3. RESULTS AND DISCUSSION

Five different monitoring plots were monitoring on November 2011. Table 1 presents the five plots and their relationship to the reforestation areas defined in the supplementary study of reforestation interventions (2009), the altitude of the planted area and the inclination. All reforestation surfaces were set over hard limestone with rock outcrops and thin soil, typically 5-30 cm deep. Climatically these plots lie in the Mediterranean mountainous coniferous zone of *Pinus nigra* and *Abies cephalonica* (Dafis S. 2008).

In total, 350 *Pinus nigra* seedlings were monitored: 68 individuals in plot 1, 62 in plot 2, 72 in plot 3, 68 in plot 4 and 80 in plot 5. The seedlings in plots 2, 3 and 4 were planted in 2010, while in the remaining surfaces 1 and 5 the seedlings were planted in 2009.

3.1 Survival rate

Plots 2 and 3 exhibit nearly the same final survival rate (Figure 1). In 2010 (Papatheodorou 2010) observed that the surfaces 1 and 4 showed homogeneity with 94.12% survival. In this work, the lower

survival rate was recorded in plots 2 and 3 with 19.35% and 19.44% respectively, while the higher is in surface 5 with 73.75% and the surface 1 with 60.29%.

During the period between the two recordings there was a very significant mortality of seedlings on all plots, especially on 2, 3 and 4 leading to a decrease of 64.52% (40 seedlings), 63.89% (46 seedlings) and 50.00% (34 seedlings) in surviving seedlings. The lowest decrease was found in plot 5 amounting to 22.50% (18 seedlings). Plots 2, 3 and 4 have poor soil over limestone with coverage of gravel and unfavorable exposure. An additional significant problem is browsing and uprooting of seedlings by deer. There are statistically significant differences among survival rates in different plots (χ^2 test, $p < 0.001$), which means that survival of seedlings until November 2011 depends on the plot in which they were planted.

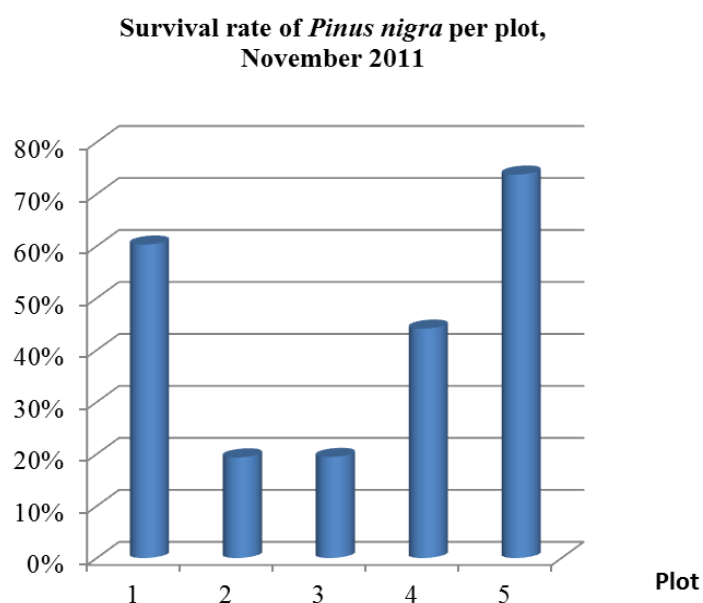


Figure 1. Survival rate of *Pinus nigra* per plot, November 2011.

3.2 Growth

Descriptive statistical measures of apical growth (average, median, standard deviation) were estimated in the growing period of the year 2011 per surface (Table 2).

The relationship between plot and apical growth of *Pinus nigra* was examined. Because the height increase values do not follow a normal distribution with equal variances (K-S test, $p < 0.001$), the test Kruskal-Wallis, which compares mean ranks was used.

Table 2. *Pinus nigra* growth (cm) per plot during the growth period of 2011.

Sample plot	Average	Median	Standard deviation
1	8.95	6	6.97
2	1.08	0	2.81
3	0.64	0	1.11
4	1.73	1	2.21
5	9.99	8	8.09

According to the average rank (mean Rank), there seems to be a grouping of plots 1-5 and 2-3 (Table 3). The difference of apical growth among plots is statistically significant (Kruskal-Wallis test, $p < 0.001$).

Table 3. Rankings of apical growth of *Pinus nigra* seedlings.

Rankings according to height growth		
Plot	Number of seedlings	MeanRank
1	41	100.12
2	12	31.75
3	14	31.32
4	30	47.2
5	59	100.09
Total	156	

3.3 Seedling condition

The condition of the seedlings in November 2011 is summarized in Table 4. The largest percentage of broken tops (19%) was observed in plot 3. Low percentages were also found in surfaces 2 and 1 with 11% and 4% respectively. The largest percentage of seedlings with browsed tops was found on plots 5 and 4, 50% and 44% respectively. The next lower percentage (34%) was found in plot 1 and the lowest, 8%, in plot 2. A low percentage (5%) of seedlings with browsed tops was found to be developing new ones solely in plot 5. Seedlings with an unnatural degree of dead needles were observed in all plots. In all cases the dead needles did not exceed one third of the total. The highest proportion of seedlings with dead needles amounted to 12% (8 seedlings) in plot 4. The symptoms of *Pinus nigra* needle die-off is the changing color of their needles, which are becoming brown, followed by necrosis and then toppling. The die-off begins from the younger needles. Seedlings in a very good condition were only found in plot 5, however, even in this case, the percentage is limited to 4% of the plot total.

Table 4. Status of *Pinus nigra* per plot on November 2011.

Plot	1	2	3	4	5
Browsed top - a new one was developing	-	-	-	-	5%
Broken top	4%	11%	19%	-	-
Browsed top	34%	8%		44%	50%
Extent of dead needles	4%	5%	6%	12%	3%
Very good condition of seedlings	-	-	-	-	4%

4. CONCLUSION

In the frame of the wider reforestation project concerning the burned areas of Parnitha *Pinus nigra* was planted in the south-facing and drier areas, where successful planting of fir is unlikely. *Pinus nigra* is not a native species of Parnitha and it was planted in order to create the appropriate environment, as a nurse plant, for a reforestation with firs later on. The prevailing climatic and soil conditions in Parnitha are particularly adverse for the growth of seedlings because of the skeletal soils, the high summer temperatures and the long dry period. The largest percentage of total rainfall occurs during the cold-wet winter months. Thus, the climate is dry, the temperature in summer is high during the day, despite the high altitude, and relatively low at night. Parnitha's microclimate has substantial differences within the same climatic zone.

The planting of *Pinus nigra* seedlings began during spring, instead of the recommended autumn period, when the soil is expected to be well watered beginning with the autumn rainfalls and until the end of January. The seedlings planted in the study plots were 350, 317 of which were found alive in October 2010 (Papatheodorou A., 2010). In the survey undertaken in this study in November 2011 only 156 were found alive, which amounts to a meager 44.57% survival rate. Thus, during the period covered by the present work there was a very significant reduction of seedlings in all plots and especially in 2, 3 and 4 in which a 64.52% (40 seedlings), 63.89% (46 seedlings) and 50% (34 seedlings) decrease was observed respectively. These plots were planted in 2010 in poor quality soils. The lowest decrease was observed in plot 5 with 22.50% (18 seedlings). A major problem for the black pine is browsing and uprooting by deer. So there was a blending of negative factors. There is a statistically significant dependence between the plots and the survival of *Pinus nigra* individuals.

The largest average apical growth of seedlings in the November 2011 survey was observed in plot 5, the next highest in plot 1 and plots 4, 2 and 3 followed. The average apical growth on surfaces 1 and 5 was lower than it was in the growing season of 2010. The difference in apical growth among plots was found to be statistically significant. It seems that plots 1-5 and 2-3 group together in this respect.

In the survey of November 2011, a large proportion of seedlings were found to have their tops browsed, especially in plots 5 and 4. A very low proportion of seedlings in plot 5 have developed a new top. Damage by browsing was lower in the rest of the plots. Compared to 2010 results are mixed, since browsing damage was more extensive in some plots and less extensive in others (see Papatheodorou A., 2010). Although *Pinus nigra* is considered to be a species that is not preferred by red deer, browsing of the seedling tops was widespread in this case and detrimental to the survival of the seedlings. Seedling tops broken by unknown causes were also observed, especially in plot 3.

Unnatural occurrence of dead needles was observed in all plots; a higher frequency was found in plot 4. In all cases the degree of needle die-off within individual seedling was not very extensive. This damage is due to water stress during the hot-dry period because of the lack of water in the soil. Indicative of the stressful environmental setting faced by the seedlings is the very low percentage of seedlings found in good condition, which were all in plot 5. In the surfaces 2, 3 and 4 increased needle die-off observed in November can be attributed to the prolonged period during which they had not been watered, despite that they were only one-year old.

The suitable soil for *Pinus nigra* seedlings is deep with little rocky material, because it has the advantage of storing a large amount of water (Kakouros P., S. Dafis 2009). In the plots we studied the soil is very thin (0-5 cm) to shallow (5- 30 cm), which means it is not appropriate.

To sum up, the biggest problem for *Pinus nigra* seedlings is browsing by deer, the poor soil quality, especially of plots 2, 3 and 4, the lack of water in the soil and the unfavorable aspect of the slope.

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