Silvicultural research of *Pinus brutia* mixed stands with reforestation: 12 years after fire

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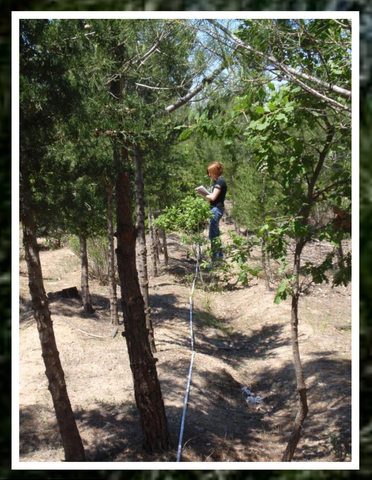
The aim

The objective of this study was to analyze structure and growth of naturally regenerated *P. brutia* stands mixed with broadleaved and conifer planted species in the peri-urban forest of Thessaloniki 12 years after the big wildfire (in 1997). The peri-urban forest of Thessaloniki, named Kedrinos Lofos, was selected because this forest constitutes a unique 'greenbelt' for a fast developing city. The acquisition of knowledge on the current stand conditions will contribute to a more appropriate and complete planning of silvicultural measures for better protection and recovery of Mediterranean type ecosystems

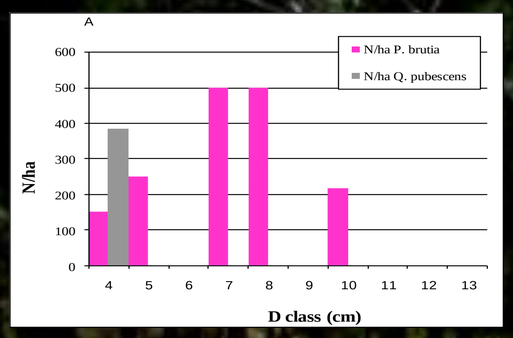
Materials and Methods

The field data on stand structure of *P. brutia* forest were taken in Spring 2009 on northern and southern aspects where the site conditions for the regeneration are favorable and harsh respectively.

In the above areas, 16 sample plots of 300m^2 (10 m x 30 m) were randomly established; six (8) plots were taken per aspect. In all sample plots the measurements made in all individuals were: the number of all individuals, the stem density (N/ha), diameter (D, cm) at breast height for trees with diameter >4cm, diameter (D, cm) at ground level for saplings and seedlings, total height (H, m), crown length (L, m), crown length % of the tree height (Cr, %), basal area (G, m^2), canopy cover (%), soil cover (%). Also the tree vitality (V) and the developmental tendency (DT) were recorded according to IUFRO classification. The tree vitality (V) is classified in three classes:10 for trees of vigorous growth, 20 for trees of normal growth and 30 for trees of declining growth. The developmental tendency (DT) is classified also in 3 classes: 1 for trees with "upward" tendency, 2 for trees with medium growth tendency and 3 for trees with descendant future growth. The stem distribution in dbh classes of 1 cm and in height classes of 1m was carried out. Also, horizontal and vertical profiles of the stands of each aspect were made. However, only data from the tree species that contribute in a percentage above 10% are presented in this study, according to the definition of mixed stands (Dafis 1990).



Results



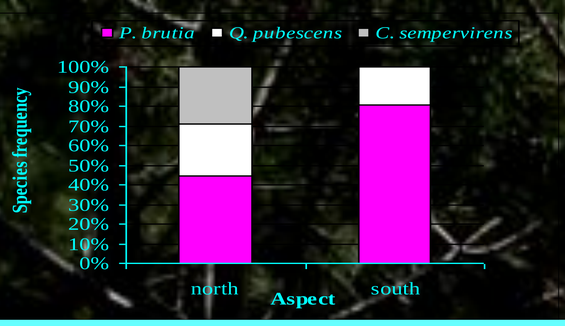


Figure 1. Species frequency in the mixed *P. brutia* stands on northern and southern aspects.

Table 2. Structural data for planted *Quercus pubescens* seedlings in the mixed stands on northern and southern aspects

Aspect	N/ha	D (cm)	H (m)	L (m)
North	666.7	0.4 (0.1)*	1.03 (0.08)*	0.96 (0.08)*
South	383.3	0.25 (0.1)*	0.65 (0.07)*	0.65 (0.07)*

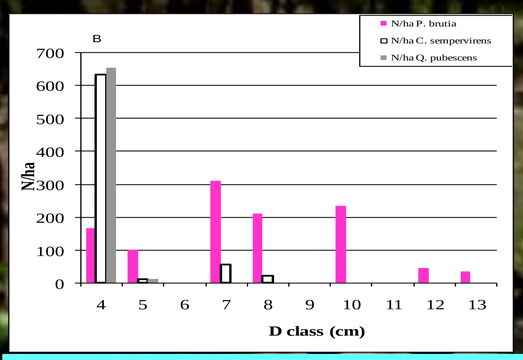


Table 3. Structural data for *Cupressus sempervirens* trees and saplings in mixed stands on northern aspects

Aspect	N/ha	D (cm)	H (m)	Cr %	G (m^2)	L (m)	V	D T
North	722	2.1 (0.2)	2.4 (0.1)	61.9 (2.0)	6.4 (1.4)	1.5 (0.1)	11.4(0.4)	1.2 (0.04)

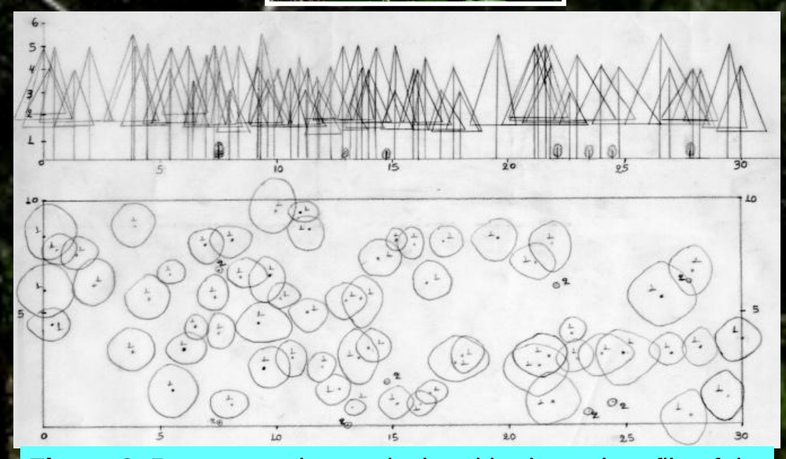


Figure 2. Representative vertical and horizontal profile of the mixed *P. brutia* stands on southern aspects. 1: *P. brutia*, 2: *Q. pubescens*.

Figure 4. Distribution of diameter classes of *P. brutia* stands on southern (A) and northern aspects (B)

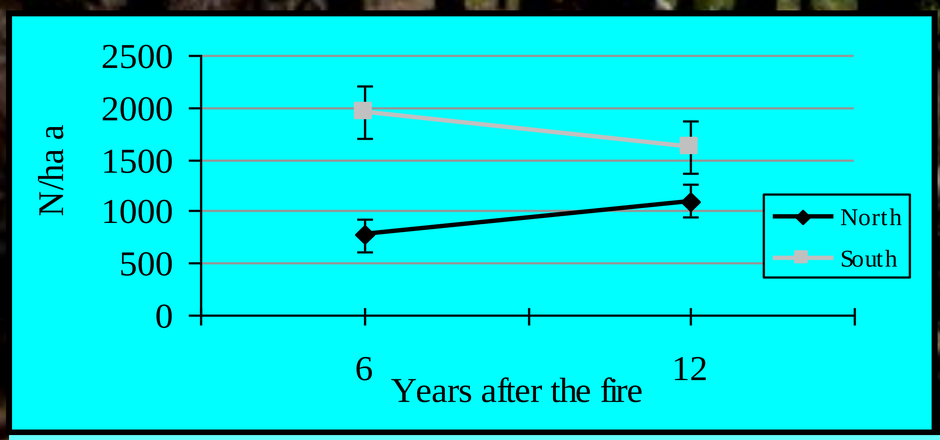


Figure 6: Stem density of *P. brutia* mixed stands on northern and southern aspects, 6 years (form Tsitsoni et al. 2004b) and 12 years after the fire.

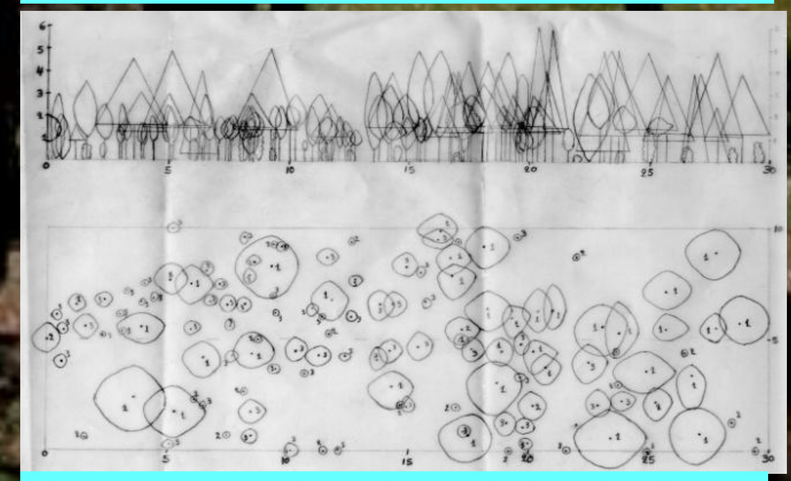


Figure 3. Representative vertical and horizontal profile of the mixed *P. brutia* stands on northern aspects.
1: *P. brutia*, 2: *Q. pubescens*, 3: *C. sempervirens.*

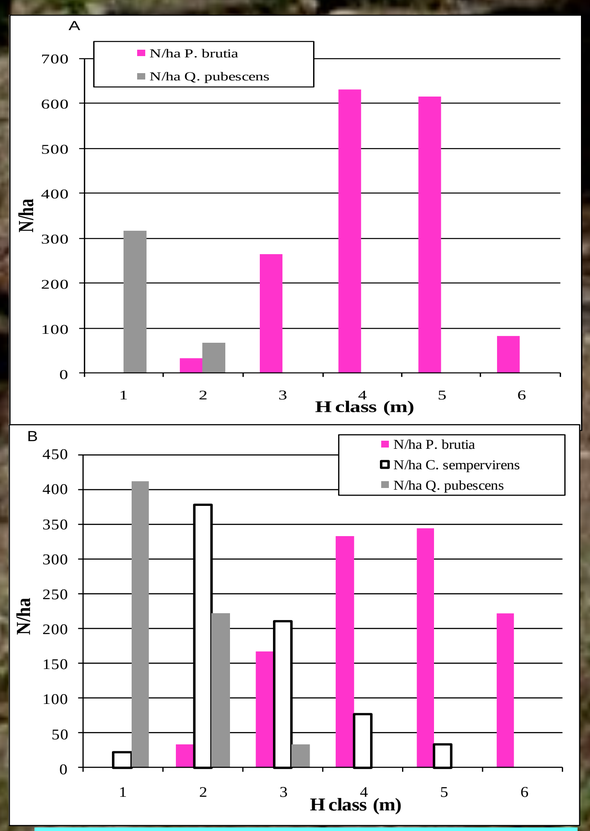


Figure 5. Distribution of height classes of *P. brutia* stands on southern (A) and northern aspects (B)

Conclusions

Based on the findings of this study it seems that:

✓The mixture of the species in the planted burned area is not in the anticipated ratio. The forest is mainly composed by *P. brutia*, in the overstorey, and *Q. pubescens* and *C. sempervirens* as a secondary stand and the mixture is per patches and lines.

✓The participation percentage of the planted species is very low, especially on the southern aspects, where the dominant species *P. brutia* reaches 81%. Although many species had planted in the study area, very few species managed to survive. On both studied aspects, the planted species that showed better survival is *Q. pubescens* which is in the range of its geographical distribution and it pre-existed the pine forest but it had been displaced in the past due to the intense human pressure.

✓All *P. brutia* and *C. sempervirens* trees are characterized by vigorous growth and good to normal stem quality.

✓The aspect did not affect the structural characteristics of naturally regenerated *P. brutia* trees. In contrast, the aspect affected the structural characteristics of planted *Q. pubescens*; on northern aspects where more favorable site conditions are prevailed, the *Q. pubescens* individuals showed greater growth than on southern aspects.

✓The intense human interventions (soil ripping, plantings, etc.) immediately after the fire, negatively affect postfire restoration of pine ecosystems.

✓Better species selection and a more appropriate reforestation planning and care need to be applied in future in order to succeed a more stable and resilient ecosystem to wildfires.