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Effects of understory removal on *Pinus halepensis* Mill. forest communities in Attica, Greece: early results

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ABSTRACT: The assessment of fuel management treatments is well documented according to fire suppression objectives, but there is a lack of studies examining the ecological soundness of such treatments. Based on the belief that fire prevention objectives should not outflank the objectives posed by biodiversity conservation, the present study aims at examining the effects of Aleppo pine understory removal on their vegetation structure and composition. Data of linear cover, height and species richness were obtained seven years after the application of such a treatment at two locations of Mt. Parnitha, Attica. Early results showed that understory vegetation had recovered well in terms of its horizontal structure, but the vegetation profile was significantly altered. Species composition was also affected, as herbaceous anemochorous species were established at the managed areas.

1 INTRODUCTION

Mediterranean ecosystems have evolved under the influence of recurring wildfires (Rundel 1981, Arianoutsou and Ne'eman 2000). Hence, fire is considered as an important factor for the maintenance of their structure and diversity (Cowling et al. 1986, Arianoutsou 2001, Kazanis and Arianoutsou in press). Apart from its role as an ecological factor, fire remains an environmental hazard that causes serious economic and ecological detrimental effects, especially when it occurs at the wildland-urban interface (Arianoutsou 1998, Eftichidis and Guarnieri 1999).

Pinus halepensis Mill. (Aleppo pine) forests cover about 2.5 million hectares in the Mediterranean region (Quezel 2000). Fire incidents are very common in Aleppo pine forests. One fifth of the fire events in Greece burst over Aleppo pine forests, between 1965 and 1990 (Arianoutsou and Ne'eman 2000). In Attica, Greece, where Aleppo pine forests constitute 40% of its forested area (Kazanis and Arianoutsou 1996), hazardous effects of fire become increasingly important.

In this direction, forest fire research developed fire suppression techniques to reduce fire danger, *inter alia*, by means of fire hazard reduction, term which is synonymous with fuel treatment. In the context of fuel management several fuel treatments have been applied worldwide, either by mechanical (e.g. clearing), chemical (e.g. herbicides) or biological (e.g. grazing) means (Xanthopoulos 1998). The scientific literature covers extensively subjects of fuel management effectiveness, cost estimation, modeling of fire hazard reduction, implications for fire behavior etc. Nevertheless, limited is the literature referring to the long-term effects of such pre-fire treatments on vegetation structure and composition, especially when these practices deal with the management of the forest's understory fuels.

The aim of this study is to evaluate the ecological impacts of *P. halepensis* Mill. forest understory removal on their vegetation structure and composition.

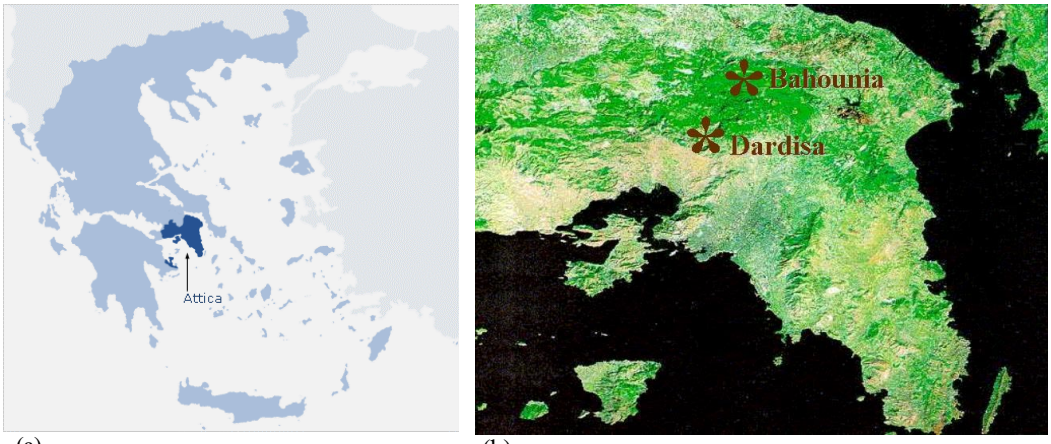
2 MATERIALS AND METHODS

The treatment of Aleppo pine forest understory removal had been applied, for scientific reasons, during November-December of 1995 by National Agricultural Research Foundation (NAGREF) in the framework of a EU Research Project, PROMETHEUS. Aleppo pine forests on Mt. Parnitha comprise of evergreen understory, dominated by sclerophyllus species, such as *Quercus coccifera* L., *Arbutus andrachne* L. and *Phillyrea latifolia* L. (Kazanis and Arianoutsou in press). Eight 50m x 50m experimental plots were established at two locations of Mt. Parnitha, three plots at Bahounia and five plots at Dradisa. The treatment consisted of mechanical cutting and removal of all woody understory vegetation up to the height of 2.5m above ground, with the exclusion of *Cistus creticus* individuals with heights less than 0.5m. Additionally, any heavy dead woody fuel present plus the lower tree branches up to the height of 2m were pruned and removed manually from the plots. Plant biomass had been chipped and redistributed back to the managed sites. Understory biomass had been estimated as a function of vegetation cover and height twice: before the treatment and four years afterwards, in 1999 (Xanthopoulos 2001, Xanthopoulos 2002).

In 2002, seven years after the treatment, these experimental plots were revisited in order to assess the effects of such a treatment on Aleppo pine forest vegetation structure and composition. According to Sutherland (1996), the effect of a treatment is determined by the simple comparison of the "managed" areas with the "controls" and it is not essential to carry out a census before the management occurs. In this case as control sites neighboring areas to the managed sites were selected, thus replication's authenticity is reassured, as sites of both types (control and managed) are identical in terms of abiotic and biotic factors.

2.1 *Description of study sites*

Locations of the two study sites (Bahounia and Dardisa) on Mt. Parnitha, Attica, are presented in Figure 1.



(a) (b)

Figure 1. a) Map of Greece with the indication of Attica prefecture (United Online S.A.) b) Locations of Bahounia and Dardisa on Mt. Parnitha, Attica, projected on a 5,4,3 (R,G,B) colour composite of Landsat TM satellite image (PROJECT PHOENIX: GIS decision support system for the prevention of desertification resulting from forest fires, http://www.survey.ntua.gr/main/labs/rsens/DeCETI/NTUA/Phoenix/phoenix2.htm).

A summary of the main abiotic characteristics of these areas is presented in Table 1. The climate is typically Mediterranean with an average annual rainfall of 420mm (Source: National Meteorological Service). In both sites, the vegetation was mature Aleppo pine forest (*Pinus halepensis* Mill.) with shrub understory dominated by the evergreen sclerophyllous tall shrubs of *Quercus coccifera* (Kermes oak).

Table 1. Abiotic characteristics of areas of interest

Location	Parent Rock	Altitude	Aspect	Slope
Bahounia	Schist	600m	North - East	Low to Moderate
Dardisa	Limestone	500m	South - East	Low

2.2 *Sampling design*

To obtain the data needed for the purposes of this study, four rectangular experimental plots were established: two at Bahounia and two at Dardisa. At each location, one of the plots was sited in the area where understory was removed in 1995 ("managed" plot) and the other one was sited in neighboring areas, which were selected to represent the non-treatment situation ("control" plots). Each plot occupied an area of 500m^2 (50m x 100m), which was the maximum possible area to sample. That was determined, first, by the size of the plots arranged for the purposes of the fuel treatment in 1995 and second, by the fact that a fire broke up at Dardisa during 2002 and burnt part of the managed area.

Sampling followed the methodology of line transects. Five 25m long line transects were established in each plot. The origin of each transect was randomly allocated in the plot but their direction was kept parallel to the main axis of the plot (Sutherland, 1996).

The following types of data were collected:

- linear cover of woody species,
- linear cover of grasses (belonging to the family of Gramineae),
- species composition.

Additionally, the height of the woody component of the understory was estimated in the managed plots. Measurements were obtained using a 50m long transect at each plot; three measurements were recorded at each point of 1m linear intervals: one onto transects and two at 1m from both sides; therefore, a data set of 150 measurements was derived from each “managed” plot.

3 RESULTS

3.1 *Understory vegetation structure*

Total understory cover in the managed plots did not reach the values recorded at the control plots, at both sites (Table 2).

Table 2. Total cover (%) of the understory and recovery (%) after comparing managed with the control plots.

Location	Total cover (%)		Recovery
	Control plot	Managed plot	
Bahounia	93.47	74.24	79.43%
Dardisa	39.94	31.86	79.77%

Linear cover of understory woody species in the managed plots proved lower than in the control plots, seven years after the treatment (Fig. 2). Comparisons with the non-treatment situations showed that linear cover of woody species was reduced by 12.7% and by 17.9%, at Bahounia and Dardisa, respectively.

Linear cover of grasses in the managed plots also proved lower than in the control plots (Fig. 3). In more detail, at the location of Bahounia, linear cover of grasses was lower by 49.7% and at the location of Dardisa by 38.2%.

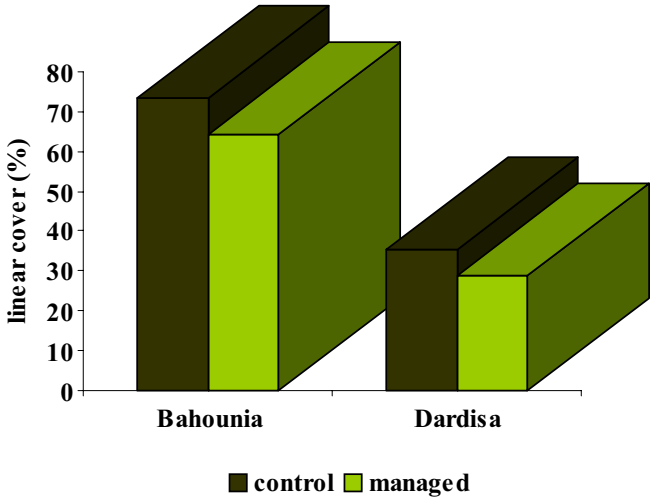


Figure 2. Linear cover of woody species.

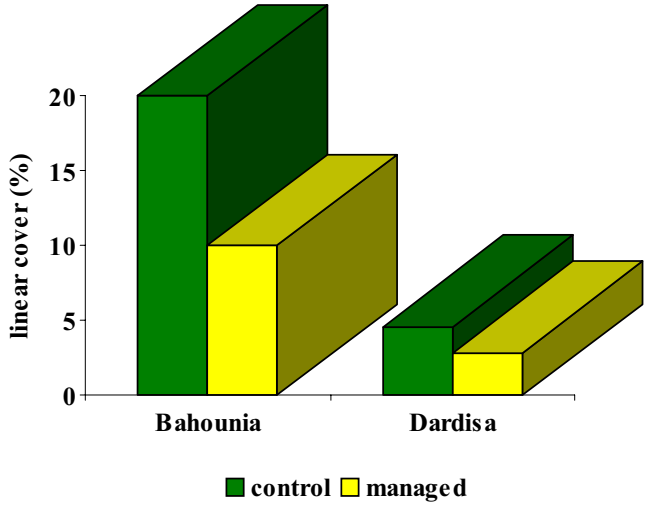


Figure 3. Linear cover of grasses.

Mean vegetation height of the understory was estimated (34.04 ± 4.84) cm at Bahounia and (8.92 ± 2.99) cm at Dardisa managed plots[1].

[1] The format followed is Average ± Confidence limits for A = 0.05, thus 95% confidence.

3.2 *Understory vegetation composition*

Species composition of the understory was recorded. The overall number of species present was not significantly affected in the managed plots compared to the control plots, being exactly the same at Dardisa and slightly greater at Bahounia (Fig. 4). Species were grouped into several categories as follows:

A. Woody and herbaceous species

At both locations, the contribution of herbaceous species to the flora of the managed plots was increased (Fig. 4).

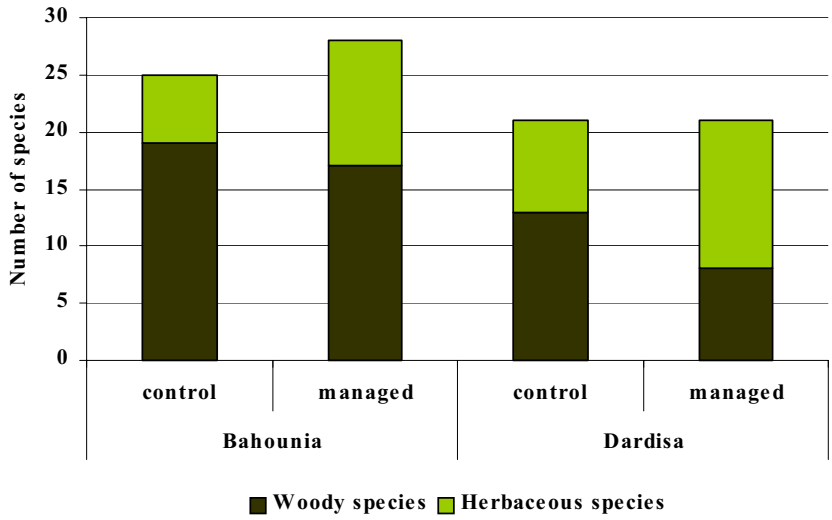


Figure 4. Species richness of woody and herbaceous understory species.

B. Life forms according to Raunkiaer's classification (Raunkiaer 1934)

The contribution of Hemicryptophytes (H) and Therophytes (T) to the species composition of both sites proved to be greater at the managed plots than in the control plots (Fig. 5 and Fig. 6).

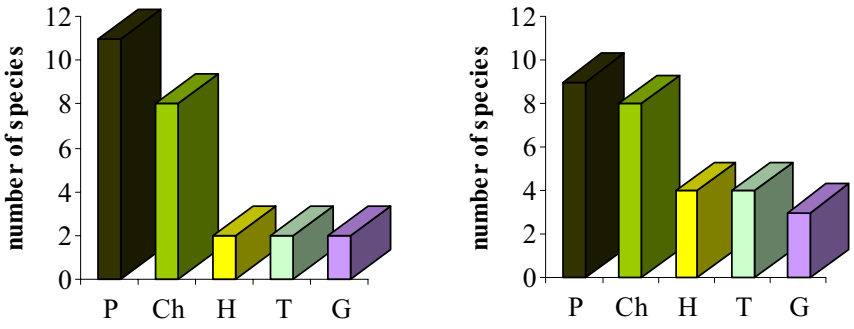


Figure 5: Species composition in terms of life forms at control (left) and managed (right) plots of Bahounia. Abbreviations follow the Raunkiaer's classification system, that is P: Phanerophytes, Ch: Chamaephytes, H: Hemicryptophytes, T: Therophytes and G: Geophytes.

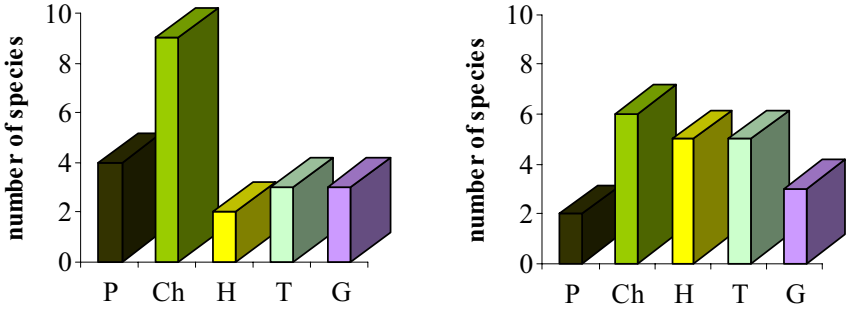


Figure 6: Species composition in terms of life forms at control (left) and managed (right) plots of Dardisa. Abbreviations follow the same typology as in Fig. 5.

4 DISCUSSION

Evidence of shrub recovery after clearing is provided only from experiments performed in Mediterranean shrublands. Recovery of dominant maquis shrubs after harvesting is vigorous in terms of height and it is achieved even during the first post-harvesting year (Margaris et al 1982). Vegetation cover of *Ulex parviflorous* shrubland was affected significantly by the treatment and four years after clearing remained lower than in the untreated plots (Baeza 2002).

The understory recovery reported in this paper does not follow the above pattern. Shrub vegetation growing under mature Aleppo pine forest seem to recover better in terms of cover than in terms of height after the treatment. Understory vegetation linear cover at Bahounia and Dardisa proved to recover by more or less 80% at both sites, seven years after treatment. Xanthopoulos (2002) reports approximately the same values of recovery, at the same plots, four years after treatment. Woody species linear cover showed a higher degree of recovery, providing values reduced by 12.7% and by 17.9%, at Bahounia and Dardisa, respectively. On the other hand, grasses did not reach their pre-treatment cover, providing values reduced by 49.7% at Bahounia and by 38.2% at the location of Dardisa.

On the contrary, understory vegetation height proved significantly lower in the managed plots. Vegetation height reached approximately 50% of the pre-treatment values (Xanthopoulos 2002), at both sites.

Species richness recorded in the managed plots seven years after treatment did not differ crucially from the control plots; it was exactly the same at Dardisa and slightly higher at Bahounia. Differences though were observed in terms of species composition. The contribution of herbaceous species (Therophytes and Hemicryptophytes) to the species composition was greater in the managed plots than in the control plots, at both sites. The presence of less Phanerophyte species at the managed plots should not be attributed to the treatment, but to the fact that the species absent from the managed plots have minor overall frequency in this type of Aleppo pine forest understory (e.g. *Pistacia lentiscus*).

The treatment provided a bare soil situation, where conditions were more favorable for annual herbs to establish. Sampling took place seven years after harvesting treatment, when the understory shrub cover had reached by 80% the pre-treatment cover. Although there is no favorable conditions available anymore, some herbaceous anemochorous species were still present at the managed plots, while were absent from the control plots, e.g. *Crupina crupinastrum* (Compositae family) at Bahounia and *Bupleurum semicompositum* (Umbelliferae family) at Dardisa.

5 CONCLUSIONS

- Understory vegetation of Aleppo pine forests recovered well in terms of cover after the application of the fuel treatment. Therefore, horizontal forest vegetation structure was not significantly affected by the treatment.
- Mean understory vegetation height remained significantly lower seven years after the treatment. Thus, the vertical structure of the forest vegetation was affected by the treatment.
- Species richness in terms of number of species presence was similar to the non-treatment conditions.
- Increased contribution of herbaceous species to the species composition at managed plots should be attributed to the fuel treatment.
- For the small areas where the treatment was applied, vegetation structure and composition was not crucially affected. However, further evaluation of such treatments should be performed especially if the treatments are applied over larger areas.
- Fire prevention objectives should not outflank the objectives posed by biodiversity conservation. The danger of forest degradation should be equally dealt with the criteria of fire danger suppression; otherwise, in the long term, natural forests will be replaced by "forested parks".

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