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Fire in Mediterranean Ecosystems

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REGENERATION OF THE LEGUMINOUS HERBACEOUS VEGETATION FOLLOWING FIRE IN A *PINUS HALEPENSIS* FOREST OF ATTICA, GREECE.

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SUMMARY

The role of legumes in the regeneration of an Aleppo pine forest during the first post-fire year has been found to be very important, not only in terms of species richness and abundance but regarding their contribution to total plant biomass and soil nitrogen replenishment as well.

1. INTRODUCTION

Fire incidents have become a repeated phenomenon during the hot, dry summer months in the Mediterranean-type ecosystems of Greece. Large forested areas are being consumed each year and most of them are left to regenerate naturally, though without being protected from the undesirable results of grazing, fencing, woodcutting, etc.

In the course of the current project, we have been trying to monitor the appearance, growth, survival and percentage contribution to vegetation of a particular plant family, that of the Leguminosae. The reason for this is that legumes have been reported to appear in great abundance within the first two post-fire years (1, 3, 5, 6, 7, 8), yet little is known about their role as N-fixing plants and almost nothing about the floristics of their succession after fire.

The results presented in this paper come from 10 months' observation of a *Pinus halepensis* Mill. forest of Attica during the first post-fire year. The project has already incorporated another study site in Attica and aims to continue observations in a number of burned forests in the region, the goal being to obtain an overall view of the floristics of post-fire succession, of the edaphic factors prevailing, of regeneration - especially of legumes- and of the specific contribution of this plant group to the maintenance of ecosystem stability.

2. METHODS

The study site was established on Mount Parnes, in Attica, Greece, approximately 400 m above sea level. The area had been burned accidentally in late August 1991. The fire consumed 300 ha of *P. halepensis* forest, entirely destroying the vegetation. The climatic conditions predominating in the area are typically Mediterranean, with mild subhumid winters and long, dry, hot summers. The soil, mainly of limestone, is characterised by poor nutrient status.

In September 1991, 4 study plots were established on two facing slopes of the mountain, constituting a total observational area of 34 m^2. Observations were made monthly; the legume seedlings were marked with a plastic ring, so that their emergence, survival and time-scale of their life-cycle could be monitored throughout the year.

Additionally, and coinciding with the monthly measurements, the above-ground biomass was harvested from 10 random quadrats (1x1, m^2), in order to estimate the contribution of legumes to total vegetation. This was achieved by comparing the dry weights of the various plant groups, after they had been oven-dried at 80 °C for at least 48 hours, cooled in a desiccator and weighed to the nearest 0.0001 g (or 0.1 g for the woody material). In the case of legumes, the dry weight of each plant part and the plant's leaf area were measured. In addition, the legume roots were extracted, so that the ability to form nodules after fire could be examined in a temporal basis context. The percentage of nodulated roots was also calculated. The roots which did not exhibit nodulation clearly were not taken into consideration.

3. RESULTS

In October 1991, about two months after the fire and at the onset of the rainy season, the emergence of legume seedlings begins (Fig. 1). New individuals continue to appear until March 1992, but the majority of the seedlings (45% of the total) emerge in December 1991 (Fig. 2).

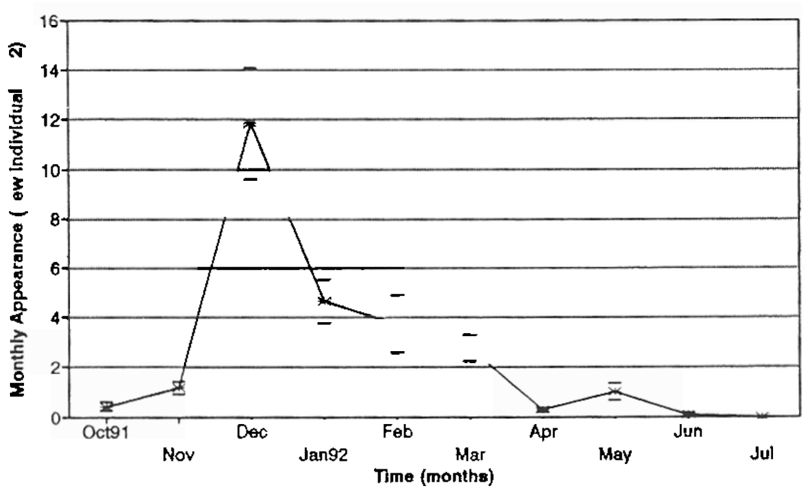

Fig. 1. The mean monthly legume increment, expressed as the number of new individuals per square meter, in the course of ten months. The Standard Error of the Mean (-) was calculated from 34 monthly values.

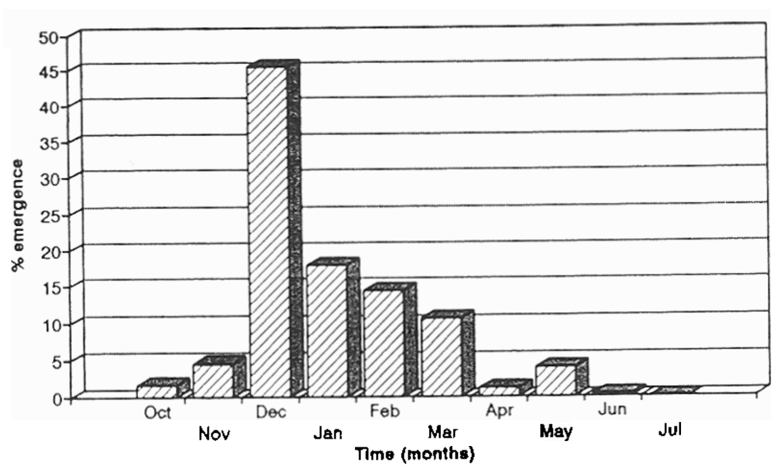

Fig. 2. The appearance of legume seedlings in 4 established study plots (34 m^2 in total), in the course of ten months' observations (October 1991 to July 1992), expressed each month as a percentage of the final total number of seedlings to emerge.

Thus, as shown in Figure 3, the mean monthly density of legumes increases until March 1992, when it reaches a plateau.

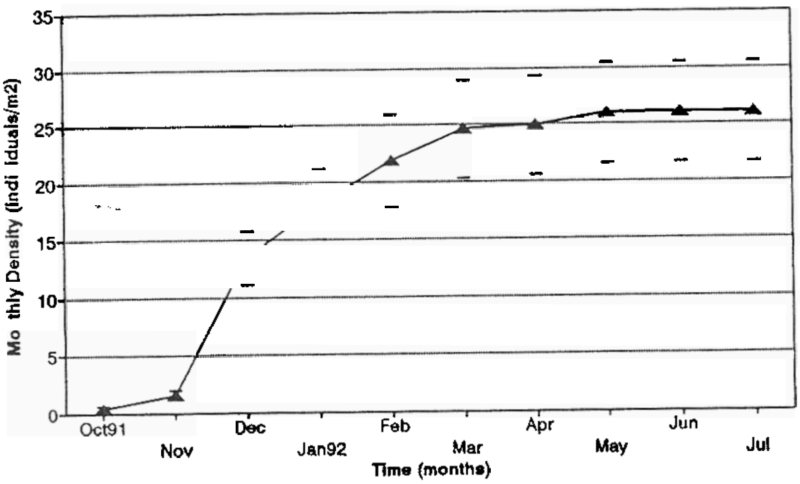

Fig. 3. The mean monthly legume density expressed as the cumulative number of individuals per square meter, in the course of a ten months' study period. The Standard Error of the Mean (-) was calculated from 34 monthly values.

The mean above-ground biomass of legumes collected monthly is found to be very low in the first 5 months of the study, i.e. not exceeding 0.4 g/m^2 (Fig. 4). In May 1992, the above-ground legume biomass increases abruptly reaching the value of approximately 8 g/m^2, while in June 1992 the highest biomass value of 23 g/m^2 is observed.

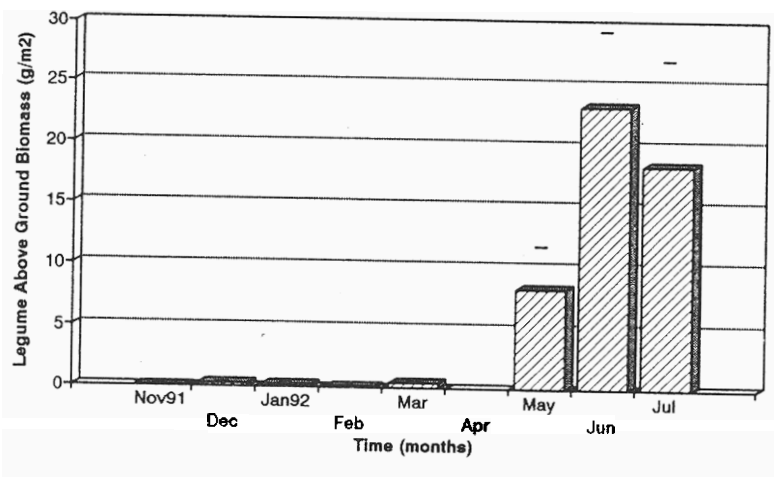

Fig. 4. The mean monthly above-ground legume biomass expressed as dry weight (g) per square meter. The Standard Error of the Mean (-) was calculated from 10 monthly values of the 10 (1x1, m^2) random quadrats.

Also in June 1992, that is 10 months after the fire, legumes exhibit their highest percentage contribution (21.5%) to total plant biomass, compared to their contribution in the rest of the months (Fig. 5).

Legume leaf area fluctuates slightly until March 1992 (Fig. 6), reaching its highest value of 700 cm^2/m^2 in June.

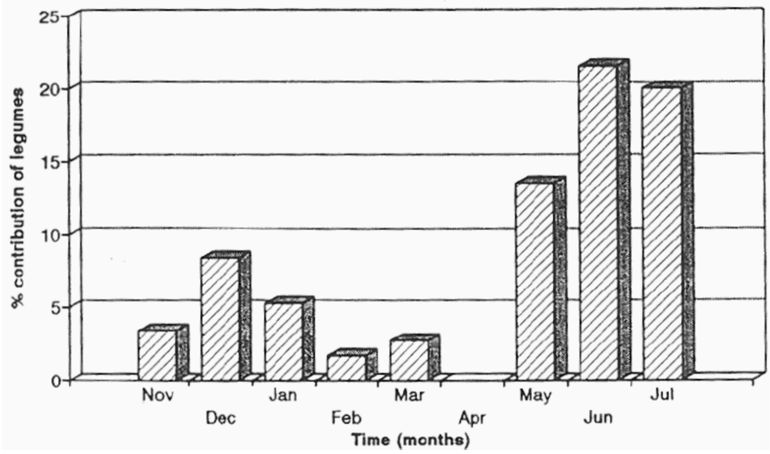

Fig. 5. The percentage contribution of legumes to above-ground plant biomass, estimated by comparing the dry weight of legumes to that of the rest of the plant groups, collected from 10 (1x1, m^2) random quadrats on a monthly basis.

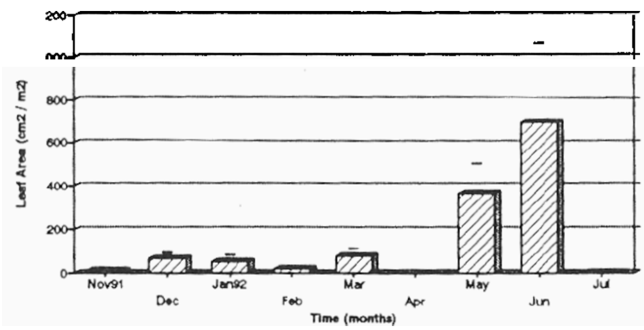

Fig. 6. The mean monthly leaf area (cm^2/m^2) of legumes gathered from 10 (1x1, m^2) random quadrats, on a monthly basis (November 1991 to July 1992). The Standard Error of the Mean (-) was calculated from 10 values, each corresponding to one of the 10 quadrats.

The Leaf Weight Ratio (LWR) of legumes decreases constantly with time, as is clearly shown in Figure 7.

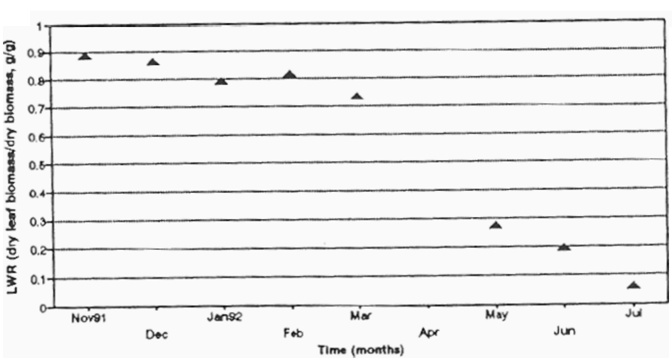

Fig. 7. Mean values of the Leaf Weight Ratio (LWR) of legumes as derived from the dry leaf biomass (g) and the dry plant biomass (g), collected from 10 (1x1, m^2) random quadrats on a monthly basis.

Table 1 shows that legumes start to dry out in June, with the majority of them (92.4%) drying out in July.

Table 1. The total number of legume seedlings in January 1991, May, June and July 1992, observed in 4 established study plots (34 m^2 in total), the corresponding number of dried out seedlings and the percentage legume mortality due to natural causes (i.e. drying out, completion of life-cycle). The seedlings which were found eaten or cut were not considered. The four months presented were those that showed dried out seedlings of Leguminosae.

	JAN 92	MAY	JUN	JUL
number of dried out seedlings	4	2	150	819
total number of seedlings	616	883	886	886
% mortality	0.6	0.2	16.9	92.4

The formation of nodules in the roots of legumes starts in December 1991, about 4 months after the fire, goes on until March 1992 with a relatively constant percentage and declines in July 1992 (Table 2).

Table 2. The total number of intact legume roots (i.e. roots most part of which was extracted and on which the presence or absence of nodules was obvious), collected from 10 random quadrats (1x1, m^2) in each of the months shown, the corresponding number of nodulated roots, and the derived percentage nodulation of legume seedlings.

	DEC 91	JAN 92	FEB	MAR	MAY	JUN	JUL
number of collected intact roots	66	151	62	72	76	38	10
number of nodulated roots	48	69	46	55	64	21	3
% nodulation	72.7	45.7	74.2	76.4	84.2	55.3	30

4. DISCUSSION

The Leguminosae family comprises plants which are among the pioneering species in the post-fire succession of the Aleppo pine forest under study. During the first year after fire, the most common species of legumes which were observed are shown in Table 3.

We expect an equal proportion of legumes in other similar ecosystems (i.e. bearing the same vegetational, substrate and climatic characteristics), yet more observations are needed in order to generalise.

The mechanism adopted by the majority of legumes for regeneration following fire is seed germination. Resprouting has been observed only in two out of 18 species (*Calicotome* sp. and possibly *Psoralea bituminosa,* Table 3) though these were also found to behave as reseeders. The legume life-cycle, as far as we can establish, is mainly annual for obligatory reseeders, which hence dry out naturally towards the end of the summer (July). Resprouters, on the other hand, are at least biennials, a fact which results in a percentage mortality for the total of legumes lower than 100 (i.e. 92.4%).

Table 3. The most common legume taxa observed during the study period in the burned Aleppo pine forest.

Taxon	Seeder	Resprouter
Anthyllis tetraphylla L.	+	
Calicotome villosa (Poiret) Link.	+	+
Coronilla scorpioides (L.) Koch.	+	
Hippocrepis sp.	+	
Hymenocarpus circinnatus (L.) Savi.	+	
Lathyrus aphaca L.	+	
Lathyrus digitatus (Bieb.) Fiori	+	
Lotus ornithopodioides L.	+	
Medicago arabica (L.) Hudson	+	
Medicago lupulina L.	+	
Medicago orbicularis (L.) Bartal.	+	
Medicago polymorpha L.	+	
Psoralea bituminosa L.	+	+(?)
Securigera securidaca (L.) Degen & Doerfler	+	
Trifolium stellatum L.	+	
Trifolium sp.	+	
Vicia disperma DC.	+	
Vicia sp.	+	

The contribution of legumes to the total plant biomass of the early post-fire community is of the utmost importance; given the herbaceous nature of the plants observed so far, which moreover are being compared to many woody species, the proportion of legumes is relatively high.

The emergence of legumes together with that of the rest of the post-fire seeders, such as *P. halepensis* and *Cistus* spp., follows the first autumn rains. The majority of seedlings appear from November to December, when the weather conditions are most favourable for germination (i.e. rather well established rainy season and mild temperatures). Such a behaviour-pattern has been shown for *Cistus* spp. and *Sarcopoterium spinosum* when regenerating after a fire (2) and for two *Cistus* species (*C. salvifolius* L. and *C. creticus* L.) from undisturbed plots (9). Although legume germination is found to be dependent on climatic status, survival does not seem to be influenced by the cold winter temperatures or the frost. Thus, they outlive the winter and complete their life-cycle in the summer, while germination of new taxa keeps occurring until late spring. The heavy snowfall and the resulting frost, which persisted for several days during the year of the study (winter of 1991-1992), made the respective period an untypical mediterranean one. Hence, a study over a longer time-period is needed in order to obtain more accurate results.

Legumes were found to form nodules early in their life-cycle, but the N-fixation effectiveness and viability of these nodules which persist until the end of spring, is under investigation. Despite the fact that the presence of legumes has already been related to N-fixation, which is expected to be activated after fire (1, 4, 6), it is still not known when it starts and whether it plays any role in seedling establishment and growth and in soil nitrogen replenishment.

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