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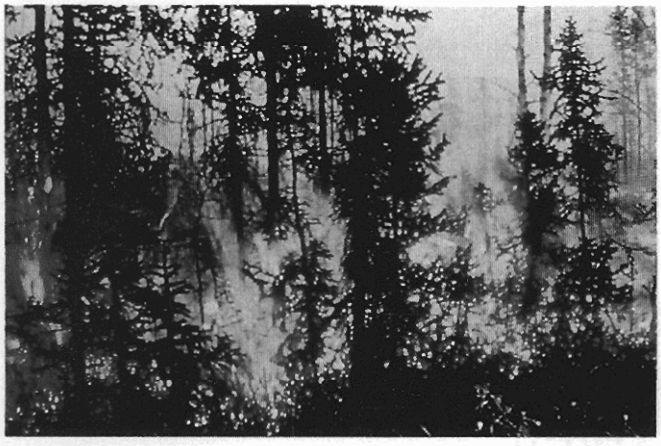

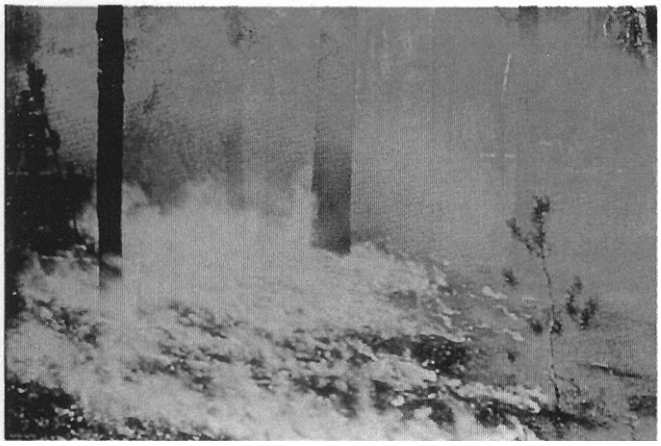

Forest fire risk and management

Proceedings of the European School of Climatology and Natural Hazards course

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NATURAL POST - FIRE REGENERATION OF LEGUMINOSAE IN A PINUS HALEPENSIS FOREST OF ATTICA, GREECE

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ABSTRACT

Post - fire regeneration of the nitrogen - fixing leguminous taxa has been monitored over a period of 9 month, since the event of an accidental fire in a *Pinus halepensis* Mediterranean forest, in Attica. Regeneration occurs mainly through seed germination. The rate of seedling recruitment starts in autumn, once the rainy season is rather well - established. The first legume seedlings emerge by middle October, and germination goes on until the end of spring. Although the majority of the legume flora appears by the end of December, new species continue to emerge until May, so that not only the density but the diversity of the legume population increases. Nodulation begins early in legume growth and occurs in the majority of the plants tested (72%). Despite the fact that this year has not been a rather typical Mediterranean one (there were three heavy snow events, which lasted for days) seedlings survived successfully.

NATURAL POST-FIRE REGENERATION OF LEGUMINOSAE IN A *PINUS HALEPENSIS* FOREST OF ATTICA, GREECE: EARLY RESULTS

1. SUMMARY

(1) The regeneration of a burned Aleppo pine forest in Attica, Greece, was followed over the first six months (October to March) after fire.

(2) Special emphasis was given to the study of the leguminous compartment of the regenerating flora in order to determine its ecological role in the early post-fire succession.

(3) Legumes were found to regenerate almost exclusively through seed germination. Seedlings began to emerge shortly (1.5 months) after the burning following the first rainfalls and their biomass increased constantly until spring.

(4) Seedlings density increased with time, although in December there was a burst of new individuals.

(5) Legume percentage contribution to post-fire flora was found to be relatively high.

2. INTRODUCTION

It is widely accepted that fire is a natural event in most Mediterranean-type ecosystems (MTE) and although it is considered to be a climate-related hazard, it is also an environmental element by itself. This is expressed through the various adaptations of the ecosystem components towards fire, which enable the organisms either to avoid or to escape the action of fire[8]. Hence, fire-following plants are classified into three groups according to their mechanisms of recovery after fire: (a) obligatory seeders, (b) obligatory resprouters, and (c) intermediate types[5].

In the current study, special emphasis has been put on legumes, plants mainly regenerating by seed germination. The Leguminosae constitute a very interesting family floristically, due to their impressively high contribution to the Mediterranean and, hereby, Greek flora[10], as well as ecologically because they display certain important ecophysiological attributes such as nyctonastic movements, hard and water impermeable seed covers, nodulation. In nature, they are associated with high temperatures[4], which result in germination stimulation following fire[9]. Their herbaceous species, in particular, are of great abundance during the initial post-fire successional stages of the ecosystem recovery[1,7,11,12,13,15]. However, in Greece nothing has been done so far concerning the floristics of this succession or the importance of legumes related to N-fixation and soil-N replenishment.

This paper presents some preliminary results on the prolific appearance of legume seedlings after fire, as a part of a longer-term project, which aims to investigate the role played by legumes in the maintenance of species richness and floristic diversity of the regenerating ecosystem, as well as their contribution in restoring pre-fire levels of total stand nitrogen.

3. METHODS

The study site is a natural *Pinus halepensis* Mill. forest located on Mount Parnis, Greece (38° 15' N 23° 40' E), approximately 400 m above sea level. The climate prevailing on the area is typical Mediterranean (see Figure 1, Daskalakou and Thanos, in the same volume). An accidental fire (caused by neglegence) outbroke on the north edge of the mountain near the village of Avlona, on 29 August 1991, and consumed a total area of 482 ha, 300 ha of which

consisted of Aleppo pine forest while 182 ha were cultivated land (olive trees).
One month after the fire (September 1991), 4 study plots were established on the burned area. The two plots of 10 m^2 each were chosen on a slope facing East, while the 2 other plots of 10 m^2 each were chosen on a slope facing South-West. All four plots were observed monthly for the emerging legume seedlings, which were marked with a plastic ring. An additional number of 10 quadrats of 1 m^2 each was randomly chosen every month and all the above-ground plant biomass was collected except for the legumes, in which case it was attempted to extract the seedling root as well. The aim was to examine the formation of nodules on a temporal basis following fire, as a percentage of the collected roots. The plant material harvested as such was separated into categories according to taxonomical criteria and then 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 heavy woody parts).

4. RESULTS

Legume seedlings begin to emerge in October 1991, 1.5 months after the incident of fire (Figure 1a). In November 1991, they show a sharp increase which is followed by a smoother yet persistent increase until March 1992.

The mean monthly legume appearance, that is the emergence of new individuals per square meter, in the established study plots is presented in Figure 1b. It is shown that the appearance of new seedlings reaches its peak in December 1991, whereas from January until March 1992 germination goes on but with a descending rate.

The mean monthly biomass of legume seedlings (expressed in g/m^2) was found to fluctuate during the first five months of the study, exhibiting the highest value in March and the lowest in November (Figure 2a). The rest of the months, constituting the intermediate period, show a slight decrease from December 1991 to February 1992. This is not the case, however, for the mean monthly total biomass, which shows a persistent increase with time (Figure 2b).

Table 1 exhibits the percentage (%) contribution of each plant group to the community, in the course of the five months study. In the case of legumes, the highest value of 8.4% contribution is observed in December and the lowest value of 1.7% in February.

Formation of nodules is initially observed in December, about 4 months after the fire. Approximately 73% of the roots collected had nodules at that time, while in January, February and March, 47%, 66% and 72% of the roots, respectively, were nodulated.

	NOV 91	DEC 91	JAN 91	FEB 92	MAR 92
Leguminosae	3.33	8.37	5.11	1.69	2.74
Cistus sp.	2.55	2.24	0.87	1.03	0.92
P. halepensis	0.29	0.64	0.67	1.43	0.62
Q. coccifera	10.71	15.1	24.56	9.05	6.44
Gramineae	43.71	13.02	23.52	22.12	12.94
Miscellaneous	39.41	60.63	45.27	64.68	76.34

Table I: The percentage (%) contribution of the various plant groups in ecosystem biomass during the early post-fire stages. The results are from five months collections.

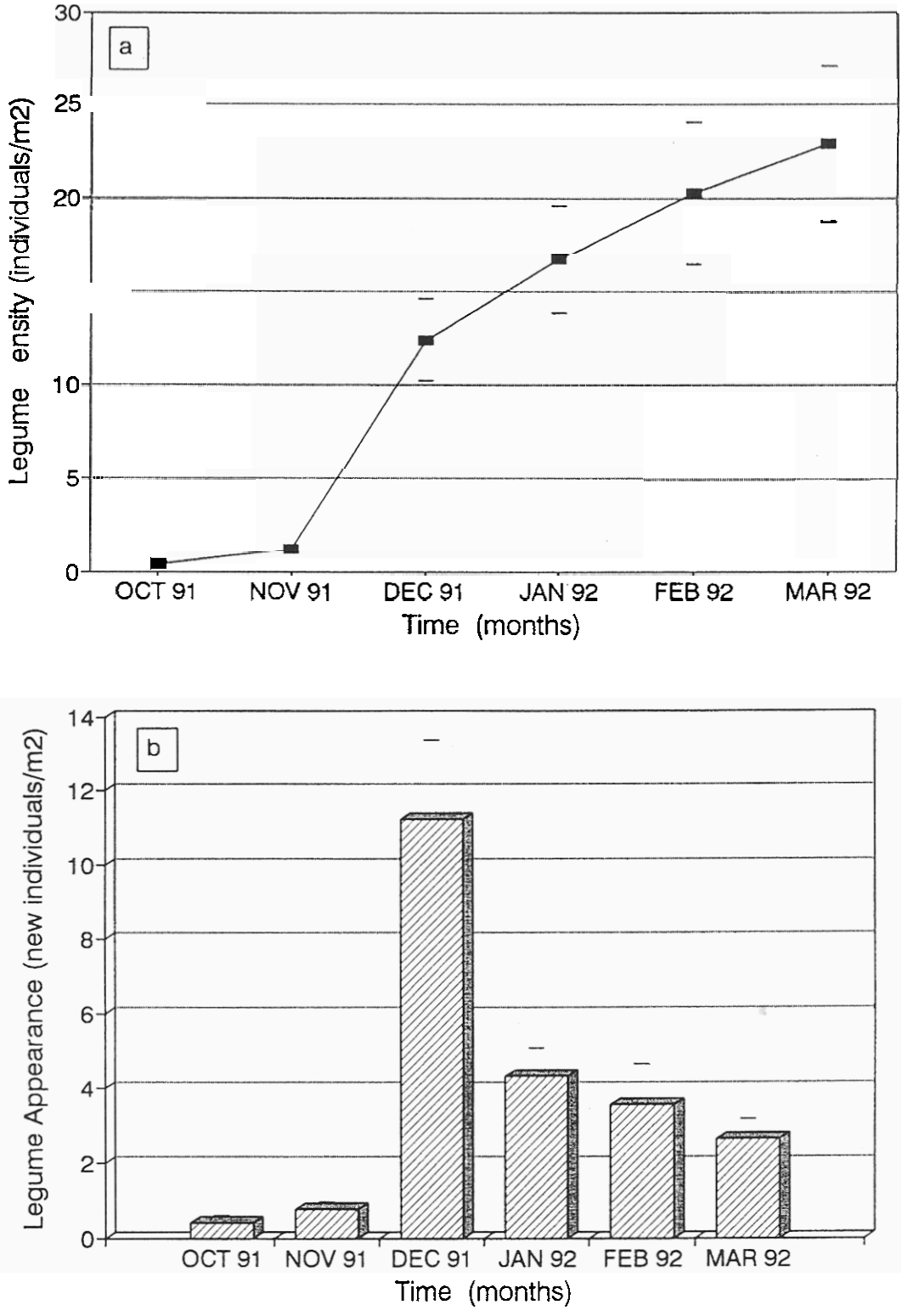

Fig. 1: -a. The mean monthly legume density expressed as the cumulative number of individuals per square meter, in the course of the six months study period. -b. The mean monthly legume increment expressed as the number of new individuals per square meter per month, in the course of the six months. The Standard Error of the Mean (S.E.), shown as a dash above each point (a) or bar (b), was calculated from 34 monthly values.

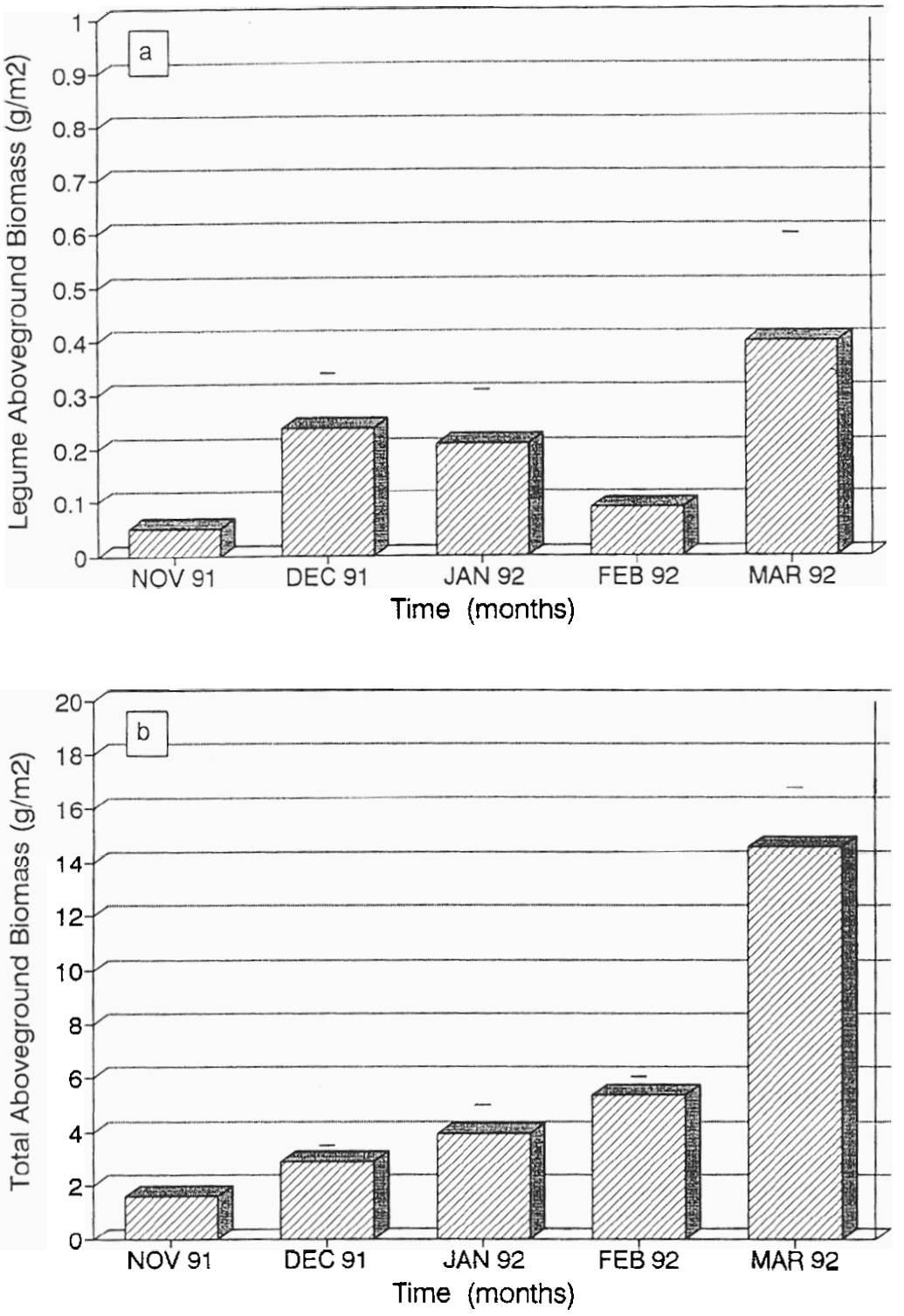

Fig. 2: -a. The mean monthly above-ground biomass of legumes expressed as dry weight (g) per square meter. -b. The mean monthly above-ground total biomass expressed as the dry weight (g) of all plants(legumes included) per square meter of all plants. The Standard Error of the Mean (S.E.), shown as a dash above each bar (a, b), was calculated from 10 monthly values of the 10 ($1x1m^2$) random quadrats.

5. DISCUSSION

Legumes are found to be of the very first post-fire pioneer plants, mainly germinating from seeds but also resprouting, although such a behaviour is followed by a very limited number of individuals and by only one species of Calicotome.

Legume emergence, together with that of the rest of the post-fire seeders, such as *Pinus halepensis* and *Cistus* sp., follows the onset of the rainy season in October, just a couple of months after the incidence of burning. The period between October and November seems to be most favourable, in terms of weather conditions (relatively high rainfall and mild temperatures), thus resulting in a vigorous increase in the number of germinating legumes, both individuals and taxa, in the study plots. The highly intensified November increase in legume density is followed until March by yet another ascent though not so rapid, despite the fact that the year of the study (1991-92) was not a typical Mediterranean one. There were three heavy snow events, from the end of December to the middle of February which lasted for 13 days in total, while the "normal" snow period had not been more than 2-3 days, estimated from data covering the period between 1946 and 1972 (see Figure 1, Daskalakou and Thanos, in the same volume). Thus, we may say that legumes did not suffer particularly because of the frost which indeed persisted for several days each time. However, this peculiarity of the weather conditions makes such a conclusion debatable and more observations on a longer term period are necessary in order to obtain more concrete results.

In the field, legume-seed germination is maximised in December. Such a behaviour has been shown for *Cistus* sp. and *Sarcopoterium spinosum* when regenerating after a fire[2] and for two *Cistus* species (*C. salvifolius* L. and *C. villosus* L.) from undisturbed plots[16]. However, as nothing is known about the life cycle of legumes in relation to post-fire recovery, more observations and laborarory experiments are needed.

Despite the low percentage of legumes in the total plant biomass of the early post-fire community, their relative contribution to the respective flora is of outmost importance. The low percent can be explained by the input to the comparison of many woody plants, which increases dramatically the weight of the miscellaneous category. Supporting the above, comes the comparison of legumes to seedlings of *Pinus halepensis*, an obligatory reseeder[1,13] and of *Cistus* sp., whose regeneration under normal or post-fire conditions is almost exclusively accomplished by seeds[3,6,14].

Up to the present, the work published cannot answer the questions: i) why legumes are so abundant after fire, and ii) why this abundance is restricted only in the early post-fire successional stages. On the other hand, the presence of legumes has been related to N-fixation, which is expected to be activated after fire[1,8,12]. Still, it is not known when N-fixation starts and whether it plays any role in legume seedling establishment during post-fire succession, thus facilitating their growth as they become more compatible.

Relatively early in their life cycle the leguminous taxa of the study site were found to form nodules. Detailed studies on the effectiveness of these nodules versus time and plant taxa are nessecary and have been scheduled within the framework of the current project.

In conclusion, we may claim that the post-fire legume flora is an important component of the Mediterranean coniferous forest community under investigation, but its ecological role still remains to be explored.

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