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Phryganic (east mediterranean) ecosystems and fire

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INTRODUCTION

Fire is a very common event in the areas covered by mediterranean type ecosystems, that means countries around the Mediterranean basin, California, Chile, SW. and W Australia and S. Africa. It is considered a natural event incorporated in the information pool of Mediterranean-type Ecosystems (M.T.E.), at least from Californian and Australian scientists. For the old world, fire is accepted as a catastrophic factor which is always attributed to criminal anthropogenic actions. But, the general consideration is changing towards the first aspect, in the Mediterranean countries, because small groups in Israel (NAVEH, 1973), Greece (LIAKOS, 1973 ; ARIANOUTSOU and MARGARIS, 1981 a and b) have started accepting fire as a necessary factor included in system's function.

If the above mentioned hypothesis is true, these ecosystems might have developed response mechanisms that help them to overcome the action of fire, both in survival and in quick recovery. This is exactly the working hypothesis on which the discussion on behaviour of phrygana after fire is held. For the definition of the term phrygana look to paper by MARGARIS and VOKOU, in this volume.

The phryganic ecosystem under study is located on the Mt Hymettus at a height of 400 m above sea level. It was burned accidentaly in late July 1976. For reasons of comparison an adjacent unburned area with the same structure is chosen. Data for this unburned site have already been given by MARGARIS (1976).

I. Ways of survival

Two main types of survival can be discerned and considered as adaptive strategies : resprouting and regeneration by seeds :

A. Resprouting is carried out from dormant buds located at the crown and which are not influenced by fire. It begins during autumn when soil moisture is in satisfactory levels, something that is suggested to be valid for California too (PLUMB, 1963). Some others have attributed it to the carbohydrates available, which are found in the plants at the moment that fire occurs (JONES and LAUDE, 1960).

From the woody species dominating in the area before fire with an above ground biomass of about 1.000 g.m^{-2} (*Phlomis fruticosa* 33%, *Euphorbia acanthothamnos* 24%, *Sarcopoterium spinosum* 13%, *Cistus* spp 8% and *Thymus capitatus* 3%; MARGARIS, 1976), *P. fruticosa* regenerates by resprouting from such buds staying undisturbed by fire. Most individuals of this species successfully recover by this way. *S. spinosum* resprouts too, but not in the same degree. Most of its individuals do not survive, especially those which are old ones. The third resprouting species is *E. acanthothamnos*, which recovers quite enough through this process.

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Cistus spp. does not resprout in any case. PAPANASTASIS (1977) refers that *S. spinosum* resprouting depends on the habitat in which it is growing. So, in N. Greece 95% of burned plants survived and regenerated while in Crete, where the conditions are more dry, only the 15%. On *Thymus capitatus* does not appear any resprouting behaviour. From the rest non dominant species, the majority is surviving by resprouting as for instance *Helianthemum, Asparagus aphyllous, Teucrium divaricatum, T. pollium, Phagnalon graecum* e.t.c.

B. The other survival adaptation of the phrygana species is the activated germination of the dormant seeds lying in the soil seed bank. After the first autumn rains a great number of seedling appears, something supporting the idea that seed germination is positively affected by fire. The case of *Cistus* spp is very typical in this aspect, since under normal conditions its seedlings are no more than 20 per m^{-2}. This number becomes 20 times greater after fire (ARIANOUTSOU and MARGARIS, 1981 b). *Thymus capitatus* seeds are favoured possibly by fire's action too. Except those seeds of the dominant woody species there are also the seeds of annuals that activated by fire, germinate resulting in an explosion of annuals the first post-fire years. The same activation of seed germination is observed by simple heating of soil samples in the laboratory (Fig. 1 and 2).

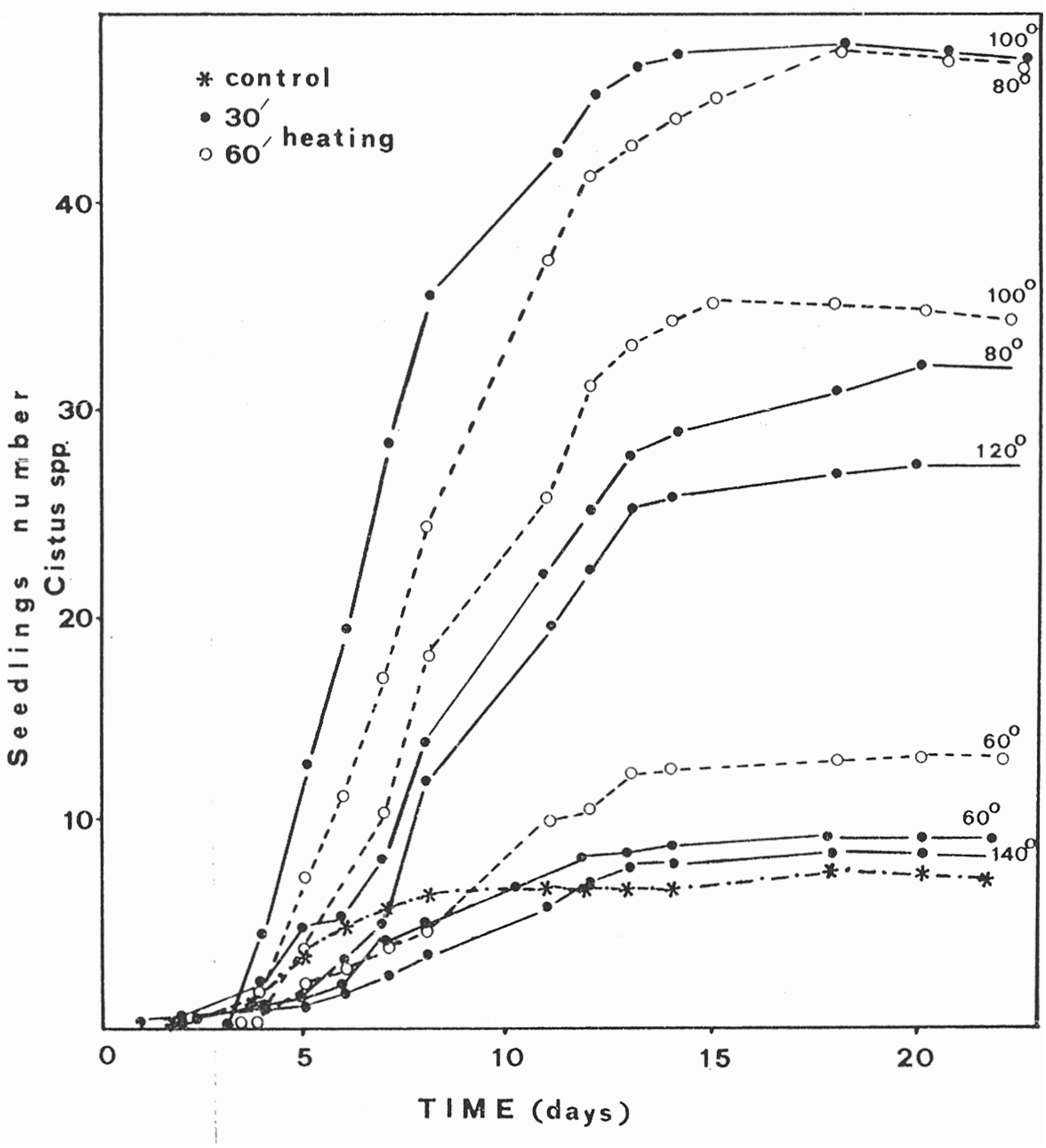

Fig. 1 : CISTUS SPP SEEDLINGS APPEARED DURING 25 DAYS IN SOIL HEATED FOR 30 OR 60 MIN in 60°, 80°, 100°, 120° and 140°C.

There is a question coming out from the above mentioned mechanism of the survival. How fire is promoting seed germination? It seems that at least three possible explanations can be developed.

(1) Fire acts mechanically by rupturing seed coasts permetting thus the entrance of water and the subsequent imbibition. This explanation might be applied to most plant species having hard and impermeable seed coasts, as for *Cistus* spp. This is proved by artificial rupturing of seed coasts, when a higher than normal percentage germination is achieved (ARGYRIS, 1977).

(2) Data from California (CHRISTENSEN and MULLER, 1975) support the aspect that germination is promoted through thermal inactivation of heat sensitive inhibitors present in soil. These inhibitors are accumulated on the leaves during the dry summer periode and pass in the soil by the first rains. If fire happens during summer time, they will be destroyed, enabling thus the seed germination to be carried out successfully.

(3) According to MARGARIS (1981) an indirect mode of fire's action is based upon the phytochrome morphogenetic system. Thus, the removal of foliage, that absorbs drastically in the 660 nm wavelength, increases the active phytochrome in seeds, leading thus to higher germination.

From field observations in artificial clearings in Mt. Hymettus and from data from Californian chaparral (CHRISTENSEN and MULLER, 1975) it seems that this explanation is well supported. Also, laboratory experiments with various seed species done by GORSKI et al (1977) result to the same phenomenon.

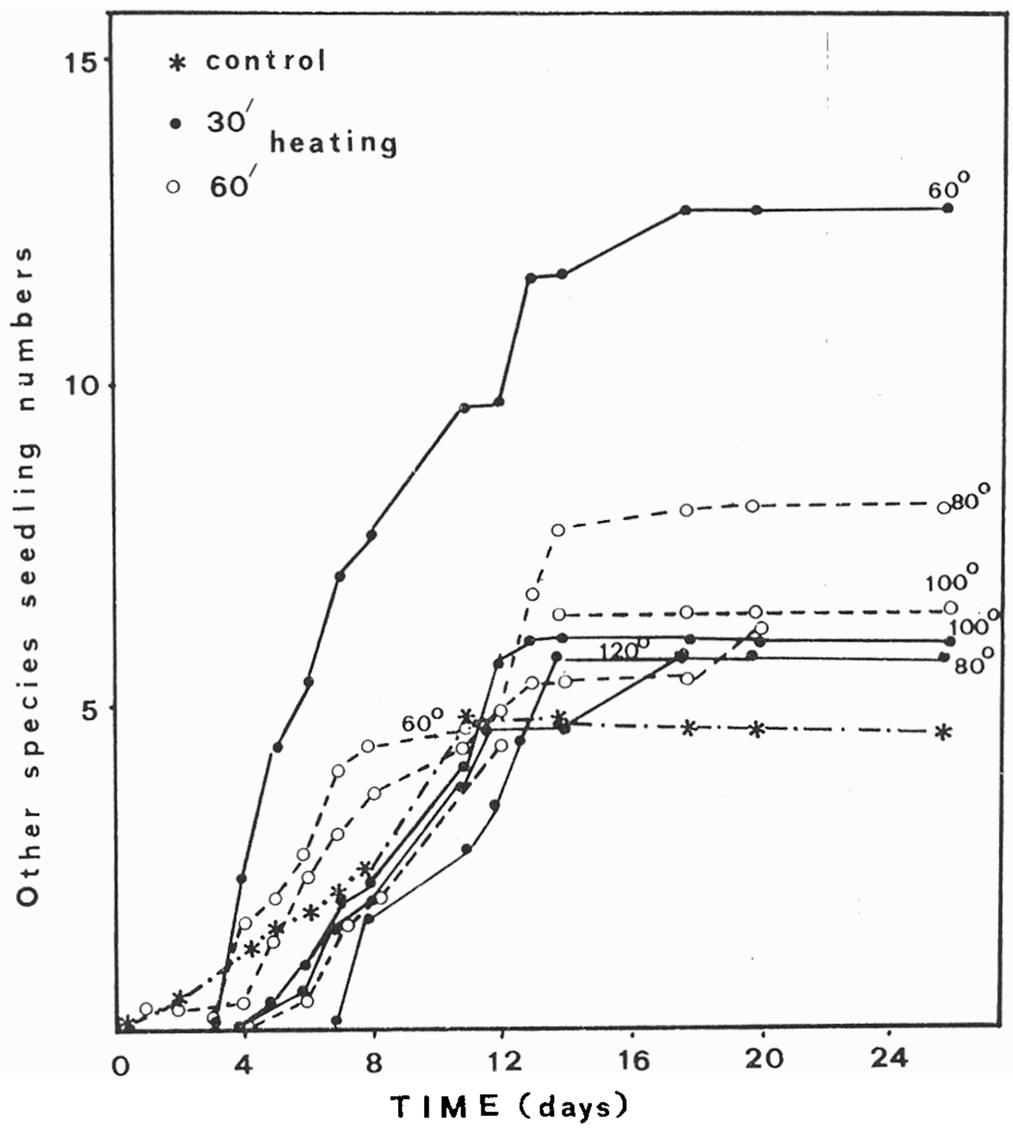

Fig. 2 : SEEDLING OF OTHER SPECIES APPEARED DURING 25 DAYS IN SOIL HEATED FOR 30 OR 60 MIN in 60°, 80°, 100°, 120° and 140°C.

Survival of the dominant woody species by seed germination is probably an adaptation that occurs mainly in phrygana. On the other hand, in maquis the only way of survival seems to be the resprouting behaviour. This resprouting soon results in a stand without great age dissimilarities between individuals. Of course, in the first post-fire years, there is abundance of herbaceous plants, but it does not last more that 5-8 years. After that their numbers are decreased. On the other hand, dominant woody species of phrygana like *P. fruticosa, E. acanthothamnos, S. spinosum, T. capitatus* and *Cistus* spp have life span of a few decades; this time period might be less than the time interval between two successive fires. So, according to MARGARIS (1976) *Cistus* sp does not live more than 15 years and the same is true for *T. capitatus* and *S. spinosum.* The species *P. fruticosa* and *E.acanthothamnos* have longer life span reaching to 50 years. Consequently these species must have also recovery mechanisms based on seed germination, as it is proved also from the fact that in the undisturbed field there are individuals of different ages. In other words, species having short life span as *Cistus* and *Thymus* must have survival mechanisms, functioning independently of fire's occurence, since it might happened later than 15 years which is the normal life span for them (Fig. 3).

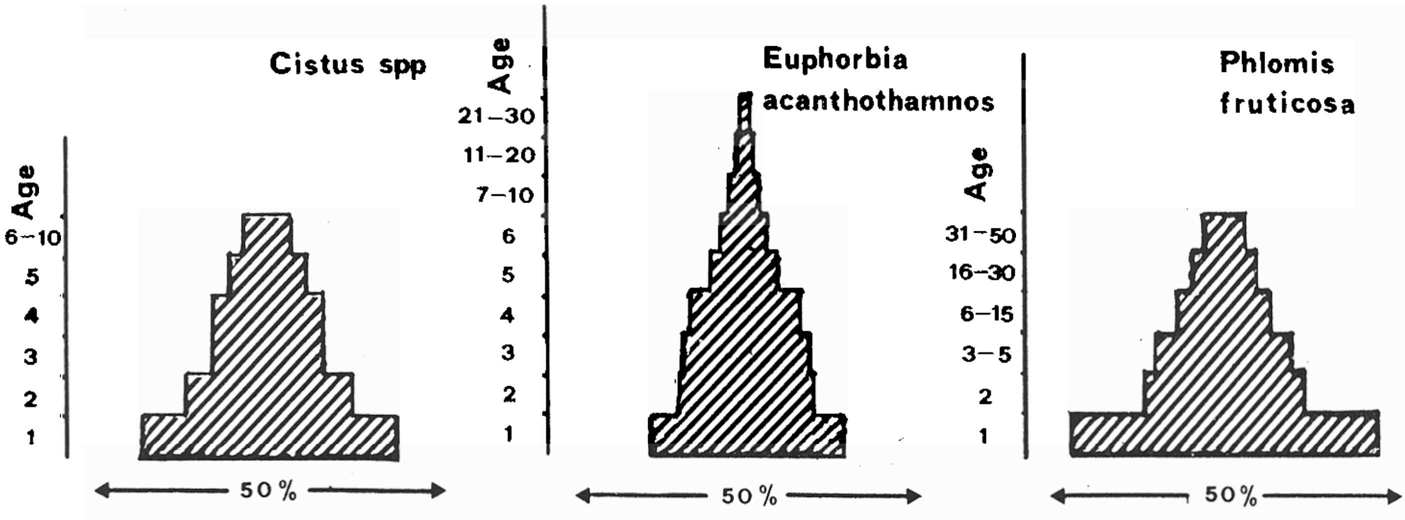

Fig. 3 : AGE DISTRIBUTION OF *CISTUS* SPP, *E. ACANTHOTHAMNOS* and *P. FRUTICOSA* PLANTS IN THE UNBURNED PHRYGANIC ECOSYSTEM.

In conclusion we can say that the species having short life span must possess adaptations to insure them their existence with or without waiting fire *(Cistus, Thymus)* in contrast to those regenerating in fire conditions with resprouting as they are doing in normal ones *(Phlomis, Euphorbia).*

II. Ways of recovery

From the above mentioned we can deduce that fire's action on phrygana activates two survival mechanism : resprouting and seed germination functioning as feed back responses for the ecosystem survival as they favour the plants already possessing them. These mechanisms are followed by a speeding up of the functions which they induce in a way that the ecosystem equilibrium and stability could be reestablished as soon as possible. For this reason resprouting, seed germination and development are carried out in faster rates comparing with those in the unburned site. In more detail :

(1) The leaves of the resprouting that are greater from the normal have more chlorophyll on leaf dry weight basis, which means increased photosynthesis (ARIANOUTSOU and MARGARIS, 1981 a) (Table 1).

(2) At the end of the wet season of the first post-fire year the characteristic phenomenon of seasonal dimorphism has appeared (Fig. 4).

(3) During the first post-fire year the most resprouting species form flowers and seeds *(S. spinosum* and *E. acanthothamnos)* while under normal conditions this takes at least several years.

(4) From the species which are seed regenerators (e.g. *Cistus* spp) the most are able to give seedlings in great numbers and capable to survive, give flowers and new seeds, thus establishing themselves quite satisfactory (ARIANOUTSOU and MARGARIS, 1981 b).

	Total chlorophyll (mg g^{-1} leaf dry weight)		
	P. fruticosa	S. spinosum	E. acanthothamnos
Before fire	2.0	2.3	4.7
After fire	3.5	5.7	5.4
Increase (%)	70.0	150.0	17.0

Table 1. Chlorophyll content in plants dominating phryganic ecosystem before and after fire (ARIANOUTSOU and MARGARIS, 1981 a)

(5) Quite remarkable is the abundance of the herbaceous part in the first stages of succession in the burned area. Among them, there is a great number of Papilionaceae species, which possibly replenish the nitrogen (N) lost in fire's smoke (95%) (ARIANOUTSOU and MARGARIS, 1981 c).

(6) The total above ground biomass at the end of the 5th growth period has reached to 48% of the adjacent unburned (Fig. 5).

(7) The percentage abundance of the dominant woody species is still different from that in the unburned site (Fig. 6).

Fig. 4 : SEASONAL DIMORPHISM OCCURING IN THE END OF THE WET PERIOD ON THE RESPROUTED *P. FRUTICOSA*

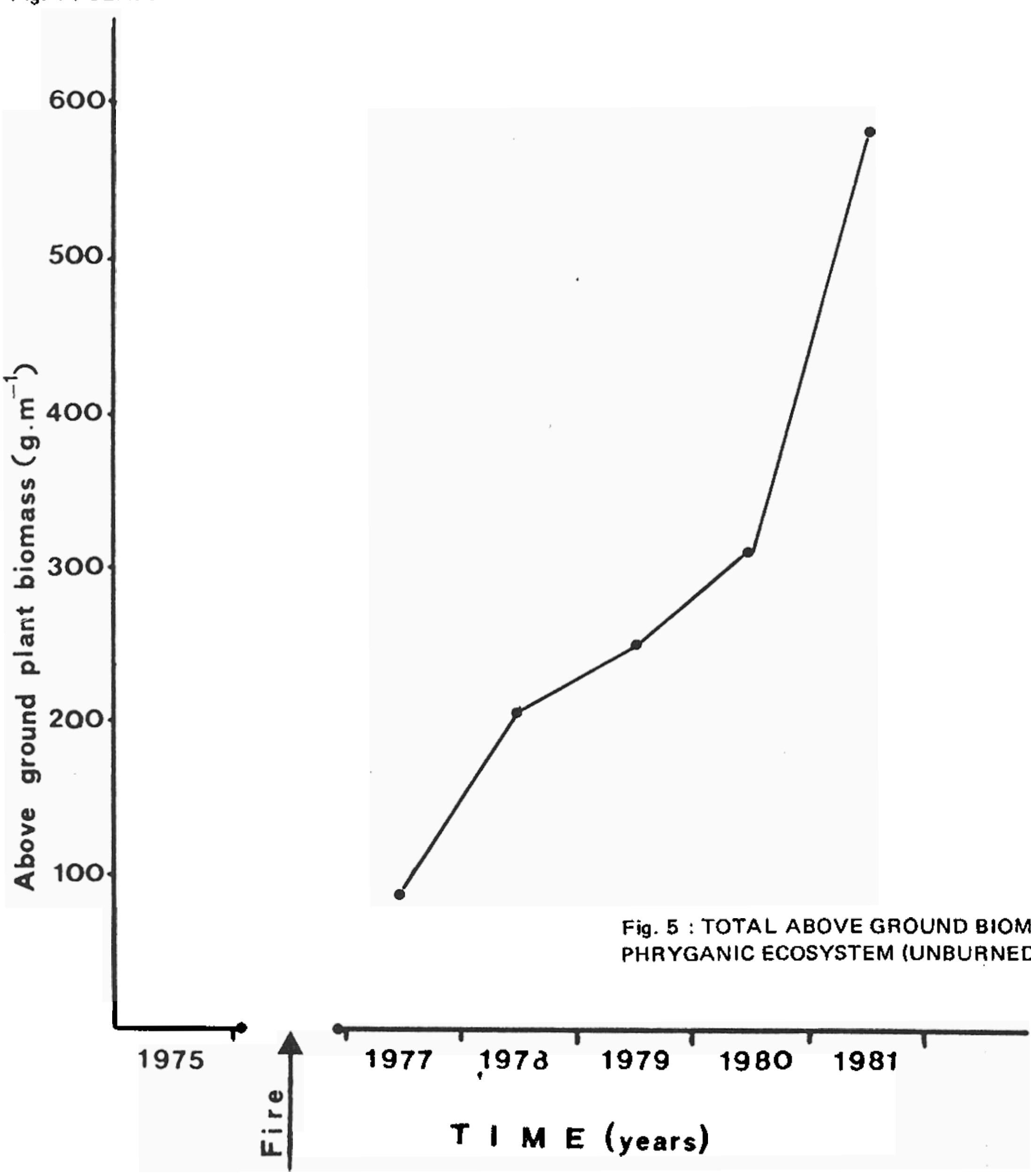

Fig. 5 : TOTAL ABOVE GROUND BIOMASS IN THE BURNED PHRYGANIC ECOSYSTEM (UNBURNED ONE : 1200 g.m^{-2})

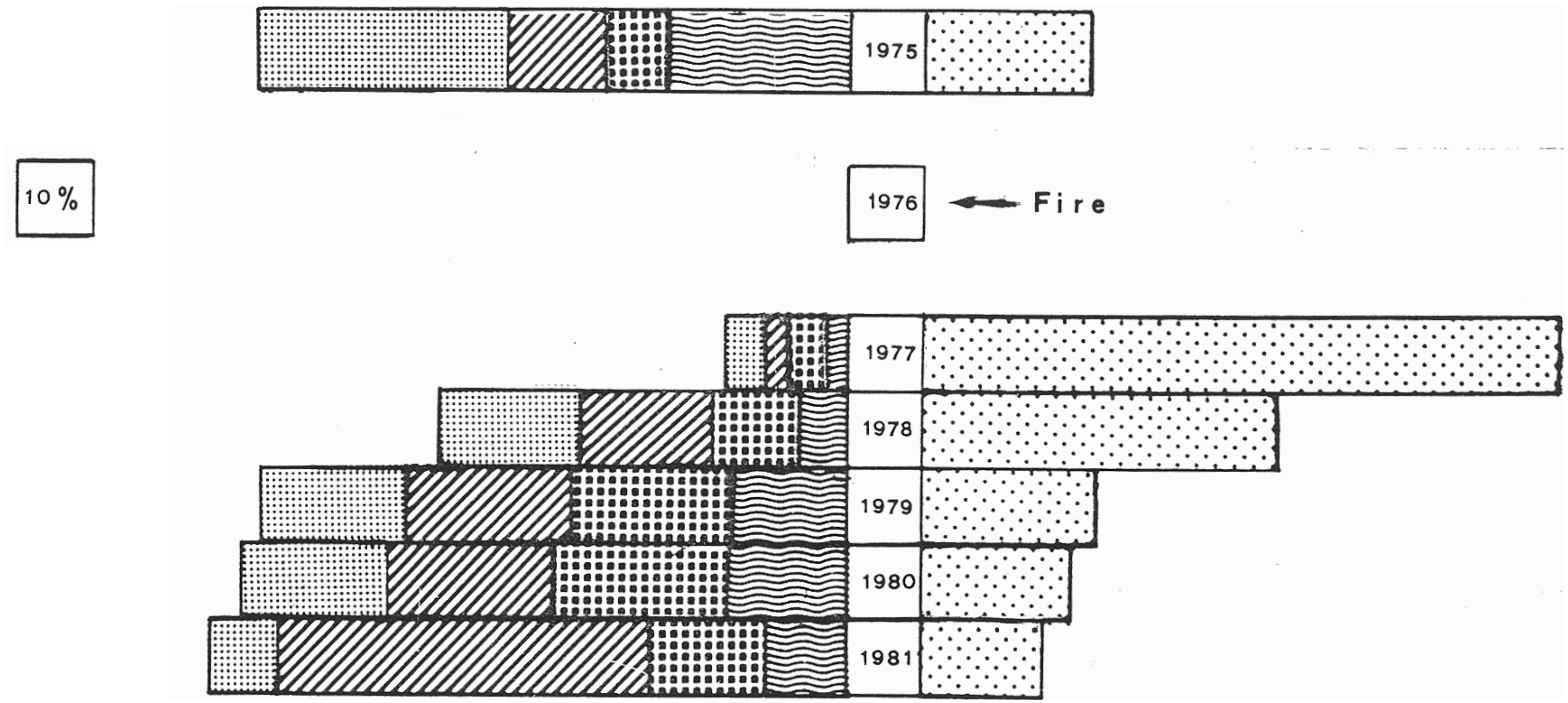

Fig. 6 : PERCENTAGE CONTRIBUTION OF THE SPECIES *PHLOMIS FRUTICOSA* , *SARCOPOTERIUM SPINOSUM* , *CISTUS* SPP , *EUPHORBIA ACANTHOTHAMNOS* AND OTHERS IN TOTAL ABOVE GROUND BIOMASS. ALL MEASUREMENTS HAVE BEEN DONE ON THE PEAK GROWTH PERIOD OF EACH YEAR (APRIL).

SOME GENERAL REMARKS

By discussing all the above, we didn't try to set doubts about the existence of degradation in many cases, which in these days are covered by phrygana and in which fires have, in the past and in the present days, played a destructive role. But most valuable, according to our opinion, is the understanding of structure and function in phryganic ecosystems as well as the stage at which they are. After that, better and beneficial management could be applied in those areas that needed such a manipulation. According to this, the phryganic ecosystems can be discerned into 3 different categories.

In the first, the climax situation, they are located in sites with low precipitation as well as in sites in which soil and parent rock material conditions lead to high water deficiency during summer. Such typical cases are the Cyclades islands as Paros (Table 2) and some other regions of Greece like Attica and Laconia.

The second type could be characterized as a successional stage starting from old fields. So, some years after their cultivation has stopped, especially in these sites with high slopes and where there used to be cultivations of cereals, invasion of phrygana dominants started and now they have covered them. This situation has nothing to do with degradation since the ecosystem is in a successional phase towards a state with higher biomass in it. In these cases species diversity is almost similar to that of climax states. Such examples might be drawn from Karystos (Table 2) and from some islands, like Alonissos.

	Families	Genera	Species
Monemvassia	13	20	21
Paros	9	20	22
Volos	12	28	29
Karystos	8	22	22
Astakos	6	13	13

Table 2 : NUMBER OF WOODY SPECIES (10 QUADRATS 10 x 10 m) IN SEVERAL REGIONS OF GREECE.

It is evident why we left for the end the discussion on the third case, which characterizes those phryganic ecosystems which are the results of maquis or forest's degradation. Undoubtedly, fire's action upon them was one of the reasons for degradation, but only when it was combined with grazing. According to our opinion, not only the old but the new practice too, of land management covered now by phrygana or *Asphodelus* species was the use of fire, set up by shepherds. We already mentioned that phrygana are quite well adapted to recurring fires. One of their adaptations in replenishing the great loss of nitrogen (95%) in fire's smoke, is through the Papilionaceae species which are able to fix the atmospheric nitrogen and are abundant the first post-fire years. It is well known especially to the shepherds that the members of this family are an excellent animal food. Then, by grazing them, the nitrogen replenishement is blocked out and subsequently the ecosystem is degradating. In the meantime and while the overgrazing continues,plants resistant to grazing and fire recover; then the shepherds wishing to get rid of them use the same practice, that is frequent fires. But the result of their action is the opposite, since *Asphodelus* species are especially adapted to grazing since they are not palatable and to fire as well, since their underground parts remain undisturbed. The Phlometum communities of W. Greece and *Asphodelus* communities of Thessaly can be considered as the results of the combination of fire and overgrazing. In W. Greece, where are the *Phlomis* communities, the situation is not so serious, since seedlings of *Quercus macrolepis* are common there, and these seedlings might be trampled or eaten by the animals and also destroyed by fire. In other words, if grazing was forbidden there, the forest would recover. All these can be proved by estimating the species diversity of those systems, which of course separates them from the others (see Astakos, Table 2).

So, taking all the above into consideration we proposed a new way of viewing fire's action, someting of course already adopted at least in the new world.

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