Prévention d'incendies dans les forêts de pin d'Alep

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Fire prevention in Aleppo pine forests

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RESUME

PREVENTION D'INCENDIES DANS LE FORETS DE PIN D'ALEP

L'évolution de la forêt méditerranéenne est conditionnée par les incendies. L'aire naturelle du *pin d'Alep* est caractérisée par la sécheresse persistante et par les forts vents de terre créant des conditions très favorables à l'ignition des combustibles forestiers et à la propagation du feu. La Région Méditerranéenne est aussi très peuplée. Alors le risque d'incendie est très élevé tout au long de la saison sèche.

Le *pin d'Alep* a développé une résistance active contre le feu à travers une régénération naturelle très poussée après le passage du feu. Beaucoup d'exemples montrent la capacité régénératrice de cette espèce et son caractère envahisseur.

La fréquence de feux dans les forêts de *pin d'Alep* est comparable à celle des territoires non boisés. D'après les statistiques, on peut atteindre le passage du feu tous les 60 ans au maximum. Si la fréquence devient plus grande la régénération naturelle pourra devenir impossible.

La prévention d'incendies dans les forêts de *pin d'Alep* doit être intégrée à la sylviculture. Dans ces forêts les objectifs de protection ont une importance comparable à celle de la production.

La sylviculture protectrice doit considérer la création de diversités pour empêcher la propagation du feu et pour favoriser la régénération des espèces après le feu.

Les différentes catégories de pare-feux, l'alternance d'espèces, l'introduction de plantes d'inflammabilité réduite, la réduction des accumulations de combustibles légers par le pâturage et le feu contrôlés sont des méthodes classiques de prévention passive mais fondamentales pour une politique de prévention.

De grands investissements dans les moyens de lutte auront une faible efficacité sans une sylviculture préventive complétée par des études sur le comportement du feu.

SUMMARY

The Mediterranean area, where the Aleppo pine grows, is a major fire danger area because its long droughts and strong, desiccating winds. The Aleppo pine has a natural ability for natural regeneration after fire, because its seeds can grow better when the soil is cleaned in the fires. Nevertheless the rate of burned surface each year is increasing in such a way that the total vegetation cover is endangered.

Prevention has to be made by fuel management, opening and maintaining peripheral and internal breaks in the stands. Controlled grazing by goats, prescribed burning and introduction of low volume and low flammable species are the most suitable techniques for maintaining properly fuel breaks, preventing both ignition and spread of fire.

FIRE AND VEGETATION

When I was asked to make a presentation on fire prevention in *Aleppo pine* (Pinus halepensis) forests I went first to the library to review some books in order to remake a comprehensive image of this species, before narrowing the field to consider the specialized subject of forest fires.

The general conclusion of that review was very curious : The word "fire" didn't appear in any text book related to *Aleppo pine*. I needed to search into papers presented in seminars or meetings, articles in reviews and pamphlets, most dated recently, to find this species cited in connection with fire.

Studies of plant succession after fire seem to confirm the generalized pyrophitism of the Mediterranean forest vegetation (Trabaud 1980). The story of botanical associations in our forests would be incomplete if the role of fire were not included. Fire has never been a rare event in these forests. It seems now more frequent than some decades ago and has more spreaded effects. But it has always been there. The vegetation can tell us whether fire burned recently in an area or not. Chestnuts and beeches are clear signs that there had been no fires for a long period. A pine grove or a *Cistus* shrub on the other hand are probable indicators of a relatively recent fire. Moreover extended grazing lands are denouncing repeated fires in short return periods.

FIRE AND THE ALEPPO PINE

The environment for the *Aleppo pine* leads it to develop mechanisms to resist fire or to disappear.

The area where natural stands can be found is depicted in Graph n° 1. Plantations have enlarged very much this area. For instance, in the Iberian Peninsula the natural stands are covering 800.000 ha. about, but the total area reaches a figure of 1.200.000 ha. about in the whole country extending this species to Central and Southern regions.

This area shows the typical Mediterranean climate. Summer droughts create such critical humidity conditions in the vegetation than even a slight heat supply can give rise to great conflagrations of fire.

The area of *Aleppo pine* in the Iberian Peninsula is characterized by two parameters: the hydric deficit and the hydric surpplus (Gandullo 1972). Combinations of data shown in Graphs n° 2 and n° 3 are defining several subregions and different qualities of *Aleppo pine* stands. Rainfall in the whole area is between 700 mm. in Cazorla Mts. and 350 mm. in Almería, but the average is around 450 mm. Summer rainfall is between 40 and 80 mm., but for most places precipitations are very irregular. So rain is falling very few days a summer and the drought is the typical characteristic of the season.

Drought is the origin of forest fires. When the dry period is long enough, the vegetation becomes "just fuel" and the dry season has to be called "the fire season". In fact the areas most affected by drought are also those which have suffered the most devastating fires (Vélez 1983).

Another climatic feature is the wind. All winds blowing from the continent to the sea are desiccating winds and contribute to reduce the fuel moisture making easier both ignition and spread of fire

Both factors, drought and wind, are recognized as main parameters by all methods of fire danger rating.

Considering again the Graph n° 1, we can realize that the largest *Aleppo pine* areas in the West of the Mediterranean Sea have sistematically dry and windy summers. The "mistral" in France, the "tramontana" and the "poniente" in Spain blow over the Aleppo pine areas. And when they blow the danger is high and many fires start.

The significance of this climatic situation seems to be the increase of the probabilities of human actions causing fires either through negligence or intentionally. Blame connot be attached simply to the drought and the wind for the increase in fire effects.

The *Aleppo pine* grows in one of the most populated areas in the World, where intensive land exploitation started thousands of years ago; where herds, sometimes of sheep, sometimes of men, considered the spread of fire as an useful method to get grass or to destroy their enemies, even in this century. (Vélez 1981 a).

In recent times this region has seen the raise of another activity, the tourism. Millions of people are overcrowding the Mediterranean coastal areas during the fire season, creating a very high risk everywhere.

If this is the picture, how the *Aleppo pine* is keeping its place in it? Let's see some recent reports.

In the Ayora-Enguera fire (July 17-21, 1979) which burned 22,796 ha. of mature pine forest in Valencia (Spain), regeneration of *Aleppo* and *pinaster pines* was abundant one year later. The autumn following the fire was very rainy so that seeds had germinated when spring arrived. They rooted well with season rains and most were able to survive along the following dry season. Pine trees 20 cm. high were found in November 1980, together with others which had just germinated. Six years later pine trees up to 5 m. high can be seen all around. Aleppo pine area is outstandingly larger than before the fire, occupying places previosly covered by pinaster pine.

In a drier area of Valencia (Serra-Portaceli fire, 1978) a lag of one year was observed. In addition little if any regeneration occurred in the driest, stoniest sites, on steep slope. Nevertheless six years later the *Aleppo pine* is coming again even in these unfavourable sites. It seems that this species can resist the initial increase of pH after fire which prevents the invasion by other species. Then its abundant production of seed allows the regeneration around mature stands. Even burned stands keep enough live seeds to germinate when humidity conditions are again right (Vélez 1981 b).

At the Adriatic coast in the Gargano peninsula (Italy) similar conclusions are established. The fire uncovers the forest floor allowing the seeds to get in contact with the soil. The fire also helps to open the cones and then seed spreading. Although scrubs regenerate very well too, pines will dominate after some years.

If fire arrives again in a short term (less than 20 years) the availability of pine seeds will be very poor. Then the succession will go to the shrub (*Philly rea, Pistacia*) or the "gariga" (*Cistus, Rosmarinus*) (Macchia l983).

Where there is a mixed forest of *Aleppo pine* and oak (*Quercus ilex*) the fire opens the forest decreasing the surface covered by trees but in the future they will regain their dominance. However repeated fires will eliminate the pines creating a shrub of oak and other schlerophytic species.

Areas covered by *Quercus coccifera* can also be invaded after fire by *Aleppo pines* growing before on the nearby rocky surfaces. Grazing by goats can eliminate the young sprouts of *Q. coccifera* after the fire making easier the invasion by pines (Montero de Burgos 1981).

The species cited as indicators of Aleppo pine climax in Spain are all pyrophitic: *Cistus albidus, Cistus libanotis, Erica multiflora, Pistacia lentiscus, Genista scorpius, Ulex parviflorus, Daphne gnidium, Rosmarimus officinalis* (Gandullo 1972).

Sometimes the Mediterranean forests are described as "wooded shrubs" because fire doesn't allow to reach the aspect of a closed forest.

OCURRENCE OF FIRE IN ALEPPO PINE FORESTS

Occurrence of fire in *Aleppo pine* forests seems to be higher than the average. If we consider for instance the case of Spain, a country with two different ecological regions (Atlantic and Mediterranean), with several danger areas spreaded all around (ICONA 1982), we can see that sinistrality is very high in the *Aleppo pine* stands.

Table 1 shows some figures of the last 15 years in Spain. It's outstanding that Aleppo pine burned surface makes from 10 to 20 % of the total area burned in the country, including forest, shrub and grazing lands. In fact occurrence in the *Aleppo pine* forests is comparable to that in non forested wildland, where accumulations of light fuel reach a maximum.

Fire is visiting a large portion of the *Aleppo pine* area every year, getting the maximum figure, 5 %, in 1979. It can be said that fire will visit every forest in a 60 years period. Such a rate could be resisted by the species according to its potential of regeneration. However occurrence is not a cyclical phenomenon and fire can visit twice a young stand in a short period preventing the trees to produce seeds and eliminating every possibility of regeneration.

Table 2 shows that hazard is two to three times higher in the young stands than in the mature ones.

That is, around 60 % of the burned stands will have difficulties to regenerate because of lack of seeds. A plantation will be needed in these cases to regenerate the forest.

Table 3 shows a list of big fires in *Aleppo pine* forests in Spain. Graph n° 4 shows the places.

Blame for this list can be distributed in an uncertain proportion between fire fighting services and fire behaviour conditions in most cases. As cited before, meteorological conditions, fuel accumulations and concentration of risk make fire suppression in these forests extremely difficult. Thousands of men and heavy equipment have to be employed in fire fighting to get a relative success.

Table 1

Burned surfaces (ha) of Aleppo pine in Spain

Year	(a) Total burned surface	(b) A. p. burned surface	100 b/a %	100 b/A (1) %
1.969	53.719	1.551	2,9	0,1
70	87.324	17.172	19,6	1,5
71	34.945	4.216	12,0	0,4
72	57.283	1.955	3,4	0,2
73	95.275	11.880	12,5	1,0
74	140.211	15.211	10,8	1,3
75	187.314	9.906	5,3	0,8
76	162.300	11.571	7,1	1,0
77	67.540	5.699	8,4	0,5
78	434.867	50.689	11,6	4,4
79	271.718	55.245	20,3	4,8
80	265.954	29.364	11,0	2,6
81	298.436	28.591	9,6	2,5
82	151.644	20.854	13,7	1,8
83	117.599	23.485	20,0	2,1
				25,0

(1) A = 1.139.464 ha. is the total Aleppo pine area in the country. (1.974 Forest Inventory)

Table 2

Distribution of burned surfaces of Aleppo pine in Spain

Year	(a) Total burned surface	(b) Young stands	(c) Mature stands	100 b/a %	100 c/a %
1.969	1.551	1.064	487	68,6	31,4
70	17.172	11.195	5.977	65,2	34,8
71	4.216	3.129	1.087	74,2	25,8
72	1.955	1.350	605	69,0	31,0
73	11.880	6.739	5.141	56,7	43,3
74	15.211	9.744	5.467	64,0	36,0
75	9.906	5.177	4.729	52,3	47,7
76	11.571	8.295	3.276	71,7	28,3
77	5.699	3.878	1.821	68,0	32,0
78	50.689	33.706	16.983	66,5	33,5
79	55.245	33.780	21.465	61,1	38,9
80	29.364	18.786	10.578	63,9	36,1
81	28.591	21.529	7.062	75,3	24,7
82	20.854	12.435	8.419	59,6	40,4
83	23.485	17.508	5.977	74,6	25,4

Table 3

Big fires in Aleppo pine stands

Year	Day	Province	Aleppo pine	Shrub
1.970	Oct. 2	Tarragona	2.621 ha.	1.988 ha.
	Jul. 14	Valencia	2.070 ha.	573 ha.
	Aug. 16	Valencia	1.785 ha.	722 ha.
1.971	Aug. 14	Alicante	930 ha.	1.100 ha.
1.973	Oct. 14	Valencia	1.686 ha.	1.221 ha.
	Aug. 31	Gerona	570 ha.	1.830 ha.
	Sep. 1	Granada	1.060 ha.	200 ha.
1.974	Aug. 16	Tarragona	1.596 ha.	621 ha.
	Sep. 23	Valencia	1.220 ha.	1.835 ha.
1.975	Nov. 14	Málaga	6.402 ha.	2.800 ha.
1.976	Jul. 30	Tarragona	2.267 ha.	2.383 ha.
	Apr. 9	Castellón	2.400 ha.	237 ha.
	Apr. 10	Valencia	1.245 ha.	205 ha.
	Aug. 21	Cádiz	2.800 ha.	2.225 ha.
1.978	Aug. 30	Valencia	7.039 ha.	6.061 ha.
	Sep. 18	Valencia	4.900 ha.	1.500 ha.
	Jul. 18	Granada	2.423 ha.	2.937 ha.
1.979	Jul. 17	Valencia	22.796 ha.	5.514 ha.
	Jul. 30	Valencia	5.046 ha.	3.002 ha.
	Aug. 9	Tarragona	3.500 ha.	1.903 ha.
1.980	Aug. 15	Valencia	4.200 ha.	1.879 ha.
	Oct. 11	Barcelona	4.332 ha.	955 ha.
1.981	Dec. 12	Tarragona	6.850 ha.	809 ha.
	Aug. 7	Cuenca	2.900 ha.	–
1.982	Jul. 5	Barcelona	4.520 ha.	2.425 ha.
	Oct. 5	Castellón	1.890 ha.	1.980 ha.
	Aug. 13	Granada	3.870 ha.	730 ha.
1.983	Apr. 11	Tarragona	3.316 ha.	1.404 ha.
	Jul. 31	Valencia	3.091 ha.	916 ha.

Records from other places can be cited. The fire in the Evvia Island, in Greece, quite close to Athens which wiped out 10,490 ha. in the summer of 1977; most fires in southern France running through the *Aleppo pine* forests; the big fires in the last years ravaging Corse and Sardinia, etc. Northern Africa has also seen big fires because of grass burning by the shepherds. A fire of 103,000 ha. was recorded in the Bona region (Algeria) in 1865. Other big fires destroyed the forests at Bougie and Oran between 1881 and 1885 (Areses 1929). The Independence War of Algeria was another time when thousands of hectares were burnt.

PREVENTION IN ALEPPO PINE FORESTS

Preceding figures are a loud call for prevention in these forests in order to protect them, against a fast and steady destruction.

Besides the classical prevention by public information and education a passive prevention by fuel management is needed.

Forests are always systems accumulating combustible material on large rural areas. Accumulation is increasing year after year, but flammability of this material is not increasing at the same rate. As a matter of fact flammability is maximum along the first years of a forest because the whole stand is formed by light fuels (thin stems, branches, etc). When stems are thick enough (diameter over 10 cm.), one can consider three strata in the system:

– lower stratum : leaves or needles, small twigs, branches, etc: high flammability.

- intermediate stratum : trunks protected by bark: low flammability.
- higher stratum : high flammability.

As fires are mainly of human origin, they are starting at the forest floor level. Wind under canopy is currently very weak. Then flames are kept close to the ground and it is not very frequent that they climb up to the crowns. However, hot air and smoke emissions from flames can scorch and even defoliate the trees which sometimes die.

Self protection of forests can therefore be obtained by preventing the fire to run under the forest canopy. The only way to reach that goal is by establishing breaks into the fuel on the ground. So, heat conduction is prevented but not radiation which can ignite fuels on the other side of the break. The wider the breaks are the less intense will the radiation be and sometimes the fire will die at the break. Unfortunately, most of the times, one may not open wide breaks. There are three main reasons:

- breaks are non productive surfaces.
- wide breaks can function as chimmeys creating an easy way for wind flow which can feed the fire.
- there is no shadow on the break floor, so weeds are growing very fast creating some dangerous fuel accumulations, the removal of which every year is costly.

Therefore, breaks have to be designed under the following conditions:

- to provide a fuel-free barrier to fire.
- to cover not a large surface.
- to have a low cost maintenance.
- to provide access through the forest.

It is possible to meet these requirements to a certain extent with two kinds of breaks:

- peripheral breaks.
- internal breaks.

(a) Peripheral breaks will consist in a strip 10 m. minimum wide in flatlands and 20 m. on slopes around every estate. It has to be prepared like a road with a bulldozer, eliminating every fuel. Piles of removed fuel have to be burnt before the dry season.

If slope is not limitative, peripheral breaks have to be used as access roads to the plantation for every purpose. If possible some parts of these breaks have to be used as roads in order to get traffic on it and to eliminate regrowth.

Access of livestock to the break surface may be allowed if a shepherd is present to prevent animals entering the plantation. Livestock can eat resproutings, keep low the fuel accumulation.

If shepherds are not available, fencing of the plantation will be needed.

(b) Internal breaks will be of two types:

- main breaks, dividing the forest into blocks of no more than 300 ha. Width of these breaks will be the same as for the peripheral ones, that is, 10 m., in flatlands and 20 m. on slopes. They have to be placed along ridges and in canyon bottoms. If possible they have to be opened with a bulldozer, preparing a track or a road along the central line. Every removed fuel has to be burnt in piles.

  Direction of breaks has to be perpendicular to that of prevailing winds.
- secondary breaks, as access lanes, omitting one row of trees every 300 m. and passing the bulldozer along.

Besides the break planning, in areas for reforestation there are some operations to be considered both before and after plantation. Some of them concern site preparation, others, maintenance of the breaks.

(c) Site preparation: If strips for plantation are prepared with a bulldozer, windrows of brush mixed with soil will be separating those strips. That dried brush will be a high hazard which has to be burnt previously. As brush and soil mixture will not burn very readily, it would be better to burn the whole surface passing the bulldozer, making a break around and having enough people there in order to prevent the fire from spreading.

(d) Maintenance of the breaks: This is an essential operation. Unfortunately there is no method both cheap and safe to prevent regrowth of floor vegetation. Two methods can be considered:

- shading the break floor, so inhibiting growths.
- cleaning the break floor periodically.

Shaded breaks are an alternative to open breaks as described in paragraphs (a) and (b). The question is to find less flammable species than the main one in order to get a differential speed for a fire spreading under the stand.

In Mallorca Island (Spain) shaded breaks by thinning intensely the pines have been tested in connection with cattle grazing.

This kind of break has to be wider than open breaks, from 60 m. on steep slopes to 100 m. on the plain.

Open breaks have to be supplemented at both sides with auxiliary strips 10 m. wide where trees will be pruned up to 4 m. and thinned 4 m. x 4 m. Branches and thinnings have to be drawn out of the plantation as firewood or piled and burnt in the break.

Following maintenance has to be made every year. Different methods can be suggested:

- prescribed burning of the break plus the auxiliary strips (30 to 40 m. x length of the break) and subsequent grazing when resprouting starts. A shepherd will be needed.
- crushing the resprouts along the break with a bulldozer and unbrushing by hand the auxiliary strips, burning brush piles, etc.
- use of phytocides can be scheduled although the elimination of the dead vegetation will be needed.

(e) Peripheral breaks have the first priority for maintenance. These breaks can be improved in the most risky areas if supplemented with a strip covered with fire retardants at the beginning of the dry season. If a special retardant is not available, some phosphate fertilizer can be used. As the fertilizer can increase resprouting, it would be interesting to plough the strip before and to seed grasses at the same time as the fertilizer is spread. Grazing will maintain low the fuel accumulations afterwards.

(f) Another concept to be retained is that of alternating stands of different species in order to get a flammability differential and prevent continuous spread of a fire over the same kind of fuel.

So the regeneration of other Mediterranean species like oak mixing them with the *Aleppo pine* has to be considered as a way to a more stable environment.

Another idea is to replace weeds growing after cleaning the fire breaks by other plants that have lower fuel volume or lower flammability than the spontaneous ones.

Some experiences made in the California chaparral can be considered to solve the problem of break maintenance in our Mediterranean region (Nord and Green 1977).

Characteristics of the desired plants are as follows:

- low volume.
- low growth form.
- wide adaptability.
- reproducibility.
- widespreading, deep root systems.
- relatively low flammability.
- palatability to animals.

Among the species tested in California there are two shrubs maybe interesting to plant on fire breaks in *Aleppo pine* forests:

- Caucasian artemisia (*Artemisa caucasica* Willd), which grows up to 1,500 m., on a pH range of 6 to 8 and more than 400 mm. of precipitation. Ash content is about 8 % so it's intermediate flammable, but because of its small fuel volume can function well in a fuel break.
- Muller's saltbush (*Atriplex mulleri* Benth), which is drought resistant, surviving even in sites with 250 mm. of rainfall, on a pH range of 6 to 8. Ash content is about 20 %, so it has very low flammability.

Presently in Spain there is a project in operation for integrated fight against desertification in the Mediterranean region (LUCDEME). In this project there are some experiences of planting *Atriplex* sp. for forage. One of the species in the experience is Australian saltbush (*Atriplex semibaccata*) which seems to withstand extreme drought and hot weather. It grows on disturbed soils, which is the case in fire breaks after preparation. A test of planting this species in fire breaks in order to transform them into fuel breaks will start this year. Other species have to be experienced for different altitudes and sites.

THE NEED FOR A PROPER SYLVICULTURE

Forest protection in Mediterranean countries has looked like an impossible task for a long time: On one side the pressure exerted by the urbanistic and agricultural interests; on the other side the concept of the forest like an economical unit to produce timber to stop the demands of land for other uses. Central European methods of management were extensively used to increase timber production and to improve its quality by natural pruning and to get the stability of the stands by natural regeneration. However ecological conditions prevented such an achievement in many cases (Liacos 1977).

To support those methods of management total prohibitions of grazing were established and the role of fire ignored. Therefore the figures we have reviewed show that destruction by fires is seriously threatening and even overwhelming that policy of reforestation and timber production in the Mediterranean countries. An agreement between the different functions of the forest is needed to get an acceptable productivity in a safer ecosystem (Morandini 1977).

Recent trends to manage fire and goats, formerly considered as enemies, to use them like new tools of sylviculture are indicators of that kind of agreement. Mixing of species, alternating of uneven aged stands, breaking the continuity of large reforestation areas are other concepts in the way to get a diversified environment making possible the ecological evolution without site degradation.

So a proper sylviculture for a region with a high level of danger like the Mediterranean one, has to include fire prevention objectives besides those for production. That is:

– Fuel management to reduce fire danger and
– Ecological management to preserve diversity of the environment.

The World strategy for Conservation (UICN-WWF-PNUMA 1980) proclaimed the following objectives:
(a) The maintenance of essential ecological processes.
(b) The preservation of genetic diversity.
(c) The sustained use of species and ecosystems.

With regard to forest fires these objectives show that we cannot protect the forest from fire by means other than Nature's own. It is necessary:

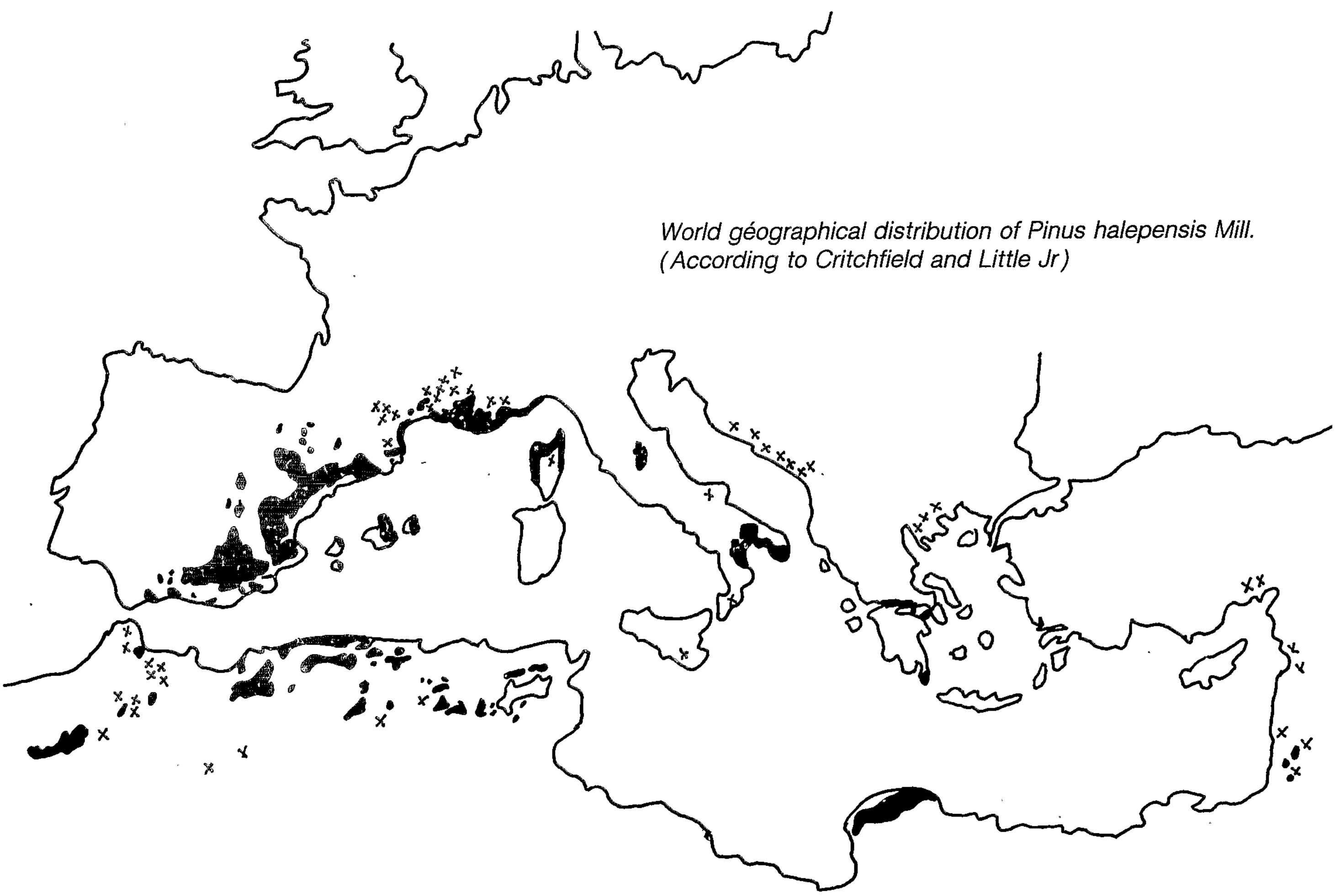
(a) To recognize fire as a basic element in the ecological processes of our forests, only harmful in excess or when it conflicts with man created values.

(b) To recognize that genetic diversity produces morphologically plural ecosystems, which are the most resistant to be perpetuated in the case of fire.

(c) To recognize fire as a recurrent process which cannot be managed only by suppression measures but also by permanent sylvicultural treatments.

In such a way Sylviculture will fulfil its role in the conservation of the Nature by ensuring the persistence of the forest.

Figure 1. Natural area of Aleppo Pine.



World géographical distribution of Pinus halepensis Mill. (According to Critchfield and Little Jr)

Figure 2.

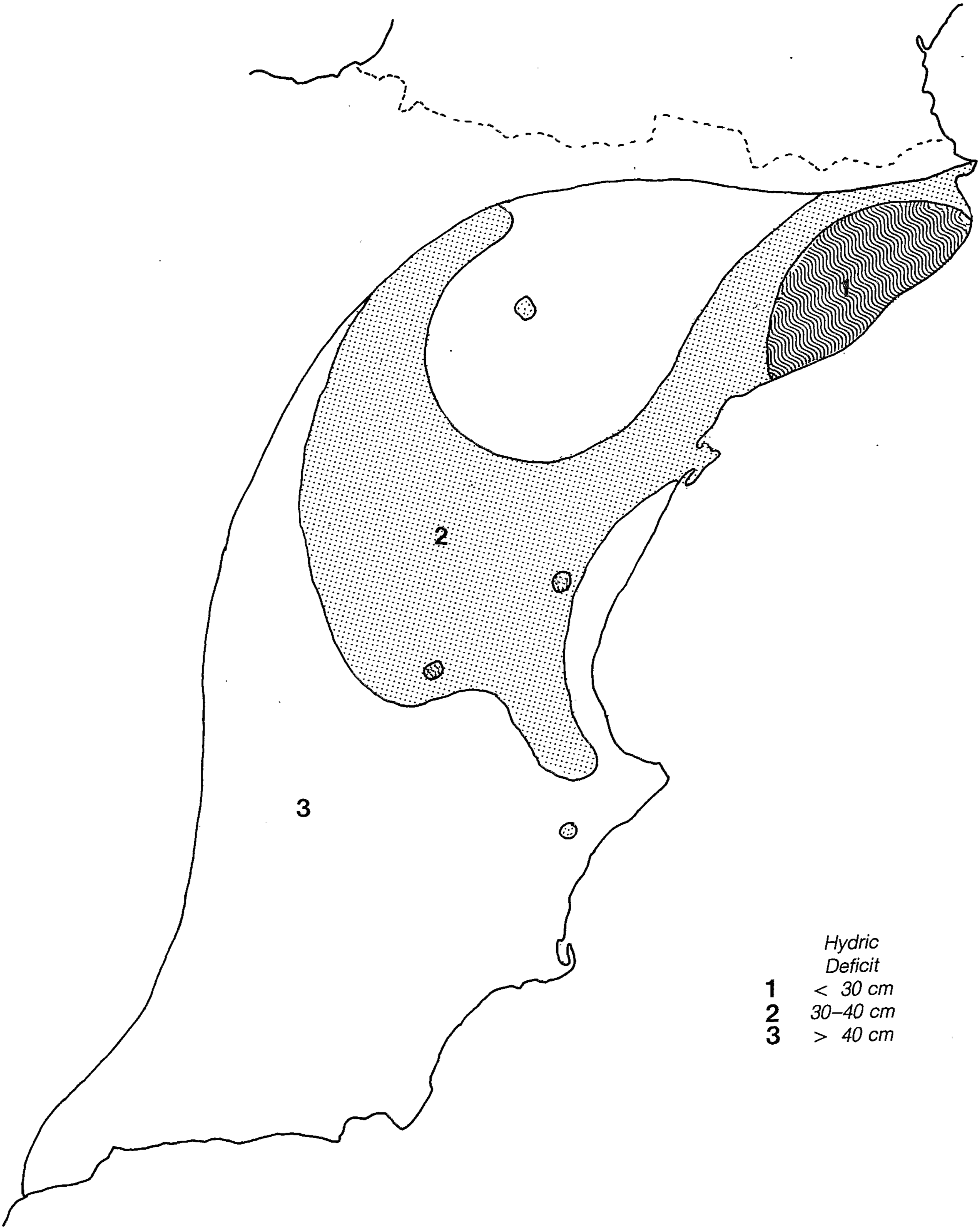
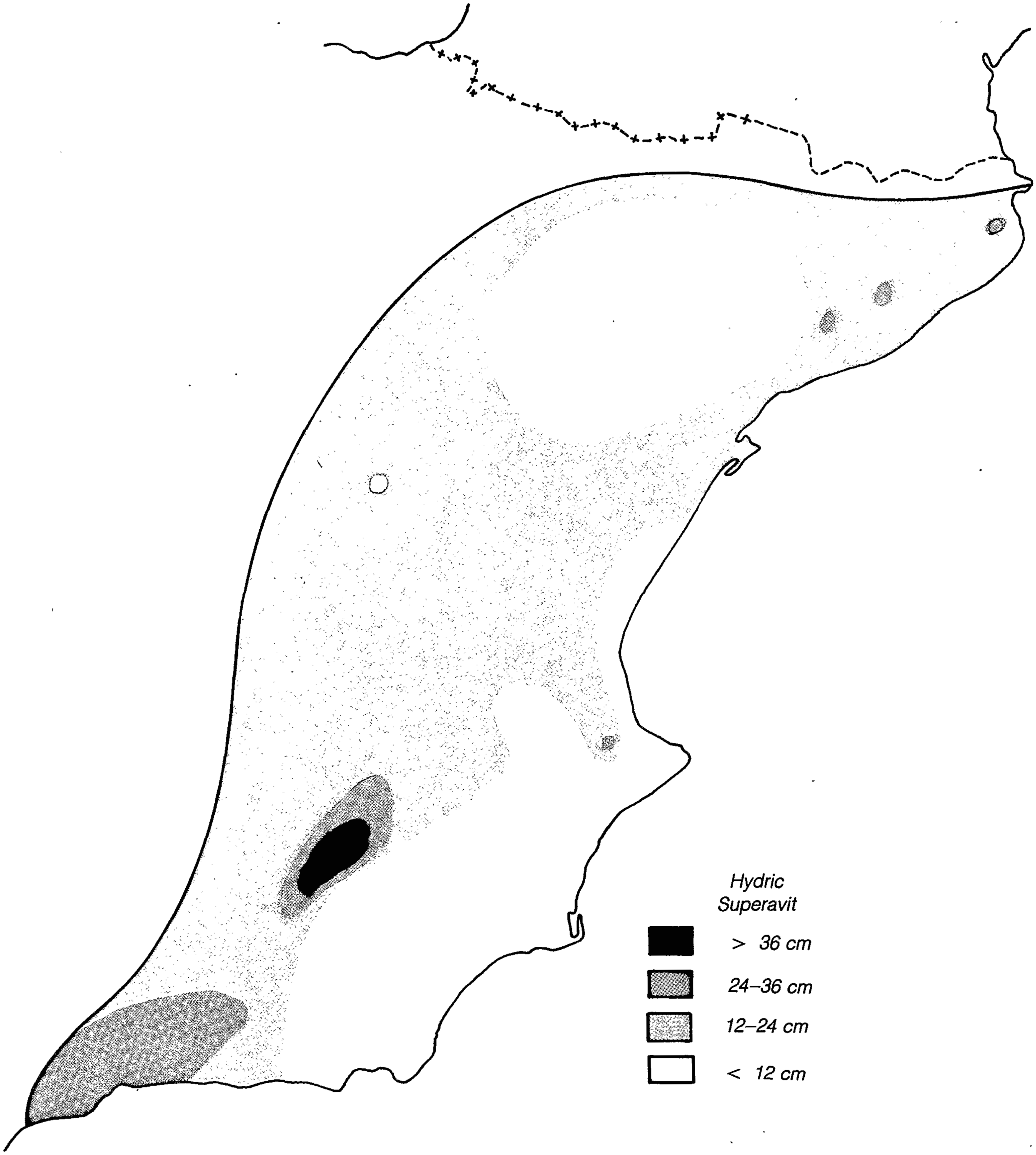


Figure 3.



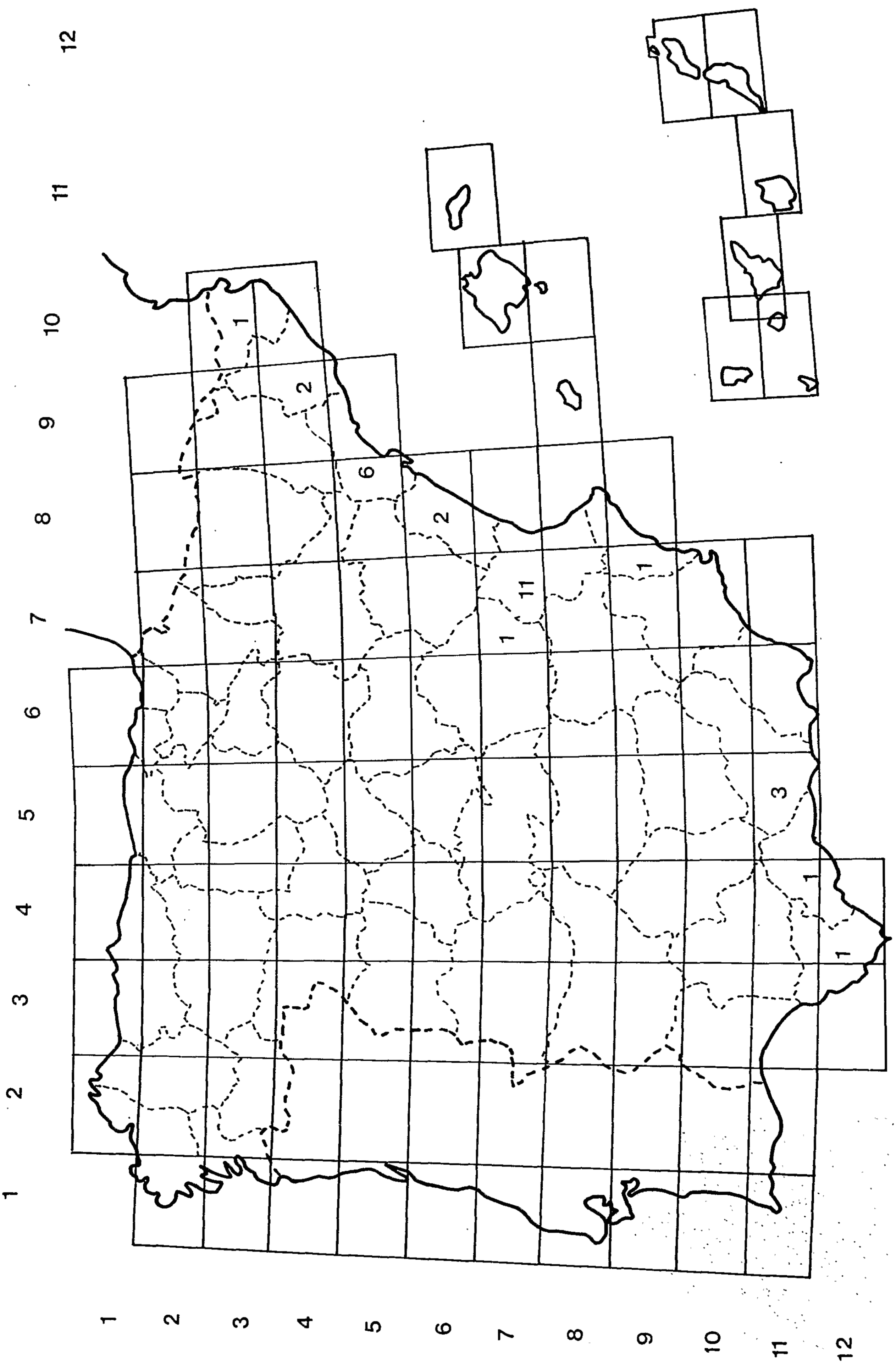


Figura 4. BIG FIRES 1969–1983.Distribution of forest fires according to Military Maps
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