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AMELIORATION OF THE BURNT ALLEPO PINE (*Pinus halepensis* Mill.) FOREST AREA IN THE MAKARSKA COASTLINE REGION

SANACIJA POŽARIŠTA SASTOJINA ALEPSKOGA BORA (*Pinus halepensis* Mill.) U MAKARSKOM PRIMORJU

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The Aleppo Pine (*Pinus halepensis* Mill.) is an allochthonous species in the Makarska coast area, i.e. it has been planted in cultures as a pioneer species for the purpose of improving and ameliorating the karst areas. This paper presents the results of the research on the improvements to the burnt area after the devastation caused by fire on a large stretch of the Aleppo Pine forest. The research was carried out where both old stands and young growth had been successively caught by fire. Two typical problems have to be understood when dealing with the Aleppo Pine, both being encountered in the Makarska Coast region. The first refers to fire in an old stand, where fire is no obstacle to stand regeneration. On the contrary, the Aleppo Pine as a pyrophyte species supplies the soil well with seed, so that thick young growth soon covers the ground. Thus, only a decade following a fire, we can see a large area of 2 m - high Aleppo Pine young growth, often with a million plants on one hectare. Since such thick growth is a dangerous inflammable material, preventive measures are required, such as reducing the number of plants. Riding cuts and roads are a priority among silvicultural operations. A much more serious problem occurs if the fire catches a stand of young, not yet fructiferous trees, so that no regeneration can take place. On these areas the planting of the Aleppo Pine, Maritime Pine, Cypress and the Evergreen Oak was carried out. Survival differs depending on the species. It emerged that the planting of small seedlings, especially one-year-old seedlings of the Evergreen Oak, over a bare surface, like the pioneer pine species, could not meet the target, since these young plants need shade in such extreme conditions of high temperature, hot sun, little moisture in the soil, and wind. Fair results were achieved with the Cypress, which, besi-

des a high survival rate, grew considerably more in the ten-year period. It should, therefore, be planted more than has been the case so far. On both areas, there are very few autochthonous evergreen broadleaves besides the Evergreen Oak. Thus, on Area 1 (900 m^2) there are 1 454 bushes of the *Cistus* sp., comprising 1.62 plants per 1 m^2.

Key words: fires, Aleppo Pine (*Pinus halepensis* Mill.), burnt area improvement, vegetation succession, Makarska Coastline

INTRODUCTION
UVOD

"...among the most important issues in the Mediterranean karst forest protection, forest fires are the first on the list as a constant threat to the cultures and forests of the region..." (Androić 1971).

With forests burning along the Adriatic coast and on the islands, forest fires have been a particular threat to the growing stock for the last 20 years. Enormous damage has been caused by fires started either in direct combat or deliberately by the rebellious Serbs in the areas around the cities of Zadar, Šibenik, Split and Dubrovnik.

According to the data of the Ministry of Agriculture and Forestry (1995), karst forests and forests of the islands and coastal areas of Croatia cover an area of 1,042,081 ha, or 43% of the country's forests and forestlands. On the 732,371 ha of the forested areas, 83% are degraded stands (52% coppices; 25% brushwood; 4% maquis, and 2% garigues), the remaining 17% are high forests (11% seedling forests, and 6% cultures and plantations).

As for ownership, 83% are state forests, the remaining 17% are private.

In the period from 1973 until 1993, in the 4,466 forest fires that broke out in this region, 182,360 ha of forests and forestlands disappeared. The average annual loss was thus 8,684 ha. These data do not include the fires and burnt areas in wartime from 1991 until 1995 in the recently occupied parts of Croatia.

The number of fires is rather steady - about 200 a year, while the burnt area has doubled in 15 years (from 5,500 to 11,000ha). The burnt area per fire also increased in the 15 years, from 26 to 59 ha.

Two items deserve a special attention:

a) the fire interval is about 25 years: the annual burnt area is 10,000 ha on an area of 250,000 ha (extremely fire-susceptible area);
b) in the last 20 years, the burnt area has grown by 300 ha a year.

According to the plant types, the 41,176 ha of pine forests make up as much as 22% of the total area; 36,891 are coppices (20%); 42,399 ha maquis (23%), while the remaining 61,894 ha (35%) belong to the areas covered with other vegetation. The damaged or burnt wood mass exceeds 1,421,142 m^3 (Projekt 1995).

Causing the biggest damage to the ecosystems in Croatia, particularly in the karst region, forest fires leave long-term, heavy social-economic consequences, far more serious than the loss of timber.

On the burnt, naked areas, covered in places with a few stunted bushes and grass, erosion begins, supported by rain and winds which, without the shield of vegetation, become stronger and more destructive. Eventually, naked karst emerges.

Besides the ecological destruction of the natural environment, fires are a threat to the economy of the Croatian Mediterranean, considering the tourist attraction of our coast. With its negative impact on the landscape, fire compromises many tourist destinations.

Research on forest fires in many countries shows that attention should be paid to the pedological, climatic and floral features of the areas where they appear and spread. Other subjects of research should be the resulting circulation of the bio-elements and the physical properties of the soil; overall conditions needed for forest regeneration following a fire, climatic, pedological (soil chemistry/fertility/erodibility), vegetational (progressive and regressive successions, sanative methods).

A decision on what to do in terms of forest regeneration in the aftermath of a fire will depend on a number of biological/ecological and economic factors. The first step should be an ecological and economic analysis of the utility of such regeneration, while determining the future use of the forest. As a rule, after big fires, all areas cannot be regenerated and adjusted to a particular purpose. Therefore, it is useful to know what kind of work should be done first (Španjol 1996).

"Though their floral and ecological properties may differ, certain plant associations in a zone or subzone form a whole that is syndinamically linked to a higher or lesser extent. Understanding it is extremely important for the regeneration and amelioration of the vegetation..." (Horvat 1962).

With the already known phytocenological differences, we can be certain that, individually or in groups, the natural or antropogene plant associations and cultures are the direct indices and objects that are different as to their type, quantity of inflammable materials, inflammability, speed of spreading and duration of the fire, and the consequences and conditions needed for the regeneration of the burnt areas. Therefore, the role of the plant associations is indispensable. Respecting their multiple indicative value, we confirm the crucial role and significance of the phytocenoses referring to protection and regeneration. This concerns the objective gradation and categorization of the terrain according to the natural threat from fire, expert programming and enforcement of the biological improvement of the burnt forest areas.

Fire causes a regressive vegetational succession. Burnt areas, depending on the type of vegetation beforehand and the biological-ecological conditions, start to develop a regressive vegetation succession. In burnt pine cultures, there can be strong indices about the directions to be taken in silvicultural operations.

Man influences the speed, quality and direction of the progressive succession, both positively and negatively. The positive approach begins with research on the condition and changes that have taken place, establishing the transitory plant associations, and determining the progressive and regressive directions with the main

and subordinate phases of their development. The forester's tasks are to begin the biological improvements on the burnt areas, considering the pedological, climatological and vegetational conditions. The latter determines whether the improvements will continue in a natural, progressive succession, or whetter they will be achieved by planting of seedlings, or sowing the seeds, or a combination of all three methods.

In the Makarska Forest Service area, forest fires have destroyed large tracts of Aleppo Pine (*Pinus halepensis*) in the last 20 years.

GENERAL FEATURES OF THE RESEARCH AREA
OPĆA OBILJEŽJA ISTRAŽIVANOG PODRUČJA

The relief of the Adriatic hillslopes of Mount Biokovo and the wider area of Baška Voda and Brela are characterized by several morphological features. Firstly, there is the vast stretch of the Baško Polje descending toward the sea in the form of a fan ending with numerous capes that, like ribs, continue back to the foot of the Biokovo. With four types of Quaternary brezzias, this relief is a direct reflection of the geological structure of the region:

1) More resistant to wearing, these well-bound brezzias consisting of unsorted rectangular fragments bound with calcite cement stick out from the surrounding relief;
2) Semi-bound brezzia conglomerates of Baško Polje built of rectangular and partly rounded fragments bound with sandy material;
3) Weakly-bound brezzias consisting of rectangular fragments that are weakly bound by a sandy-loamy cement. They are found in the prolongation of today's "siparas";
4) Unbound brezzias, today's "sipara", consisting of rectangular, mainly loose fragments.

The genesis of the Quaternary sediments goes back to the gravitation processes on the mountain hillslope, similar to today's "siparas". A significant role in their formation was played by the torrents, especially in the warmer periods of the Quaternary "great ice age", when the climate was humid and the Biokovo snow melted into huge quantities of water (Grgasović 1995).

The pedological characteristic of the Baško Polje area is the mainly skeletal colluvium, prevailingly forming rendzinas and calcocambisols.

On the Climatic map of Croatia (Seletković & Katušin 1992), the Makarska coastline is classified as region Csa, a basic Mediterranean coastal climate, characterized by mild winters and dry summers, with a rainfall three times higher in the rainiest winter month than in the driest summer month, the latter being less than 40 mm. The summers are hot, dry and sunny. The climates Csa and Cfsax are marked as olive climates. The basic type of the Csa olive climate is on the island of Lošinj and the areas west of the line Zadar-Šibenik-Split-Imotski and the Opu-

zen/Dubrovnik inland area, together with all the central and south Dalmatian islands.

The chief climatic indices are shown in Walter's climatogram for the period 1982-1993 (Figure 1), and in Table 1.

Table 1. Monthly rain factor (Kfm), humidity (Hum), and thermal character (T.k.) in Makarska 1981-1993

Tablica 1. Mjesečni kišni faktor (Kfm), humidnost (Hum) i toplinski karakter (T.k.) u Makarskoj od 1981. do 1993. godine

month *mjesec*	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	yearly *godišnje*
KFm	7.1	14.6	9.4	5.7	3.8	2.8	1.2	1.0	2.6	7.9	11.3	11.4	60.9 KFg
Hum	h	h	h	sh	sa	a	a	a	a	h	h	h	sh
T.k.	ut	ut	ut	t	t	v	v	v	v	t	t	ut	t

The Martonne aridity index is 37.9

Martonneov indeks aridnosti iznosi 37,9

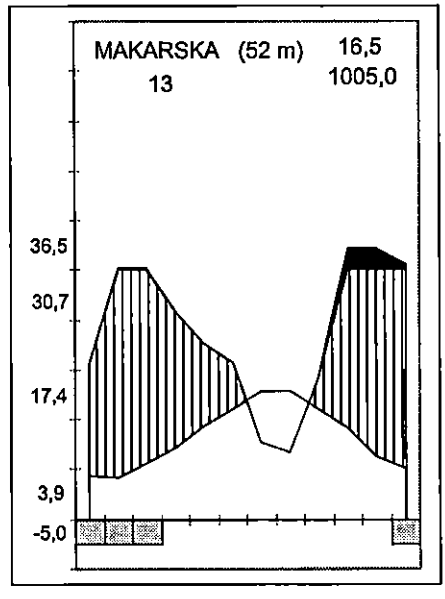

Figure 1. Climatogram according to Walter for the period 1981-1993

Slika 1. Klimadijagram prema Walteru za razdoblje od 1981. do 1993. godine

In terms of vegetation, i.e. bioclimatically, the Makarska coastal region is situated in the climatozone belt of the evergreen oak forests (*Orno-Quercetum ilirici* H-ić 1958).

THE SITUATION BEFORE THE FIRES
STANJE PRIJE POŽARA

In the last 20 years, forest fires have destroyed the largest part of the Aleppo Pine stand. Among the several test plots that were selected from this vast burnt area to monitor the ameliorative effects of vegetation within the improvement measures, the most significant are the ones in Donje Baško Polje. On August 6 1985, fire destroyed 862 ha, of which 552 ha were national (347.6 ha forests, 177 ha forestlands), and 310 ha private forests. They were mainly Aleppo Pine, while in the higher areas there was also Black Pine. The age ranged from 25 to 85 years, and the volume was 50.7 m^3/ha, or altogether 19,000 m^3. Test plot 1 (30x30) was set on an area that burnt again in 1986; test plot 2 (50x35 m) burnt in 1985 and 1988. This location is also used for monitoring the development of the Aleppo Pine upon the burnt area (plant number, heights, and diameters which, considering their age, have just begun to be measured).

SANATIVE AND REGENERATIVE MEASURES
SANACIJA I OBNOVA IZGORJELIH POVRŠINA

Afforestation was carried out in two turns, in 1987 and 1988, by planting an indefinite number of Maritime Pine seedlings (*Pinus maritima*) on test plot 1 (30 x 30 m) following the removal of the burnt wood mass. The last additions were made with the Aleppo and the Maritime Pines and Cypresses *(Cupressus sempervirens)*. All seedlings were one-year old plants with naked roots. Thus, besides the ongoing natural pine succession, we have today on this ameliorated area plants coming from three different afforestation periods.

The second test plot (2) was laid on the area that had burnt on two occasions. After the first, the old Aleppo Pine stands did not need any biological measures, since the terrain had been exceptionally well supplied with the seeds from the old pines. However, when this young growth vanished in the 1988 fire, amelioration measures had to be applied, as there was no source of seed any more. Immediately after the second fire, an indefinite number of one-year old naked-rooted seedlings of the following species were planted: Cypress *(Cupressus sempervirens)*; Aleppo Pine *(Pinus halepensis)*; Evergreen Oak (*Quercus ilex*); Maritime Pine *(Pinus pinaster)*. The results were poor, especially with the Evergreen Oak. Slightly better results were achieved with the Cypress. Such a bad outcome may be blamed on the method, the time of planting, and the quality of the seedlings.

In one part of the Makarska region, in Baško Polje, that had been devastated by a single fire (1985), no biological ameliorative measures were required, since the Aleppo Pine grew after the fire, covering the burnt area with lush new growth.

RESEARCH RESULTS
REZULTATI ISTRAŽIVANJA

PEDOLOGICAL FEATURES
PEDOLOŠKA OBILJEŽJA

The Baško Polje area is pedologically a colluvium of a strong skeletal character that has developed for the most part rendzinas and calcocambisols (Bogunović 1982). Two pedological profiles are distinguished in the upper and rear part of Baško Polje. In the lower part there are texturally somewhat heavier soils, though equally well supplied with humus and nutrients, except for the physiologically active phosphorus (Tables 2 and 3).

Table 2. Contents of the biogene elements and ashes in the O-horizon (Area: Baško Polje)
Tablica 2. Sadržaj biogenih elemenata i pepela u O-horizontu (predjel: Baško polje)

Location and soil type *Lokacija i tip tla*	Plot *Oznaka plohe*	Depth of O-horizon *Debljina O-horiz.*	Nitrogen *Dušik (N)*	Phosphorus *Fosfor (P)*	Potassium *Kalij (K)*	Calcium *Kalcij (Ca)*	Magnesium *Magnezij (Mg)*	Ash *Pepeo*
		cm	%					
Baško Polje Rendzina	P1	1.5	0.74	0.07	0.23	0.31	0.22	81.60

Legend: P1 = plot in burnt area
Legenda: P1 = ploha na požarištu;

Since the situation on both plots is identical, the O-horizon has been taken only on Plot 1.

FLORISTIC PROPERTIES OF THE TEST PLOTS
FLORISTIČKA OBILJEŽJA POKUSNIH PLOHA

With the whole area of the costal Makarska region located in an Evergreen Oak forest belt (*Orno-Qercetum ilicis* H-ić 1958), there is a flora in the cultures of the Aleppo Pine that is typical or this climatozone region. The floristic composition of Plot 1 is as follows:

I Shrub layer (35-40%)

Pinus pinaster	+	*Phillyrea latifolia*	+
Pinus halepensis	1	*Juniperus oxycedrus*	+
Cupressus sempervirens	+	*Cistus salviefolius*	3
Pistacia lentiscus	+	*Cistus incanus*	2

II Low growth layer (95%)

Brachypodium retusum	3	*Daucus major*	+
Asparagus acutifolius	+	*Plantago lanceolata*	+
Rosa sempervirens	+	*Clematis flammula*	+
Teucrium polium	1	*Carlina corymbosa*	+
Hedypnois rhagadioides	+	*Trifolium arvense*	+

Table 3. Mechanical composition and some chemical soil properties (Area: Baško Polje)
Tablica 3. Mehanički sastav i neka kemijska svojstva tla (predjel: Baško polje)

Location and soil type *Lokacija i tip tla*	Plot *Oznaka plohe*	Horizon *Horizont*		Coarse sand *Krupni pijesak*	Fine sand *Sitni pijesak*	Dust *Prah*	Loam *Glina*	Textural symbol *Teksturna oznaka*	pH		Carbonates *Karbonati* ($CaCO_3$)	Humus	Nitrogen *Dušik*	C/N	Physiologically active phosphorus and potassium *Fiziološki aktivni fosfor i kalij*	
		symbol *Oznaka*	lower border *D. granica*	0.2-2	0.02-0.2	0.002-0.02	<0.002		H_2O	0.01 M $CaCl_2$					P_2O_5	K_2O
			(cm)	(tež. %)							(%)	(%)	(%)		(mg/100g)	
Baško Polje Rendzina on skeletal colluvium	P1	A	5	8.00	21.20	31.50	39.30	l. G.	7.5	7.0	5.86	12.29	0.39	18.3	5.8	69.6
		(B)rz	18	3.40	27.10	23.40	46.10	t. G.	7.4	7.0	2.51	6.44	0.23	16.2	2.2	41.4
	P2	A	6	8.40	8.80	29.90	52.90	t. G.	7.6	6.9	5.86	12.53	0.40	18.2	5.1	100.0
		(B)rz	26	10.70	11.50	15.90	61.90	t. G.	7.6	6.9	10.77	7.16	0.26	16.0	2.9	49.7

Briza maxima	1	*Fumana ericoides*	1
Erica manipuliflora	1	*Inula varbascifolia*	+
		Seseli tomentosum	+ and others

A similar floristic composition is found on Test Plot 2 that had been devastated in the fires of 1985 and 1988.

In the brush layer covering the plot to an extent of 25-30%, there are the following plant species:

Pistacia lentiscus	1	*Paliurus spina-cristi*	+
Myrtus communis	+	*Pirus amygdaliformis*	+
Pinus halepensis	+	*Rhamnus intermedia*	+
Cupressus sempervirens	+	*Olea oleaster*	+
Quercus ilex	+	*Ficus carica*	+
Phillyrea latifolia	+	*Crategus transalpina*	+
		Colutea arborescens	+

The low growth layer covers almost 95% of the area:

Brachypodium retusum	4	*Inula verbascifolia*	+
Rosa sempervirens	+	*Sonchus sp.*	+
Rubus dalmatinus	2	*Bupleurum veronense*	+
Asparagus acutifolius	1	*Convolvulus contabricus*	+
Smilax aspera	+	*Alyssanthus sinuatus*	+
Fumana ericoides	+	*Eryngium amethustinum*	+
Consolida regalis	+	*Carlina corimbosa*	+
Trifolium angustifolium	+	*Sanguisorba muricata*	+
Scleropoa rigida	+	*Dorycnium hirsutum*	+
Arvena barbata	+	*Clematis flammula*	1
Centaurea cristata	+	*Osyris alba*	1
Petrorhogia saxifraga	+	*Convolvulus elengatissimus*	+
Euphorbia spinosa	+	*Salvia Bartolonii*	+
Caloamintha glandulosa	+	*Trifolium arvense*	+
Seseli tomementosum	+	*Verbascum thagsus*	+
Stachys slaviefolia	+	*Phleum subulatum*	+
Picris sp.	+	*Plantago lanceolata*	+
Teucrium polium	1	*Daucus major*	+
Anagillis arvensis	+	*Briza maxima*	+
		Hedypnois rhagadioides	+

On the areas where the Aleppo Pine young growth remained after the 1985 fire, the floristic composition is almost the same as the one on the areas where the dense canopy of the Aleppo Pine young trees allowed the development of other species. The following shrubs are encountered in places:

Pistacia lentiscus	*Cistus salviefolis*
Fraxinus ornus	*Cistus incanus*
Myrtus communis	*Coronila emeroides*
Erica manipuliflora	*Spartium junceum*

In the low growth layer, the dominant species is *Brachypodium retusum*, besides others found on other plots.

FLORISTIC FEATURES OF THE TEST PLOTS
FLORISTIČKA OBILJEŽJA KONTROLNIH PLOHA

A phytocenological survey has been made in the coastal region of the Aleppo Pine cultures that was spared from fire.

Area: 20 x 20 m
Inclination: 10°
Exposition: south
Date: 19.7.1993.

	I Tree layer (90%)		
Pinus halepensis	5		
	II Shrub layer (80%)		
Phyllyrea latifolia	2	*Paliurus spina-cristi*	+
Coronila emeroides	2	*Juniperus oxycedrus*	+
Pistacia lentiscus	2	*Pistacia terebinthus*	+
Spartium junceum	1	*Juniperus phoenicea*	+
Colutea arborescens	+	*Erica manipuliflora*	1
	III Low growth layer		
Brachipodium retusum	4	*Rubia peregrina*	+
Asparagus acutifolius	1	*Teucrium polium*	+
SMilax aspera	+	*Briza maxima*	+
Clematis flammula	+	*Dorycnium hirsutum*	+
Micromeria juliana	+	*Fumana ericoides*	+

STRUCTURAL FEATURES
STRUKTURNA OBILJEŽJA

The structural features are shown in Tables 4 and 5 for both test plots.

Measurements were also made in areas with dense young growth of Aleppo Pine. The density of the young growth and trees is measured along with some silvicultural thinnings. As these are tiny plants and since the data refers to a time period of only three years, they are not adequate for presentation. However, it should be said that a decade following the fire the number of plants per 1 m^2 ranged from 20 to 127, altogether 100. Or, per 1 ha there are about 1 million plants that have already reached 300 cm in height.

By comparing these data with the results of other authors, we may say that future regeneration is certain. Thanos C.A. & others (1989); Thanos & Marcon

(1991), and Daskalakon & Thanos (1993) consider a much smaller number of plants (0.15 and more per m^2) sufficient for natural regeneration.

Table 4. Distribution of measured heights
Tablica 4. Distribucija izmjerenih visina

Forest service: Makarska
Area: Donje Baško Polje - fires of 1985 and 1986
Area: 30 x 30 m = 900 m^2 = 0.09 ha

Plot: 1
Exposition: south
Inclination: level

Šumarija: Makarska
Predjel: Donje Baško Polje - požar 1985. i 1986. god.
Površina: 30 x 30 m = 900 m^2 = 0,09 ha

Ploha: 1
Ekspozicija: Južna
Nagib: ravno

Height class Visinska klasa (cm)	May 1994 svibanj 1994.							January 1996 siječanj 1996.						
	1	2	3	4	5	6	Σ	1	2	3	4	5	6	Σ
1-10		54	9				63		5	7				12
11-20		13	1				14		28	3	1			32
21-30	3			1		1	5		10				1	11
31-40	1	6		1			8	1	3					4
41-50	5	7					12							
51-60	1	7		1	1		10				1			1
61-70	1	5		1			7	1	3		1			5
71-80	2	6		1	1		10		2			1		3
81-90	2	3					5	2	1		2	1		6
91-100	3	6					9	2	1					3
101-110	2	1					3	1	7					8
111-120		2					2		7					7
121-130									5					5
131-140								2	1					3
141-150									4					4
151-160								2	1					3
161-170								2	2					4
171-180								2						2
181-190								1	2					3
191-200									6					6
201-210								1						1
211-220								1	1					2
Σ	20	110	10	5	2	1	148	18	89	10	5	2	1	125
Po ha	222	1222	111	56	22	11	1644	200	989	111	56	22	11	1389

1. Maritime Pine (*Pinus pinaster*)
2. Aleppo Pine *(Pinus halepensis)*
3. Cypress (*Cupressus sempervirens)*
4. *Pistacia lentiscus*
5. *Phillyrea latifolia*
6. Juniper (*Juniperus oxycedrus)*

1. Primorski bor (Pinus pinaster)
2. Alepski bor (Pinus halepensis)
3. Obični čempres (Cupresuss sempervirens)
4. Tršlja (Pistacia lentiscus)
5. Zelenika (Phillyrea latifolia)
6. Šmrika (Juniperus oxycedrus)

Table 5. Distribution of measured heights
Tablica 5. Distribucija izmjerenih visina

Forest service: Makarska
Area: Donje Baško Polje - fires of 1985 and 1988
Area: 50 x 35 m = 1750 m2 = 0.18 ha

Plot: 2
Exposition: south
Inclination: 3°

Šumarija: Makarska
Predjel: Donje Baško Polje - požar 1985. i 1988. god.
Površina: 50 x 35 m = 1750 m² = 0,18 ha

Ploha: 2
Ekspozicija: Južna
Nagib: 3

Height class Visinska klasa (cm)	April 1993 *travanj 1993.*												January 1996 *siječanj 1996.*											
	1	2	3	4	5	6	7	8	9	10	11	Σ	1	2	3	4	5	6	7	8	9	10	11	Σ
1-10		2	1		1							4					1							1
11-20		20							1			26		9							1			10
21-30		64			3	1	1		1		1	73		27	1						1			29
31-40	1	31		1			2		1			36		44	2		1	1	1				1	50
41-50	2	27		1	1		1		1			33	1	28	2		1				1			33
51-60	2	18		6			2			1		30	2	33	2	2	1				1			41
61-70	3	7		1			5		2			18		24		1			3		1			29
71-80	8	11		6		1	2	1	2			31	3	9	1	3			2		1			19
81-90	6	3		5		3	6					23	3	6		1			3	1	1	1		16
91-100	12	1		12		1	2					28	5	3		1			2					15
101-110	7			7			2					16	6	1		2			5					15
111-120	9	1		2			1	1				14	5			2			5					13
121-130	2			2			1					5	12			5			1					18
131-140	1			2			1					4	8			2			1					11
141-150				4								4	5			3			2					10
151-160				1								1	3			4				1				8
161-170				1								1				4			1					5
171-180															1	3								4
181-190																7								7
191-200							1					1												
201-210																3			1					4
211-220																1								1
221-230																2								2
231-240																1								1
241-250																2								2
251-260																1								1
261-270																1								1
Σ	53	185	9	51	5	6	27	2	8	1	1	348	52	184	9	51	5	6	27	2	7	1	1	346
Po ha	303	1057	51	291	29	34	154	11	46	6	6	1989	303	1051	51	291	29	34	154	11	40	6	6	1977

1. Myrtle (*Myrtus communis*)
2. *Pistacia lentiscus*
3. Aleppo PIne *(Pinus halepensis)*
4. Cypress (*Cupressus sempervirens*)
5. Evergreen Oak *(Quercus ilex)*
6. *Phillyrea latifolia*
7. *Paliurus spina-cristi*
8. *Pyrus amygdoliformis*
9. *Rhamnus intermedia*
10. Olive *(Olea oleaster)*
11. *Fig (Ficus carica)*

1. *Mirta (Myrtus communis)*
2. *Tršlja (Pistacia lentiscus)*
3. *Alepski bor (Pinus halepensis)*
4. *Obični čempres (Cupresuss sempervirens)*
5. *Crnika (Quercus ilex)*
6. *Zelenika (Phillyrea latifolia)*
7. *Drača (Paliurus spina-cristi)*
8. *Krušica (Pyrus amygdaliformis)*
9. *Trnika (Rhamnus intermedia)*
10. *Maslina (Olea oleaster)*
11. Smokva (Ficus carica)

CONCLUSION
ZAKLJUČNA DISKUSIJA

In the Makarska coastal region where fire has devastated large stretches of forests, great attention has been paid to the protection of these forests, particularly against forest fire. Intensive forest protection began in 1967 with a wide series of measures. Thus, since 1970 the Makarska region has had one the most efficient systems for forest fire protection in all the Croatian Littoral (Management Programme 1982-1991).

Tables 4 and 5 show that the afforestation on both plots has only partly succeeded. Considering the number of plants per area unit, there was more success on Plot 1, where more than 100 Stone Pines and Maritime Pines grew on 900 m^2. Unfortunately, such success was not achieved on Plot 2. On Plot 1 afforestation was carried out in three turns, while on Plot 2 only once immediately following the fire. We have already mentioned that the method and time of planting is very important in these climatic conditions. Another reason for the poor survival of the seedlings is that they were planted with naked roots instead of being grown in containers. Planting of small, particularly one-year-old seedlings of the Evergreen Oak over an unprotected area cannot be successful, since these young, tiny plants need shade in such an extreme climate with a high temperature, hot sun, and little moisture in the soil, wind, etc. Cypress was more successful for two reasons. Firstly, it showed a high rate of survival, and secondly, it grows higher in a ten-year time period. It should therefore be introduced more widely. There are surprisingly few evergreen broadleaves from the Evergreen Oak forest on either of the plots. It is also interesting that Plot 1 (900 m^2) has 1,454 brushes of *Cistus* sp., i.e 1.62 per 1 m^2.

In the Makarska Forest Service range we can speak of two typical issues concerning forest fires in the Aleppo Pine stands. The first is fire in old stands, which should not be a problem for the regeneration of these forests. A pyrophyte, the Aleppo Pine will fertilize the area well with its seeds, so that a thick young growth will readily emerge. As for further care and protection, there are several illustrations in the Makarska region. About ten years following the fire, large tracts of the Aleppo Pine young trees, 2 m in height, were threatened by repeated fire. This huge green area of almost 700 ha therefore started to be reduced. The first among the measures was the building of riding cuts as fire protection with some elements

of forest roads. Another measure was the reduction of the plant number by removing the plants along lanes of a particular length (3 m or more). This was done mechanically, since manual work would have been very expensive. In 1995 the Steyr Forst 9078 tractor with a capacity of about 2 800 m^2 = 2 000 m/8h was used for these operations. The width of the blade drum was 140 cm, the wheel distance 190 cm. There were several problems with this machine on such terrain. One was the work with the circular blade on such a rocky and rather uneven surface. The blades wore or broke very fast and frequently, so that they had to be replaced, which happened every 70-75 of work hours, instead of the usual 200-250 hours. Another problem was that the blade of the circular blade saw, due to unfavourable conditions, could not be lowered down to the soil, and therefore left the side twigs, which then, receiving plenty of light, assumed the role of the tree top, and in one year's time reached almost half the height of the pines in the left-over lanes (up to 1 m). An additional problem was that the distance between the tractor wheels was 50 cm longer (25 cm at each side), whereby the tractors caused permanent damage to the young pines along the lane edges, i.e. the trees that should play the principal role in the growth and soon form the canopy over other uncompetitive specimens.

In our opinion, considering the limited success such expensive operations on such hard terrain should not be carried out. Such huge stretches of young pine growth are best protected by measures of prevention. These include in the first place a great number of forest riding cuts with forest road elements, in order to make every part of the terrain accessible for monitoring, and if necessary, fighting a forest fire. Such an area that is intersected into, say, pine oases, should be left to develop independently and spontaneously. Ten years after a fire, no silvicultural measures of cleaning are needed with 100 plants on 1 m^2. This is confirmed by a test on 10 x 10 m plots with, in turns, 100, 50, 20, and 10 plants of highest quality. With the results being monitored only for 3 years, no significant differences in the development of the thus reduced plants have been recorded. Neither has any dieback been noticed. However, we have observed that on the plots with 100 and 50 plants, there were bigger height differences than where fewer plants on 100 m^2 grew under similar conditions and without competition. These young trees, being fewer in number, are generally weaker, the number of needles is reduced and the crowns are unsubstantial. The reasons are the severe conditions of life in terms of hot sun, temperature, winds, etc., without the protection of the surrounding plants. Accordingly, spontaneous development is desired to let the natural selection work and for the best trees to be chosen to take the leading roles. The first silvicultural measures should be carried out between the age of 15 and 20, depending on plant density and vitality.

A completely different activity is required in the areas that burnt after a thick young growth covered them in the aftermath of the first fire. If this happens at an age when young plants have not yet fructified, there is no progression, and the soil remains almost naked without woody species, particularly pioneering ones such as the Aleppo Pine. Such surfaces are encroached on by a specific burnt area associa-

tion with thick, low-growth vegetation, as illustrated in our plots. Then foresters must take action with biological measures of amelioration or by sowing/planting. Since there are usually specimens of the old Aleppo Pine cultures in the vicinity, the natural progressive succession on such a terrain does not stop when it comes to the Aleppo Pine, although it is present only to a lesser extent. We can always count on that. The remaining work is the routine between selecting the species and the quality of the seedling material. We believe that generally, in such circumstances, we should start with as many species as possible and later do supplements which, particularly when it comes to the autochthonous broadleaves such as the Evergreen Oak, *Phillyrea latifolia*, and myrtle, should appear when the Aleppo Pine, a pioneer species, creates sufficiently appropriate conditions after only a few years (5-10). We also consider appropriate the introduction of a smaller number of plants, 1 000 - 1 500 per hectare, but stronger, more developed and older ones, grown in adequate containers, enabling a smooth continuation when transferred into the open area. This particularly refers to the root system.

Pedological research on the average samples have confirmed the known facts about the destructive impacts of fire on the pedosphere, especially when it comes to the erosive processes, the change in the humus content, and biogene factors - nitrogen, phosphorus, carbon and potassium.

Considering a great number of factors, we can finally conclude that every fire and the following amelioration measures differ from one another. Some of them are good in one situation and bad in another. It is crucial therefore to know the local circumstances and ecological factors, as well as the biological/ecological features of the species to be used in the coming improvement measures.

The forest fires of the Mediterranean region are a historical fact, an integral part of this ecosystem and its evolution. This was scientifically confirmed by Naveh (1975). The shock combined with the impacts of fire, drought and grazing has led to a convergence in the plant forms and functions within the Mediterranean climate, favouring genetic and ecological differences. Arianoutson & Margaris (1981) and Dafis (1991) attach to the forest systems that are susceptible to fire terms such as "fire ecosystems"; "fire climax"; "fire adapted"; "fire induced", and "pyrophil".

When investigating the impact of temperature on the Aleppo Pine seed, Martinez-Sanches et al. (1995) found that the temperatures of 90°C, 110°C, 150°C, and 200°C did not affect their fertility and germination. He therefore thinks that the Aleppo Pine is not a pyrophyte, but rather a "colonizer" of the burnt areas.

Fires are not necessary for the regeneration of the mentioned species. They therefore need not be considered as simply pyrophytic, as they can be regenerated in similar conditions without a fire. An illustration of this is the forest driving cuts, clearings, and cutting areas, all encroached on by the pine.

Together with other factors of degradation and devastation in the Mediterranean, fires are a link in a dynamic process that has always been present in such forests in a perpetual interchange of regressive and progressive circles of forest vegetation.

The Mediterranean forests have vanished through cutting, grazing, browse and fire. The results are the degradation stadia in the eumediterranean and submediterranean regions. Today, the former has coppices, maquis, garigues, and naked karst, the latter coppices, brushwood, scrub forests and naked karst.

In afforestation, mixed cultures should be raised: mixed conifers, and conifers/broadleaf mixtures. Priority should be given to autochthonous vegetation, trees and brushes, and also to fire-resistant species. Dafis (1991) refers to the latter, suggesting *Arbutus* sp., *Olea* sp., *Quercus ilex, Viburnum* sp., and others. As to the ratios, the same author suggests 60% of conifers and 40% of broadleaves to reduce the risk of fire. As a fire-protection measure, he also suggests even-aged stands. This can be achieved by afforestation and succession after a forest fire. Different age, i.e. group selection, is natural.

Velez (1990) suggests *Atriplex* sp. and *Tamarix* sp., which, thanks to the salt they contain, burn slowly. *Tamarix* sp. is currently being planted along the fire-protection rails and riding cuts in Israel. Velez (1990) suggests the planting of the so-called "species mosaics", considering the inflammability and the number of the species. Dugalay (1966) suggests fire-resistent species, particularly the oaks *Q. suber, Quercus ilex, Q. pubescens,* and the sweet chestnut (*Castanea sativa)* on acid, rich and moist soils. Exotic species should be avoided, he says, as they, for reasons yet unknown, usually fail after the first promising results.

Wherever possible, natural succession should be supported by silvicultural measures, particularly over the Aleppo Pine burnt areas, where the surface has been richly sown and the progressive succession has begun richly.

As already said, the fires in old stands and those in the young ones should be distinguished. On the old stand areas, the succession is very rich in the aftermath of a forest fire. While an old tree is burning, its seeds are well protected within the cone. In the process of cooling, the cone suddenly opens and throws the seeds, which fall on the cooled ground covered with ash and, soon after the first rain, begin to grow. In good pedological conditions, a very thick young growth appears within a period of three to five years, densely covering the ground. Although such development is considered a vegetation succession, it is not so in the phytocenological sense (Trinajstić 1993).

A much more difficult case for forestry is when the fire catches and destroys a young pine stand that has not yet fructified. As a result, the first rain is followed by a lush green mass of herbs and woody plants with *Brachypodium retusum* as the dominating grass. Such areas then become ideal grazelands, which was one of the reasons for the deliberate burning of these forests in the past. From the underground organs of the woody plants, numerous sprouts emerge to cover the area entirely in the following decade. The woody garigues of *Erica arborea* and *Arbutus unedo* prevail, which develop small trees and suppress the real scrubs of the families *Cistus, Rosmarinus officinalis*, etc. "Thus a special type of maquis is formed to display an even floral composition on the large Mediterranean region and the Croatian Littoral coast" (Trinajstić 1993). Phytocenologically, these stands join the as-

sociation *Erico-Arbutetum*. "It remains as a permanent phase for a long number of years and is generally well resistant to fire... The Aleppo Pine and the Evergreen Oak have great difficulties in moving into this community" (Trinajstić 1993). The same author correctly remarks that the association *Erico-Arbutetum* renders an exceptional aesthetic atmosphere in its winter flowering period. With this association being exceptionally suitable for browse, uncontrolled breeding of sheep and goats is a severe problem.

Among the protective measures, the riding cuts with forest road elements should be built as densely as possible, both in old and young cultures. Depending on the terrain configuration, forest tracts should not be bigger than 600 ha. A well-made and maintained road-cut is a recess area the inflammable plant material, both horizontally and vertically. Besides roads, other preventive measure include the erection of protective walls made of rocks and a well-organized system of surveying connected with the operations centre and the police. It is common knowledge that prevention is incomparably cheaper than afforestation of the burnt areas.

Among the preventive measures to be applied here, the most appropriate are pruning of the lower branches and thinning. As a rule, after afforestation, no silvicultural operations are done in the pine cultures, so that valuable biomass is wasted and such cultures are attractive for damaging insects and fungi, and are particularly susceptible to fire.

With the karst conifers and the pioneer cultures as possible only in the primary production of biomass while waiting for the return of the autochthonous broadleave vegetation, we should bear in mind the economic aspect: timber production. We cannot afford to waste the huge biomass. Accordingly, more attention should be paid to the better management of the available and the newly-raised stands. Our wood industry should find a challenge here in the processing of pine timber for furniture and other manufacturing. Another big consumer of the pine biomass is the pulp mill (Matić 1986).

The role of brushes and low vegetation in the Mediterranean forests at the time of a fire is a controversial issue in the literature. Some dispute, others support, the fire. Guyot (1990) recommends pine stands with lush fire-protecting low growth.

An important silvicultural method in the Mediterranean is the clearing of the vegetation along the roadways, with strips at least 10-15 (20) m wide on each side of the road. This is particularly important in the summer months, when traffic along the coastline increases due to the tourist season.

The vast areas of the eumediterranean and submediterranean coastal karst require proper valorization of forestry strategies. Conservative opinions on the issue have been overcome in certain segments. Huge tracts cannot be ameliorated in the near future in order to be turned into forest ecosystems. As this is a zone comprising major economic and urban assets, there is considerable pressure for these forests to be used for general benefits connected with the tourist trade. Accordingly,

besides all biological-ecological and ameliorative aspects, these areas require the planting of other species appropriate to the aesthetic function of the areas. The biological-ecological and ameliorative group of plants will have a purely economic function. Such species of trees, brushes and low growth may be planted for fruits, medical use, etc. The idea of "agroforestry" has been frequently referred to when looking for the solutions to the burnt areas. However, Croatian forestry has as yet not shown much understanding and is missing an opportunity in finding a great source of profit.

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SANACIJA POŽARIŠTA SASTOJINA ALEPSKOGA BORA (*Pinus halepensis* Mill.) U MAKARSKOM PRIMORJU

SAŽETAK

Požari su u Republici Hrvatskoj posebna opasnost za šume, osobito za šume na jadranskoj obali i otocima posljednjih dvadesetak godina. Velike su štete izazivali požari nastali zbog ratnih djelovanja ili zbog toga što su ih namjerno podmetnuli pobunjeni Srbi tijekom Domovinskoga rata na području Zadra, Šibenika, Splita i Dubrovnika.

Prema podacima Ministarstva poljoprivrede i šumarstva (1995) šume na kršu, odnosno šume koje se nalaze na otocima i u priobalju Republike Hrvatske zauzimaju površinu od 1 042 081 ha što čini 43 % ukupne površine šuma i šumskoga zemljišta u Hrvatskoj. Na obraslim površinama, koje iznose 732 371 ha, najviše su zastupljene degradirane sastojine s 83 % (panjače 52 %, šikare 25 %, makije 4 % i garizi 2 %) dok visoke šume zauzimaju samo 17 % obraslih površina.

Prema vrsti vegetacije na opožarenim površinama udio je borovih šuma čak 22 % od ukupnih površina (41 176 ha), panjača 20 % (36 891 ha), makije 23 % (42 399 ha), dok se ostali dio od 61 894 ha (35 %) odnosi na ostale obrasle površine. Oštećeno ili izgorjelo drvo prelazi obujam od 1 421 142 m^3 (Projekt 1995).

Proučavanje šumskih požara u mnogim zemljama pokazuje da pozornost valja obratiti pedološkim, klimatskim i vegetacijskim uvjetima njihova nastanka i širenja, utjecaju na kruženje bioelemenata i na fizikalna svojstva tla, te svekolikim uvjetima obnove šuma nakon požara: klimatskim, pedološkim (kemizam tla, plodnost, erodibilnost tla i dr.), vegetacijskim (progresivna i regresivna sukcesija, metode sanacije).

Odluka o tome što učiniti u vezi s obnovom šuma koje su bile zahvaćene požarom ili njime uništene ovisi o nizu biološko-ekoloških i gospodarskih čimbenika. Prije toga valja napraviti ekološku i ekonomsku analizu svrhovitosti obnove (uz određivanje buduće namjene šume). Najčešće se nakon većih požara ne mogu odjednom sve površine obnoviti i privesti namjeni, pa je važno znati koje je radove potrebno obnoviti najprije (Španjol 1996).

Reljefni su oblici izravan odraz geološke građe ovoga terena, i to u prvom redu odraz rasprostranjenosti i tipa kvartalnih taložina. Izdvojena su četiri tipa kvartalnih breča (Grgasović 1995).

Područje Baškoga Polja obilježava u pedološkom smislu koluvijalni nanos većinom jako skeletnoga karaktera na kome su se razvile uglavnom rendzine i smeđe tlo (Bogunović 1982). Na ovom su području otvorena dva pedološka profila - u gornjem i u zadnjem dijelu Baškoga Polja. U donjem dijelu Baškoga Polja to su teksturno nešto teža tla, a podjednako su dobro opskrbljena humusom i hranivima (izuzev fiziološki aktivni fosfor).

Makarsko primorje prema karti klimatske podjele Hrvatske (Seletković i Katušin 1992) pripada klimatskom području Csa.

U vegetacijskom, odnosno bioklimatskom pogledu područje makarskog primorja nalazi se u klimatskozonskom pojasu šume hrasta crnike (*Orno-Quercetum iliricis* H-ić 1958)

Na području makarske šumarije šumski su požari posljednjih 20 godina uništili najveći dio sastojine alepskoga bora. Na tom velikom izgorenom području izdvojeno je nekoliko pokusnih ploha radi praćenja meliorativnih učinaka vegetacije na sanaciju požarišta. Najznačajnije su pokusne plohe u Donjem Baškom Polju. Tu je požar izbio 6. kolovoza 1985. godine. Tada je izgorjelo 862 ha, od toga državnih šuma 552 ha (347,6 ha šuma i 177 ha šumskoga zemljišta) i 310 ha privatnih. Pretežito je bio alepski bor, a na višim predjelima bilo je i crnoga bora. Šumska je dob bila 25 - 85 godina, obujam je bio 50,7 m^3/ha ili ukupno 19 000 m^3. Pokusna ploha 1 (30 m x 30 m) postavljena je na površinu koja je gorjela osim 1985. godine i 1986. godine, dok je pokusna ploha 2 (50 m x 35 m) postavljena na površinu koja je gorjela 1985. i 1988. godine. Na tom se području prati razvoj alepskoga bora na požarištu (broj biljaka, visine, promjeri, što je s obzirom na dob tek početak praćenja).

Na pokusnoj plohi 1 (30 m x 30 m) nakon sanacije terena vađenjem izgorenoga drva i uspostavljanjem šumskoga reda pošumljavalo se dvaput primorskim borom (*Pinus maritima*), 1987. i 1988. godine, nepoznatim brojem biljaka. Posljednji se put pošumljavalo (popunjavalo) alepskim i primorskim borom te običnim čempresom (*Cupressus sempervirens*). Sve su bile jednogodišnje sadnice gologa korijena. Danas na saniranoj površini rastu biljke osim iz prirodne sukcesije bora na požarištu, koja i dalje traje, i biljke sađene u tri navrata radi pošumljavanja i popunjavanja.

I druga je pokusna ploha (2) postavljena na požarištu koje je dvaput gorjelo. Nakon prvoga požara stare sastojine alepskoga bora nije bilo potrebno biološki sanirati jer je teren bio izuzetno naplođen sa starih borova. Međutim, kada je u požaru 1988. godine izgorio taj pomladak i ponik, morala se sanirati površina, koju ovaj put nije imalo što naploditi. Tako je neposredno nakon drugoga požara pošumljavano s nepoznatim brojem biljaka po hektaru, i to jednogodišnjim biljkama gologa korijena. Sađene su ove vrste: obični čempres (*Cupressus sempervirens*), alepski bor (*Pinus halepensis*), crnika (*Quercus ilex*), primorski bor (*Pinus pinaster*). Uspjeh pošumljavanja bio je vrlo loš pogotovo s crnikom. Nešto je bolje uspio čempres. Tako loš rezultat pošumljavanja treba tražiti u načinu i vremenu sadnje te u kakvoći sadnica.

Na dijelu makarskog područja u Baškom Polju, gdje je požar bio samo jednom, tijekom 1985. godine, nikakve biološke mjere sanacije nisu bile potrebne jer je alepski bor bujno niknuo nakon požara i potpuno prekrio izgorjelo područje.

Raščlanjujući podatke o metodama obavljene sanacije možemo uočiti da je uspjeh pošumljavanja na obje plohe djelomičan. S obzirom na broj biljaka po jedinici površine svakako je mnogo bolji rezultat postignut na plohi 1 na kojoj na 900

m^2 ima više od 100 biljaka pinije i primorskoga bora. Nažalost takav uspjeh nije postignut na plohi 2. Treba tu navesti činjenicu da se na plohi 1 pošumljavalo u tri navrata, dok se na plohi 2 samo jednom pošumljavalo neposredno nakon požara. Već je rečeno da su način i vrijeme sadnje za ovakve klimatske prilike vrlo važni. I upotreba sadnica gologa korijena, a ne kontejnerski uzgojenih sadnica djelomično je razlog slabijeg uspjeha preživljavanja biljaka. Pokazalo se da sadnja malih, posebice jednogodišnjih sadnica hrasta crnike na goloj površini poput pionirskih vrsta borova ne može polučiti uspjeh jer mlada biljčica crnike svakako treba zaklon u ovakvim ekstremnim uvjetima (visoke temperature, suncožar, mala količina vlage u tlu, vjetar i dr.). Dobar uspjeh postignut je s običnim čempresom koji, osim što je pokazao velik postotak preživljavanja postiže i znatnije visine za desetak godina. Stoga bi ga trebalo više saditi. Zanimljivo je da autohtonih vazdazelenih listača iz šume hrasta crnike ima malo na obje plohe. Zanimljiv je podatak da na plohi 1 (dakle na 900 m^2) ima 1454 grmova bušina *Cistus* sp., što je 1,62 biljke po 1 m^2.

Dakle u makarskoj su šumariji bila dva tipična požara u sastojinama alepskoga bora, ali s različitim posljedicama. Prvi požar u staroj sastojini nije bio problem za obnovu ovih šuma. Alepski bor, kao pirofit, dobro je naplodio površinu sjemenom te je niknuo gust ponik. Kako dalje provoditi zaštitu i njegu? U Makarskom primorju ima više primjera. Desetak godina nakon požara veliki kompleksi pomlatka alepskoga bora visine do 2 m opet su velika opasnost za ponovni požar. Stoga se išlo na smanjivanje te velike zelene površine od gotovo 700 ha. Prva je mjera bila izgradnja šumskih protupožarnih prosjeka s obilježjima šumskih cesta. Broj se biljaka smanjivao i odstranjivanjem biljaka u prugama određenoga razmaka (3 m ili više). Kako bi ručno to bilo vrlo skupo, radilo se strojno. Tako je početkom 1995. godine to rađeno traktorom Steyr Forst 9078 kome je prikopčan rotacijski čistač. Problem je što rotacijski sjekač zbog nepovoljnih uvjeta tla ne može spustiti sjekač do tla tako da ostaju na prerezanim borićima postrane grančice koje sada, dobivši veliku količinu svjetla, preuzimaju ulogu vrha te za jednu godinu (proljetna i jesenska vegetacija) već postignu visinu do gotovo polovice visine borova u ostavljenim trakama (do 1 m). Problem je i taj što je razmak kotača na traktoru 50 cm veći (25 cm sa svake strane) pa se pri prolazu traktora trajno oštećuju biljke borova upravo onih koji bi na rubovima ostavljenih traka preuzeli dominantnu ulogu u rastu i u dogledno vrijeme u sklapanju sklopa iznad ostalih nekonkurentnih jedinki.

Nameće se zaključak da tako skupe zahvate na ovako teškim terenima nije potrebno provoditi s obzirom na ograničeni uspjeh. Veliki kompleksi borova ponika i pomlatka najbolje se mogu zaštititi preventivnim mjerama. Riječ je u prvom redu o izgradnji što većega broja šumskih prosjeka s obilježjima ceste kako bi svaki dio terena bio dostupan radi službe opažanja i motrenja te eventualne potrebe gašenja. Tako ispresijecanu površinu u nazovimo ih zelene borove oaze treba pustiti da se razviju samostalno, spontano. Pokazalo se da 10 godina nakon požara još nije potrebno čistiti kada na 1 m^2 raste i preko 100 biljaka. Treba dakle pustiti da se spontanim razvojem i pozitivnom prirodnom selekcijom izdvoje najvrsnija i najbolja stabla koja će preuzeti vodeću ulogu i svojim visinskim prirašćivanjem potisnuti

konkurenciju. Prvo čišćenje treba provesti (gdje je tako gust sklop) između 15 - 20 godine, ovisno o gustoći biljaka i njihovoj vitalnosti.

Sasvim drugačije šumarske postupke traže površine koje su nakon što su poslije prvoga požara bile gusto naplođene ponikom ili pomlatkom alepskoga bora izgorjele. Ako se to dogodilo u dobi kada mlade biljke još ne fruktificiraju, nema nove progresije, već tlo ostaje gotovo golo, bez drvenastih vrsta, posebice pionirskih kakav je alepski bor. Takve površine zaposjedne specifična zajednica požarišta, na kojemu se razvije gusta vegetacija niskoga rašća, što je vidljivo iz primjera (ploha 1 i 2). Tada šumar stručnjak mora intervenirati biološkim mjerama sanacije požarišta sjetvom ili sadnjom biljaka. Kako obično u okolici ostaju dijelovi stare kulture alepskoga bora ili pojedini primjerci, ni prirodna progresivna sukcesija alepskoga bora na takvu terenu u potpunosti ne prestaje. Iako u znatno manjoj mjeri ona je i dalje prisutna, pa na nju uvijek moramo računati. Sve je ostalo stvar operative, od izbora vrste do kakvoće sadnica. Općenito bi se u ovakvim prilikama trebalo ići sa što je moguće više vrsta već na početku ili naknadno popunjavati. To se naknadno popunjavanje posebice odnosi na autohtone listače (crnika, zelenika, mirta i dr.), koje trebaju i mogu doći kada alepski bor kao pionirska vrsta stvori kakve-takve specifične mikroklimatske uvjete već nakon nekoliko godina (5 - 10). Također bi trebalo saditi manji broj biljaka (1000 - 1500 biljaka) po hektaru, ali jačih, razvijenijih i starijih sadnica u odgovarajućim kontejnerima koji će im omogućiti razvoj. U tom slučaju biljka će nakon presađivanja nastaviti normalan razvoj, napose korijenskog sustava, bez većih šokova.

Pedološka istraživanja dobivena na prosječnim uzorcima na istraživanim plohama potvrdila su poznate rezultate o razarajućem djelovanju požara na pedosferu, posebice na eroziju i na mijenjanje sastava humusa, odnosno biogenih čimbenika: dušika, fosfora, ugljika, kalija.

Na kraju se može zaključiti da je svaki požar, a time i njegova sanacija s obzirom na velik broj čimbenika koji ga opisuju, različit jedan od drugih. Dok je za sanaciju jednih dobro, to kod drugih ne mora biti. Stoga za uspješnu sanaciju treba dobro poznavati lokalne prilike i uvjete (ekološke čimbenike) te biološko-ekološke osobine vrsta potencijalnih za sanaciju.

Arianoutson i Margaris (1981) i Dafis (1991) šumske sustave podložne vatri (*Pinus* sp., *Quercus* sp., *Cistus* sp. i dr.) nazivaju "požarni ekosustavi" ili "požarni klimaks", "na vatru adaptirani" (*fire adapted*), "od vatre inducirani" (*fire induced*), "pirofilnim".

Istražujući utjecaj temperature na plodnost i klijavost sjemena alepskoga bora, Martinez-Sanchez i dr. (1995) ustanovljuju da temperature od 90 °C, 110 °C, 150 °C i 200 °C ne utječu na njihovu plodnost i klijavost. Stoga on smatra da alepski bor nije pirofit, već "kolonizator" na opožarenim površinama (*colonizers*).

Požari nisu nužni za obnovu spomenutih vrsta i zbog toga te vrste ne treba smatrati samo "pirofitnima" jer se u sličnim uvjetima bez požara one mogu obnoviti. Dokaz tomu su šumske prosjeke, čistine, sječine koje osvaja bor.

Požari zajedno s ostalim čimbenicima degradacije i devastacije u Sredozemlju karika su jednoga dinamičnog procesa koji oduvijek postoji u takvim šumama u vječnoj izmjeni regresivnih i progresivnih tokova šumske vegetacije.

Sredozemne su šume nestale sječom, brstom, ispašom i požarima. Posljedica tih procesa na eumediteranskom i submediteranskom dijelu su degradacijski stadiji, u eumediteranu: panjača, makija, garig, goli krš, a u submediteranu: panjača, šikara, šibljak, goli krš.

Pri pošumljavanju treba podizati mješovite kulture i s obzirom na mješovitost četinjača i s obzirom na odnos četinjače : listače kako bi se što brže dobila mješovita struktura. Svakako prednost treba dati autohtonoj vegetaciji (vrstama drveća i grmlja) te vrstama otpornima na vatru. Dafis (1991) navodi ove vrste otporne na vatru: *Arbutus* sp., *Olea* sp., *Quercus ilex*, *Viburnum* sp. i dr. Što se tiče omjera vrsta pri podizanju kultura, isti autor preporučuje omjer 60 % četinjača : 40 % listača, čime se smanjuje rizik od vatre. Dafis (1991) preporučuje kao jednu od mjera zaštite od požara uzgoj jednodobnih (jednolikih) sastojina. To se može postići pošumljavanjem i nakon požara sukcesijom zbog približno istodobnoga nastajanja. Prirodna je nejednolikost: različita dob = grupno selekcionirane vrste.

Gdje je god moguće, treba maksimalno poticati uzgojnim mjerama i radovima (popunjavanje, čišćenje itd.) prirodnu sukcesiju, napose na požarištima alepskoga bora, gdje je površina obilno naplođena alepskim borom i gdje je progresivna sukcesija bujno krenula.

Od mjera zaštite šuma, napose borovih kultura, primarno treba raditi na izradi što gušće mreže protupožarnih prosjeka s obilježjima šumskih cesta. Protupožarne prosjeke treba raditi i u starim a i u mladima i u tek podignutim kulturama. Ovisno o konfiguraciji terena, ali svugdje gdje je izgradnja šumske ceste moguća, šumski kompleksi ne bi trebali prelaziti površinu od 200 ha do 600 ha. Dobro izvedena i održavana prosjeka (cesta) radi prekid zapaljivih biljnih tvari u okomitom i vodoravnom slijedu. Osim cesta važna je preventivna mjera izgradnja zaštitnih pojasa (suhozidi), promatračnica te uspostava odgovarajućega i funkcionalnog sustava veza šumskih djelatnika (promatrači, ophodnje) s operativnim centrom i MUP-om.

Od uzgojnih preventivnih mjera u obzir dolazi čišćenje, posebice potkresivanje donjih grana, te proreda radi smanjenja drvne zalihe (i broja stabala) u borovim kulturama koje se nakon pošumljavanja obično ne uzgajaju te ne samo što propada vrijedna biomasa nego takve kulture postaju pogodne za pojavu štetne entomofaune, fitopatogenih gljiva, a napose su osjetljive na zapaljenje (kulture alepskoga bora na Rabu - Matić 1986).

Autori u svojim istraživanjima nisu jedinstveni u mišljenju o ulozi grmlja i niskoga rašća u sredozemnim šumama za vrijeme požara. Neki smatraju da usporavaju, dok drugi da raspiruju vatru.

Jedan od važnijih uzgojnih zahvata u sredozemnom dijelu naše zemlje jest i čišćenje vegetacije uz prometnice. Ti bi pojasi trebali biti bar 10 - 15 (20) m široki sa svake strane ceste. Ta je preventivna mjera vrlo značajna osobito u ljetnim mjesecima kada je zbog dolaska turista višestruko povećan promet našim primorskim prometnicama.

Velika prostranstva primorskoga krša (eumediteran i submediteran) traže u strategiji razvoja šumarstva na ovim prostorima potpuno i pravilno njegovo vred-

novanje. U nekim su segmentima prevladana konzervativna mišljenja o ovoj problematici. Tako velika prostranstva nije moguće u skoro vrijeme meliorirati i privesti šumskim ekosustavima. Kako se upravo u toj zoni naše zemlje nalazi vrlo velik dio našega gospodarskog i urbanog potencijala, veliki su pritisci, i prostorni i ekološki, na ova područja. Stoga se sve više teži da zelenilo, tj. šumski kompleksi na našem primorju obavljaju općekorisne funkcije ponajprije u sklopu turističke gospodarske djelatnosti. S tim u vezi takvi prostori zahtijevaju da se na mnogo mjesta, osim primarnoga biološko-ekološkog i meliorativnog aspekta, posveti i estetsko-pejzažnoj strani sadnje biljaka. To traži da se prema specifičnim pojedinim potrebama i težnjama sade i mnoge druge vrste. Drugu skupinu biljaka činile bi one koje osim biološko-ekološke i meliorativne te često i estetsko-pejzažne imaju i gospodarsku zadaću. To su one vrste drveća, grmlja i niskog rašća koje se mogu saditi radi dobivanja plodova, ljekovitih svojstava i sl. U šumarskoj terminologiji sve se više govori o pojmu *agroforestry* koji djelomice definira i pronalazi rješenje i za mnoge opožarene površine. Napose se to odnosi na zemlje istočnoga Sredozemlja u kojemu mnoge opožarene površine postaju gospodarski vrednovane zbog iskorištavanja vrsta iz prirodne sukcesije (medonosno i ljekovite biljke) ili zbog podizanja kultura isplativih vrsta. Tu šumarstvo u nas nije dosada našlo smisao ni interes, što je potpuno krivo shvaćanje i olako propuštanje dobiti.

Ključne riječi: požari, alepski bor (*Pinus halepensis* Mill.), sanacija požarišta, sukcesija vegetacije, Makarsko primorje

Photo 3. A thick young growth of Aleppo Pine (*Pinus halepensis* Mill.) a decade after the fire - Baško Polje (Photo: Ž. Španjol)
Fotografija 3. Gusti pomladak alepskoga bora (Pinus halepensis Mill.) desetak godina nakon požara - Baško polje (snimka: Ž. Španjol)

Photo 4. Removing strips of young Aleppo Pine trees (*Pinus halepensis* Mill.) with a circular blade saw in Baško Polje (Photo: Ž. Španjol)
Fotografija 4. Odstranjivanje pomlatka alepskoga bora (Pinus halepensis Mill.) u prugama rotacijskim čistačem - Baško polje (snimka: Ž. Španjol)

Photo 1. Test Plot 2 in Baško Polje - Fires in 1985 and 1988 (Photo: Ž. Španjol)
Fotografija 1. Pokusna ploha u Baškom polju - požar 1985. i 1988. godine (snimka: Ž. Španjol)

Photo 2. Circular blade saw Steyer Forst 9078 on the site in Baško Polje (March 3 1995) (Photo: Ž. Španjol)
Fotografija 2. Rotacijski čistač STEYR FORST 9078 u radu u Baškom polju (6.3.1995.) (snimka: Ž. Španjol)