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EFFECTS OF PINE CULTURES ON A DEGRADED SITE IN THE TRANSITIONAL SUBMEDITERRANEAN AREA

UTJECAJ BOROVIH KULTURA NA DEGRADIRANO STANIŠTE U PRIJELAZNOM PODRUČJU SUBMEDITERANA

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Abstract

The paper analyzes the impact of pioneer forest vegetation (pines) on a degraded site afforested seventy years ago. In the meantime, research activities were undertaken in 1977 and 1991. Sample plots were established in pine cultures, while control plots intended for pedological research were established outside the stand. Measurements included phytocoenological research, stand structure research and previous pedological research. The condition of seedlings and young growth representing the return to climatozonal vegetation was monitored. Research was conducted in the transitional area of the sub-Mediterranean and eu-Mediterranean vegetation zone. This is the Musapstan area within the forest office of Zadar. According to our research, the regeneration process of climatozonal deciduous vegetation is slow. Among other factors, this is attributed to the unfavourable structure of the stand for regeneration. The productive capacity of pine cultures is satisfactory, so they simultaneously fulfill their protective role in the climate of the Mediterranean karst area. The absence of silvicultural treatments is becoming an important factor in the context of increased danger of forest fires. In case of a fire, the already slow succession processes would be additionally aggravated.

Key words: amelioration, forest cultures, Mustapstan, climatozonal vegetation

Sažetak

U radu je istražen problem odnosa i utjecaja pionirske šumske vegetacije (borova) na degradirano stanište koje je bilo pošumljeno prije sedamdeset godina. U međuvremenu su obavljena istraživanja 1977. i 1991. godine. Na pokusnim plohama unutar borovih kultura su postavljene pokusne plohe i kontrolne usporedne izvan sastojine samo za pedološka istraživanja. Izmjerom su obuhvaćena fitocenološka, istraživanja strukture sastojine, te prethodna pedološka istraživanja. Nadalje praćeno je stanje ponika i pomlatka što predstavlja odnos prema povratku klimazonalne vegetacije. Za istraživanje je odabrano prijelazno područje submediteranske i eumediteranske vegetacijske zone. Radi se o predjelu Musapstan u šumariji Zadar. Istraživanjima je pokazano kako je proces obnove klimazonalne vegetacije listača usporen. Razlozi tome su i u nepovoljnoj strukturi sastojine za obnovu. Zadovoljavajuća je proizvodna sposobnost borovih kultura koje istovremeno ispunjavaju i zaštitnu ulogu u uvjetima podneblja na mediteranskom prostoru krša. Nedostatak šumsko-uzgojnih radova postaje bitan u kontekstu veće opasnosti od šumskog požara. U tom slučaju bili bi otežani ionako spori sukcesijski procesi.

Ključne riječi: melioracije, šumske kulture, Musapstan, klimazonalna vegetacija

INTRODUCTION
UVOD

The choice of an amelioration method depends on a number of degradation factors and site conditions. There are several ameliorative treatments, including a ban on grazing, resurrection felling and the introduction of new tree and shrub species. Pioneer species are introduced into distinctly degraded sites owing to their ability to adapt to adverse site conditions.

Their positive impact on soil productivity and on the protective role of climatozonal vegetation in the process of its regeneration is also of utmost importance. Regression and erosion processes in degraded sites should be halted (Requena et al. 2001; Clemente et al. 2004). Mediterranean conditions pose a number of aggravating obstacles to the regeneration process. Court-Picon et al. (2004) point out summer dry periods and high carbonate content in the soil. Rambal (1993) stresses water and dry periods as the prime limiting factors in plant development. The success of afforestation depends on the choice of the species to be used for a particular afforestation area, as well as on their silvicultural characteristics. For this reason, the afforesting species included conifers, mostly pines. Other Mediterranean countries meet with similar problems (Maestre & Cortina 2004). The role of pines can be highlighted through improved soil fertility and structure, which guarantees progressive succession in a degraded site (Kutiel & Naveh 1987, Certa 1998, Barčić et al. 2006).

One of the main goals of the work was to assess the ameliorative impact of pioneer pine species on a degraded site. Positive impacts of pines on long-term succession processes of broadleaved species and the regeneration of site conditions are highlighted (Montero and Alcanda, 1993, Gil and Aránzazu 1993, Lookinbill and Zavala 2000). Another objective was to find out the extent to which some significant changes in the soil - vegetation interaction can be manifested over a period of thirty years. The next aim of this research was to determine the productive capacity of the site if pioneer pine species are planted. The investigated ameliorative effect is manifested in the following: the relationship towards site quality, the return of climatozonal deciduous vegetation, the preservation of productive soil capacity, the fulfillment of non-market functions of forests and forest soil in the Mediterranean karst area.

MATERIAL AND METHODS
MATERIJALI I METODE

Research area
Područje istraživanja

As defined by the Management Plan for the management unit Musapstan (2005 - 2014), the management unit Musapstan, Zadar Forest Office, is situated very close to the City of Zadar. Unlike the major part of the Adriatic coast, there are no mountain chains in the immediate hinterland; rather, the macro-relief is a spacious limestone plateau. The micro-relief of the area is composed of stone blocks of limestone that resurface up to 0.5 m. The highest point in this management unit is in compartment 18c, at an altitude of 110 m (the hill of Čubrijan). The lowest point is situated in compartment 59d at 10 m above sea level. The inclination generally does not exceed 8 %. The exposition is northern, contributing to the strong impact of bura (the northerly wind) in the area (Management Plan, 2005). The wider Zadar area is situated in the climatic zone marked as *Csa*. According to Šegota and Filipčić (2003), this is the climate of the warmest part of Littoral Croatia and is characterized by hot summers. The basic climatic indicators are presented in the climatogram in Figure 1.

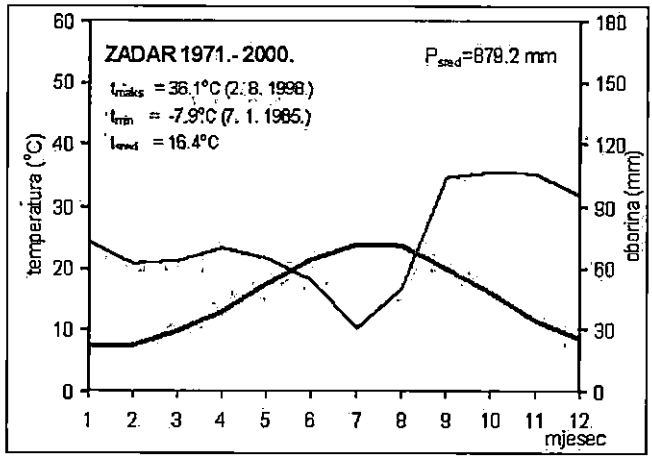

Figure 1 Climatic diagram for Zadar according to Walter (1955) for the period 1971 – 2000.
Slika 1. Klimatski dijagram za Zadar prema Walteru (1955) za razdoblje 1971-2000.

According to the Management Plan for the Management Unit Musapstan (2005 - 2014), the dominant soil type in a broader research area in cambisol on limestone and dolomite (96.2% of the management unit), and the rest are anthropogenized soils. There are sporadic occurrences of parts of massive rocks of varying dimensions, including larger rock fragments on different depths. In between, there are shallow skeletoidal and skeletal soils and thicker soil accumulations.

The vegetation of Musapstan is presented according to the works of Horvat (1950), Horvatić (1957), Bertović (1975), Bertović and Lovrić (1985), Trinajstić et al. (1992), Vukelić and Rauš (1998).

Class: *Quercetea ilicis* Br.-Bl. 1947
Order: *Quercetalia ilicis* Br.-Bl. (1931) 1936
Alliance: *Quercion ilicis* Br.-Bl. (1931) 1936
As: *Fraxino orni – Quercetum ilicis* H-ić 1956/1958

Class: *Querco-fagetea* Br.-Bl. Et Vlieger 1937
Order: *Quercetalia pubescentis* Br.-Bl (1931) 1932
Alliance: *Ostryo-Carpinion orientalis* Ht. (1954) 1958
As: *Querco-Carpinetum orientalis* H-ić 1939
Subas: *Phillyrea media*

Class: *Brachypodio-chrysopogonetea*
Order: *Scorzonero-chrysopogonetalia*
Alliance: *Chrysopogoni-satureion*
As: *Koelerio-festucetum illyricae* Trinajstić 1992

Field work
Terenska istraživanja

The management unit of "Musapstan" is situated at the transition from the eu-Mediterranean into the sub-Mediterranean area. The largest part of the management unit belongs to the natural range of forests of pubescent oak of the alliance *Ostryo-Carpinion orientalis*. A smaller part along the southwestern boundary, and especially the southern part, belongs to the natural range of forests of holm oak of the alliance *Quercion ilicis*. The forest of holm oak, as well as the forest of pubescent oak, occurs here in its degraded form - maquis, which sporadically turns into garrigue, i.e. scrub or pseudomaquis. Silvicultural treatments are applied in accordance with the Management Plan of this area. These treatments mainly involve afforestation and thinning. The relatively densely populated area and the vicinity of a larger city are responsible for the distinct impact of man through several centuries (grazing, recreation). A significant portion of the area is covered by forest cultures of allochthonous conifers, which includes the pine culture on Musapstan, one of the largest and best preserved in the Adriatic region. The predominantly mixed composition of the culture consists of approximately equal shares of Aleppo pine (*Pinus halepensis* Mill.), maritime pine (*Pinus pinaster* Aiton) and stone pine (*Pinus pinea* L.). Of other species there are black pine (*Pinus nigra* Arnold) and cypress (*Cupressus sempervirens* L.), as well as small amounts of cedar (*Cedrus deodara* (Roxb.) G. Don.). Field measurements were conducted in the management unit of Musapstan, in compartments 18a, 26a and 27a. Five plots (plot size 25 m x 4 m) were established in each compartment. Tree heights and breast diameters above the taxation limit of 7 cm were measured in each plot. The obtained data were used to calculate the main structural elements (number of trees, basal area and volume). Measurements in the sample plots also included the structure of seedlings and young growth by height classes and tree species. Phytocoenological relevés were made according to the plant sociology method (Braun-Blanquet 1964).

RESEARCH RESULTS
REZULTATI ISTRAŽIVANJA

Past research in the management unit of Musapstan conducted by Tomašević (1994) was used as a basis for comparative analysis with new data and for the analysis of the obtained data.

The situation recorded in the plot set up in compartment 27a (16) was as follows: 319 stone pines, 112 cypresses and 117 Aleppo pines per hectare. Research undertaken thirty years later showed 320 stone pines, 120 cypresses and 80 Aleppo pines per hectare. In 1977, there were a total of 574 trees per hectare, compared with 520 trees per hectare today. With an insignificant decrease in the number of trees per hectare, the basal area rose from 31.30 m^2/ha to 60.60 m^2/ha, and volume from 205.6 m^3/ha to as much as 510.8 m^3/ha. In compartment 27a (16) the mean height of the stone pine was 12.6 m, and the mean diameter of the stone pine was 26.6 cm. Our research related to the stone pine showed the mean height of 16.7 m, and the mean diameter of 34.2 cm.

In the plot of compartment 181 (12), Tomašević (1994) recorded 139 stone pines, 60 cypresses and 373 trees of Aleppo pine per hectare, totalling 575 trees per hectare. Today, the same stand contains 80 stone pines, 260 Aleppo pines and 180 cypresses per hectare, which amounts to 520 trees per hectare in all. The number of trees decreased in this stand as well, but the basal area increased significantly from 28.44 m^2/ha to 87.20 m^2/ha, and so did the volume from 214.83 m^3/ha to 330.60 m^3/ha. In compartment 18a (12) containing a mixed culture, the mean tree diameter for Aleppo pine was 27.4 cm and the mean height was 16.4 m. In our research, the mean diameter for Aleppo pine was 40.6 cm, and the mean height was 19.0 m.

Table 1 Stand structure per hectare (ha) Forest office Zadar; Management unit Musapstan; Compartment: 27a (16); Year of measurement: 1977; Source: Tomašević (1994).
Tablica 1. Struktura sastojine po hektaru (ha) Šumarija Zadar; gospodarska jedinica Musapstan; odjel: 27a (16); godina izmjere: 1977; izvor: Tomašević (1994).

Tree species *Vrsta drveća*	Stone pine (*Pinus pinea* L.) *Pinija*			Aleppo pine (*Pinus halepensis* Mill.) *Alepski bor*			Mediterranean cypress (*Cupressus sempervirens* L.) *Obični čempres*			Maritime pine (*Pinus pinaster* Aiton) *Primorski bor*			Total - *Ukupno*		
Diameter classes (cm) *Debljinski razred* (cm)	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V
5 – 10							13	0,05	0,4	1	0,0002	0,02	14	0,05	0,42
11 – 20	56	1,43	8,1	8	0,23	1,3	91	1,71	10,7	15	0,28	1,4	170	3,65	21,5
21 – 30	189	9,69	59,5	37	2,1	13,8	8	0,29	2,1	5	0,31	2,1	239	12,39	77,5
31 – 40	73	6,55	41,5	51	4,98	36,3				4	0,34	2,3	128	11,87	80,1
41 – 50	1	0,13	0,9	19	2,79	21,7							20	2,92	22,6
51 - 60				2	0,42	3,5							2	0,42	3,5
Σ	319	17,8	110	117	10,52	76,6	112	2,05	13,2	25	0,93	5,8	573	31,3	205,6

Table 2 Stand structure per hectare (ha) Forest office Zadar; Management unit Musapstan; Compartment 27a (16); Year of measurement: 2008.
Tablica 2. Struktura sastojine po hektaru (ha) Šumarija Zadar; gospodarska jedinica Musapstan; odjel: 27a (16); godina izmjere: 2008.

Tree species *Vrsta drveća*	Stone pine (*Pinus pinea* L.) *Pinija*			Aleppo pine (*Pinus halepensis* Mill.) *Alepski bor*			Mediterranean cypress (*Cupressus sempervirens* L.) *Obični čempres*				Total - *Ukupno*		
Diameter classes Debljinski razred (cm)	N	G	V	N	G	V	N	G	V		N	G	V
11 – 20													
21 – 30				1	0,05	0,45	2	0,08	0,66		3	0,13	1,11
31 – 40	11	1,16	8,7	1	0,1	0,79	4	0,38	3,22		16	1,64	12,71
41 – 50	4	0,6	4,99	1	0,15	1,27					5	0,75	6,26
51 - 60				1	0,22	2,23					1	0,22	2,23
61 - 70	1	0,29	3,23								1	0,29	3,23
Σ (5 x 100 m²)	16	2,05	16,92	4	0,52	4,74	6	0,46	3,88		26	3,03	25,54
Per ha *Po ha*	320	41	338,4	80	10,4	94,8	120	9,2	77,6		520	60,6	510,8

Table 3 Structure of seedlings and young growth by height class and tree species in compartment 27a (16).
Tablica 3. Struktura ponika i pomlatka po visinskim klasama i vrsti drveća u odjelu 27a (16).

Tree species *Vrsta drveća* / Height classes *Visinska klasa* (cm)	Mediterranean cypress (*Cupressus sempervirens* L.) *Obični čempres*	Stone pine (*Pinus pinea* L.) *Pinija*	Holm oak (*Quercus ilex* L.) *Hrast crnika*	Maritime pine (*Pinus pinaster* Aiton) *Primorski bor*	Aleppo pine (*Pinus halepensis* Mill.) *Alepski bor*	Total *Ukupno*	Total per ha *Ukupno po ha*
– 25	18	34	5	5	2	64	1280
26 -50	53	83	3	20	3	162	3240
51 – 75	35	25		7	1	68	1360
76 – 100	11	2		4		17	340
101 – 125	3					3	60
126 – 150							
151 – 175							
176 – 200							
201 – 225							
226 – 250							
251 – 275							
276 – 300							
Total *Ukupno*	120	144	8	36	6	314	6280
Total per ha *Ukupno po ha*	2400	2880	160	720	120		

Table 4 Stand structure per hectare (ha) Forest office Zadar; Management unit Musapstan; Compartment 18a (12); Year of measurement: 1977; Source: Tomašević (1994).
Tablica 4. Struktura sastojine po hektaru (ha) *Šumarija Zadar; gospodarska jedinica Musapstan; odjel: 18a (12); godina izmjere: 1977; izvor: Tomašević (1994).*

Tree species *Vrsta drveća*	Stone pine (*Pinus pinea* L.) *Pinija*			Aleppo pine (*Pinus halepensis* Mill.) *Alepski bor*			Mediterranean cypress (*Cupressus sempervirens* L.) *Obični čempres*			Himalayan cedar (*Cedrus deodara* (Roxb.) G. Don) Himalajski cedar			Total - *Ukupno*		
Diameter classes Debljinski razred (cm)	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V
5 – 10	1	0,0003	0,02				17	0,01	0,5	2	0,01	0,03	20	0,02	0,55
11 – 20	59	1,42	8	58	1,36	9,2	38	0,66	3,8	1	0,01	0,03	156	3,45	21,03
21 – 30	72	3,51	22,1	219	11,4	88	4	0,18	1,3				295	15,09	111,4
31 – 40	7	0,62	4,1	90	8,29	69,3	1	0,08	0,6				98	8,99	74
41 – 50				6	0,89	7,8							6	0,89	7,8
51 - 60															
Σ	139	5,55	34,2	373	21,94	174,3	60	0,93	6,2	3	0,02	0,06	575	28,44	214,83

Table 5 Stand structure per hectare (ha) Forest office Zadar; Management unit Musapstan; Compartment 18a (12); Year of measurement: 2008.
Tablica 5. Struktura sastojine po hektaru (ha) *Šumarija Zadar; gospodarska jedinica Musapstan; odjel: 18a (12); godina izmjere: 2008.*

Tree species *Vrsta drveća*	Stone pine (*Pinus pinea* L.) *Pinija*			Aleppo pine (*Pinus halepensis* Mill.) *Alepski bor*			Mediterranean cypress (*Cupressus sempervirens* L.) *Obični čempres*				Total - *Ukupno*		
Diameter classes Debljinski razred (cm)	N	G	V	N	G	V	N	G	V		N	G	V
11 – 20							1	0,03	0,19		1	0,03	0,19
21 – 30	1	0,07	0,54	3	0,18	1,42	6	0,24	1,81		10	0,49	3,77
31 – 40	3	2,48	0,31	7	0,7	5,94	2	0,16	1,3		12	3,34	7,55
41 – 50				3	0,5	5,02					3	0,5	5,02
Σ (5 x 100 m²)	4	2,55	0,85	13	1,38	12,38	9	0,43	3,3		26	4,36	16,53
Per ha *Po ha*	80	102	17	260	2,76	247,6	180	8,6	66		520	87,2	330,6

Table 6 Structure of seedlings and young growth by height class and tree species in compartment 18a (12).
Tablica 6. Struktura ponika i pomlatka po visinskim klasama i vrsti drveća u odjelu 18a (12).

Tree species *Vrsta drveća* / Height classes *Visinska klasa* (cm)	Mediterranean cypress (*Cupressus sempervirens* L.) *Obični čempres*	Stone pine (*Pinus pinea* L.) *Pinija*	Holm oak (*Quercus ilex* L.) *Hrast crnika*	Aleppo pine (*Pinus halepensis* Mill.) *Alepski bor*	Pubescent oak (*Quercus pubescens* Willd.) Hrast medunac	Total *Ukupno*	Total per ha *Ukupno po ha*
– 25	2		5	5	1	13	260
26 -50	6	1	3	6		16	320
51 – 75	12		3			15	300
76 – 100	7		3			10	200
101 – 125	3		4			7	140
126 – 150	6					6	120
151 – 175	2					2	40
176 – 200	2					2	40
201 – 225							
226 – 250							
251 – 275							
276 – 300							
Total *Ukupno*	40	1	18	11	1	71	1420
Total per ha *Ukupno po ha*	800	20	360	220	20		

Table 7 Stand structure per hectare (ha) Forest office Zadar; Management unit Musapstan; Compartment 26a (11); Year of measurement: 1977; Source: Tomašević (1994).
Tablica 7. Struktura sastojine po hektaru (ha) Šumarija Zadar; gospodarska jedinica Musapstan; odjel: 26a (11); godina izmjere: 1977; izvor: Tomašević (1994).

Tree species *Vrsta drveća*	Stone pine (*Pinus pinea* L.)			Aleppo pine (*Pinus halepensis* Mill.)			Mediterranean cypress (*Cupressus sempervirens* L.)			Maritime pine (*Pinus pinaster* Aiton)			Total - Ukupno		
Diameter classes Debljinski razred (cm)	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V
11 – 20	79	1,93	9,2	5	0,12	0,5	4	0,05	0,2	1	0,02	0,1	89	2,12	10
21 – 30	294	15,38	98,5				1	0,04	0,3	4	0,21	1,2	299	15,63	100
31 – 40	124	11,14	61,4	2	0,19	1,1				4	0,34	1,2	130	11,67	63,7
41 – 50	9	1,39	8,2										9	1,39	8,2
51 - 60	1	0,22	1,4										1	0,22	1,4
Σ	507	30,06	178,7	7	0,31	1,6	5	0,09	0,5	9	0,57	2,5	528	31,03	183,3

Table 8 Stand structure per hectare (ha) Forest office Zadar; Management unit Musapstan; Compartment 26a (11); Year of measurement: 2008.
Tablica 8. Struktura sastojine po hektaru (ha) Šumarija Zadar; gospodarska jedinica Musapstan; odjel: 26a (11); godina izmjere: 2008.

Tree species *Vrsta drveća*	Stone pine (*Pinus pinea* L.)				Mediterranean cypress (*Cupressus sempervirens* L.)				Total - Ukupno		
Diameter classes Debljinski razred (cm)	N	G	V		N	G	V		N	G	V
11 – 20											
21 – 30	6	0,41	3,2		1	0,05	0,37		7	0,46	3,57
31 – 40	20	1,87	14,63						20	1,87	14,63
41 – 50	2	0,14	2,97						2	0,14	2,97
51 - 60											
Σ (5 x 100 m²)	28	2,42	20,8		1	0,05	0,37		29	2,47	21,17
Per ha *Po ha*	560	48,4	416		20	1	7,4		580	49,4	423,4

Table 9 Structure of seedlings and young growth by height class and tree species in the compartment 26a (11).
Tablica 9. Struktura ponika i pomlatka po visinskim klasama i vrsti drveća u odjelu 26a (11).

Tree species *Vrsta drveća* Height classes *Visinska klasa* (cm)	Mediterranean cypress (*Cupressus sempervirens* L.) *Obični čempres*	Stone pine (*Pinus pinea* L.) *Pinija*	Holm oak (*Quercus ilex* L.) *Hrast crnika*	Total *Ukupno*	Total per ha *Ukupno po ha*
– 25	4	5	4	13	260
26 -50	12	29	3	44	880
51 – 75	10	22	1	33	660
76 – 100	2	1		3	60
101 – 125	2	1		3	60
126 – 150					
151 – 175		1		1	20
176 – 200					
201 – 225					
226 – 250					
251 – 275					
276 – 300					
Total *Ukupno*	30	59	8	97	1940
Total per ha *Ukupno po ha*	600	1180	160	1940	

The compartment 26a (11) features a pure stone pine stand with only a few Aleppo pines, cypresses and Himalayan cedars. In 1977, there were 507 stone pine trees of the total of 528 trees in the plot. In 2008, there were 560 stone pine trees and 580 trees in all. An increase in the number of trees is attributed to newly formed gaps and to natural regeneration of Aleppo pine in the plot. Basal area rose from 31.03 m^2/ha to 49.40 m^2/ha, and volume rose from 183.3 m^3/ha to 423.40 m^3/ha. In compartment 26a (11), the mean height of the stone pine was 10.8 m, and the mean tree diameter was 27.5 cm, while today the mean height of the stone pine is 16.6 m, and the mean diameter is 32.4 cm.

The basic soil properties are also provided in the description of the profile (Tomašević, 1994) that presents this pedosystematic unit (terra rossa, lessivated, colluvial, clayey). This soil type is found in the pine cultures in compartments 26a, 27a, and 18a. The profile was taken from a smaller plateau in compartment 27a. The rockiness of the area around the profile is 40% and towards the edge part of the plateau it increases to as much as 90% of the area.

O1 (3-1cm) undissolved pine needle litter without any dissolution signs.

Oh (1-0cm) thin layer of humified pine needle litter, dark and affiliated with mold micelia. It breaks up into larger horizontal rag-like patches.

Aoh (0-3cm) silty non-structural loam with about 30% of limestone skelet, dark brown in dry condition, densely intertwined with rootlets of ground vegetation, porous and friable, soil mass non-carbonate. In a diffuse state it transforms into:

E (3-19cm) silty-clayey loam, light reddish, medium granular to blocky subangular structure. Contains about 70% of rock fragments. Rooting is very dense. Gradually transforms into:

(B)rz, t (19-50cm) clayey loam to loamy clay, red. Has a characteristic polyedric structure. Thin light membranes on the surface of structural aggregates are visible, relatively deep rooting. Transforms abruptly into:

R (over 50 cm) massive compact limestone rock.

One of the important factors in the comparison of ameliorative effects on a degraded site is the relationship towards the return of climatozonal vegetation. The basic issue is whether the conditions for a more abundant occurrence of main deciduous species from the climatogenic forest community are ensured. Table 10 shows species abundance and changes in the process of vegetation succession relative to the investigation period. This is a thirty-year period, although we should point out that progressive succession has been going on for a number of decades, or more precisely, for a hundred and more years. Succession is largely dependent on anthropogenic impacts and climatic conditions.

DISCUSSION
RASPRAVA

Mixed stands of Aleppo pine and stone pine are found in compartments 27a and 18a, and a pure stone pine culture occurs in compartment 26a. According to Tables 1, 2, 4, 5, 7 and 8, the number of trees of the main species has not changed significantly in the past 30 years.

Structural analysis of the stands shows their development; thus, the present stands aged about 70 achieve considerable wood production. A comparison of the results with those of Tomašević (1995) reveals that the soil has retained its productive capacity. The growing stock in the sample plots ranges from 330 to 510 m^3/ha. This confirms the fact that pioneer species, in this case the stone pine, can fulfil their ecological, social and commercial function in a degraded site (Plaisance 1977).

Table 10 Phytocoenological relevés in the sample plots in 1976 (1 – symbol n the table) and 2008 (2 – symbol in the table).
Tablica 10 Fitocenološke snimke na pokusnim plohama 1976. (1– oznaka u tablici) i 2008. (2- oznaka u tablici) godine.

Potential vegetation *Potencijalna vegetacija*	*Querco-Carpinetum orientalis*																													
Compartment *Odjel*	27a(16)										18a(12)										26a(11)									
Plot dimension *Veličina plohe m²*	625										625										625									
Parent material Matična podloga	Limestone *Vapnenac*																													
Soil *Tlo*	*Vapnenačko dolomitna crnica posmeđena, smeđe tlo na vapnencu tipično, plitko*																													
Exposure *Ekspozicija*	Straight *Ravno*										Straight *Ravno*										Straight *Ravno*									
Inclination *Inklinacija*	Straight *Ravno*										Straight *Ravno*										Straight *Ravno*									
Culture *Kultura*	*Pinus pinea, Pinus halepensis, Cupressus sempervirens*										*Pinus pinea, pinus halepensis*										*Pinus pinea*									
Survey *Izmjera*	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Plot *Ploha*	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15
Tree coverage % *Pokrovnost sloja drveća (%)*	90	100	75	100	90	100	85	100	90	95	90	95	90	95	90	95	90	100	80	95	90	90	90	90	75	85	75	95	90	95
Shrub coverage % *Pokrovnost sloja grmlja (%)*	15	5	10	90	10	5	10	5	5	15	20	60	15	70	35	85	25	50	25	65	25	3	20	5	25	20	25	5	20	10
Ground vegetation coverage % *Pokrovnost sloja prizemnog rašća (%)*	80	85	90	25	70	85	70	70	60	95	60	25	60	85	60	10	60	60	70	70	60	100	60	100	60	100	80	100	60	10
Bursts coverage % *Pokrovnost sloja mahova (%)*	10	-	10	80	10	-	10	10	10	20	5	-	5	20	5	30	5	55	5	5	5	-	5	45	10	-	5	-	10	-
Total coverage % *Ukupna pokrovnost (%)*	100		100		100		100		100		100		100		100		100		100		100		100		100		100		100	
SLOJ DRVEĆA																														
Pinus pinea L.	2	3	2	4	2	5	2	4	3	4	2	3	1	3	1	3	1	3	1	2	4	5	4	5	4	5	4	5	4	5
Pinus halepensis Mill.	2	1	2	1	2	1	2	2	2	2	3	2	2	1	3	2	4	2	3	3	.		.		+		.		+	
Cupressus sempervirens L.	1	1	+	1	+	+	1	3	+	1	+	2	+	2	1	1	+	1	+	1	.		.		.		.		.	
Cedrus deodara (Roxb.) G. Don	.		.		.		.		.		.		.		.		.		+		.		.		.		.		.	
Pinus nigra Arnold	.		.		+		.		.		.		.		.		.		.		.		.		.		+		.	
Pinus pinaster Aiton	+		+		.		.		.		.		.		.		.		.		.		.		.		.		.	
Quercus ilex L.	+		.	1	.		.	+	.		.	1	.	1	.	1	.		.	1	.		.		.	+	.		.	
SLOJ GRMLJA																														
Juniperus oxycedrus L.	2		2	1	2		2		2		3	+	2	+	2		2		2	+	2		2		3	1	3		3	+
Phillyrea media L.	1	+	+	1	2	1	1	1	1	+	+	1	+	1	+	1	+		+	1	+	1	+	+	.	2	+	+	+	+
Paliurus aculeatus Mill.	1		.		1		+		.	+	+		1		+		+		.		+		+		.		.		+	
Rubus discolor Weihe et.Ness	+	1	.	1	.	+	.		+		1	1	+		+	+	+	+	+	1	+		+		.	1	+		+	+
Quercus pubescens L.	+	1	+		+		.	+	+	+	.	+	.		+	+	.	+	+	+	+	+	+	+	.	+	+		.	+

Culture *Kultura*	*Pinus pinea, Pinus halepensis, Cupressus sempervirens*										*Pinus pinea, pinus halepensis*										*Pinus pinea*									
Survey *Izmjera*	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Plot *Ploha*	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15
Cuperssus sempervirens L.	+		+	2	.	1	.	+	.	1	.	+	.	1	+	+	+		+	1	+		.		.		.		+	
Rosa sempervirens L.	.	1	.		.		.	+	.		.		.		.		.	+	.		+		+		.		.		+	+
Prunus mahaleb L.	+		.	1	.		+	+	+		.	+	.	+	.		.	+	.		+		+		+	+	.		.	
Lonicera etrusca Santi	+		+		.		.		.		.	+	.		:		.		.	1	+		.		.		+		.	
Quercus ilex L.	1		+	1	1		2	+	1	+	.	2	.	+	.	1	.	+	.	2	.	+	.		.	+	.	+	.	+
Acer Monspessulanum L.	.		.		+		.		+		+	+	.		.		.		.		.		.		.		.		.	
Quercus cerris L.	+		.		.		.		.		+		.		.		.		.		.		.		.		.		.	
Cedrus deodara (Roxb.) G. Don	.		.		.		.		.		.		+		.		.		+		.		.		.		.		.	
Crataegus transalpina Jacq.	.		.		.		.		.		.		.		.		+		+		.		.		.		.		.	
Rhamnus intermedia Steud. Et Hohst.	.		.		.		+		.		.		.		.		.		.		.		+		.		.		.	
Pinus pinea L.	.	+	.		.		.	1	.	1	.		.	2	.	+	.	1	.	1	.		.	+	+	1	.		.	+
Fraxinus ornus L.	.		.	+	+		.		+	+	.		.		.		.		.	+	.		.		.		.		+	
Viburnum tinus L.	.		.		.		.		.		.		.		.		.		.		.		.		.		.		+	
Osyris alba L.	+		.	1	+	+	.		+		.		.		.		.		.		.		.		.		.		.	
Libustrum vulgare L.	+		.		+		.		+		.		.		.		.		.		.		.		.		.		.	
Ostrya carpinifolia Scop.	.		+		.		.		.		.		.		.		.		.		.		.		.		.		.	
Sorbus domestica L.	.		.		+		.		.		.	+	.		.		.		.		.		.		.		.		.	
Prunus avium L.	.		.		+		.		.		.		.		:		.		.		.		.		.		.		.	
Acer obtusatum Waldst. Et Kit. Ex Willd.	.		.		.		.		+		.		.		.		.		.		.		.		.		.		.	
Pinus halepensis Mill.				1				1		2				4		4		3		1						+				+
Prunus spinosa L.								+																						
Ruscus aculeatus L.												+		+																
SLOJ PRIZEMNOG RAŠĆA																														
Asparagus acutifolius L.	+	+	+		+	+	.	+	+		+		+	+	+		+	+	+	+	+	+	+	+	+		+	+	+	+
Hieracium pillosela Vill.	+		+		+		.	1	+		+	+	+		+	+	+		+		+		+		+		.	+	+	+
Rubus discolor Weihe et Ness	+	+	+	+	.	+	+		+		+	+	+		+		+		+	+	1		1		+		+		+	
Teucrium polium L.	+		+		+		+	1	+		+		1		+		1		+		+		+		+		+		+	
Sesleria autumnalis (Scop.) F.W.Schultz	+		1		+	3	1		2		3		2		+		2		+		2		1	3	1	3	1	4	+	1
Asphodelus microcarpus Mill.	+		+	+	+		1		.		1		+		1		+		+		+		+		+		+		+	
Stachys pratensis	+		+		+		+		.		+		+		+		+		.		+		+		+		+		+	
Potentilla erecta L.	+		+		+		+		+		+		+		+		.		+		+		+		+		+		+	
Clematis flammula L.	+		+		+		+	+	+		+		+		.		+		+		+	+	+	+	+		+		.	

Culture *Kultura*	*Pinus pinea, Pinus halepensis, Cupressus sempervirens*										*Pinus pinea, pinus halepensis*										*Pinus pinea*									
Survey *Izmjera*	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Plot *Ploha*	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15
Teucrium chamaedrys L.	+		+		+		+		+		+		.		+		+		+	+	+		+	+	.	+	+		+	
Rhamnus internedia Steud. Et Hohst.	+		+		+		+		+		1		1		1		+		+		.		+		+		+		+	
Euphorbia fragifera Jan	+		+		.		+		+		+		+		+		+		+		+		+		1		+		1	
Crepis paludosa (L.) Moench	+		+		+		+		+		+		+		+		.		+		+		+		+		+		+	
Helianthemum ovatum L.	+		+		+		+		+		1		1		1		+		+		.		+		+		+		+	
Chalinus hyspanicus	+		+		+		+		+		1		1		1		1		1		+		+		+		+		1	
Quercus pubescens Willd.	+	+	+	+	+		+		1		.	+	1	+	+	+	+	+	+		1		+	+	+		+		+	
Pinus halepensis Mill.	+	+	1		1		1		1	+	+	+	1		1	1	+		1	+	.		.		.	+	.		.	
Thymus serpyllum L.	.		+		.		+		.		+		+		1		+		+		.		+		.		+		+	
Phillyrea media L.	+		+	1	+		+		.		+		.	+	+		+	+	+	+	.		+		+		+		+	
Sanguisorba minor Scop.	.		.		.		+		+		+		+		+		+		+		+		+		1		1		1	
Eryngium amethysti-num L.	.		.		+		+		+		+		+		+		.		+		+		+		+		+		+	
Galium lucidum All.	.		.		.		+		.		+		+		+		+		+		+		+		+		+		+	
Bromus erectus Huds.	.		+		+		+	1	+		+		.		+		+		+		+		+		1		2		.	
Cephalaria leuchanta (L.) Roem. Et Schult.	+		+		+		+		+		+		.		.		.		+		+		+		+		+		+	
Filipendula hexapetala Moench.	+		+		+		+		+		.		+		+		.		+		1		1		.		+		+	
Rosa sempervires L.	.		+		.		+	+	.		+		.		+		+		.		+		.		.		.		+	
Rubia peregrina L.	+	+	+	+	+		.	+	+	+	+	+	.		.	+	+	+	.	1	+	+	+	+	.		+	+	.	+
Trifolium pratense L.	R		.		.		.		.		+		.		+		+		+		.		.		+		+		.	
Cupressus sempervirens L.	1		+		+	+	+		1	+	+	+	+	+	+		.		+		.		.		.		.		.	
Astragalus sp.	.		+		+		+		+		+		.		+		+		+		+		.		.		.		.	
Doricnum germanicum (Gremli) Rikli	+		+		.		.		+		+		+		.		.		+		+		+		.		.		+	
Cardus pycnocepha-lus L.	.		.		.		+		.		+		+		+		+		+		+		+		.		+		.	
Doricnium hirsutum (L.) Ser.	.		+		.		+		.		.		.		+		+		+		+		.		+		.		.	
Prunus mahaleb L.	.	+	.		+	+	+	+	+	+	.	+	.	+	.		+		+		+		.		+		+		+	
Verbascum flomoides L.	.		.		+		+		+		+		+		+		+		+		+		.		.		.		.	
Pinus pinea L.	1	+	1		+	+	.		+	+	.		.		.	+	.		.	+	1		1	+	1		1		1	+
Festuca heterophylla Lam.	.		+		+		2		1		.		.		.		.		.		1		1	1	1	2	1	-	.	
Prunella laciniata L.	+		.		+		+		.		.		1		+		+		+		.		+		.		.		.	
Echynops ritro L.	.		.		.		.		.		+		.		.		.		.		+		.		+		+		+	
Oryganum majorana L.	.		+		.		.		.		+		.		.		.		.		+		.		.		+		.	
Tamus communis L.	+		.		.		+		.		+		.		.		.		+		+		.		.		.	+	.	

Culture *Kultura*	*Pinus pinea, Pinus halepensis, Cupressus sempervirens*										*Pinus pinea, pinus halepensis*										*Pinus pinea*									
Survey *Izmjera*	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Plot *Ploha*	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15
Smilax aspera L.	+		.		.		.		.		+		.		.		.		+		+		.		.		+	+	.	
Ligustrum vulgare L.	.		.		.		.		+		+		.		.		+		.		.		+		+		.		.	
Laurus nobilis L.	.		.		.		.		.		+		+		+		.		+		+		.		.		.		.	
Celtis australis L.	.		.		.		.		.		+		+		.		+		+		+		.		.		.		.	
Juniperus oxycedrus L.	.		1	1	.		.		.		+	+	.	+	.		+		.		+		1		.		.		.	
Hedera helix L.	1		.		.		+	1	+		.		.		+		+		.	+	.		+		.		.		.	
Geranium valentianum L.	.		.		.		.		+		.		+		.		.		.		.		+		+		+		+	
Fraxinus ornus L.	.		.		.		.		.	+	.	+	+		.		.		.	+	.		+		+	+	.		+	
Pistacia lentiscus L.	.		.		.		+		.		.		+		.	+	.		.		+		+		+		.		.	
Helichrysm italicum G. Don.	.		.		.		.		.		+		.		+		+		+		.		.		+		.		.	
Acer monspessu-lanum L.	.		.		.		+		+		.		+		.		.		.		.		+		.		.		.	
Quercus ilex L.	.		.	+	+		+		+		.	+	+	+	.	+	.	+	.	+	.		.		.		.		.	
Osyris alba L.	+		+	1	+	+	.		+		.		.		.		.		.		.		.		.		.		.	
Centaurea montana	.		.		.		.		.		.		.		.		.		.		+		+		+		+		.	
Fragaria vesca L.				+																										
Sorbus domestica L.												+																		
Arhenatherum elatius L.		I		+																										
Geranium roberticenum L.		+		+																										
Brachypodium sylvaticum (Huds.) P.B.				1				1				1						I		1		1								1
Festuca ovina L.				+						1		1						1		+										1
Koeleria gracilis Pers.				+																										
Carduus acanthoides L.		+																												
Dachylis hispanica Roth		1												+		+		+				1								1
Brachypodium pinnetum (L.) Beauv.		1								3												5								
Sanguisorba umricaba L.				+						+																				
Carduus pycnocephalus L.								+																						
Cynosurus echinatus L.						1		1																						
Koeleria pyramidula (Lam.) Dimin								1																						
Festuca capillata Lam.		I						1																						
Avena pubescens Huds.						1		2		1																				
Arrhenatherum elatius (L.) C.Presl						I																I		1		2				
Genista dalmatica Bartl.				+										+		+														

Culture *Kultura*	*Pinus pinea, Pinus halepensis, Cupressus sempervirens*										*Pinus pinea, pinus halepensis*										*Pinus pinea*									
Survey *Izmjera*	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Plot *Ploha*	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15
Cuperssus sempervirens L.	+		+	2	.	1	.	+	.	1	.	+	.	1	+	+	+		+	1	+		.		.		.		+	
Rosa sempervirens L.	.	1	.		.		.	+	.		.		.		.		.	+	.		+		+		.		.		+	+
Prunus mahaleb L.	+		.	1	.		+	+	+		.	+	.	+	.		.	+	.		+		+		+	+	.		.	
Lonicera etrusca Santi	+		+		.		.		.		.	+	.		.		.		.	1	+		.		.		+		.	
Quercus ilex L.	1		+	1	1		2	+	1	+	.	2	.	+	.	1	.	+	.	2	.	+	.		.	+	.	+	.	+
Acer Monspessulanum L.	.		.		+		.		+		+	+	.		.		.		.		.		.		.		.		.	
Quercus cerris L.	+		.		.		.		.		+		.		.		.		.		.		.		.		.		.	
Cedrus deodara (Roxb.) G. Don	.		.		.		.		.		.		+		.		.		+		.		.		.		.		.	
Crataegus transalpina Jacq.	.		.		.		.		.		.		.		.		+		+		.		.		.		.		.	
Rhamnus intermedia Steud. Et Hohst.	.		.		.		+		.		.		.		.		.		.		.		+		:		.		.	
Pinus pinea L.	.	+	.		.		.	1	.	1	.		.	2	.	+	.	1	.	1	.		.	+	+	1	.		.	+
Fraxinus ornus L.	.		.	+	+		.		+	+	.		.		.		.		.	+	.		.		.		.		+	
Viburnum tinus L.	.		.		.		.		.		.		.		.		.		.		.		.		.		.		+	
Osyris alba L.	+		.	1	+	+	.		+		.		.		.		.		.		.		.		.		.		.	
Libustrum vulgare L.	+		.		+		.		+		.		.		.		.		.		.		.		.		.		.	
Ostrya carpinifolia Scop.	.		+		.		.		.		.		.		.		.		.		.		.		.		.		.	
Sorbus domestica L.	.		.		+		.		.		.	+	.		.		.		:		.		.		.		.		.	
Prunus avium L.	:		.		+		.		.		.		.		.		.		.		.		.		.		.		.	
Acer obtusatum Waldst. Et Kit. Ex Willd.	.		.		.		.		+		.		.		.		.		.		.		.		.		.		.	
Pinus halepensis Mill.				1				1		2				4		4		3		1						+				+
Prunus spinosa L.								+																						
Ruscus aculeatus L.												+		+																
SLOJ PRIZEMNOG RAŠĆA																														
Asparagus acutifolius L.	+	+	+		+	+	.	+	+		+		+	+	+		+	+	+	+	+	+	+	+	+		+	+	+	+
Hieracium pillosela Vill.	+		+		+		.	1	+		+	+	+		+	+	+		+		+		+		+		.	+	+	+
Rubus discolor Weihe et Ness	+	+	+	+	.	+	+		+		+	+	+		+		+		+	+	1		1		+		+		+	
Teucrium polium L.	+		+		+		+	1	+		+		1		+		1		+		+		+		+		+		+	
Sesleria autumnalis (Scop.) F.W.Schultz	+		1		+	3	1		2		3		2		+		2		+		2		1	3	1	3	1	4	+	1
Asphodelus microcarpus Mill.	+		+	+	+		1		.		1		+		1		+		+		+		+		+		+		+	
Stachys pratensis	+		+		+		+		.		+		+		+		+		.		+		+		+		+		+	
Potentilla erecta L.	+		+		+		+		+		+		+		+		.		+		+		+		+		+		+	
Clematis flammula L.	+		+		+		+	+	+		+		+		.		+		+		+	+	+	+	+		+		.	

Culture *Kultura*	*Pinus pinea, Pinus halepensis, Cupressus sempervirens*										*Pinus pinea, pinus halepensis*										*Pinus pinea*									
Survey *Izmjera*	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Plot *Ploha*	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15
Agrimonia eupatoria L.								+						+		+		+												
Leontodon hispidus L.								1																						
Geranium columbinum L.										+				1		1														
Centaurea jacea L.										+																				
Carex strigosa Huds.																				+	1									
Salvia pratensis L.																								+		+				
Genista sylvestris Scop.																				1				+		+		+		+
Carex humilis Leyss.																								1						
Carex sempervirens Vill.												+				+								1		2				1
Hieracium bauhinii Schult.																				1				1		2				
Brachypodium ramosum (Pers.) P.Beauv.																												1		+
Melica nutans L.												1		1		1		2		1										
Actaea spicata L.																				1										
Sonchus blaberrimus L.												+			+					+										
Avena pratense L.																				+										
Cytisus hirsutus L.												+				+														
Senecio sylvaticus L.														+																
Trifolium campestre Schreb														1		1														
Sanguisorba minor Scop.														+		+														
Festuca duriuscula L.														+		+														
Crepis biennis L.														+		+														
Sonchus tenerimus L.														+		+														
Melica nutans L.												1		1		1		2		1										
Actaea spicata L.																				1										
Sonchus blaberrimus L.												+			+					+										
Avena pratense L.																				+										
Cytisus hirsutus L.												+				+														
Trifolium campestre Schreb														1		1														
Sanguisorba minor Scop.														+		+														
Festuca duriuscula L.														+		+														
Crepis biennis L.														+		+														
Sonchus tenerimus L.														+		+														
Crepis biennis L.														+		+														
Sonchus tenerimus L.														+		+														

The analysis of the measured seedlings and young growth in the sample plots in the cultures (Tables 3, 6 and 9) shows the exceptionally weak (Table 10) occurrence of autochthonous elements of the climatozonal community of pubescent oak and oriental hornbeam (*Querco-Carpinetum orientalis* H-ić 1939). This suggests the initial stage of succession processes, which is still insufficient for more satisfactory natural regeneration. The prevalence of pines indicates early succession species (xerophytes, heliophytes); in contrast, the prevalence of holm oak or pubescent oak denotes late succession species (Papió 1994, Retana et al. 1996, Broncano et al. 1998). Since the Musapstan area is the contact zone between the forest of pubescent oak and oriental hornbeam (*Querco-Carpinetum orientalis* H-ić 1939) and the forest of holm oak and manna ash (*Fraxino orni-Quercetum ilicis* H-ić 1956), there are holm oak seedlings in the area (Tables 3, 6 and 9) but almost no pubescent oaks. Even those rare samples that do exist are less than 1 m tall. The reasons can most probably be attributed to the naturally formed micro-gaps (wind broken and fallen trees, dieback) which are re-colonized by conifers, so that the structure of the seedlings and young growth are dominated by the species of the culture itself, i.e. cypress, Aleppo pine and stone pine. Owing to the density of the culture, only some individual species in the seedling and young growth structure have reached a height above 100 cm. The reason lies in the absence of intensive cleaning and thinning treatments in the culture. Since the canopy does not open, growth and development of the seedlings and young plants is restricted. In terms of amelioration, the targeted role has not been fulfilled in the sense of the return of climatozonal vegetation. Naturally, the defined goals of establishing the culture should also be taken into account; in other words, was the initial intention to establish a commercial stand or to achieve subsequent stand conversion? For this reason, it is difficult to predict any more favourable impacts on the sites of pure or mixed cultures. In order to make any such predictions, it would have been necessary to apply silvicultural treatments during the rotation and undertake research into the quantity and composition of the forest floor. Our investigations reveal the still unfavourable site conditions. The frequent occurrence of juniper (*Juniperus oxycedrus* L.) in the cultures, which is also present in the areas outside the culture, is indicative. At the same time, the surrounding area has been exposed to severe anthropogenic impacts for decades, resulting in the dominance of degraded and devastated forms of forest vegetation.

Phytocoenological relevés of Tomašević (1994) and our research of 2008 also confirm very slight share of woody autochthonous elements in the shrub and ground vegetation layers.

Only one pedosystematic unit was identified in compartments 26a, 27a and 18a in the investigated pine cultures. This is terra rossa, lessivated, colluvial and clayey. The soil has the following profile: O1 - O h - AE - (B) - R (Tomašević 1994).

The restricted, humus-rich O horizon consists of two sub-horizons: the O1, with undissolved litter that consists of the needles, and the Oh horizon, in which microbiological transformation has affected the litter to such a degree as to make it impossible to determine the character of the original material. It is dark in colour and breaks horizontally into larger fragments of organic mass. The entire mass of this horizon is intertwined with mould fungi mycelia. In general, the humus accumulative horizon in the profile of 3 - 5 cm depth is poorly developed. It occurs in the form of a thin, dark surface layer which is friable, silty and of undefined structure in dry condition. The dark humus accumulative horizon is gradually followed by the light-red initial eluvial horizon, whose depth reaches up to 20 cm. It has been formed by the eluvial migration of clay from this horizon. Three are indications that it also contains traces of allochthonous, so-called loess-like material, mentioned by Škorić (1979) for the area of Istria. The horizon is gradually converted into the (B) horizon in which the membranes of chloride accumulations indicate the illuvial process. In terms of the relief, this pedosystematic unit is found in the lowest parts of weakly pronounced, plate-like micro-depressions. These geomorphological forms are generally characterized by the slight rockiness of the lowest parts and a gradual increase in the rockiness towards the edge of these depressions.

The analysis of Tomašević's pedological results (1994) shows that in terms of mechanical composition, the soil in the Musapstan cultures is heavy clay. Compared with the soil in the clearings, the soils under the forest vegetation manifest a higher percent content of clay and coarse sand fractions. Of other physical features, the lowest porosity, i.e. the highest compactness, was found in the soil without any forest vegetation. The highest value was recorded in the pure stone pine culture. Similar relations were also found for water and air holding capacity of soil. Forest vegetation improves porosity and consequently, water-air relations.

There are irregularities in terms of the humus content. As the forest cover progresses, the humus content in the surface horizon increases. It is the lowest in the clearing. There are also differences related to the nitrogen content. There is sufficient nitrogen in both mixed stands, but the highest nitrogen content was found in the pure stone pine stand. This is the result of the specific profile stratigraphy, where the humus-rich horizon of high humification degree occurs below the leaf litter and the restricted humus horizon.

High regularity of the C/N ratio in the investigated soils was determined with certainty. Nitrogen release and assimilation capacity in higher plants begins only when the C/N ratio is lower than 25. Total assimilation by microorganisms occurs when the C/N ratio is higher than 33 (biological immobilization). At the same time, the narrowing down of the C/N ratio to between 10 and 12 does not ensure sufficient energy needed by microorganism metabolism; as a result, the mineralization process is halted (Vukadinović, Lončarić, 1998). The C/N ratio between 12 and 25 is considered favourable for higher plants.

The lowest C/N ratio in the investigated soils (8, 6, 4) was found in the soil without any forest vegetation. Namely, the influx of organic matter from scarce natural vegetation is very modest. This matter is prone to relatively rapid humification, ending with relatively mature humus. The C/N ratio broadens with the increased presence of coniferous species in both mixed stands and amounts to 19.9 and 28.3, similarly to the pure stone pine culture where the ratio is 35.7. The C/N ratio in all the soils decreases with an increase in depth.

Tomašević (1994) conducted certain microclimatic measurements within his research. The results of his measurements show that light intensity in the pure stone pine culture, compartment 26a (11), amounts to 17.80 %. Day air temperature in the forest and in the open space ranged from 17.71 °C to 22.60 °C. The oscillation amounted to 4.89 °C. In the open space, the temperature ranged from 19.10 °C to 22.70 °C, with the oscillation reaching 3.69 °C. Relative air humidity in the forest oscillated between 73% and 90%, whereas in the clearing it was between 64% and 82%. Assumption is that relations in the stand are still the same. In that period between there were no application of silvicultural treatments. Silvicultural treatments could have impact on the ecological factors.

The oscillation of the soil surface geo-temperature was 3.74 °C in the forest and 4.10 °C in the open space. As the depth increases, the difference in geo-temperatures becomes smaller. From 30 cm depth onwards there are no significant differences between the temperature in the forest and in the open space.

CONCLUSIONS
ZAKLJUČCI

The choice of an ameliorating method to be used in a certain area depends on the condition of the site to be ameliorated. The types of amelioration treatments differ accordingly. The most important activity in degraded sites relates to the introduction of primarily pioneer tree species, since these species possess the capacity to adapt to adverse site conditions. Their growth and development in such terrains can have a favourable effect on site conditions; in turn, this opens the possibility of regeneration for climatozonal broadleaved vegetation. However, the introduction of pioneer species does not automatically guarantee regeneration success. Success also depends on the knowledge of biological properties, ecological requirements and silvicultural characteristics of the

species to be used for amelioration. Ameliorative activities should be followed by silvicultural activities, which will contribute to the qualitative improvement of the stand. Our research confirmed the absence of this vital segment in stand management.

According to earlier research by Tomašević (1994 and 1995) and the latest research of 2008, in the past the Musapstan area suffered devastation from the vegetational aspect and degradation from the pedological aspect. Pioneer species were primarily intended to improve soil productivity and progressive vegetation succession. Naturally, the exceptional aesthetic and protective character that these species enhance should not be neglected. Afforestation can provide multiple benefits; however, it should be pointed out that these benefits can only be achieved if clearly defined goals are set and if the prescribed silvicultural activities are implemented during the rotation. Otherwise, the results will be disappointing.

Our research confirmed that the existing pioneer vegetation encourages, albeit very slowly, the return of autochthonous broadleaved vegetation. The structure of the seedlings and young growth revealed hesitant return of deciduous species, whereas pioneer conifers occurred by natural succession. This can be attributed to the still unfavourable conditions for regeneration in the site. A special problem arises from the non-application of intensive silvicultural treatments of tending and thinning. The use of these treatments will lead to more optimal relationship towards light as an ecological factor of regeneration.

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