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POSTFIRE RESUCCESSIONAL PROCESS IN JUNIPER-POPLAR WOOD IN BUGAC KISKUNSÁG NATIONAL PARK, HUNGARY

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ABSTRACT

Resuccession of cryptogamous and higher plants were investigated in 9 permanent quadrats in a burnt area in Bugac Kiskunság National Park, Hungary. Species diversity increase along the transect parallel with depth of burnt soil. Alien and opportunist species intruded in to burnt area while the return of the wild perennial flora took place slowly, except for creeping plants. Highest similarity occured among the 4th, 5th and 6th quadrats situated in the middle of sample series, with and without algae.

INTRODUCTION

There are four national parks and numerous protected landscape and natural conservation areas — all together 35 — in Hungary.

The conservation strategy of threatened plants and animals or "nature gene banks" are generally directed always to a definite area. Such projects aiming at the protection of one plant population only is rare, and this could be hardly successfull.

The main aim to protect these threatened plants is necessary against Man's habitat destruction for the Man's use in the future. Still, catastrophes can happen even in these protected areas. Fire is one of the dangers which can influence the preservation in an opposite direction.

Fire events are very frequent in mediterranean regions of Australia, U.S.A. and South-Africa as a consequence of wildfires in dry seasons, lighting and man-controlled burns. The goal of the latter is to alter the species composition, to increase the production. The controlled burns are usually reiterated from time to time (Noble and Slatyer 1977, Menke 1979). Postfire succession were studied among others by Noble and Slatyer (1977), Menke (1979), Mishra and Ramakrishnan (1983), Everett and Ward (1984), Fritsch and Salysbury (1915), Johansen *et al.* (1982), and Abrahamson (1984); problems of productivity, community structure and diversity were examined by Menke (1979), Trabaud and Lepart (1980); and individual species responses to fire events were studied by Abrahamson (1984a, b), Givens, Layne, Abrahamson and White-Schuler (1984).

Temperate regions, also in Hungary, burns are confined to small areas beside the side of ditches, railway beds etc. Burning up litter and other plant remnants in the gardens is confined to small patches and it happens at early spring when the "rancid-grass" and litter is wet and the soil can not become very hot. These burn events do not result in any damage to sprouts of perennials and seeds, bulbs, rhizomes and they can survive in the soil without any loss. All these are positive conditions for the regeneration of the vegetation. The soil inhabiting animals are deeper than the penetration depth of the fire at this time. Hence damage caused by fire is unimportant in consumer-decompositer groups. Stubble-burning which is very harmful from man's point of view, is forbidden by order.

Forest-fires caused by carelessness devastate randomly during the driest conditions for the vegetation. Forest-fires are frequent in Hungary and they cause heavy damages mainly in planted pinions.

Regeneration power was studied in burnt plant community in the sixth unit of the Kiskunság National Park in Hungary.

MATERIAL AND METHODS

A part of Bugac Juniper-poplar forest [Junipereto-Populetum albae] was devastated by fire in consequence of the above mentioned reasons in June of 1976. The examinations were started in March of 1978. Floristic composition and cover of interlocking quadrats were studied. The study area was composed of nine 2 × 2 m quadrats, termed "large quadrats" located along a transect in Festucetosum vaginatae subassocitiation of Juniper-polar community. On the gentle slope the first and the second quadrats represented the preburn vegetation — they were untouched by fire — and the 8th and 9th quadrats represented the postburn conditions — they were located on absolutely deeply burnt sand, where 6-8 m high and charred Juniperus communis specimens occurred. The burnt soil layer thickened gradually from the 3rd quadrat to the 7th one.

The species composition of permanent quadrats, chosen on burnt and unburnt areas, were recorded on nine occasion : 06. 03. 1978; 11. 04. 1978; 27. 05. 1978; 20. 06. 1978; 18. 07. 1978; 13. 10. 1978; 25. 06. 1979; 01. 0.8. 1979 and 14. 09. 1979. Beside the observations of responses of flowering plants soil algological examinations were carried on along the same transect in March, June, July and October of 1978. Soil algal species occurring were identified from soil samples of 5-10 g taken at every meter termed "small quadrats" along the 20 m long permanent line removing the 1-2 cm upper soil layer. Soil samples were put into sterile Petri-dishes and they were moistened by distilled water. Microscopical investigations were carried out for a month from sampling and five or ten slides were examined from each of samples. Soil water content, soil temperature and air vapour content were measured at every five meters. Soil water content was measured by air-drying and it was calculated on the basis of formula : $100\frac{a-b}{a}$; where a = the weight of wet soil; b = the weight of the dry soil. Light intensity was measured in March, June and October of 1978. The data are given in the Table 7 by SI system. Air vapour content [relative humidity] was measured by Assman's psyhrometer at one time.

Algal species are listed in Table 6 by phyla and within these alphabetically. Flowering plants are listed in Table 1 by the layering of vegetation and within these alphabetically.

Our aim was to observe the changes of the floristic composition — the development of floristic richness and the stabilization of the vegetation, namely spatial and temporal changes of floras within the observation plots. That is, to follow the pattern transformations of vegetation in postfire condition in an open-forest in Hungary.

Diversity Index (Shannon 1948) was calculated on the basis of sum of dates of the quadrats /H'Q/ and evenness was calculated by Pielou's formula (Pielou 1975). Changes of structure of flowering plants within the quadrats — stability — were examined on the basis of species frequency values of every species in the row of the table suplemented with the species number quadrat. Temporal frequency of species diversity (HF) and evenness (JF) were calculated for detecting all the species present to any·aijspecies's frequency. The examination of life-forms of flowering plant are based on the ratio of participation of the species.

The number of shoots/originated from one group/length was measured for production and productivity investigation in 06. 03. 1977 /1/, 07. 03. 1979 /2/ and 17.09.1980 /3/ in 6., 7., 8. large quadrats and then continued the quadrats along bottom of sand dune valley following the depth of burnt area. Quadrats are sign as 8/1, 8/2...... The RGR = $\frac{\log_2 L_2 - \log_2 L^1}{t_2 - t_1}$ = productivity value, where L = length of shoot in cm; t_2 and t_1 means the space of time between two measurements expressed in days (Květ *et al.* 1971). Similarity function of Jaccard (1908) was used for binary date (floristical composition of samples) with- and without algal species. The WPGMA fusion technique was used for the similarity coefficients (Sneath and Sokal 1973). The BP program package of the Botanical Department of the Hungarian Natural History Museum was run on the CDC-3000 computer of the Hungarian Academy of Sciences. This program was applied here by M. Rajczy.

RESULTS AND DISCUSSION

Postfire changes of the flowering plant community :

The highest difference in species number was observed in the 5th, 7th, 8th and 9th standard quadrats Table (2). The maximal postfire "species density" during the resuccessional process was registered in May and June of 1978 in the "half-open" areas. The species number reaches the lowest value in the 1st and 2nd quadrats. The temporal changes in species number of the quadrats showed rather periodicity than subsidience — taking into consideration the flowering plants only, due to the seed reserves in the soil and/or immigration of opportunistic species in postburnt free soil surface.

Both diversity (HQ) and evenness values (JQ) of the examined quadrats were rather similar (Table 3) column 1. and 2. The highest values occurred in the 1st and 4th quadrats while the lowest ones were in the 7th quadrat but the difference is negligable. Considering the number of observations which were equal (S=number of quadrats) values of H'Q and JQ depend on evenness (*e.g.* H'Q, JQ values of the first quadrat). The structural changes within the quadrats can be expressed more exactly by the temporal or permanent presence of certain species (aij) because their conduct to life-forms as species, vital attribute is characteristic on places being more or less vacated by fire (Raunkiaer 1907, Szujkó-Lacza — Fekete 1969, Fekete — Szujkó-Lacza 1971, Zedler 1977).

H'F values reached the lowest values in the 1st quadrat in contrast with the H'Q values and H'F values reached peak in the 8th quadrat (Table 3, column 3). The lowest JF value was calculated in the 2nd quadrat and the highest one was in the 3rd quadrat (Table 3, column 4).

On the basis of H'F and JF values shown in Table 3, structural stability was modified mostly by the fire in the 8th quadrat. Consequently, no stabilization was reached in species composition during our examinations. *Quercus coccifera* garrigue existing in the French mediterranean regions and burnt repeatedly, is a typical "pyrophytic" community, but postfire stability can come into existance during 90-100 months (Trabaud and Lepart, 1980); 3-6 years are required in a meadow and 15-35 years are required for the chaparral regeneration (Daubenmire 1968, Hanes 1971, Biswell 1974, Wright and Bailey 1982).

Considering the floristic composition: *Astragalus varius, Cephalanthera rubra,* *Koeleria glauca* occurred excepting tree-like species in the 1st and 2nd quadrats. But these perennials were absent in the further quadrats. *Koeleria glàuca* appeared in the 3rd quadrat in 20.04.1978 as a tussock but this species could not settle in other burnt quadrats dùring the next two vegetational periods (Table 1).

In 1978 *Calamagrostis arundinacea, Carex liparicarpos* and *Holoschoenus ramosus* ssp.*ramosus* increased the initial response by their rootstocks, creeping shoots running in deeper level in soil, *e.g.* with rather quick spreading power of species, so-called "vital attributes" (Noble 1981). They are present continuously in more quadrats with 6 or 8 frequency values since April 1978. Considering density values *Calamagrostis* and *Carex* belong to the invasive group of perennials, with tolerate attributes.

The number of perennial herb species were 4-6 and the number of therophytons were 11-13 from the 4th quadrat to the 9th one. Therophyton flora was the richest in the 7th quadrat and most of the mosses settled down here too (Table 1). According to this, structural change in the floral assemblages was the maximum in the 7th quadrat probably due to the soil overstructuration (Almendros *et al.*, 1984a, b) perturbed by burning.

Postfire effects are reflected indirectly in the species-composition differences also. Phosphorous and potassium accumulate in the soil of burnt areas (Rundell, 1979). "Changing in total and resin-extractable phosphorous not altered significantly immediately after the fire, but reduction occurred during the winter (in south-western Cape), and phosphorous increased significantly, but prefire levels were re-attained within four months after fire" (Brown and Mitchell, 1986). The phosphorous and potassium content are favourable for plants requiring higher quantity of minerals. Characteristic representatives of such opportunist plants are the annual *Lappula echinata* and *Funaria hygrometrica* a moss species.

Nutrient cycling in fallow were studied by Mishra and Ramakrishnan (1983) also. The soil fertility was increased postbur but utilization of release nutrients took place earlier in the herbs and later on in dicots or Pinus trees (*cf.* Mishra and Ramakrishnan *l.c.*).

Presumably, the species assemblage of the first quadrat being out of fire effects is determined by the available nutrients and water (Babos 1955a, b; Szodfridt 1979) while the species composition of the 7th, 8th and 9th quadrats mainly depended on available nutrients and light intensity in postfire.

Diversity values based on life-forms were lower than that of H'Q and HF. These lower values were interfered by the lower numbers of the categories *e.g.* life-forms where the S = 6 only. The evenness values reflect really the absence of some species belonging to certain life-form categories.

The structural alternation observed in the intensively burnt areas were determined by *Juniperus communis, Populus alba* and *P. tremula* but in different direction and time. All parts of *Juniperus communis* are rich in resin and they are very flammable. Because of these special quality it plays an important role in increasing the intensity of fire in every period of the year but especially in June. The carbonization of Juniperus and the deep burnt soil results in the rich resin content of the soil. The postfire mineralization and absence of Juniperus give a good opportunity to the invasion of other tree species namely *Populus alba* and *P. tremula.*

Considering the shoot number, *P. alba* is susceptible to activize a great number of buds while *P. tremula* form more vigorous sprouts but less in number. The shoots of *P. alba* were developed in maximal number in the time of second observation but withered sprouts were observed at the same time. The diameter of the sprouts usually were about 5-10 mm, some of them reached 15 mm in diameter and in one or two cases the diameter of the sprouts was 25 mm. One of the sprouts reached a maximal length, it was 213 cm in the time of the third observation. At the same time the mean length of the sprouts of *P. tremula* were bigger than that of *P. alba* in six quadrats. The diameter of *P. tremula*'s sprouts reached 5 mm rarely, and they were usually 12-15 mm in diameter, some of them exceed 30 mm. RGR (relative growth rate) values can be calculated in case of *P. alba* because of the frequency of the observations. A maximal productivity was registered at the lower part of the slope in the time of the second observation (Table 5).

POSTFIRE OBSERVATION IN THE ALGAL SYNUSIA

Pioneers on the naked soil are always the soil algae which disappear with increasing density of higher plants on the site. Results of algological examinations carried out in the burnt Juniper forest at Bugac in 1978 are shown in Table 6. The observation dates can be analised in different points of view: on the basis of algal species assemblage existing in the burnt area; by the algal floras leaving in various permanent quadrats in different time of observations and on the basis of algal floras existing different time in connection with ecological conditions, sticking to the essentials. Species of the Cyanophyta (14) and then Chlorophyta (7) are characteristic here. They were most frequent in summer generally, while no algae were found six cases in March and five cases in October (Table 6).

The 0-1 m area is shaded by Juniper shrub and this quadrat is characterized by low light intensity and soil temperature and somewhat higher water content (Table 7). There were only blue-green algae the maximum of species number were observed in summer. The highest value of light intensity were measured from 2 – into 5 m of the transect (Table 7), where rather extensive bare soil patches occurred and the high soil temperature coupled with very low air vapour and soil water content. Rich Cyanophyton flora was registered (2-5 quadrat), diatoms and coccoid green algae occurred rarely. In intact unburnt or weekly burnt soil there are Nostoc commune (1-4 small quadrats), *Navicula mutica* (in 1., 6., 9.), *Pinnularia borealis* (2., 3., 4., 6. and 7. small quadrats) occurring. *Phormidium corium* occur in moderately burnt quadrats in summer and in autumn also, *Plectonema gracillinum* in March and June (except one case). The appearance of *Holoschoenus* (Table 1) between 6-10 m relate to relatively higher soil water content. Light intensity and soil temperature were lower than in the upper part because shading of the relatively big species. Cyanophyta, Chlorophyta and Chrysophyta species occurred equally but the number of species were low and soil samples were absolutely negative in six case. The 11-13 m section were characterized by lower density of the flowering plants (Table 1 , large quadrats 6), the number of species were rather high during the vegetational period, there was only one sample without algae. Beside Cyanophyton dominance some diatom, green and yellow-green algal species were registered also in the samples.

Between 15 m and 20 m rigorous sprouts of *Populus alba* and *P. tremula* (Table 5) occurred and by their strong evaporation, the soil water level was permanently lower than in the other parts of the sandy area and low light intensities were coupled with high relative air vapour content (Table 7).

This section was characterized by the absence of Cyanophyton species. Beside the rare occurrence of diatoms the frequent presence of green and yellow-green algal species are characteristic (Table 6).

Only in the deeply burnt soil *Chlorhormidium dissectum* and the somewhat more widely tolerant *C. flaccidum* and *Heterothrix strichococcoides,* appear.

There are signs of seasonality *e.g. Nostoc microscopicum* occurs in 1., 4. and 5. small quadrats in March; the three most frequent species *Gloeocapsa punctata* grow in 15, *Chlorella zofingensis* in 12 and *Vischeria stellata* in 13 small quadrats in summer; and *Phormidium foveolarum* with highest frequency value 26 case in 15 small quadrats since summer till autumn.

Pinnularia borealis moderately frequent (15 case) in five small quadrats restricted to July and October.

Presence of *Chlorhormidium humicolum* and *Hantzschia amphyoxis* seems to be independent of the time and space here (Table 6). Taking into consideration the spatial and temporal distribution of flowering plants (Table 1) the indirect regulator factors of the number of algae cause the presence of flowering plants, their growth-type and density because of their effects on light conditions and by the change of the air vapour content.

SIMILARITY INVESTIGATIONS

The question was : what is the similarity between the samples (quadrats) pair-wise and how they altered in time with and without soil algae species.

There are no steady decreasing or increasing values between the pairs in any case. Maximal similarity is exhibited between the large quadrats 7 and 8 in 27 May 1978, but the values remained high enough in July 1978 and also in June 1979. Quadrats 6 and 7 in June 1978 show similarity. However, the similarity altered between the pairs during investigation.

The unburnt first and second quadrats have less similarity to each other and any others considering the higher- and cryptogamous species, without soil algae, during investigation (Figs. 1-13). Quadrats are divided almost always into two or three main groups (Figs.1-13). The groups seem to follow an opposite direction to the elevation. This direction of slope is parallel to the thickening of burnt soil, without algae species. New similarity relations among the quadrats appear due to complete species composition (Figs. 10-13).

The 7th quadrat is altered in position among the groups. This is a transitional sample because of the invasion of *Populus tremula* in the 7th quadrat, later than in the 8th and 9th quadrats; the "flora" of therophytonous annuals was richest in the 7th; most of mosses and two lichen species settled down here. These lichens are absent in the next two quadrats. This quadrat has the highest number of soil algae also. Fifteen algae species (Table 6 , 13. and 14. small quadrats) occur in it. Special character was given by cryptogamous species, that strengthened dissimilarity among "own group" (7., 8., 9. large quadrats) by soil algae (Figs.10-13). Seasonality, resuccession and species invasion effects predominate in this quadrats.

Highest similarity occurs among the 4th, 5th and 6th quadrats situated in the middle of the sample series, with and without algae.

Species attribute of *Populus alba* and *P. tremula* — the creeping shoot in the soil — becomes characteristic in the last three quadrats forming a bush by new shoots in the deeper part of "valley" of the slope while *P. alba* appears threadwise in the middle quadrats.

Considering all of the species from soil algae to the higher plants in four cases we have the next results : the first three (large) quadrats stand in one group by dissimilarity in the first and fourth recording time, while the third one is almost independent without

Similarity dendrograms without soil algae

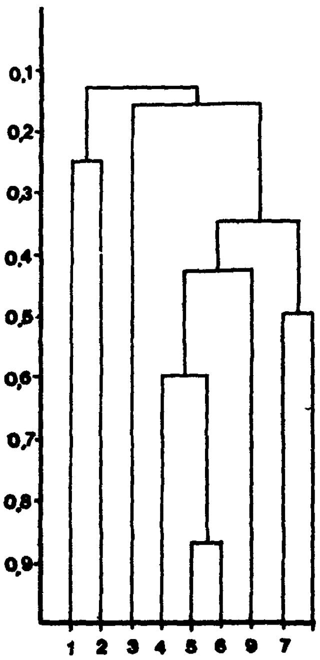

Fig. 1.

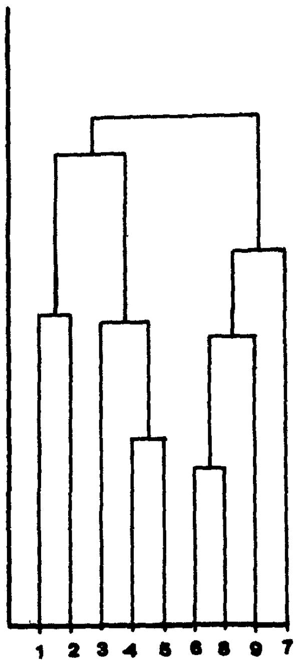

Fig. 2.

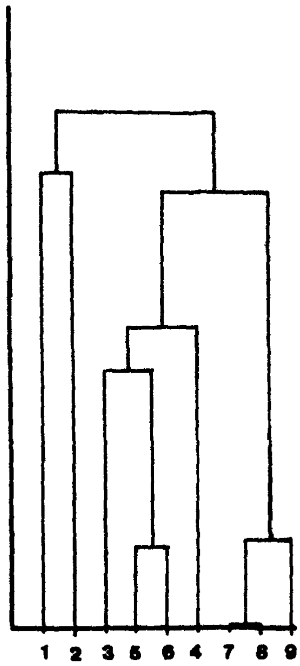

Fig. 3.

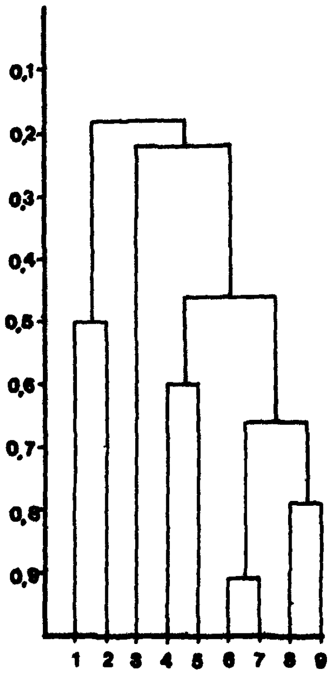

Fig. 4.

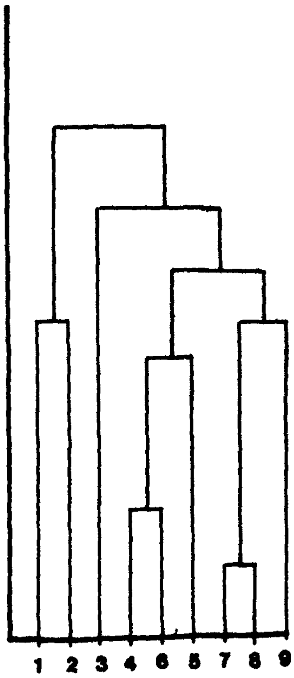

Fig. 5.

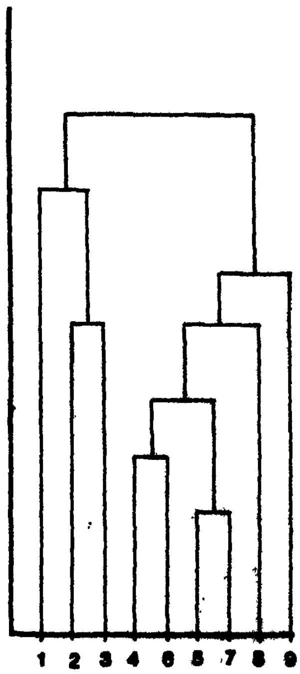

Fig. 6.

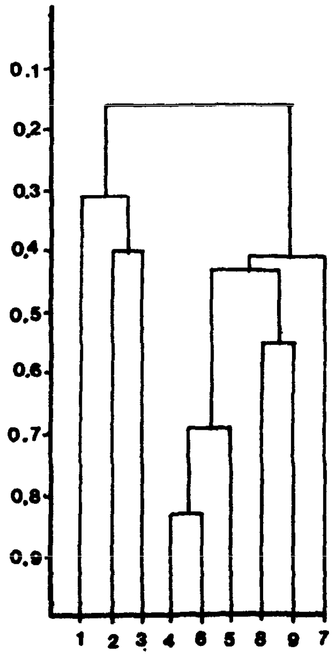

Fig. 7.

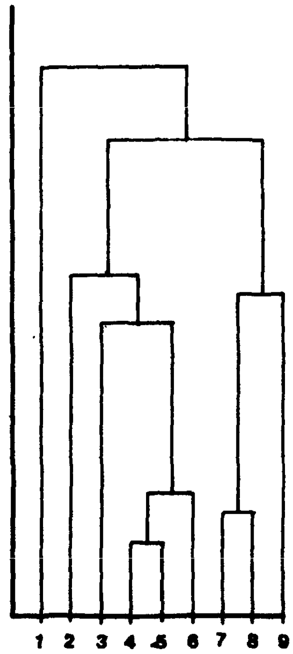

Fig. 8.

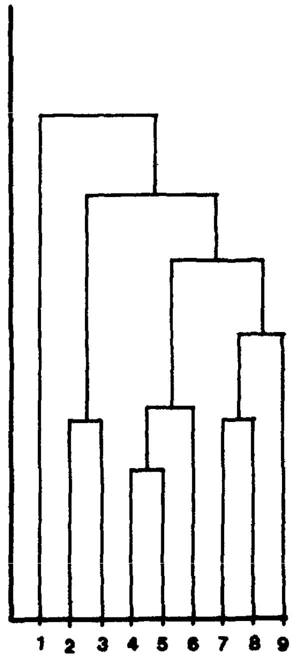

Fig. 9.

Similarity dendrograms of higher and cryptogamous species

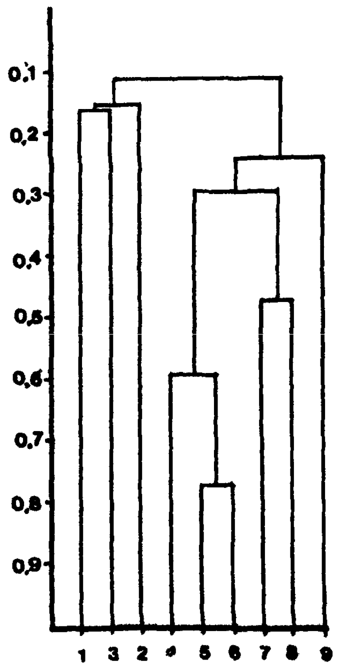

Fig. 10.

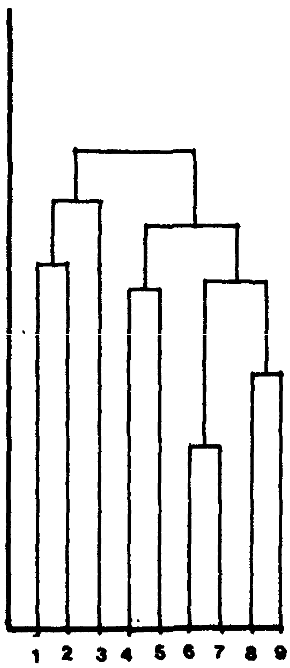

Fig. 11.

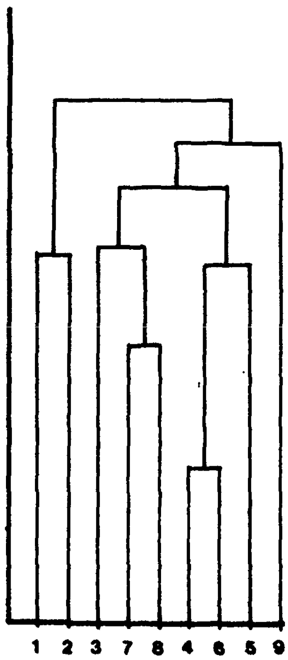

Fig. 12.

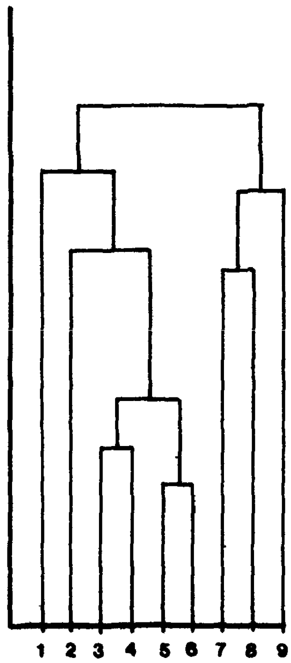

Fig. 13.

Occurrence of flowering, moss and lichen species in burnt Juniper-poplar forest at Bugac in Hungary.

TABLE 1 (Continued up to p. 100)

	Large quadrat No.	1.		2.		3	
	Ser. no. of recording time						
	Species	1.2.3.4.5.6.7.8.9.		1.2.3.4.5.6.7.8.9.		1 2 3 4 5 6.7 8.9.	
Canopy A.	*Juniperus communis*	1 1 1 1 1 1 1 1 1	9	_ _ _ _ _ _ _ _ _	0	_ _ _ _ _ _ _ _ _	0
	Populus alba	1 1 1 1 1 1 1 1 1	9	_ _ _ _ _ _ _ _ _	0	_ _ _ _ _ _ _ _ _	0
Shrub B.	*Populus alba*	_ _ _ _ _ _ _ _ _	0	1 1 1 1 1 1 1 1 1	9	_ _ _ _ _ _ _ _ _	0
Herb C.	*Alkanna tinctoria*	_ _ _ _ _ _ _ 1 1	2	_ _ _ _ _ _ _ _ _	0	_ _ _ _ _ _ _ _ _	0
	Arenaria serpyllifolia	_ _ _ _ _ _ _ _ _	0	_ _ 1 _ _ _ _ _ _	1	1 _ 1 _ _ _ _ _ _	2
	Astragalus varius	_ _ _ _ _ _ _ 1 1	2	_ _ _ _ _ _ _ _ _	0	_ _ _ _ _ _ _ _ _	0
	Bromus squarrosus	1 _ _ _ _ _ _ _ _	1	1 _ _ _ _ _ _ _ _	1	_ _ _ _ _ _ _ _ _	0
	Calamagrostis arundinacea	_ _ _ _ _ _ _ _ _	0	_ _ _ _ _ _ _ _ _	0	_ _ 1 1 1 1 1 1 _	6
	C. epigeos	1 1 1 1 1 1 1 1 1	9	_ 1 1 1 1 1 _ _ 1	6	_ _ _ _ _ _ _ _ _	0
	Carex liparicarpos	1 1 1 1 1 1 1 1 1	9	1 1 1 1 1 1 1 1 1	9	1 1 1 1 1 1 1 1 1	9
	Cephalanthera rubra	_ _ _ _ _ _ _ _ _	0	_ _ 1 _ _ _ _ _ _	1	_ _ _ _ _ _ _ _ _	0
	Cynodon dactylon	_ _ _ _ _ _ _ _ _	0	_ _ _ _ _ _ _ _ _	0	_ _ _ 1 _ _ _ _ _	1
	Erophyla verna	_ 1 _ _ _ _ _ _ _	1	_ 1 _ _ _ _ _ _ _	1	_ 1 _ _ _ _ _ _ _	1
	Erygeron canadensis	_ _ _ _ _ _ _ _ _	0	_ _ _ 1 _ 1 _ _ 1	3	_ _ _ _ 1 1 _ 1 1	4
	Holoschoenus ramosus ssp. holoschoenus	_ _ _ _ _ _ _ _ _	0	_ _ _ _ _ _ _ _ _	0	_ 1 1 _ _ _ _ _ _	2
	Koeleria glauca	_ 1 1 1 1 1 1 1 1	8	1 1 1 1 1 1 1 1 1	9	_ _ _ 1 1 1 1 1 1	6
	Minuartia verna	_ _ 1 1 _ _ _ _ _	2	1 1 _ 1 _ 1 _ _ _	4	_ _ _ _ _ _ _ _ _	0
	Myosotis micrantha	_ _ _ _ _ _ _ _ _	0	_ _ 1 _ _ _ _ _ _	1	_ 1 1 _ _ _ _ _ _	2
	Tragopogon floccosus	_ _ _ _ _ _ _ _ _	0	_ _ _ _ _ _ _ _ _	0	_ _ _ 1 _ _ _ _ _	1
	Tragus racemosus	_ _ _ _ _ _ _ _ _	0	_ _ _ _ _ _ _ 1 1	2	1 _ _ _ 1 _ 1 1 1	5
	Senecio vulgaris	_ _ _ _ _ _ _ _ _	0	_ _ 1 _ _ _ _ _ _	1	_ _ _ _ _ _ _ _ _	0
	Setaria viridis	_ _ _ _ _ _ _ _ _	0	_ _ _ _ _ 1 _ _ _	1	_ _ _ _ 1 1 _ _ _	2
	Viola arvensis	_ _ _ _ _ _ _ _ _	0	_ _ _ _ _ _ _ _ _	0	_ 1 1 1 _ _ _ _ _	3
	Lichenes						
	Ceratodon purpureus	_ _ _ _ _ _ _ _ _	0	_ _ _ _ _ _ _ _ _	0	_ 1 1 _ _ _ _ _ _	2
	Tortella inclinata	_ _ 1 1 1 _ _ 1 1	5	1 1 _ _ _ _ _ _ _	2	_ 1 1 1 _ 1 _ 1 1	6
	Tortula ruralis	1 _ _ 1 1 1 _ _ _	4	_ _ _ _ _ _ _ _ _	0	_ 1 1 1 _ 1 1 1 1	7
	N =	6 6 7 8 7 6 5 8 8=59		6 7 8 6 4 7 3 4 6=51		3 8 9 8 6 7 5 7 6=59	

N = HQ sum of the columne, S = number of investigation = 9;
N = HF = sum of row; S = number of species in quadiat;

Contd. Table 1

Large quadrat No.	4										5										6.									
Serial no. of recording time / Species	1	2.	3.	4.	5.	6.	7.	8.	9.		1	2.	3	4	5	6	7	8	9		1.	2.	3	4.	5.	6.	7	8:	9	
A. *Juniperus communis*	—	—	—	—	—	—	—	—	—	0	x	x	x	x	x	x	x	x	x	X	x	x	x	x	x	x	x	x	x	X
B. *Populus alba*	1	1	1	1	1	1	1	1	1	9	1	1	1	1	1	1	1	1	1	9	1	1	1	1	1	1	1	1	1	9
C. *Arenaria serpyllifolia*	1	—	—	—	—	—	—	—	—	1	1	—	1	1	—	—	—	—	—	3	1	—	1	1	—	—	—	—	—	3
Calamagrostis arundinacea	—	1	1	1	1	1	1	1	1	8		1	1	1	1	1	1	1	1	8	—	1	1	1	1	1	1	1	1	8
Carex liparicarpos	1	1	1	1	1	1	1	1	1	9	1	1	1	1	1	1	1	1	1	9	1	1	1	1	1	1	1	1	1	9
Cerastium dubium	—	1	—	—	—	—	—	—	—	1	—	1	—	1	—	—	—	—	—	2	—	1	—	—	—	—	—	—	—	1
Cynodon dactylon	—	—	—	—	1	—	—	—	—	1	—	—	—	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	0
Cynoglossum officinale	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	0	—	1	—	—	—	—	—	—	—	1
Erophyla verna	1	1	—	—	—	—	—	—	—	2	1	1	—	—	—	—	—	—	—	2	1	1	—	—	—	—	—	—	—	2
Erigeron canadensis	1	—	—	1	1	1	1	1	1	7	—	—	—	1	1	1	1	1	1	6	—	—	—	1	1	1	1	1	1	6
Holoschoenus ramosus ssp. holoschoenus	1	1	1	1	—	1	1	1	1	8	1	1	1	1	1	—	1	1	1	8	1	1	1	1	—	1	1	1	1	8
Koeleria glauca	—	—	—	—	—	—	—	—	—	0	1	1	—	—	—	—	—	—	—	2	1	—	—	—	—	—	—	—	—	1
Lappula echinata	—	—	—	—	—	—	—	—	—	0	1	—	1	1	—	—	—	—	—	3	—	—	1	1	—	—	—	—	—	2
Lithospermum arvense	—	—	1	1	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	0
Medicago lupulina	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	0	—	1	—	—	—	—	—	—	—	1
Minuartia verna	—	—	1	—	—	—	—	—	—	1	—	—	—	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	0
Myosotis micrantha	—	1	1	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	0	—	—	—	1	—	—	—	—	—	1
Pimpinella saxifraga	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	0	—	—	1	1	—	1	—	—	—	3
Poa angustifolia	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	0	—	—	—	1	—	—	—	—	—	1
Populus alba	—	—	—	—	—	—	1	1	1	3.	—	—	—	—	—	—	1	1	1	3	—	—	—	—	—	—	—	—	—	0
Saxifraga tridactylites	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	0	—	1	—	—	—	—	—	—	—	1
Senecio vulgaris	—	—	—	—	—	—	—	—	—	0	1	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	1
Setaria viridis	—	—	—	—	—	1	—	1	1	3	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	0
Stellaria media	—	—	—	—	—	—	—	—	—	0	—	1	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	1
Taraxacum officinale	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	1	1
Tragopogon floccosus	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	0
Tragus racemosus	—	—	—	—	—	—	—	1	1	2	—	—	—	—	—	—	1	1	—	2	—	—	—	1	—	—	—	1	1	3
Viola arvensis	—	1	1	1	—	—	—	—	—	3	—	1	1	1	—	—	—	—	—	3	—	—	1	—	—	—	—	—	—	1
V. kitaibeliana	—	—	—	—	—	—	—	—	—	0	—	—	—	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	0
Bryophytes																														
Bryum argenteum	1	—	—	—	—	—	—	—	—	1	1	1	—	—	—	—	—	—	—	2	1	—	—	—	—	—	—	—	—	1
Tortella inclinata	1	—	—	1	1	1	1	1	1	7	1	1	1	1	1	1	1	—	1	8	1	1	1	1	1	1	1	1	—	8
Tortula ruralis	1	—	—	1	1	1	1	1	1	7	1	1	1	1	1	1	1	1	1	9	1	1	1	1	1	1	1	1	—	8

Contd. Table 1

Lichenes	4.		5.		6.	
Cladonia convoluta	— — — 1 — 1 1 1 —	4	1 — 1 — — — — — —	2	— — — — — 1 — 1 —	2
Cl. cornutoradiata	1 — — — — — — — —	1	— — — 1 — — 1 — —	2	— — — — — — — — —	0
Parmelia pokornyi	— — — — — — — — —	0	— — — 1 — — — — —	1	— — — — — — — — —	0
N =	108 8 107 9 9 11 10	=82	12 12 10 13 10 6 11 8 8	= 90	10 12 10 13 6 9 7 9 7	= 83

Large quadrat No.	7.		8.		9.	
Serial no. of recording time	1. 2. 3. 4. 5. 6. 7. 8. 9.		1. 2. 3. 4. 5. 6. 7. 8. 9.		1. 2. 3. 4. 5. 6. 7. 8. 9.	
Species						
A. *Juniperus communis*	x x x x x x x x x	X	x x x x x x x x x	X	x x x x x x x x x	X
B. *Euonymus europaeus*	— — — — — — — — —	0	— — — — — — — — —	0	— — 1 1 1 1 1 1 1	7
Ligustrum vulgare	— — — — — — — — —	0	— — — — — — — — —	0	— — — 1 1 1 1 1 1	6
Populus alba	1 1 1 1 1 1 1 1 1	9	1 1 1 1 1 1 1 1 1	9	1 1 1 1 1 1 1 1 1	9
P. termula	— — 1 1 1 1 1 1 1	7	1 1 1 1 1 1 1 1 1	9	— — 1 1 1 1 1 1 1	7
C. *Arenaria serpyllifolia*	1 1 1 1 1 — — — —	5	1 1 1 1 1 — — — —	5	1 1 1 1 1 — — — —	5
Calamagrostis arundinacea	— 1 1 1 1 1 1 1 1	8	— 1 1 1 1 1 1 1 1	8	1 — 1 1 1 1 1 1 1	8
Carex liparicarpos	— 1 1 1 1 1 1 1 1	8	— 1 1 1 1 — 1 — 1	6	1 — 1 1 1 1 — — 1	6
Cerastium dubium	— 1 — — — — — — —	1	— 1 — — — — — — —	1	1 — — — — — — — —	1
Cynodon dactylon	— — — — 1 — — — —	1	— — — — 1 — — — —	1	— — — — — — — — —	0
Cynoglossum officinale	— 1 1 — — — — — —	2	— 1 1 — — — — — —	2	— 1 1 — — 1 — 1 —	4
Erophyla verna	1 — — — — — — — —	1	1 1 — — — — — — —	2	1 1 — — — — — — —	2
Erygeron canadensis	— 1 — 1 1 1 — 1 1	6	1 — — 1 1 1 1 1 1	7	1 — — 1 1 1 1 1 1	7
Holoschoenus ramosus ssp. *holoschoenus*	— — — 1 — — 1 — 1	3	— 1 — 1 — 1 — — —	3	— 1 — 1 1 — 1 — —	4
Koeleria glauca	1 — — — — — — — —	1	— — — — — — — — —	0	— — — — — — — — —	0
Lappula echinata	1 — 1 1 — — — — —	3	1 — 1 — — — — — —	2	— — 1 — — — — — —	1
Medicago lupulina	— 1 1 — — — — — —	2	1 1 1 — — — — — —	3	— 1 1 — — — — — —	2
Myosotis micrantha	— — — 1 — — — — —	1	— — — 1 — — — — —	1	— — — 1 — — — — —	1
Pimpinella saxifraga	1 — 1 1 1 — 1 1 —	6	— — 1 1 — — — 1 1	4	— — 1 1 1 — — — 1	4
Poa angustifolia	1 1 1 1 — — — — —	4	1 — 1 1 — 1 1 — 1	6	1 — 1 1 — 1 1 — 1	6
Populus tremula	— — — — — — 1 — 1	2	— — — — — — — — 1	1	— — — — — — — — —	0
Saxifraga tridactylites	— — — — — — — — —	0	— 1 — — — — — — —	1	— 1 — — — — — — —	1
Senecio vulgaris	— — 1 — — — — — —	1	— — 1 — — — — — —	1	1 — 1 — — — — — —	2

Contd. Table 1

7.

Species										
Setaria viridis	—	—	—	—	1	—	—	—	—	1
Taraxacum officinale	—	—	—	—	—	—	—	—	—	0
Tragus racemosus	—	—	—	1	—	—	—	—	—	1
Viola arvensis	—		1	—	—	—	—	—	—	1
Bryum argenteum	—	—	—	—	—	—	—	—	—	0
Ceratodon purpureum	—	—	—	—	—	—	—	—	—	0
Funaria hygrometrica	—	—	—	—	—	—	—	—	—	0
Tortella inclinata	1	1	1	—	—	—	1	1	1	6
Tortula ruralis	—	1	1	1	—	—	—	1	—	4
Cladonia convoluta	—	1	1	—	—	—	—	—	—	2
Parmelia pokornyi	—	1	—	—	—	—	—	—	—	1
N =	8	13	15	13	9	5	8	8	8	=87

8.

Species										
Setaria viridis	—	—	—	—	1	—	—	—	—	1
Taraxacum officinale	—	—	—	—	—	—	—	—	—	0
Tragus racemosus	—	—	—	—	—	—	—	—	—	0
Viola arvensis	—	—	1	1	—	—	—	—	—	2
Bryum argenteum	1	—	—	—	—	—	—	—	—	1
Ceratodon purpureum	—	—	—	—	—	—	—	—	—	0
Funaria hygrometrica	—	—	—	—	—	—	—	1	—	1
Tortella inclinata	1	1	1	—	—	—	1	1	1	6
Tortula ruralis	—	1	1	—	—	—	1	1	1	5
Cladonia convoluta	—	—	—	—	—	—	—	—	—	0
Parmelia pokornyi	—	—	—	—	—	—	—	—	—	0
N =	10	13	14	11	8	6	8	8	10	=88

9.

Species										
Setaria viridis	—	—	—	—	—	—	—	—	—	0
Taraxacum officinale	1	1	1	1	1	1	—	—	1	7
Tragus racemosus	—	—	—	—	—	—	—	—	—	0
Viola arvensis	—	—	1	1	—	—	—	—	—	2
Bryum argenteum	1	1	1	—	—	—	—	1	1	5
Ceratodon purpureum	1	1	1	—	—	—	—	1	1	5
Funaria hygrometrica	1	1	1	1	1	1	1	1	1	9
Tortella inclinata	—	—	—	—	—	—	—	—	—	0
Tortula ruralis	—	—	—	—	—	1	—	—	—	1
Cladonia convoluta	—	—	—	—	—	—	—	—	—	0
Parmelia pokornyi	—	—	—	—	—	[ ]	—	—	—	0
N =	13	11	17	15	12	14	9	10	13	=114

Abbreviations : [ ] = mushrooms; x = remnants of carbonized Junipers; Two *mushrooms Tulostoma brunale* and *T. melanocyclum* grow here. The next species 60-80 cm occurring far from burnt area :

Asperula cynanchica, Carduus nutans, Chrysopogon gryllus, Coronilla varia, Festuca vaginata, Fumana procumbens, Linum hirsutum ssp. *glabrescens, Melandrium album, Onosma arenaria, Salix rosmarinifolia, Teucrium chamaedrys.*

TABLE 2

Changes in species number in the quadrats from 6.03. 1978 till 14.09.1979

Number of quadrats	Number of species min.	max.	diff.	Date of the maximum	
1.	5	8	3	20.04.	1978
2.	3	8	5	27.05.	"
3.	3	9	6	27.05.	"
4.	7	11	4	27.03-05.	"
5.	6	13	7	20.06.	"
6.	6	13	7	20.06.	"
7.	5	15	10	27.05.	"
8.	6	14	8	27.05.	"
9.	9	17	8	27.05.	"

TABLE 3

Diversity /H'Q/, equitability /JQ/ values in the different quadrats and diversity /H'F/ and evenness /JF/ values calculated on the basis of the occurrence /Frequency/ of the same plant species /Table 1/

Number of quadrats	H'Q	JQ	H'F	JF
1.	3.1582	0.9963	3.1415	0.9081
2.	3.1119	0.9817	3.3616	0.8604
3	3.1297	0.9887	3.8492	0.9231
4.	3.1531	0.9947	3.9697	0.9038
5.	3 1398	0.9904	4.2820	0.9111
6	3.1288	0.9870	4.0999	0.8829
7.	3.0887	0.9744	4.2880	0.9123
8.	3.1453	0.9922	4.3563	0.9162
9.	3.1456	0.9923	4 1516	0.8832

TABLE 4

Diversity and evenness values calculated by life-form of the species

Number of quadrats	Life-forms					
	Th	H	G	M-MM	lichens	mosses
1.	3	5	0	2	0	2
2.	8	4	1	1	0	1
3.	8	6	0	1	0	3
4.	11	4	0	1	2	4
5.	11	6	0	1	3	4
6.	13	5	0	1	3	3
7.	13	66	0	2	3	4
8.	12	4	0	3	0	4
9.	11	5	0	4	0	4

N= 192 = the sum of the species number in different life-form categories, S= the sum of the life-form categories, + = mosses and lichens were considered as independent life-form categories.

TABLE 5

Production and productivity — RGR — of Populus alba specimens occurring in deeply burnt area

Number of quadrats	time /1/ Shoot number	Shoot $\bar{x}$ length in cm	/2/ Shoot number	Shoot $\bar{x}$ length in cm	/3/ Shoot number	Shoot x length in cm	RGR t_2-t_1	RGR t_3-t_2
6	3	92	7	97	4	125	0.0265	0.0845
7	4	82	4	97	5	118	0.0840	0 0653
8.	7	108	6	112	3	166	0.0181	0 1311
8/1	5	92	3	112	6	85	0.0983	0.0919
8/2	2	94	4	100	2	150	0.0309	0.1351
8/3	3	85	3	117	8	141	0.1597	0.0622
8/4	6	64	8	133	4	110	0.3657	0.0633

Production of Populus tremula specimens in t /3/

Number of quadrats	Shoot number	Shoot x length in cm
6.	2	186
7.	2	245
8.	2	112
8/1	2	136
8/2	8	142
8/3	2	282
8/4	3	175

TABLE 6

Occurrence of soil algae in burnt Juniper-poplar community at Bugac

Large quadrat No.	1.								2								
Small quadrat No.	1.				2.				3.				4.				
Month of observations	III.	VI.	VII.	X.	III.	VI.	VII.	X.	III.	VI.	VII.	X.	III.	VI.	VII.	X.	Freq.
Species																	
Chroococcus minutus													1				1
Cylindrospermum vouki													1				1
Gloeocapsa punctata		1					1						1	1			4
Nostoc commune		1					1		1				1				4
Nostoc microscopicum	1												1				2
Phormidium angustissimum		1															1
Ph. foveolarum		1		1			1	1				1		1	1	1	8
Ph. paulsenianum													1				1
Plectonema gracillinum	1																1
Synechococcus aeruginosus	1																1
Chlorella zofingensis											1			1			2
Chlorhormidium flaccidum																	0
Chlorococcum humicolum		1					1								1		3
Hantzschia amphyoxis						1	1			1						1	4
Navicula mutica	1																1
Pinnularia boralis							1				1					1	3
Summa	4	5	0	1	0	1	6	1	1	1	2	1	6	3	2	3	

Contd. Table 6

Large quadrat No.	3.								4.								
Small quadrat No.	5.				6.				7.				8.				
Month of observations	III.	VI.	VII.	X.	III.	VI.	VII.	X.	III.	VI.	VII.	X.	III.	VI.	VII.	X.	Freq.
Species																	
Gloeocapsa punctata		1			1						1						3
Microcoleus vaginatus	1																1
Nostoc microscopicum	1																1
Phormidium angustissimum			1														1
Ph. foveolarum	1			1				1				1				1	5
Plectonema gracillinum															1		1
Tolypotrix distorta	1																1
Chlorella zofingensis		1								1							2
Chlorhormidium flaccidum					1												1
Chlorococcum humicolum							1	1			1	1			1		5
Pleurochloris commutata			1								1						2
Vischeria stellata					1												1
Hantzschia amphyoxis				1	1	1		1								1	5
Navicula mutica					1												1
Pinnularia borealis								1				1					2
	4	2	2	2	5	1	1	4	0	1	3	3	0	0	2	2	

Contd. Table 6

Large quadrat No.	5.								6.								
Small quadrat No.	9.				10.				11.				12.				
Month of observations	III.	VI.	VII.	X.	III.	VI.	VII.	X.	III.	VI.	VII.	X.	III.	VI.	VII.	X.	Freq.
Species																	
Gloeocapsa punctata						1				1	1			1	1		5
Phormidium angustissimum										1				1			2
Ph. corium										1				1			2
Ph. foveolarum			1	1				1		1	1	1		1		1	8
Plectonema gracillinum						1				1					1		3
Chlorella zofingensis		1	1			1				1				1			5
Chlorococcum humicolum				1						1	1	1			1		5
Monodus subterranea		1															1
Vischeria stellata		1				1		1		1		1		1			6
Pleurochloris commutata															1		1
Hantzschia amphyoxis				1				1	1	1		1			1	1	7
	0	3	2	3	0	4	0	3	1	9	3	4	0	6	5	2	

Contd. Table 6

Large quadrat No.	7.								8.								
Small quadrat No	13.				14.				15.				16.				
Month of observations	III.	VI.	VII.	X.	III.	VI.	VII.	X.	III.	VI.	VII.	X.	III.	VI.	VII.	X	Freq
Species																	
Cylindrospermum vouki					1												1
Gloeocapsa punctata	1		1			1	1						1				5
Phormidium angustissimum		1	1														2
Ph. corium		1	1	1													3
Ph. foveolarum		1		1			1										3
Ph. fragile			1														1
Plectonema gracillinum	1																1
Synechococcus aeruginosus		1															1
Chlorhormidium flaccidum				1													1
Chlorococcum humicolum			1	1			1	1			1	1	1				7
Palmellococcus miniata	1																1
Heterothrix stichococcoides								1									1
Pleurochloris cummutata			1								1						2
Vischeria stellata	1	1			1	1					1		1				6
Hantzschia amphyoxis	1								1				1		1		4
	5	5	6	4	2	2	3	2	1	0	3	1	4	0	1	0	

Contd. Table 6

Large quadrat No.	9.								10								
Small quadrat No.	17.				18.				19.				20.				
Month of observations	III.	VI.	VII.	X.	III.	VI.	VII.	X.	III.	VI.	VII.	X.	III.	VI.	VII.	X.	Freq.
Species																	
Gloeocapsa punctata		1				1				1	1						4
Phormidium foveolarum																1	1
Chlorella zofingensis		1				1				1	1			1	1		6
Chlorhormidium dissectum	1		1		1												3
Ch. flaccidum	1	1	1		1												4
Chlorococcum humicolum									1		1						2
Trebouxia arboricola					1												1
Heterothrix stichococcoides					1												1
Vischeria stellata		1	1			1			1		1			1			6
Hantzschia amphyoxis			1				1		1								3
	2	4	4	0	4	3	1	0	3	2	4	0	0	2	1	1	

TABLE 7

Ecological data

Year 1978	Soil Temperature °C					Soil water content					Light intensity in Lux				
m.:	0.	5.	10.	15.	20.	0.	5.	10.	15.	20.	0.	5.	10.	15.	20.
Month															
03	15.2	19.0	15.8	15.2	15.8	12.9	4.1	5.4	2.9	2.2	8500	17000	—	13000	—
06	20.6	41.0	30.2	28.2	29.4	0.6	0.2	0.4	1.2	0.4	—	—	—	—	—
07	23.6	32.4	32.4	30.4	31.2	0.7	0.2	0.3	0.9	0.5	6800	24000	20000	12000	16000
10	20.0	23.1	16.2	20.2	18.0	0.5	0.6	0.6	3.8	1.8	9000	44000	15000	11000	5000

	Air vapour content in %			
06	70	60	80	90

soil algae (Figs.1 , 4). This own character was restricted to the first two quadrats in the fifth and sixth recording time. The 3rd quadrat comes to a loose connection with the seventh and eighth in the 5th, and than with fourth, fifth and sixth quadrats in the 6th recording time.

Strongest similarity degree remains among the 4th, 5th and 6th quadrats with and without soil algae (Figs 1 10). Algae seem to be sensitive to burning effect (cf. Johansen *et al.* 1982), as shown here by the fact that similarities decrease between the 4th and 5th quadrats and the next two pairs (6-7, 8-9) considering all the flowering and cryptogamous species in the fourth recording time (Figs. 4 11). Similar phenomena appear between the 4 and 6, and the 7 and 8 quadrats pairwise in the 5th recording time. New quadrats connection took place 4., 6., 5., 7. (Fig. 6); 3., 4., 5., 6. (Fig. 13) considering the soil algae too. Competitive effect of Fumaria and higher plants against the soil algae prevails and there is increased dissimilarity among the last three quadrats in the sixth recording time (Figs.6 22).

CONCLUSION

Summarising the results, it can be stated that the examined flowering plant community existing on the burnt area did not reach to stability within two growing seasons.

H'Q and JQ values support less information than H'F and JF values in the case of stability and in the measurement of the effects of fire.

Considering the life-forms of flowering plants exhibiting in the burnt quadrats, it can be stated that the number of Therophyts doubled including the mosses and lichens while the number of perennials were moderate. This duality relates to the existence of secunder and resuccessional process. As this community has a very flammable species component — Juniperus — it is moderately resistent to fire perturbation.

Most of the flowering plants occurring in control areas are perennials but the density of herb layer is moderate resulting in the occurrence of the following species : *Setaria italica, Tragus racemosus* (both of them have a short life-cycle) and lichens.

The part of Bugac Juniper forest burnt in July 1976 is surrounded by unburnt wild Junipereto-Populetum stands. Therophyton species, lichens and mosses returned from the wild areas, and soil seed reserves were activated during two vegetational periods. Characteristic opportunist moss species, *Funaria hygrometrica* occupy rather big-areas in deeply burnt soil surfaces. *Chlorhormidium dissectum, C. flaccidum* and *Heterotrix stichococcoides* soil algae are associated to *Funaria* here.

Koeleria glauca was the first among perennials which could return to burnt areas. *Calamagrostis arundinacea, Carex liparicarpos, Populus alba, P. tremula* belong to the group of invasional species and they spread by underground sprouts. *Phormidium foveolarum, Chlorhormidium humicolum* and *Hantzschia amphyoxis* algae species may belong to this opportunist group. According to these, our investigations are not in concordance with Abrahamson (1984 a) who stated "Fire is not a successionating disturbance in the Clementsian sense" Considering our results, postfire succession is strongly "habitat-dependent" process. including changes of burnt soil, seed reserve, in it, and remained species surrounding the fire site also.

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