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Early post-fire changes in *Pinus brutia* forests (Amanos Mountains, Turkey)

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Abstract – We studied the species composition and soil nutrients in a *Pinus brutia* forest after a fire that occurred in 1989. Four permanent plots were created in the burnt and not burnt areas in the Amanos Mountains of Turkey. The floristic richness, biological spectra, above ground phytomass and soil features in the study areas were assessed during the first three years after the fire. After the fire, we found a reduced amount of organic matter (14.3%), total nitrogen (22%) and soil water saturation (13.1%), but an increased amount of available phosphorus (71%), acidity (3.6%), cation exchange capacity (9.9%), exchangeable sodium (20.8%) and exchangeable potassium (37.1%). The aboveground phytomass in the burned area reached 5284 kg ha^{-1}, the third year after the fire. Forty-six pre-fire species were renewed in the first three years after the fire. *Juniperus oxycedrus* could not renew within three years after the fire. Pine phytomass has increased five times within three years after the fire.

Key words: Forest, fire, *Pinus brutia*, succession, soil

Introduction

Fire is one of the most important ecological factors in Mediterranean-type ecosystems. Most Mediterranean-type vegetation is composed of woodland in various degradation stages created by the long history of human activities (LE HOUREOU 1974, NAVEH 1990, TRABAUD 2000, BILGILI and SAĞLAM 2003). Depending on their post-fire reaction, plant species are classified as »seeders«, »sprouters«, or both types. Pine forest communities are very flammable during drought periods as they contain rich resins, essential oils, litter and understory shrub layers. On the other hand, these are resistant to fire in the absence of human pressures such as grazing, cutting and cultivation (MAZZOLENI and ESPOSITO 1993, NE'EMAN et al. 2004).

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Pinus brutia Ten. covers extensive areas in the Eastern Mediterranean: mainly Turkey, Greece, Cyprus, W. Syria, Lebanon and Italy; scantly N. Iraq, W. Caucasus and Crimea (GEZER 1986, FADY et al. 2003) (Fig. 1). The total *P. brutia* forest cover is estimated to be over 4 million hectares, 3.8 million hectares of which are in Turkey, accounting for 20.2% of Turkey's total forest area. Of this, 2.2 million hectares are productive while 1.6 million hectares are degraded. Economically, it is Turkey's most important forest tree species (DAVIS 1965–1985, FADY et al. 2003, BOYDAK 2004).

Fires are started for reasons like acquiring new grazing land, clearing for new farmland, smoking, arson, camping, glass waste and various accidents with 99% of the forest fires in Turkey being caused by humans; with only ca 1% of the recorded forest fires being started by lightning. The origin of about half the human-caused fires is shown to be negligence (25%) and deliberate fire-setting (26%). It is assumed that most of the fires with unknown origins are intentionally set fires, including arson (SEREZ 1995).

Forty-eight percent (9 732 840 ha) of the forests in Turkey are susceptible to fire due to the Mediterranean climate (TÜRKMEN and DÜZENLİ 2005), and the flammable and combustible vegetation. An average of 23 127 ha y^{-1} of natural vegetation was burnt in Turkey between 1937–2003 with 72 316 fires occurring and 1 549 506 ha of forest being burnt.

The post-fire succession in pine forests has not previously been studied in Turkey, although some studies on this subject were conducted in other countries with Mediterranean type ecosystems such as France (TRABAUD 2000), Greece (ARIANOUTSOU-FARAGGITAKI 1984, THANOS et al. 1989), Italy (MAZZOLENI and ESPOSITO 1993), Spain (FARACO et al. 1993), the United States (HANES 1970, KEELEY 1987) and Israel (NAVEH 1975). The aim of the present study is therefore to examine the effects of fire on the soil properties and the floristic diversity of *Pinus brutia* forests in Turkey, from the immediate post-fire period up to three years after the fire.

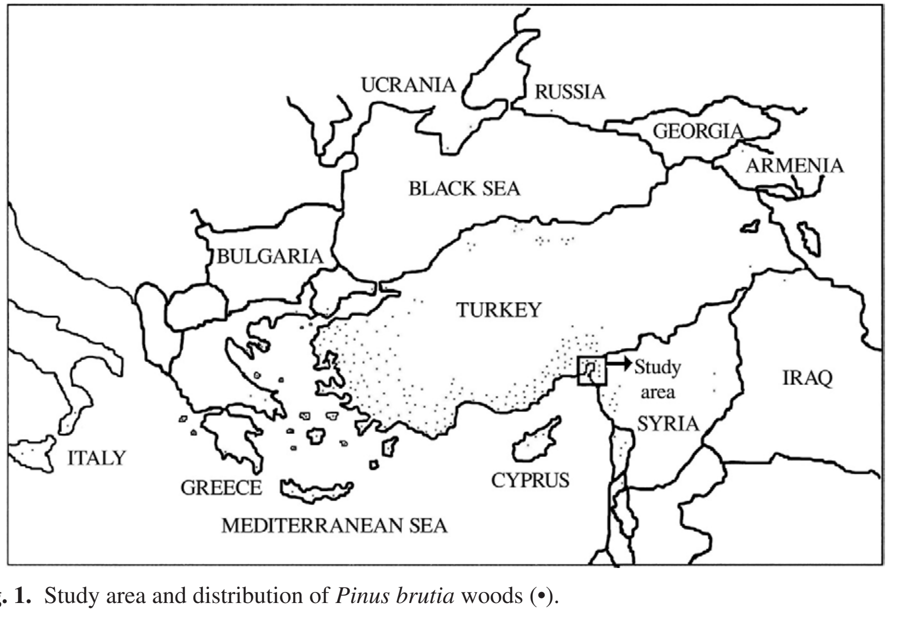

Fig. 1. Study area and distribution of *Pinus brutia* woods (•).

Study area

The study area is located on a hillside near Erzin town (36° 57' N. 36° 16' E), Hatay Province, Turkey, ca. 550 m above sea level and 14 km from the İskenderun Gulf (Fig. 1).

Climate

The Mediterranean climate in the study area is characterized by long summer droughts and mild and rainy winters. The mean annual precipitation is about 1019.3 mm, while the monthly precipitation is approximately 22.4 mm in July and 130.3 mm in January. The mean maximum temperatures range from 15.2 °C in January to 32.2 °C in August and the mean minimum temperatures from 6.8 °C in January to 23.8 °C in August. The bioclimatic diagram prepared for the study area shows the months with dry and rainy periods (Fig. 2).

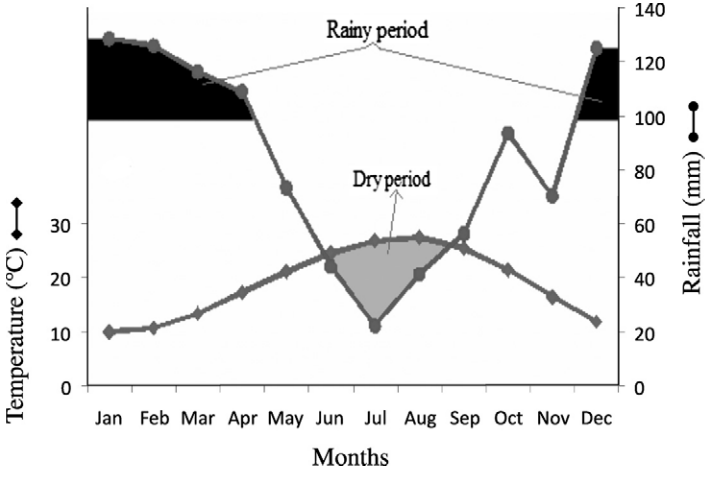

Fig. 2. Ombrothermic diagram of the study area. The dry period in July – August, the rainy period (>100 mm / month in December – April, and transitional period in May and November.

Geology

The geological structure of the area is of Mesozoic and Cretaceous limestone, Upper Cretaceous ultra-basic rocks (gabro and serpentine) and Tertiary marls. The common soil formation distinguished in the area is brown forest soils (Türkmen and Düzenli 1998).

Vegetation

The native woody vegetation of the study area is mainly composed of *Pinus brutia Ten., Quercus cerris* L., *Styrax officinalis* L.. *Fraxinus ornus* L.. *Cotinus coggyrea* Scop.. *Pistacia terebinthus* L.. *Cistus salviifolius* L.. *Cercis siliquastrum* L.. *Erica manipuliflora* Salisb.. *Sorbus torminalis* (L.) Crantz. *Genista lydia* Boiss. and *Smilax aspera* L.. A part of the *Pinus brutia* vegetation in the Amanos Mountains under the responsibility of the Dörtyol Forestry Administration of Hatay Province in Turkey was intensely burnt at the end of February 1989 as a result of negligence by a shepherd.

Materials and methods

In order to analyze the changes in species composition, soil elements, above ground phytomass and physiognomy of the plant community in this area, four permanent plots were established in the burned area and four in the adjacent unburned area. The unburned plots are the control plots. Each plot was 100 m^2 (10 m × 10 m). Both burned and unburned plots were evaluated as single plots. All floristic records were made monthly from February 1989 to February 1992. In each of the burned plots, four sub-plots (2 m × 2 m) were randomly created for post-fire plant biomass determination. All the vascular plants in sub-plots were cut with hand equipments (with bucksaw, hatchet and prune scissors) as close to the soil surface as possible.

To determine phytomass, the harvested material was air dried in an oven at 105 °C. Five robust suckers from each woody species were cut, dried in the oven and weighted.

In total, 24 soil samples from the study plots were taken (24 of these samples from burned plots. and 4 from unburned plots). Each soil sample was created by mixing the upper soil layer (0–15 cm as depth) in the center of the corner of each plot. These soil samples were dried in the open air, and after being sieved in a fine sieve in the laboratory were analyzed using relevant methods. Air-dry sieved soil samples were analyzed in the Department of Soil Sciences, Çukurova University.

The soil analysis was performed according to BAYRAKLI (1987). Lime ($CaCO_3$) was determined with a Scheibler calcimeter measuring the carbon dioxide pressure. Organic carbon was determined by Walkley-Black wet oxidation method, total nitrate by the semi-micro Kjeldahl method. Available phosphorus (P_2O_5 kg ha^{-1}) was determined according to Olsen et al. (1954) (using phosphorus solubility in sodium bicarbonate). Exchangeable sodium (expressed as $cmol_c$ kg^{-1}, i.e. centimoles of charge per kilogram of dry soil) was determined by 1N ammonium acetate, exchangeable potassium ($cmol_c$ kg^{-1}) by 1N ammonium acetate. Total salt was determined by electrical conductivity within the 100 g water-saturated soil. For cation exchange capacity ($cmol_c$ kg^{-1}) 1N sodium acetate-soil mixture was washed with 2N ammonium acetate. Acidity (pH) was determined using distilled water-saturated soil samples, after waiting 24 hours, using a Beckman pH meter connected to a glass-calomel electrode pair. Soil water saturation (%) was determined by measuring the amount of saturated pure water of 100 g air-dried soil.

Sorensen's similarity index (SI) was used to compare the species diversity of the burned and unburned areas:

$$SI = 2\,w / (a + b)$$

where a is the total number of species in sample 1, b is the number of species in sample 2 and w is the number of species common to both samples.

The collected plant material was numbered and kept as samples for botanical identification. Taxonomical determination was performed according to DAVIS (1965–1985). A voucher specimens of each species was kept in the Herbarium of Çukurova University, Faculty of Science and Letters, Department of Biology.

Results

The flora of the unburned area (400 m^2) consisted of 47 resident species and floristically it did not change during the three years after the fire. In the burned area (400 m^2), the presence of plant species that changed throughout the observation period is as follows: 26 species (24 autochthonous specific for the brutia pine community, and 2 allochthonous or exotic for the brutia pine community in the first year; 55 species (39 autochthonous and 16 allochthonous) in the second year; and 66 species (46 autochthonous and 20 allochthonous) in the third year (Tab. 1).

Ninety-eight percent of the pre-fire species (i.e. 46 species) occurred in the first three years after the fire, while the remaining 2% (i.e. 1 species) did not occur during this time. The floristic richness of the burnt community showed a tendency that resembles the stabile balance that existed before the fire (Fig. 3, Tab. 2).

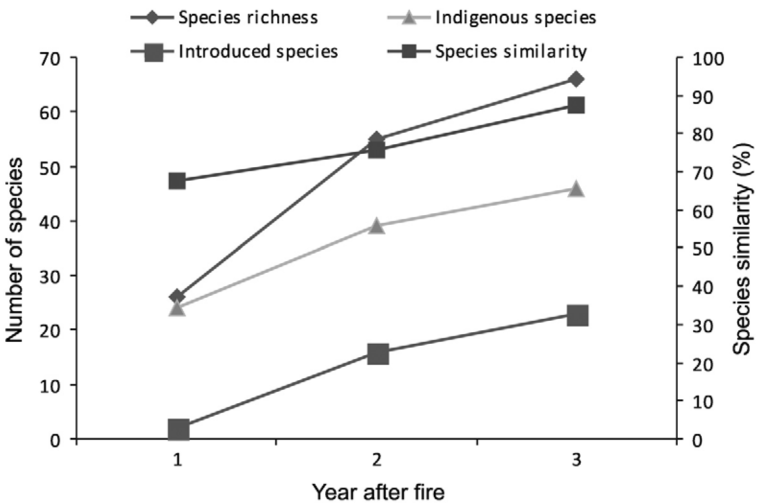

Fig. 3. Development and floristic composition after the fire.

The phytomass above ground of the burnt vegetation reached 5283.8 kg ha^{-1} (herbaceous phytomass 2845.9 kg ha^{-1}, woody phytomass 2437.9 kg ha^{-1}) showing rapid growth at the end of third year. Phytomass of the pine seedlings were much lower (9.9 g per 5 seedlings) than a woody resprouter species (e.g., phytomass of oak species is 401 times greater than that of pine species) due to both the pine species being an obligate seeder and woody resprouter species being capable of vigorous re-growth with spare nutrients (Tabs. 3, 4). The first three years, root growth of the pine was faster than stem growth (the root length was 18.3 cm in second year and 29.6 cm in third year while the stem length was 7.1 cm and 19.8 cm respectively).

The soil analysis in the study area (Fig. 4) indicated that immediately after the fire organic C (%)decreased from 13.37 to 11.46, later was reduced to 5.14. Total N (%) immediately after the fire decreased from 0.391 to 0.305, and then later was reduced to 0.217. Soil water saturation immediately after the fire decreased from 103.2 to 89.7, later was reduced

Tab. 1. Occurrence of the plant species in the study area. **LF** denotes life form: **Th** – terophyte, **Ge** – geophytes, **H** – hemicryptophyte, **Ph** – phanerophyte, **Ch** – chamaeophyte. **L** denotes life span: **A** – annual, **B** – biannual, **P** – perennial. **RS** denotes reproductive strategy: **G** – generative, **V** – vegetative, **VG –** both generative and vegetative. Presence of species in terms of time after fire: **m** – first three mounts, **1** – first year, **2** – second year, **3** – third year. – denotes absence, **+** denotes presence.

Species	Family	LF	L	RS	m	1	2	3
Autochthonous species								
Alyssum strigosum Banks et Sol. ssp. *strigosum* T. R. Dudley	Brassicaceae	Th	A	G	–	–	–	+
Asparagus acutifolius L.	Liliaceae	Ge	P	G	–	–	+	+
Asperula cymulosa (Post) Post	Rubiaceae	Ch	P	VG	–	–	+	+
Asperula stricta Boiss. ssp. *stricta* Ehrend. et Schönb.-Tem.	Rubiaceae	Ch	P	VG	–	–	+	+
Asplenium adiantum-nigrum L.	Aspleniaceae	H	P	G	–	–	–	+
Brachypodium pinnatum (L.) P. Beauv.	Poaceae	H	P	V	+	+	+	+
Centaurea ptosimopappa Hayek	Asteraceae	H	P	G	+	+	+	+
Cercis siliquastrum L. ssp. *hebacarpa* (Bornm.) Yalt.	Fabaceae	Ph	P	V	+	+	+	+
Chrysopogon gryllus (L.) Trin.	Poaceae	H	P	V	+	+	+	+
Cistus salviifolius L.	Cistaceae	Ch	P	G	+	+	+	+
Clinopodium vulgare L. ssp. *arundanum* (Boiss.) Nyman	Lamiaceae	Ch	P	VG	–	–	+	+
Cotinus coggyrea Scop.	Fabaceae	Ph	P	V	+	+	+	+
Crepis reuterana Boiss.	Asteraceae	H	P	G	+	+	+	+
Cytisopsis dorycniifolia Jaub. et Spach ssp. *dorycniifolia* D.F.Chamb.	Fabaceae	Ch	P	G	–		–	+
Dactylis glomerata L. ssp. *hispanica* (Roth) Nyman	Poaceae	H	P	V	+	+	+	+
Dorycnium graecum (L.) Ser.	Fabaceae	Ch	P	VG	–	–	+	+
Epipactis helleborina (L.) Crantz	Orchidaceae	Ge	P	VG	+	+	+	+
Erica manipuliflora Salisb.	Ericaceae	Ph	P	VG	+	+	+	+
Eryngium falcatum Delar	Apiaceae	H	P	VG	+	+	+	+
Euphorbia apios L. var. *lamprocarpa* Boiss.	Euphorbiaceae	Ge	P	V	–	–	+	+
Euphorbia macrostegia Boiss.	Euphorbiaceae	H	P	G	–	+	+	+
Ferulago cassia Boiss.	Apiaceae	H	P	G	–	–	–	+
Fraxinus ornus L. ssp. *cilicica* (Lingelsh.) Yalt.	Oleaceae	Ph	P	V	+	+	+	+
Genista lydia Boiss. var. *antiochia* (Boiss.) P. Gibbs.	Fabaceae	Ch	P	VG	+	+	+	+
Gladiolus italicus Miller	Iridaceae	Ge	P	VG	–	–	+	+
Hedera helix L.	Araliaceae	Ch	P	V	–	–	–	+
Iris unguicularis Poiret	Iridaceae	Ge	P	VG	–	–	+	+
Juniperus oxycedrus L. ssp. *oxycedrus* Coode et Cullen	Cupressaceae	Ph	P	G	–	–	–	–
Lesquereuxia syriaca Boiss. et Reut.	Scrophullariaceae	H	P	VG	–	–	+	+
Melica minuta L.	Poaceae	H	P	V	+	+	+	+
Muscari tenuiflorum Tausch	Liliaceae	Ge	P	VG	–	–	+	+
Origanum laevigatum Boiss.	Lamiaceae	Ch	P	VG	–	+	+	+

Tab. 1. – continued

Species	Family	LF	L	RS	m	1	2	3
Osyris alba L.	Santalaceae	Ch	P	G	–	–	+	+
Pinus brutia Ten.	Pinaceae	Ph	P	G	–	–	+	+
Pistacia terebinthus L. ssp. *palaestina* (Boiss.) Engl.	Anacardiaceae	Ph	P	V	+	+	+	+
Potentilla micrantha Ramond ex DC.	Rosaceae	H	P	G	–	–	+	+
Quercus cerris L. var. *cerris* Hedge et Yalt.	Fagaceae	Ph	P	V	+	+	+	+
Quercus infectoria Oliv. ssp. *boissieri* (Reut.) O.Shwarz	Fagaceae	Ph	P	V	–	–	–	+
Rubus canescens DC. var. *glabratus* (Godr.) Davis et Meikle	Rosaceae	Ch	P	V	+	+	+	+
*Ruscus aculeatu*s L. var. *angustifolius* Boiss.	Liliaceae	Ch	P	V	–	+	+	+
*Saccharum strictum(*Host) Sprengel	Poaceae	H	P	VG	+	+	+	+
Salvia tomentosa L.	Lamiaceae	H	P	G	–	–	+	+
Smilax aspera L.	Liliaceae	Ph	P	VG	+	+	+	+
Sorbus torminalis (L.) Crantz var. *torminalis* Gabrieljan	Rosaceae	Ph	P	VG	+	+	+	+
Stachys diversifolia Boiss.	Lamiaceae	Ch	P	VG	–	–	+	+
lpar*Styrax officinalis* L.	Styracaceae	Ph	P	V	+	+	+	+
Viola alba Besser ssp. *dehnhardtii* (Ten.) Becker	Violaceae	H	P	G	–	–	–	+
Allochthonous species								
Carex flacca Schreber ssp. *serrulata* (Biv.) Greuter	Cyperaceae	H	P	G	–	–	–	+
Cephalaria taurica Szabo	Scrophullariaceae	H	P	G	–	–	+	+
Chenopodium album L. ssp. *album*	Chenopodiaceae	Th	A	G	–	–	–	+
Conyza bonariensis(L.) Cronquist	Asteraceae	Th	A	G	–	–	+	+
Dorycnium penthaphyllum Scop. ssp. *haussknetchii* (Boiss.) Gams	Fabaceae	Ch	P	G	–	–	+	+
Hypericum montbretii Spach	Hypericaceae	Th	A	G	–	–	–	+
Inula vulgaris(Lam.) Trevis.	Asteraceae	H	B	G	–	–	+	+
Lactuca serriola L.	Asteraceae	H	B	G	–	–	+	+
Lathyrus spathulatus Cel.	Fabaceae	H	P	G	–	–	+	+
Lotus peregrinus L. var. *peregrinus* Heyn	Fabaceae	Th	A	G	–	–	–	+
Michauxia campanuloides L'Her. ex Aiton	Campanulaceae	H	B	G	–	–	–	+
Orobanche crenata Forssk.	Orobanchaceae	Th	A	G	–	–	+	+
Pterdium aquilinum (L.) Kuhn	Hypolepidaceae	Ge	P	G	+	+	+	+
Rhus coriaria L.	Anacardiaceae	Ph	P	G	–	–	–	+
Senecio vernalis Waldst. et Kit.	Asteraceae	Th	A	G	–	–	+	+
Sideritis perfoliata L. var. *condensata* Boiss.	Lamiaceae	H	P	G	–	+	+	–
Silene confertifolia Chowdh.	Caryophyllaceae	H	P	G	–	–	+	+
Sonchus oleraecus L.	Asteraceae	Th	A	G	–	–	+	–
Thesium bergeri Zucc.	Santalaceae	Ch	P	G	–	–	+	+
Thlaspi annuum Koch	Brassicaceae	Th	A	G	–	–	+	+
Torilis arvensis (Huds.) Link ssp. *arvensis* Cullen	Brassicaceae	Th	A	G	–	–	+	+
Trifolium campestre Schreb.	Fabaceae	Th	A	G	–	–	+	–
Verbascum galileum Boiss.	Scrophulariaceae	H	B	G	–	–	–	+

Tab. 2. Relative contribution of autochthonous and allochthonous species at the burnt site, and the species similarity between burned and unburned areas after fire.

Time afterthe fire	Number of autochthonous species (and relative contribution)	Number of allochthonous species (and relative contribution)	Sorensen similarity index (%)
1 year	24 (51.1)	2 (8.7)	67.5
2 years	15 (31.9)	14 (60.9)	76.4
3 years	7 (14.9)	7 (30.4)	81.4
Total	47 (97.9)	23 (100)	–

Tab. 3. Characteristics of the plant species appearing in the first three years after fire (pine seedlings did not occur within the first year; to avoid damage to the vegetation. the biomass of the second year was not determined).

Characteristics	First year	Second year	Third year
Pine seedlings:	–	7.1	19.8
Height (cm)			
Root lenght (cm)	–	18.3	29.6
Stem phytomass (g per 5 suckers)	–	1.1	5.2
Needle phytomass (g per 5 suckers)	–	0.7	3.1
Root phytomass (g per 5 suckers)	–	0.3	1.2
Total pine phytomass (g per 5 suckers)	–	2.2	9.9
Vegetation biomass (kg per ha):	162	–	5283.2

Tab. 4. Height and phytomass values of dominant understory woody species of the pine forest in the third year.

Species	Woody (g of 5 suckers)	Herbaceous (g of 5 suckers)	Total (g of 5 suckers)	Max. heights (cm)
Quercus cerris	2455	849	3304	391
Styrax officinalis	1636	272	1908	305
Pistacia terebinthus	923	311	1235	171
Fraxinus ornus	947	106	1052	226
Cercis siliquastrum	619	250	869	230
Cotinus coggyrea	525	210	736	198
Cistus salviifolius	213	76	289	82
Sorbus torminalis	94	57	151	30
Erica manipuliflora	44	19	63	38

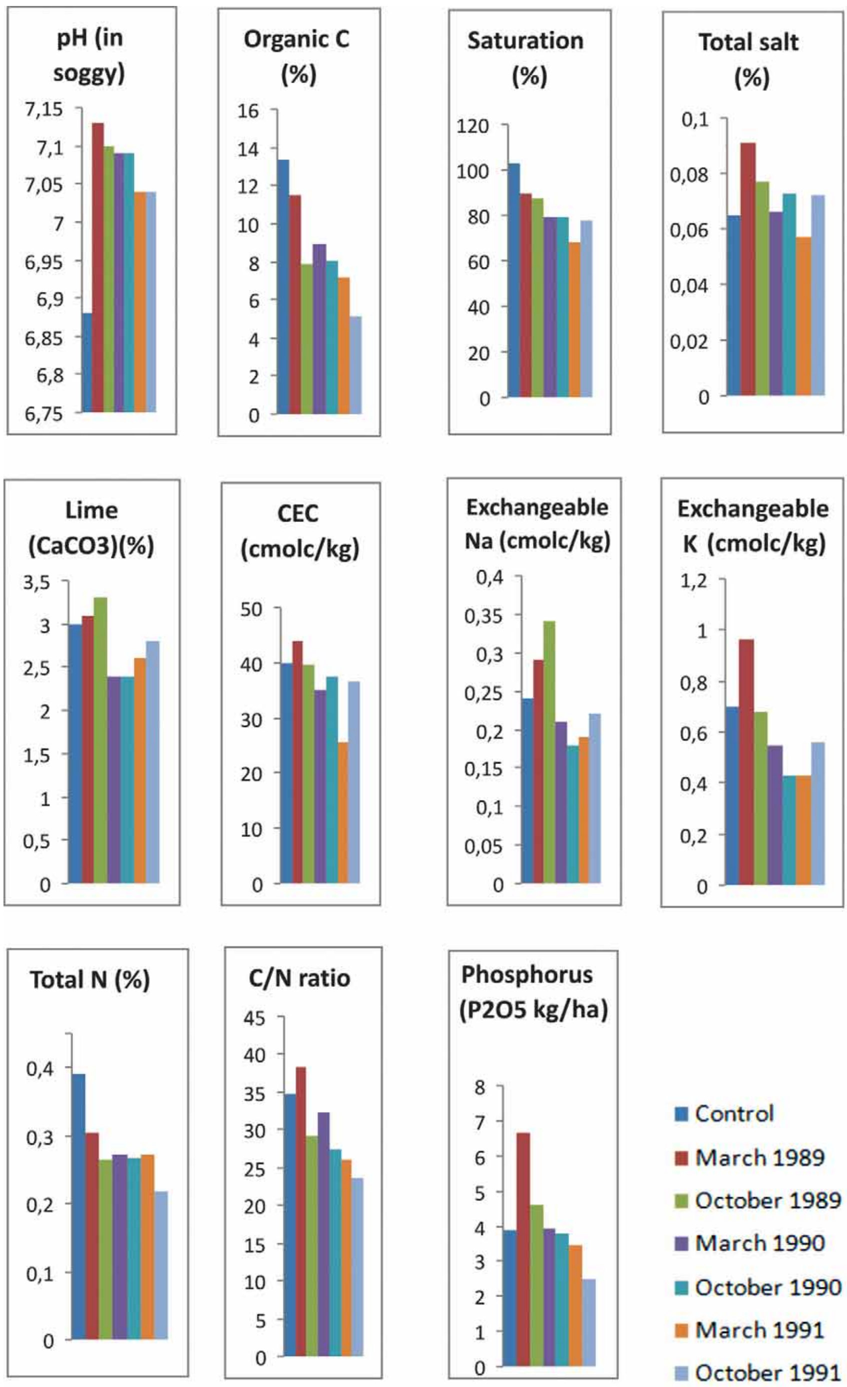

Fig. 4. Changes of soil ph, organic carbon content, water saturation, contribution of coluble salt, lime ($CaCO_3$), cation exchange capacity (CEC), exchangeable Na, exchangeable K, total nitrogen, C/N ratio, and available phosphorus (P_2O_5) after the fire.

to 77.9. C/N ratio immediately after the fire increased from 34.83 to 38.27, later was reduced to 23.55. Available phosphorus (P_2O_5 kg ha^{-1}) immediately after the fire increased from 0.390 to 0.667, later was reduced to 0.250; pH value (in soggy soil) immediately after the fire increased from 6.88 to 7.13, later was reduced to 7.04 cmol$_c$ kg^{-1}; exchangeable K. immediately after the fire increased from 0.70 to 0.96, later was reduced to 0.56 cmol$_c$ kg^{-1}; exchangeable Na immediately after the fire increased from 0.24 to 0.29, later was reduced to 0.22 cmol$_c$ kg^{-1}; cation exchange capacity immediately after the fire increased from 39.86 to 43.80, later was reduced to 36.45 cmol$_c$ kg^{-1}; lime ($CaCO_3$) immediately after the fire increased from 3.0 to 3.1, later was reduced to 2.8 %; total salt immediately after the fire increased from 0.665 to 0.091, later was reduced to 0.072 %. Similar trends were found in the earlier studies, elsewhere (AHLGREN and AHLGREN 1960, RAISON 1979, KUTIEL and SHAVIV 1989).

Discussion

All the existing species before the fire (species at the control site), except for *Juniperus oxycedrus* L.*,* emerged again within the first three years after the fire. *Juniperus oxycedrus* did not resprout from the lignotubers or burls. The new habitat conditions created by fire led to the emergence of allochthonous opportunistic species such as *Sonchus olereacus, Sideritis perfoliata, Senecio vernalis, Trifolium campestre, Conyza bonariensis, Lactuca serriola and Verbascum galileum.* These species caused an increase in the floristic richness of the area in the first three years (the richness includes both native and non-native species) but an elimination started by the dominance of the autochthonous sprouting phanerophytes. The most typical sprouter phanerophytes were *Quercus cerris. Fraxinus ornus. Cotinus coggyrea. Pistacia terebinthus and Erica manipuliflora* which can vigorously regenerate by root sprouting. The woody species that reproduce by seedlings only were *Pinus brutia* and *Cistus salviifolius*. These two woody species are known pyrophytes because of better germination and growth show in burned areas. The re-sprouting species remained alive in the fire, stored food reserves are developed by sprouting from vegetative organs. Many herbaceous re-sprouters having subterranean root organs (rhizomes or tubers) such as *Saccharum strictum, Brachypodium pinnatum, Dactylis glomerata* and *Epipactis helleborina* regenerated easily in the first year after the fire. These results agreed with those presented by the other authors (DAUBENMIRE 1968, TRABAUD 1973, VERROIUS and GEORGIADIS 2002, TÜRKMEN and DÜZENLI 2005).

The allochthonous species (species not seen in the control site occurred only from seeds in the burned areas. In the presence of autochthonous species, their seeds and / or vegetative organs were able to continue.

Subterranean organs are protected from fire by the soil, which is a good insulator and conducts little heat produced by the burning vegetation (ASTON and GILL 1976). Mooney and Dunn (1970) found that nearly 50% of the small woody shrubs in California and Chile sprouted after a fire. NAVEH (1975) in Israel, TRABAUD and LEPART (1980) in southern France, THANOS et al. (1989) in Samos Island of Greece and TÜRKMEN and DÜZENLI (2005) in the Turkish Mediterranean Region found that nearly all the woody species of these regions sprouted after a fire within 3-5 years.

The emergence of the original species was 51.1% in the first year, 31.9% in the second year and 14.7% in the third year. It is known that some Mediterranean ecosystems evolve with fire and that most plant species have developed adaptive mechanisms (TRABAUD 1987). These mechanisms could be associated with the strategies of persistence after a fire (e.g. species that regenerate well or disseminate numerous seeds after a fire).

Among the allochthonous species, the most prolific families were Asteraceae (5 species) and Fabaceae (4 species). The Fabaceae are of special interest due to their waterproof hard-coated seeds and ability to fix atmospheric nitrogen. These characteristics increased the germination abilities of their seeds in the soil seed bank after the fire. The diminished nitrogen in the burnt soils can be slightly resolved through the quick nitrogen fixation of the leguminous species. The dispersal abilities of the many species that belong to the Asteraceae are usually more than those in other families (VERROIUS and GEORGIADIS 2002). Most of these plants occur usually in open areas such as forest roadsides, forest-adjacent agricultural areas and abandoned fields and have small, light seeds with pappus-like structures. Therefore, it was observed that these families were more abundant during the study period than before the fire.

The pre-fire species were detected in early post-fire vegetation and species richness increased during the three years after the fire due to the high abundance of short-lived herbaceous plants, which benefit from enriched supply with nutrients and light, as has been explained before (BUHK et al. 2006).

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