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# Floristical and Ecological Studies on Burned Blackpine (*Pinus nigra* Arn. subsp. *pallasiana* (Lamb) Holmboe) Forest Area at Central Anatolia

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**Abstract:** In the burned forest area between 1999-2002 the floristical and ecological studies were conducted. In this period, successional development of the area was observed. After the fire in 1995, new life forms migrated from unburned parts of Sundiken Mountains and occupied the burned area in 7-8 years. There were 133 plant taxa were collected at the first year of the study and during the successional development the number of plant taxa decreased to 75. The secondary succession of the area were determined between 1999-2002. After the fire the dominant plant species of the study area is *Cistus laurifolius*.

**Key words:** Flora, forest fire, succession

## INTRODUCTION

Fire is an important ecological factor in many habitats worldwide (Kozlowski and Ahlgren, 1974; Trabaud, 1987). Vegetation composition and dynamics are strongly influenced from the local fire regime (Trabaub and Lepart, 1981; Keeley, 1994). In nature, fire is classified as a disturbance, but it is neither good nor bad; it is simply the consequences of natural conditions. Fire has influenced the evolution of the various species of the forests and grasslands, as well as the xeric shrub communities of Mediterranean climate regions of the world. Among other disturbances wild fires are widely common in boreal forests, temperate grasslands, tropical savannas and Mediterranean woodlands (Kozlowski and Ahlgren, 1974; Attiwill, 1994; Bond and van Wilgen, 1996; Lloret *et al*., 2002) and they have long played an important role in the ecology and evolution of Mediterranean climate regions (Montenegro *et al*., 2004). Frequency of fires is also important, frequent fires results in vegetation that has fire resistant species and this vegetation is called fire climax.

The various types of fires are divided into three main classes, based on stratum and intensity; ground, surface and crown fires. A positive feedback system exists in which the interaction between fire and vegetation is such that fire may be as important as climate in determining the physiognomy of the vegetation (Barbour *et al*., 1999).

Pine species have been used for reforestation in Mediterranean regions especially since 19th century (Pausas *et al*., 2004).

In Turkey, most of the fires are caused by humans. Natural fires are rare, about 1% in Turkey. Especially in summers fires caused by humans results in loss of huge forest areas (Turkmen, 1994).

## MATERIALS AND METHODS

**Study area:** According to the grid system of Davis the study area is at B3 square and has the coordinates as; 39°55’ 11’’ -31°26’ 52’’ north, 39°54’ 58’’ -31° 26’ 52’’ south, 31°55’ 03’’ -31° 22’ 01’’ east and 39° 54’59’’ 31° 26’51’’ west. The altitude of the study area changes from 1390 to 1481 m at Sundiken Mountain range. The total area is 110 decameter and the slope is in between 30-40% (Fig. 1).

The dominant soil type of the study area is non-calcareous brown forest soil. Mother rock is gnays with light acidic or very light basic pH values. Soils are rich in organic matter content.

The study area is under the influence of Mediterranean climate. Mean annual precipitation was measured as 543.4 mm at Mihaliccik meteorological station. The mean annual temperature, maximum temperature of the hottest month and the minimum temperature of the coldest month are as follows, respectively; 9, 25.6 and -4.5°C. According to Emberger the climate of the study area is semi arid very cold Mediterranean climate (Emberger, 1930).

The study area burned in August 1994 because of the human impact, before the fire the study area was covered with *Pinus nigra* Arn. subsp. *pallasiana* forest.

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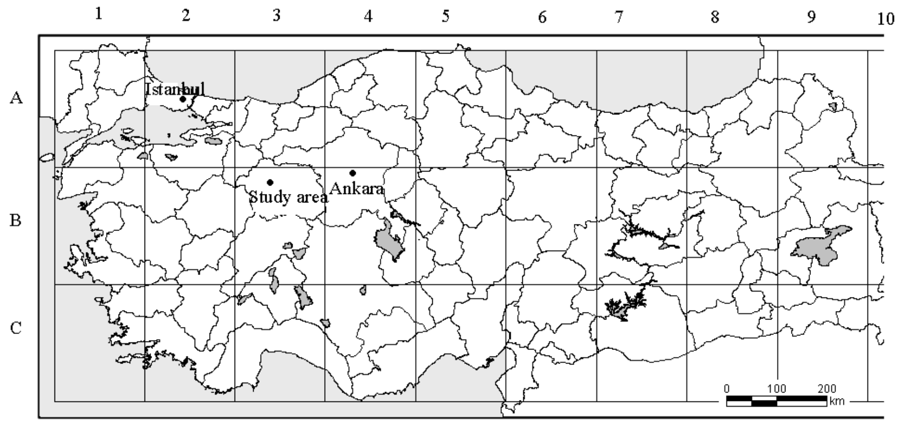


Fig. 1: Location of the study area

After the fire all the debris were cleared from the area. Between 1999 and 2002 the study area was visited periodically and floristical and vegetational characteristics were investigated.

In 1999, after the examination of the study area for the comparison of burned and unburned areas 2 soil profiles of 90 cm were taken. Samples from 0-30, 30-60 and 60-90 cm were analyzed. Also samples from burned areas were taken from 0-20 cm depth from different localities, mixed, analyzed and the mean values of each analyzed parameter were determined.

All the sampling sites at the burned areas had the same altitude; 1450 m, area; 125 $cm^2$, exposure; south and mother rock; gnays.

**Methods of soil analysis**

**Physical analysis:** Soil texture was determined with bouyoucos' hydrometer method and soil type defined according to American Soil Classification Triangle.

**Soil reaction:** pH was measured with Beckman Expanded Sole pH meter with the sensitivity of ±0.01.

**$CaCO_3$:** Total $CaCO_3$ contents of the soil samples were determined by using Schaibler calcimeter with active $CaCO_3$ titration method

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**Organic matter:** Determined by Walkley Black method (Nelson and Sommers, 1982).

**Total nitrogen:** Measured by Total Kejdalh Nitrogen method (Bremner and Mulvaney, 1982).

**Cation Exchange Capacity (CEC) and exchangeable cations ($Ca^{2+}$, $Mg^{2+}$, $K^+$ and $Na^+$):** These variables determined by atomic absorption/emission spectrometry after extraction with 1 normal ammonium acetate (Thomas, 1982).

**Phosphorous content ($P_2O_5$):** Determined by using Olsen method (Olsen and Sommers, 1982).

**Electrical Conductivity (EC):** EC was measured with conductivity meter (Rhoades, 1982).

Plant specimens were collected from 1999 to 2002 during the vegetation period. Identification of plant specimens were done according to Flora of Turkey and East Aegean Islands (Davis, 1959-1965). Identified plant specimens were conserved at the herbarium of Osmangazi University. The vegetation of the study area was defined according to Braun-Blanquet (1932).

## RESULTS

**Soil analysis results:** The results of soil analysis were shown in Table 1.

**Texture:** There is not any specific difference between burned and un-burned areas.

**Soil reaction (pH):** The pH of the soils increased slightly after the fire from 6.3 to 7.1 and 6.8. This can be caused by the cations enter the soil system with the ash.

**$CaCO_3$ (%):** All the soil samples from burned and un-burned areas did not have $CaCO_3$.

**Organic matter (%):** Organic matter content of the un-burned areas were measured as 7.55%. After the fire this values decreased to 4.71%. There is a 37.7% decrease in the content of organic matter.

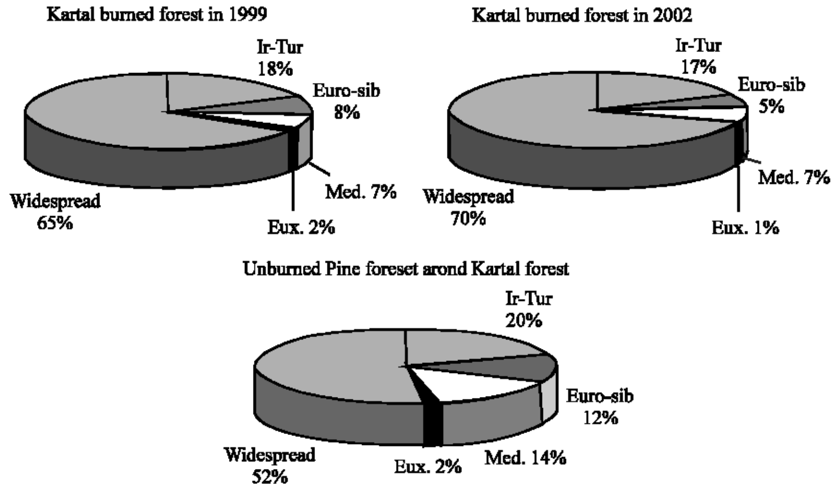


Fig. 2: Distribution of species in phytogeographical regions

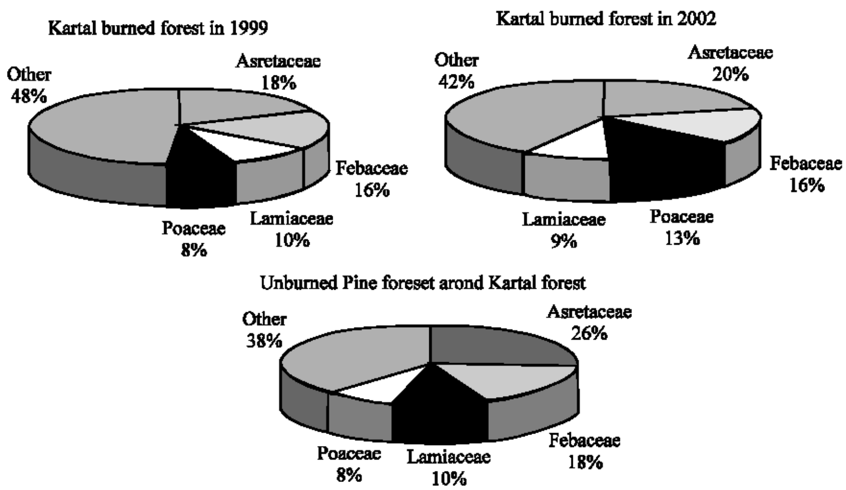


Fig. 3: Distribution of species in families

**Total nitrogen:** The amount of N in burned area was measured as 24-23%, but at un-burned areas this value was measured as 38% which means a 36.9% decrease.

**Usable phosphorous (ppm):** There was a 14% increase in the amount of P after the fire.

**Total salt:** Although there was a 21% increase in the total salt amount this value was still not high to prevent plant development.

**CEC (ppm):** Exchangeable Ca ratio: There was a decrease in this value but it was not important for the plant life or soil structure. Exchangeable Mg ratio: There was an important decrease in the amount of this element. Exchangeable K ratio: There was a 33.3% decrease after the fire. Exchangeable Na: Although there was a 15% decrease after the fire this is not important. Exchangeable Fe ratio: There was a 52% decrease after the fire. Exchangeable Mn ratio: There was a 71.4% decrease after the fire. Exchangeable Zn ratio: There was a 35.5% decrease after the fire. Exchangeable Cu ratio: No change detected.

It was found that the amount of essential elements for plant nutrition decreased.

During the study period, in 1999 three years after from the fire 133 taxa were determined. According to these values species belong to Irano-Turanien phytogeographical region were dominant in the study area (Fig. 2) The most common families and their number of species were shown in Fig. 3 Endemism ratio of the area was 14.29% in 1999, three years after the fire.

The successional stage of the study area in 1999 was shown in Table 2 with the abundance and sociability

Table 1: Results of soil physical and chemical analysis

| Physical analysis | | | | | Chemical analysis | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Profile No. | Depth (cm) | Sand (%) | Dust (%) | Clay (%) | Soil type | pH | Lime (%) | Organic matter (%) | Total nitrogen (%) | $P_2O_5$ | Ecx$10^{3-}$ (mS $cm^{-1}$) | $Ca^{2+}$ (ppm) | $Mg^{2+}$ (ppm) | $K^+$ (ppm) | $Na^+$ (ppm) | $Fe^{2+}$ (ppm) | $Mn^{2+}$ (ppm) | $Zn^{2+}$ (ppm) | $Cu^{2+}$ (ppm) | Areas |
| 1 | 0-30 | 64.99 | 16.88 | 18.12 | Sandy mud | 6.3 | 0.0 | 7.54 | 0.38 | 40 | 0.28 | 17.03 | 4.54 | 0.63 | 0.07 | 0.41 | 8.24 | 0.31 | 0.51 | Under forest |
| 1 | 30-60 | 50.85 | 18.84 | 30.31 | Sandy-clay mud | 6.7 | 0.0 | 1.65 | 0.08 | 16 | 0.17 | 13.89 | 6.40 | 0.47 | 0.08 | 0.62 | 1.13 | 0.31 | 0.51 | Under forest |
| 1 | 60-90 | 52.64 | 16.88 | 30.47 | Sandy-clay mud | 6.6 | 0.0 | 1.07 | 0.05 | 42 | 0.19 | 12.18 | 6.98 | 0.37 | 0.10 | 0.20 | 0.20 | 0.31 | 0.51 | Under forest |
| 2 | 0-30 | 56.84 | 23.02 | 20.14 | Sandy mud | 7.1 | 0.0 | 4.71 | 0.24 | 59 | 0.34 | 16.93 | 3.93 | 0.42 | 0.06 | 0.20 | 2.36 | 0.20 | 0.51 | Burned area |
| 2 | 30-60 | 44.49 | 26.08 | 30.43 | Clay mud | 6.8 | 0.0 | 1.37 | 0.07 | 6 | 0.14 | 13.57 | 5.88 | 0.32 | 0.08 | 0.82 | 0.51 | 0.20 | 0.62 | Burned area |
| 2 | 60-90 | 44.70 | 29.08 | 26.21 | Clay mud | 6.7 | 0.0 | 0.78 | 0.04 | 9 | 0.15 | 15.39 | 7.17 | 0.26 | 0.08 | 0.51 | 0.62 | 0.20 | 0.62 | Burned area |
| 3 | 0-20 | 65.08 | 10.68 | 24.24 | Sandy-clay mud | 6.8 | 0.0 | 4.65 | 0.23 | 47 | 0.25 | 17.19 | 2.67 | 0.37 | 0.06 | 0.10 | 0.41 | 0.10 | 0.51 | Burned area |

Table 2: Successional development of Kartal forest area after fire (1999)

| Sampling area No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Slope (%) | 30 | 30 | 30 | 35 | 35 | 30 | 40 | 35 | 35 | 30 | 35 | 30 | 40 | 35 | 30 | 35 | 40 | 40 | 40 | 35 | Constancy |
| **Shrub formations** | | | | | | | | | | | | | | | | | | | | | |
| *Cistus laurifolius* | 22 | 12 | 11 | 12 | 11 | 22 | 12 | 11 | 11 | 11 | 11 | 12 | 22 | 12 | 12 | 22 | 33 | 22 | 23 | 22 | V |
| *Genista lydia* var. *lydia* | +1 | +1 | - | - | - | +1 | 11 | - | +1 | +1 | - | - | +1 | +1 | 11 | - | - | - | +1 | - | IV |
| *Rubus canescens* var.*glabrata* | 11 | 11 | - | +1 | - | - | - | 11 | - | - | 11 | - | - | +1 | - | 11 | - | - | - | - | III |
| *Colutea cilicica* | - | - | - | 11 | - | +1 | - | - | - | - | - | +1 | - | - | +1 | - | - | - | - | 11 | II |
| *Crataegus monogyna* subsp. *monogyna* | - | 11 | 12 | -- | - | - | - | +1 | - | - | +1 | - | - | - | - | - | 11 | - | - | - | II |
| *Quercus pubescens* | +1 | - | - | - | 11 | - | 11 | - | - | - | - | - | 11 | - | - | - | - | - | 11 | - | II |
| *Ephedra major* | +1 | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | +1 | - | 11 | - | - | II |
| *Rosa canina* | - | - | - | - | - | - | 11 | - | - | - | - | - | 11 | - | - | - | - | - | - | - | I |
| *Juniperus excelsa* | - | - | - | - | - | - | - | - | 22 | - | - | - | - | - | - | - | - | - | - | - | I |
| *Rhus coriaria* | - | - | - | - | - | - | - | - | - | - | - | - | - | 22 | - | - | - | - | - | | I |
| *Lonicera etrusca* var. *etrusca* | - | - | - | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | I |
| **Herbaceous formations** | | | | | | | | | | | | | | | | | | | | | |
| *Aegilops cylindrica* | +1 | +1 | +1 | 11 | +1 | +1 | - | +1 | +1 | +1 | +1 | 11 | +1 | - | +1 | - | +1 | - | +1 | +1 | V |
| *Trifolium pannonicum* | +1 | +1 | - | +1 | +1 | +1 | +1 | +1 | +1 | +1 | - | +1 | +1 | +1 | +1 | - | +1 | +1 | +1 | - | V |
| *Vicia cracca* | - | +1 | 11 | +1 | - | +1 | +1 | +1 | - | 11 | 11 | 11 | +1 | - | +1 | +1 | +1 | - | +1 | +1 | IV |
| *Trifolium caudatum* | +1 | - | +1 | +1 | - | +1 | - | +1 | +1 | +1 | +1 | +1 | +1 | +1 | - | +1 | +1 | +1 | +1 | - | IV |
| *Euphorbia macroclada* | +1 | +1 | +1 | +1 | +1 | - | +1 | - | +1 | +1 | +1 | +1 | - | - | - | +1 | - | +1 | - | +1 | IV |
| *Thymus sibthorpii* | +1 | 11 | +1 | - | - | +1 | - | +1 | - | +1 | 11 | 12 | 11 | +1 | 11 | - | +1 | +1 | 11 | +1 | IV |
| *Viola kitaibeliana* | +1 | +1 | +1 | +1 | - | +1 | +1 | - | +1 | - | +1 | - | +1 | - | +1 | +1 | +1 | +1 | +1 | | IV |
| *Silene armena* | +1 | +1 | - | - | 11 | +1 | +1 | +1 | - | +1 | - | +1 | - | +1 | - | +1 | 11 | +1 | 11 | +1 | IV |
| *Epilobium angustifolium* | - | +1 | - | 11 | 11 | +1 | +1 | - | - | +1 | +1 | - | +1 | - | +1 | 11 | 12 | 22 | +1 | - | IV |
| *Trigonella fischeriana* | - | +1 | - | +1 | +1 | +1 | +1 | - | +1 | +1 | - | - | +1 | - | +1 | - | +1 | +1 | +1 | +1 | IV |
| *Crupina crupinastrum* | +1 | +1 | +1 | - | - | +1 | +1 | - | - | +1 | +2 | +1 | - | - | +1 | +1 | +1 | +1 | - | - | IV |
| *Lotononis genistoides* | +2 | +1 | +1 | - | +1 | - | 12 | +1 | - | +1 | - | 11 | - | +1 | - | +1 | +1 | - | +1 | | IV |
| *Filago pyramidata* | - | +1 | +1 | +1 | - | +1 | +1 | - | - | +1 | +1 | +1 | +1 | - | - | +1 | +1 | +1 | - | - | IV |

Table 2: Continued

| Sampling area No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Slope (%) | 30 | 30 | 30 | 35 | 35 | 30 | 40 | 35 | 35 | 30 | 35 | 30 | 40 | 35 | 30 | 35 | 40 | 40 | 40 | 35 | Constancy |
| *Festuca callieri* | +1 | - | +1 | - | +1 | - | - | +1 | +1 | +1 | +1 | - | - | +1 | - | +1 | +1 | +1 | - | +1 | IV |
| subsp. *callieri* | | | | | | | | | | | | | | | | | | | | | |
| *Dorycnium graecum* | +1 | +1 | - | +1 | - | +1 | - | +1 | - | +1 | +1 | +1 | - | - | +1 | +1 | - | +1 | - | - | III |
| *Centaurea depressa* | - | +1 | +1 | +1 | - | - | +1 | - | +1 | +1 | - | - | +1 | - | +1 | - | +1 | - | +1 | +1 | III |
| *Teucrium polium* | - | - | +1 | +1 | +1 | - | - | - | +1 | +1 | - | +1 | +1 | +1 | +1 | - | - | +1 | - | +1 | III |
| *Secale cereale* var. *creale* | +1 | - | - | +1 | +1 | +1 | - | +1 | - | - | +1 | +1 | +1 | - | +1 | - | +1 | - | +1 | - | III |
| *Onobrychis armena* | +1 | +1 | | +1 | +1 | +1 | - | - | - | +1 | - | - | - | +1 | +1 | +1 | - | - | +1 | +1 | III |
| *Vicia pannonica* | - | +1 | - | +1 | - | +1 | +1 | - | +1 | - | +1 | - | +1 | - | - | +1 | +1 | - | +1 | +1 | III |
| var. *purpurascens* | | | | | | | | | | | | | | | | | | | | | |
| *Koeleria cristata* | - | - | +1 | - | - | +1 | - | +1 | - | - | +1 | +2 | - | +1 | +1 | - | +1 | - | +1 | +1 | III |
| *Phleum exeratum* | +1 | +1 | - | - | +1 | +1 | - | - | - | +1 | - | - | +1 | - | - | -+1 | - | +1 | +1 | +1 | III |
| *Achillea biebersteinii* | +1 | - | +1 | +1 | - | +1 | +1 | - | +1 | - | - | +1 | +1 | - | +1 | | +1 | - | - | - | III |
| *Capsella bursa-pastoris* | - | +1 | - | - | +1 | - | +1 | - | +1 | +1 | +1 | - | - | +1 | +1 | - | - | +1 | - | +1 | III |
| *Centaurea urvillei* | +1 | - | +1 | +1 | +1 | - | - | +1 | - | - | +1 | +1 | - | - | +1 | - | +1 | - | - | - | III |
| subsp. *stepposa* | | | | | | | | | | | | | | | | | | | | | |
| *Verbascum lasianthum* | - | +1 | - | - | - | - | - | - | 11 | +1 | +1 | +1 | - | - | +1 | - | - | +1 | +1 | +1 | III |
| *Alyssum borzaenum* | +1 | - | - | +1 | - | - | +1 | - | +1 | | - | - | +1 | +1 | +1 | - | | +1 | | +1 | III |
| *Cardaria draba* | +1 | +1 | 11 | - | 11 | - | - | +1 | - | - | - | +1 | - | +1 | - | +1 | - | | +1 | - | III |
| subsp. *draba* | | | | | | | | | | | | | | | | | | | | | |
| *Lathyrus czeczottiana* | +1 | - | +1 | - | +1 | +1 | - | - | - | +1 | - | - | +1 | - | +1 | +1 | - | - | +1 | - | III |
| *Hypericum perforatum* | - | - | - | +1 | - | +1 | - | +1 | - | - | - | - | +1 | +1 | +1 | - | +1 | +1 | - | +1 | III |
| *Cynodon dactylon* | - | - | +1 | - | - | +1 | +1 | +1 | | +1 | +1 | | | - | +1 | - | +1 | - | | +1 | III |
| *Veronica chamaedrys* | +1 | - | - | - | +1 | - | - | - | +1 | +1 | - | - | +1 | - | - | +1 | - | - | +1 | +1 | III |
| *Hordeum bulbosum* | - | +1 | - | - | +1 | - | - | +1 | 12 | +1 | - | +1 | - | - | - | - | +1 | - | +1 | - | III |
| *Ziziphora tenuior* | +1 | - | - | +1 | | +1 | - | - | - | +1 | - | +1 | +1 | - | - | +1 | - | - | +1 | - | III |
| *Bromus sterilis* | | +1 | | - | +1 | | | +1 | +1 | | | | +1 | | | +1 | | +1 | | +1 | III |
| *Allium scoroprodasum* | - | +1 | +1 | - | +1 | - | +1 | - | +1 | - | - | - | +1 | - | - | - | +1 | - | - | +1 | III |
| subsp. *rotundum* | | | | | | | | | | | | | | | | | | | | | |
| *Sisymbrium altissimum* | - | - | +1 | - | +1 | - | - | - | - | +1 | - | - | - | +1 | +1 | - | - | +1 | +1 | +1 | III |
| *Globularia orientalis* | +1 | +1 | - | +1 | - | - | - | +1 | +1 | - | - | +1 | - | - | - | +1 | - | +1 | - | - | III |
| *Stipa bromoides* | +1 | - | - | 11 | - | +1 | - | - | - | - | +1 | - | +1 | - | +1 | | - | - | +1 | +1 | III |
| *Papaver rhoeas* | - | - | +1 | - | - | +1 | - | +1 | - | - | +1 | +1 | - | +1 | - | - | - | +1 | - | +1 | III |
| *Consolida regalis* | - | - | +1 | - | - | - | - | +1 | +1 | +1 | - | +1 | +1 | - | - | - | - | +1 | - | +1 | III |
| subsp. *paniculata* | | | | | | | | | | | | | | | | | | | | | |
| *Rumex acetosella* | +1 | +1 | - | - | - | - | +1 | - | - | - | +1 | +1 | - | +1 | - | +1 | +1 | - | - | - | III |
| *Convolvulus arvensis* | +1 | - | - | - | +1 | +1 | - | - | - | +1 | - | - | - | +1 | +1 | +1 | - | - | - | - | II |
| *Galium verum* subsp. *verum* | +1 | +1 | - | - | +1 | +1 | | +1 | - | - | - | - | - | - | - | - | +1 | +1 | - | - | II |
| *Geranium tuberosum* | - | - | +1 | +1 | - | - | +1 | - | - | - | +1 | - | +1 | - | - | +1 | - | +1 | - | - | II |
| subsp. *tuberosum* | | | | | | | | | | | | | | | | | | | | | |
| *Coronilla varia* | - | - | +1 | 11 | +2 | +1 | - | - | - | - | - | +1 | - | - | +2 | +1 | - | - | - | - | II |
| subsp. *varia* | | | | | | | | | | | | | | | | | | | | | |
| *Plantago lanceolata* | - | - | - | +1 | - | - | +1 | - | - | +1 | - | - | +1 | - | - | - | - | - | +1 | +1 | II |
| *Paeonia peregrina* | 11 | 12 | - | - | +1 | - | - | 11 | - | - | - | +1 | - | - | - | - | - | +1 | - | - | II |
| *Pastinaca armena* | - | - | - | - | - | - | - | - | +1 | +1 | - | +1 | +1 | - | - | +1 | +1 | - | - | - | II |
| subsp. *dentata* | | | | | | | | | | | | | | | | | | | | | |
| *Epilobium tetragonum* | +1 | +1 | +1 | - | +1 | - | +1 | - | - | - | +1 | - | - | - | - | - | - | - | - | - | II |
| subsp. *tetragonum* | | | | | | | | | | | | | | | | | | | | | |
| *Jurinea consaqunea* | - | - | - | - | - | +1 | - | +1 | - | - | - | | - | +1 | +1 | - | - | - | +1 | +1 | II |

Table 2: Continued

| Sampling area No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Slope (%) | 30 | 30 | 30 | 35 | 35 | 30 | 40 | 35 | 35 | 30 | 35 | 30 | 40 | 35 | 30 | 35 | 40 | 40 | 40 | 35 | Constancy |
| *Erysimum diffusum* | - | - | - | +1 | +1 | - | - | - | +1 | +1 | - | +1 | - | - | - | - | +1 | - | - | - | II |
| *Cichorium intybus* | - | - | - | - | - | +1 | - | +1 | - | +1 | - | - | - | - | +1 | +1 | +1 | - | - | - | II |
| *Veronica multifida* | | +1 | | +1 | | +1 | - | - | - | +1 | | +1 | | +1 | | | | | | | II |
| *Cephalanthera rubra* | - | - | +1 | +1 | - | - | - | - | - | - | +1 | - | - | +1 | - | - | - | - | +1 | +1 | II |
| *Ajuga chamaepithys* subsp. *chia* var *chia* | +1 | - | - | - | +1 | +1 | - | +1 | +1 | - | - | - | - | - | - | +1 | - | - | - | - | II |
| *Anthemis tinctoria* var. *pallida* | - | - | - | - | +1 | - | +1 | +1 | +1 | - | - | - | +1 | +1 | - | - | - | - | - | - | II |
| *Centaurea solstitialis* | - | - | +1 | - | - | - | - | - | - | - | +1 | - | +1 | - | - | - | - | +1 | +1 | +1 | II |
| *Melilotus officinalis* | +1 | - | - | - | - | +1 | +1 | | | +1 | - | +1 | - | - | +1 | - | - | - | - | - | II |
| *Xanthium spinosum* | - | - | +1 | +1 | +1 | - | - | - | - | - | +1 | - | - | +1 | - | - | - | - | +1 | - | II |
| *Inula ensifolia* | - | - | - | +1 | - | +1 | - | - | +1 | - | - | +1 | +1 | - | - | - | - | | - | +1 | II |
| *Trigonella velutina* | - | - | - | - | +1 | +1 | - | +1 | - | - | - | - | - | - | +1 | +1 | +1 | - | - | - | II |
| *Helycrisum arenarium* subsp. *aucheri* | - | +1 | +1 | - | - | - | - | +1 | - | - | - | - | +1 | +1 | - | - | - | - | - | +1 | II |
| *Onosma bornmuelleri* | - | - | - | - | +1 | +1 | - | +1 | - | - | - | - | - | - | +1 | - | -- | - | +1 | - | II |
| *Tragopogon latifolius* var. *angustifolius* | +1 | +1 | - | - | +1 | - | +1 | - | - | - | - | +1 | - | - | - | - | - | - | - | - | II |
| *Astragalus sterocalyx* | - | - | - | - | - | - | +1 | - | +1 | - | - | +1 | - | 11 | - | - | - | - | - | +1 | II |
| *Chenopodium foliosum* | +1 | - | - | +1 | - | +1 | - | +1 | - | - | - | - | - | +1 | - | - | - | - | - | - | II |
| *Picris strigosa* | - | - | +1 | - | +1 | +1 | - | - | - | - | +1 | - | +1 | - | - | - | - | - | - | - | II |
| *Viola alba* | - | - | - | +1 | +1 | - | - | +1 | +1 | - | - | - | - | - | - | - | +1 | - | - | - | |
| *Eryngium bithnicum* | - | +1 | - | - | - | - | - | - | - | +1 | - | +1 | +1 | - | - | - | - | - | - | - | II |
| *Sanquisorba minor* subsp. *muricata* | 11 | +1 | - | +1 | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | II |
| *Campanula glomerata* | - | - | - | - | - | - | +1 | - | - | +1 | +1 | - | - | - | - | - | - | +1 | - | - | II |
| *Muscari comosum* | - | - | - | +1 | - | - | - | - | - | - | - | +1 | | - | - | - | +1 | - | +1 | - | II |
| *Anchusa undulata* | - | - | - | - | +1 | - | +1 | - | - | - | - | - | +1 | - | - | - | - | - | - | +1 | II |
| *Phlomis armeniaca* | - | - | - | 11 | - | +1 | - | - | - | - | - | - | - | +1 | - | - | +1 | - | - | - | II |
| *Potentilla argentea* | +1 | - | - | +1 | - | +1 | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | II |
| *Hieracium pannosum* | - | - | +1 | - | - | - | - | - | +1 | - | - | - | - | - | +1 | - | - | +1 | - | - | II |
| *Alyssum murale* var. *alpinum* | - | +1 | - | - | - | - | - | - | +1 | +1 | - | - | - | - | - | - | - | - | - | +1 | II |
| *Thlaspi perforatum* | +1- | - | - | - | - | - | - | +1 | - | - | - | +1 | +1 | - | - | - | - | - | - | - | II |
| *Salvia cadmica* | - | - | - | - | - | - | +1 | - | - | -+1 | - | - | - | - | - | - | -+1 | +1 | - | - | II |
| *Convolvulus compactus* | - | - | - | +1 | - | - | - | - | - | - | - | +1 | +1 | +1 | - | - | - | - | - | - | II |
| *Linaria corifolia* | - | - | - | - | - | +1 | - | - | - | +1 | - | +1 | - | - | +1 | - | - | - | - | - | II |
| *Nepeta congesta* var. *congesta* | - | - | - | - | +1 | - | - | - | - | - | +1 | - | - | - | +1 | +1 | - | - | - | - | II |
| *Orlaya grandiflora* | - | +1 | - | - | - | - | - | +1 | +1 | +1 | - | - | - | - | - | - | - | - | - | - | II |
| *Euphorbia amygdaloides* | - | - | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | +1 | +1 | - | +1 | II |
| *Saponaria viscosa* | - | +1 | - | - | - | - | +1 | - | - | - | - | - | +1 | - | - | - | - | - | +1 | - | II |
| *Sedum acre* | - | - | - | - | - | - | - | +1 | - | - | - | - | - | +1 | +1 | - | +1 | - | - | | II |
| *Digitalis lamarckii* | +1 | +1 | +1 | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | II |

Table 2: Continued

| Sampling area No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Slope (%) | 30 | 30 | 30 | 35 | 35 | 30 | 40 | 35 | 35 | 30 | 35 | 30 | 40 | 35 | 30 | 35 | 40 | 40 | 40 | 35 | Constancy |
| *Acinos rotundifolius* | - | - | - | +1 | - | - | - | - | +1 | - | +1 | +1 | - | - | - | - | - | - | - | - | II |
| *Phleum montanum* | - | +1 | - | - | - | 11 | - | +1 | - | - | - | - | - | - | - | - | +1 | - | - | - | II |
| *Orobanche alba* | - | - | - | - | +1 | - | +1 | - | - | +1 | - | - | - | - | - | +1 | - | - | - | - | II |
| *Ajuga orientalis* | - | - | - | - | - | - | - | - | - | - | - | - | +1 | +1 | - | - | - | - | - | +1 | II |
| *Wiedemmania orientalis* | +1 | - | +1 | - | - | - | - | - | - | - | - | +1 | - | - | +1 | - | - | - | - | - | II |
| *Agrimonia eupatoria* | 11 | +1 | - | - | +1 | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | II |
| *Convolvulus lineatus* | - | - | - | - | - | - | +1 | - | - | +1 | +1 | - | - | - | - | - | - | - | +1 | - | II |
| *Pilosella piloselloides* | - | - | - | - | - | - | - | +1 | +1 | - | - | - | - | - | +1 | - | - | - | - | +1 | II |
| *Trifolium heldreichianum* | - | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | - | - | +1 | II |
| *Trifolium medium* var. *eriocalycinum* | +1 | - | - | - | - | +1 | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | II |
| *Campanula lyrata* subsp. *lyrata* | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | +1 | - | - | - | +1 | - | II |
| *Urtica dioica* | - | +1 | - | - | - | - | +1 | +1 | - | - | - | - | - | - | | - | - | - | - | - | II |
| *Asyneuma limonifolium* | - | - | - | - | - | - | - | - | +1 | - | +1 | - | - | - | - | - | - | +1 | - | - | II |
| *Centaurea drabifolia* | - | - | - | - | - | +1 | - | - | - | - | - | +1 | - | +1 | - | - | - | - | - | - | II |
| *Cirsium arvense* | +1 | - | +1 | - | - | - | - | +1 | - | | - | - | - | - | - | - | - | - | - | - | II |
| *Taraxacum officinale* | - | - | - | - | +1 | - | - | - | - | +1 | - | - | - | - | - | - | +1 | - | - | - | II |
| *Carduus nutans* | - | - | - | - | - | - | - | - | - | - | +1 | - | - | - | +1 | - | - | - | - | +1 | II |
| *Ononis adenotricha* var. *adenotricha* | - | - | - | - | - | - | - | - | - | - | - | - | +1 | - | - | +1 | - | - | +1 | - | II |
| *Tragopogon longirostris* | - | - | - | +1 | - | - | - | +1 | - | - | - | - | | - | - | - | - | - | - | - | I |
| *Asplenium trichomones* | - | - | - | - | - | - | | - | +1 | - | - | - | - | +1 | - | - | - | - | - | - | I |
| *Torillis arvensis* subsp. *neglecta* | - | - | +1 | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | I |
| *Anthemis tinmctoria* var. *tinctoria* | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | +1 | - | - | - | I |
| *Ornithogalum orthophyllum* | - | - | - | - | - | - | +1 | - | - | - | - | +1 | - | - | - | - | - | - | - | - | I |
| *Lamium amplexicaule* | +1 | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | I |
| *Colchicum bornmuelleri* | - | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | I |
| *Ornithogalum ulophyllum* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | I |
| *Xeranthemum inaperdtum* | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | - | I |
| *Picnomon acarna* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | I |
| *Astragalus densifolius* | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | I |
| *Athyrium filix-foemina* | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | I |
| *Dorycnium pentaphyllum* | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | I |
| *Clinopodium vulgare* subsp. *vulgare* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | - | - | I |
| *Marrubium cephalanthum* | - | - | - | - | - | - | - | -- | - | - | - | - | - | +1 | - | - | - | - | - | - | I |
| *Moenchia mantica* | - | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | I |
| *Astragalus microcepus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | I |

Table 3: Successional development of Kartal forest area after fire (2002)

| Sampling area No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Slope (%) | 30 | 30 | 30 | 35 | 35 | 30 | 40 | 35 | 35 | 30 | 35 | 30 | 40 | 35 | 30 | 35 | 40 | 40 | 40 | 35 | Constancy |
| **Shrub formations** | | | | | | | | | | | | | | | | | | | | | |
| *Cistus laurifolius* | 44 | 34 | 34 | 33 | 34 | 44 | 34 | 35 | 45 | 44 | 44 | 44 | 44 | 33 | 34 | 45 | 44 | 45 | 44 | 35 | V |
| *Genista lydia* var. *lydia* | - | +1 | - | - | - | +1 | 11 | - | +1 | +1 | - | - | - | +1 | +1 | - | - | - | +1 | - | III |
| *Colutea cilicica* | - | - | - | 11 | - | +1 | +1 | - | - | - | - | - | +1 | - | - | - | - | - | - | 11 | II |
| *Crataegus monogyna* subsp. *monogyna* | - | 11 | 12 | -- | - | - | - | +1 | - | - | +1 | - | - | - | - | - | 11 | - | - | - | II |
| *Quercus pubescens* | +1 | - | - | - | 11 | - | 11 | - | - | - | - | - | 11 | - | - | - | - | - | 11 | - | II |
| *Ephedra major* | +1 | - | - | - | +1 | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | II |
| *Rosa canina* | - | - | - | - | - | - | 11 | - | - | - | - | - | 11 | - | - | - | - | - | - | - | I |
| *Juniperus excelsa* | - | - | - | - | - | - | - | - | 22 | - | - | - | - | - | - | - | - | - | - | - | I |
| *Rhus coriaria* | - | - | - | - | - | - | - | - | - | - | - | - | - | 22 | - | - | - | - | - | | I |
| **Herbaceous formations** | | | | | | | | | | | | | | | | | | | | | |
| *Aegilops cylindrica* | +1 | - | +1 | - | +1 | 11 | - | +1 | +1 | +1 | +1 | - | 11 | +1 | +1 | - | +1 | +1 | +1 | +1 | V |
| *Centaurea urvillei* subsp. *stepposa* | +1 | +1 | - | +1 | +1 | - | +1 | +1 | - | - | +1 | +1 | - | - | +1 | - | +1 | - | +1 | +1 | IV |
| *Crupina crupinastrum* | +1 | +1 | - | +1 | - | +1 | - | +1 | - | +1 | +1 | - | +1 | +1 | - | - | - | +1 | - | +1 | IV |
| *Verbascum lasianthum* | +1 | +1 | - | - | - | - | +1 | - | 11 | +1 | +1 | +1 | - | - | +1 | - | - | +1 | +1 | +1 | IV |
| *Filago pyramidata* | - | +1 | - | +1 | +1 | - | +1 | - | +1 | - | - | +1 | - | - | - | +1 | - | +1 | +1 | +1 | III |
| *Cynodon dactylon* | +1 | - | +1 | - | - | +1 | +1 | +1 | | +1 | +1 | | | - | +1 | - | | - | +1 | +1 | III |
| *Phleum exeratum* | +1 | +1 | - | - | +1 | +1 | - | - | +1 | +1 | - | - | +1 | - | - | +1 | - | +1 | +1 | - | |
| *Bromus sterilis* | - | +1 | - | +1 | +1 | +1 | - | +1 | +1 | | | | +1 | | | +1 | | +1 | | +1 | III |
| *Festuca callieri* subsp. *callieri* | +1 | - | +1 | - | +1 | - | - | +1 | +1 | - | +1 | - | - | +1 | - | +1 | +1 | - | - | +1 | III |
| *Dorycnium graecum* | - | - | - | +1 | - | +1 | - | +1 | - | +1 | +1 | +1 | - | - | +1 | +1 | - | +1 | - | - | III |
| *Teucrium polium* | - | - | +1 | - | +1 | - | - | - | +1 | +1 | - | +1 | +1 | +1 | +1 | - | - | - | - | - | III |
| *Stipa bromoides* | +1 | - | - | 11 | - | +1 | - | - | - | - | +1 | +1 | +1 | - | +1 | | - | - | +1 | - | III |
| *Rumex acetosella* | +1 | +1 | - | - | - | - | +1 | - | - | - | +1 | +1 | - | +1 | - | +1 | +1 | - | - | - | III |
| *Ziziphora tenuior* | +1 | - | - | +1 | | +1 | - | - | - | +1 | - | +1 | +1 | - | - | +1 | - | - | - | +1 | III |
| *Hordeum bulbosum* | +1 | +1 | - | - | +1 | - | - | +1 | - | +1 | - | +1 | - | - | - | - | +1 | - | +1 | - | III |
| *Centaurea depressa* | - | - | - | +1 | - | - | +1 | - | +1 | +1 | - | - | +1 | - | +1 | - | +1 | - | - | - | II |
| *Eryngium bithnicum* | - | +1 | - | - | - | - | - | - | - | +1 | - | +1 | +1 | - | - | +1 | - | - | +1 | +1 | II |
| *Koeleria cristata* | - | - | +1 | - | - | +1 | - | +1 | - | - | +1 | +2 | - | +1 | - | - | - | - | +1 | - | II |
| *Chenopodium foliosum* | +1 | - | - | +1 | - | +1 | - | +1 | - | - | +1 | - | - | +1 | - | - | - | - | - | +1 | II |
| *Onobrychis armena* | - | +1 | - | +1 | +1 | - | - | - | - | +1 | - | - | - | - | - | - | - | - | +1 | +1 | II |
| *Astragalus sterocalyx* | - | - | - | - | - | - | +1 | - | +1 | - | - | +1 | - | +1 | - | - | - | +1 | - | +1 | II |
| *Viola kitaibeliana* | - | - | +1 | - | - | +1 | - | - | +1 | - | - | - | - | - | +1 | +1 | - | - | +1 | - | II |
| *Epilobium angustifolium* | - | +1 | - | - | - | +1 | - | - | - | - | +1 | - | +1 | - | +1 | - | - | 11 | - | - | II |
| *Vicia pannonica* var. *purpurascens* | - | +1 | - | +1 | - | - | - | - | - | +1 | - | - | +1 | - | - | - | +1 | - | - | - | II |
| *Secale cereale* var.*creale* | - | - | - | +1 | - | - | - | - | - | - | +1 | - | - | - | +1 | - | +1 | - | +1 | | II |
| *Achillea bieberstenii* | +1 | | - | - | - | +1 | +1 | - | - | - | - | - | +1 | | | | +1 | - | - | - | II |
| *Phleum montanum* | - | +1 | - | - | - | +1 | - | +1 | - | - | - | - | - | - | +1 | - | +1 | - | - | - | II |
| *Capsella bursa-pastoris* | - | +1 | - | - | - | - | +1 | - | - | - | - | - | - | - | +1 | - | - | - | - | +1 | II |
| *Vicia cracca* | - | - | - | +1 | - | +1 | - | +1 | - | - | - | - | - | - | - | - | - | - | +1 | - | II |
| *Convolvulus arvensis* | - | - | +1 | - | - | +1 | - | - | - | +1 | - | - | - | - | - | +1 | - | - | - | - | II |
| *Jurinea consaqunea* | - | - | - | - | - | +1 | - | +1 | - | - | - | | - | +1 | +1 | - | - | - | - | - | II |
| *Anthemis tinctoria* var. *tinctoria* | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | +1 | - | - | - | +1 | II |

Table 3: Continued

| Sampling area No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Slope (%) | 30 | 30 | 30 | 35 | 35 | 30 | 40 | 35 | 35 | 30 | 35 | 30 | 40 | 35 | 30 | 35 | 40 | 40 | 40 | 35 | Constancy |
| *Cardaria draba* subsp. *draba* | - | - | - | - | - | - | - | - | - | - | - | +1 | - | +1 | - | +1 | - | | +1 | - | II |
| *Silene armena* | - | - | - | - | +1 | - | - | - | - | - | - | +1 | - | - | - | - | - | - | +1 | - | II |
| *Picnomon acarna* | - | - | +1 | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | +1 | II |
| *Hypericum perforatum* | - | - | - | +1 | - | - | - | +1 | - | - | - | - | - | - | - | - | - | +1 | - | - | II |
| *Veronica chamaedrys* | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | +1 | - | - | - | +1 | II |
| *Asyneuma limonifolium* | - | - | - | - | - | - | - | - | +1 | - | +1 | - | - | - | +1 | - | - | - | - | - | II |
| *Globularia orientalis* | - | - | - | +1 | - | - | - | +1 | - | - | - | - | - | - | - | - | - | +1 | - | - | II |
| *Allium scoroprodasum* subsp. *rotundum* | - | - | - | - | - | - | +1 | - | +1 | - | - | - | - | - | - | - | +1 | - | - | +1 | II |
| *Veronica multifida* | | - | | - | | +1 | - | - | - | - | - | +1 | - | +1 | - | - | - | - | - | - | II |
| *Alyssum borzaenum* | - | - | - | +1 | - | - | - | - | - | | - | - | - | - | +1 | - | | - | | +1 | II |
| *Lotononis genistoides* | +1 | - | - | - | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | +1 | - | II |
| *Thymus sibthorpii* | - | - | - | - | - | - | - | - | - | - | +1 | - | 11 | - | - | - | - | +1 | - | - | II |
| *Cephalanthera rubra* | - | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | +1 | II |
| *Ajuga chamaepithys* subsp. *chia* var. *chia* | +1 | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | II |
| *Anthemis tinctoria* var. *pallida* | - | - | - | - | - | - | +1 | - | +1 | - | - | - | - | - | - | - | - | - | - | - | I |
| *Centaurea solstitialis* | - | - | +1 | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | I |
| *Xanthium spinosum* | - | - | - | - | +1 | - | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | I |
| *Trigonella velutina* | - | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | +1 | - | - | - | I |
| *Onosma bornmuelleri* | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | +1 | - | I |
| *Picris strigosa* | - | - | +1 | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | I |
| *Alyssum murale* var. *alpinum* | - | +1 | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | I |
| *Salvia cadmica* | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | I |
| *Euphorbia amygdaloides* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | - | - | - | I |
| *Ajuga orientalis* | - | - | - | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | I |
| *Trifolium caudatum* | - | - | - | - | - | - | - | - | - | - | - | +1 | - | - | - | | - | | +1 | - | I |
| *Euphorbia macroclada* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | I |
| *Trifolium pannonicum* | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | I |
| *Cirsium arvense* | +1 | - | I | - | - | - | - | I | - | | - | - | - | - | - | - | - | - | - | - | I |
| *Taraxacum officinale* | - | - | - | +1 | - | - | - | - | - | +1 | - | - | - | - | - | - | +1 | - | - | - | I |
| *Carduus nutans* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | I |
| *Ononis adenotricha* var. *adenotricha* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | - | I |
| *Sedum acre* | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| *Torillis arvensis* subsp. *neclecta* | - | - | - | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | I |
| *Lamium amplexicaule* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | - | - | |

Table 4: Plant formations of *P. nigra* subsp. *pallasiana* comunities around Kartal burned forest area

| Sampling area No. | 3 | 7 | 9 | 6 | 17 | 22 | 11 | 10 | 18 | 12 | 21 | 28 | 36 | 30 | 23 | 16 | 25 | 39 | 4 | 29 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area (m$^2$) | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | |
| Altitude (m) | 1450 | 1470 | 1450 | 1460 | 1440 | 1450 | 1450 | 1470 | 1470 | 1450 | 1430 | 1460 | 1450 | 1450 | 1450 | 1440 | 1450 | 1460 | 1450 | 1470 | |
| Exposure (S = South) | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | |
| Slope (%) | 30 | 30 | 30 | 35 | 35 | 30 | 40 | 35 | 35 | 30 | 35 | 30 | 40 | 35 | 30 | 35 | 40 | 40 | 40 | 35 | |
| Mother rock (G = Gnays) | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | Constancy |
| **Shrub formations** | | | | | | | | | | | | | | | | | | | | | |
| *Quercus pubescens* | 11 | +1 | - | 11 | - | +1 | +1 | - | - | - | - | 11 | - | - | - | - | - | +1 | - | +1 | III |
| *Genista lydia* var. *lydia* | - | - | +1 | - | - | - | - | +1 | - | - | +1 | - | - | - | - | - | +1 | - | +1 | - | II |
| *Ephedra major* | - | - | - | - | +1 | - | - | - | +1 | - | - | - | +1 | +1 | - | - | - | - | - | +1 | II |
| *Cistus laurifolius* | +1 | - | - | - | - | - | - | - | - | +1 | - | - | +1 | - | +1 | - | - | +1 | - | - | II |
| *Crataegus monogyna* subsp. *monogyna* | - | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | +1 | - | - | - | I |
| *Juniperus excelsa* | - | - | - | 11 | - | - | - | - | - | - | - | - | - | - | - | 11 | - | - | - | - | I |
| **Herbaceous formations** | | | | | | | | | | | | | | | | | | | | | |
| *Thymus sibthorpii* | +1 | - | +1 | - | 11 | +1 | 11 | +1 | - | +1 | 11 | - | - | +1 | 11 | - | +1 | +1 | 11 | +1 | IV |
| *Teucrium polium* | +1 | - | +1 | - | +1 | - | +1 | +1 | +1 | - | - | +1 | - | +1 | - | +1 | - | +1 | - | +1 | III |
| *Ziziphora tenuior* | - | +1 | +1 | - | | +1 | - | - | - | +1 | - | +1 | +1 | - | +1 | +1 | +1 | - | +1 | +1 | III |
| *Trifolium pannonicum* | +1 | - | - | +1 | +1 | - | - | +1 | - | - | +1- | - | +1 | +1 | +1 | - | +1 | +1 | - | - | III |
| *Hieracium pannosum* | - | +1 | +1 | +1 | - | - | +1 | +1 | - | - | +1 | - | +1 | +1 | +1 | - | - | +1 | - | - | III |
| *Helycrisum arenarium* subsp. *aucheri* | - | - | +1 | +1 | - | - | +1 | - | +1 | - | - | - | - | - | +1 | - | +1 | - | +1 | +1 | III |
| *Campanula lyrata* subsp. *lyrata* | +1 | - | - | +1 | - | +1 | - | +1 | - | - | +1 | - | - | +1 | +1 | - | - | +1 | - | - | III |
| *Vicia cracca* | - | - | - | +1 | - | - | +1 | - | - | - | +1 | - | +1 | - | - | +1 | - | +1 | +1 | +1 | III |
| *Lotononis genistoides* | - | +1 | - | - | +1 | - | - | +1 | - | +1 | - | +1 | - | +1 | - | +1 | - | - | - | | II |
| *Achillea bieberstenii* | +1 | - | +1 | - | - | - | +1 | - | +1 | - | - | - | +1 | - | - | | +1 | - | - | - | II |
| *Cephalanthera rubra* | - | - | +1 | +1 | - | - | - | - | - | - | +1 | - | - | +1 | - | - | - | - | +1 | +1 | II |
| *Galium verum* subsp. *verum* | - | - | - | - | - | +1 | - | - | +1 | - | - | +1 | +1 | - | +1 | - | +1 | - | - | - | II |
| *Stipa bromoides* | - | - | - | - | - | - | - | - | - | +1 | - | - | +1 | +1 | +1 | +1 | - | - | - | +1 | II |
| *Aegilops cylindrica* | - | - | +1 | - | - | - | +1 | - | +1 | - | - | +1 | - | - | - | - | +1 | - | +1 | - | II |
| *Crupina crupinastrum* | - | - | +1 | +1 | - | +1 | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | II |
| *Filago pyramidata* | - | - | - | - | +1 | - | - | - | - | - | - | - | +1 | - | - | +1 | - | +1 | - | - | II |
| *Inula ensifolia* | - | - | - | +1 | - | +1 | - | - | +1 | - | - | +1 | +1 | - | - | - | - | | - | +1 | II |
| *Dorycnium graecum* | - | +1 | - | +1 | - | - | - | +1 | - | - | +1 | - | - | - | - | - | - | - | - | - | II |
| *Ajuga chamaepithys* subsp. *chia* var. *chia* | +1 | - | - | - | +1 | - | - | - | +1 | - | - | - | - | - | - | +1 | - | - | - | - | II |
| *Xanthium spinosum* | - | +1 | - | - | - | - | - | - | - | +1 | - | - | - | +1 | - | - | - | - | - | +1 | II |
| *Dactylohirrza romana* | - | - | - | - | - | +1 | +1 | - | - | - | - | - | - | - | +1 | | +1 | - | - | - | II |
| *Eryngium bithnicum* | - | | +1 | - | - | - | - | - | - | +1 | - | - | - | +1 | - | - | - | - | +1 | - | II |
| *Campanula glomerata* | - | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | +1 | - | +1 | - | +1 | II |
| *Digitalis lamarckii* | - | - | +1 | - | +1 | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | II |
| *Cirsium arvense* | +1 | - | - | - | - | - | - | +1 | - | | - | - | - | - | - | - | +1 | - | - | - | II |

Table 4: Continued

| Sampling area No. | 3 | 7 | 9 | 6 | 17 | 22 | 11 | 10 | 18 | 12 | 21 | 28 | 36 | 30 | 23 | 16 | 25 | 39 | 4 | 29 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area ($m^2$) | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | |
| Altitude (m) | 1450 | 1470 | 1450 | 1460 | 1440 | 1450 | 1450 | 1470 | 1470 | 1450 | 1430 | 1460 | 1450 | 1450 | 1450 | 1440 | 1450 | 1460 | 1450 | 1470 | |
| Exposure (S = South) | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | |
| Slope (%) | 30 | 30 | 30 | 35 | 35 | 30 | 40 | 35 | 35 | 30 | 35 | 30 | 40 | 35 | 30 | 35 | 40 | 40 | 40 | 35 | |
| Mother rock (G = Gnays) | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | Constancy |
| *Carduus nutans* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | - | - | +1 | +1 | II |
| *Vicia pannonica* var. *purpurascens* | - | - | - | +1 | +1 | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | II |
| *Ononis adenotricha* var. *adenotricha* | - | - | - | - | - | - | - | +1 | +1 | - | - | - | - | +1 | - | - | - | - | - | - | II |
| *Phleum exeratum* | - | - | - | +1 | - | - | - | - | - | +1 | - | +1 | - | - | - | - | - | - | - | - | II |
| *Centaurea urvillei* subsp. *stepposa* | - | - | +1 | - | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | +1 | - | II |
| *Alyssum borzaenum* | - | - | - | - | +1 | - | - | - | - | | +1 | - | - | - | - | - | | - | | - | I |
| *Hypericum perforatum* | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | I |
| *Cynodon dactylon* | - | - | - | - | - | - | - | - | | - | - | | | - | - | +1 | - | - | | - | I |
| *Veronica chamaedrys* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | I |
| *Globularia orientalis* | - | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | I |
| *Asyneuma limonifolium* | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | I |
| *Coronilla varia* subsp. *varia* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | - | - | - | I |
| *Dorycnium pentaphyllum* | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | | I |
| *Veronica multifida* | +1 | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | I |
| *Asplenium trichomones* | - | - | - | - | - | - | | - | +1 | - | - | - | - | +1 | - | - | - | - | - | - | I |
| *Torillis arvensis* subsp. *neglecta* | - | - | +1 | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | I |
| *Lamium amplexicaule* | +1 | - | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | I |
| *Xeranthemum inaperdtum* | - | - | - | - | - | - | - | - | +1 | - | - | - | - | - | - | - | - | - | - | - | I |
| *Picnomon acarna* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | +1 | I |

status of 133 taxa. According to these observations, the population density, cover percentage and society constitution power of *Cistus laurifolius*, which is a semi dominant formation, is at average levels. The species of shrub formations like *Genista lydia*, *Juniperus oxycedrus* subsp. *oxycedrus*, *Rhus coriaria*, *Quercus pubescens*, *Crataegus monogyna* subsp. *monogyna*, *Ephedra major* and *Lonicera etrusca* are poor with respect to these parameters.

Species that belong to meadow and steppe vegetations, have the highest dominance, cover percentage and society constitution power and show constancy above average, which means that have constancy level of V and VI according to Braun-Blanquet, are as follows; *Aegilops cylindrica*, *Vicia cracca*, *Trifolium caudatum*, *Trifolium pannonicum*, *Euphorbia macroclada*, *Thymus sibhorptii*, *Viola kitaibeliana*, *Silene armena*, *Epilobium angustifolium*, *Trigonella fishcheriana*, *Crupina crupinastrum*, *Lotononis genistoides*, *Filago pyramidata*, *Festuca callieri*, *Dorycnium graecum* and *Teucrium polium.*

Successional development of the area was observed until 2002, in three years period (Table 3). Although this period is respectively short, there were exact changes at the successional stage of the area. During this short period of 3 years, the number of taxa at the burned area decreased to 77. The most common families and their number of species and genera were shown in Fig. 3. Irano-Turanein species were still dominant at the study area (Fig. 2) and the endemism ratio was determined as 10.7%. *C. laurifolius*, that showed an average dominance at the study area, became dominant over all other herbaceous and shrub species. Species of *Cistus* L. are considered the most common post fire colonizers in the Mediterranean Basin (Moravec, 1990; Tavsanoglu and Gurkan, 2005). Even if they are absent in mature forests, they generally persist in soil seed banks and may reappear in these areas after the fire (Tavsanoglu and Gurkan, 2005). Most of the herbaceous species were eliminated from the area but some of the members of Poaceae, Lamiaceae, Asteraceae and Scrophulariaceae continue their density, coverage percentage and sociability with the dominant *C. laurifolius*.

Before the fire, the area was covered with *P. nigra* subsp. *pallasiana* forest. And also around the burned area there are still a *P. nigra* subsp. *pallasiana* forest with 50 plant taxa. The phytosociological characteristics of the *P. nigra* subsp. *pallasiana* forests surrounding the burned area were shown in Table 4. There were 6 endemik species at the area and the endemism ratio of the unburned Pine forest around Kartal forest was found as 12%. The distribution of species in most abundant families and the phytogeographical region were shown in Fig. 2 and 3, respectively.

The most common families of burned Kartal forest and unburned forest around Kartal forest were all the same; Asteraceae, Fabaceae, Lamiaceae and Poaceae. The flora of the burned areas depend on the flora of neighbouring areas and this result fitted with this fact. The differences in the number of species was the result of competition in burned area and succession and the poor plant biodiversity of the forest vegetation with respect to the steppe vegetation. The endemism ratio of burned area in 1999 and 2002 and unburned forest were close to each other as a result of migration of plants from unburned neighbouring areas.

## DISCUSSION

The floristic and ecological studies at Kartal burned forest were conducted between 1999 and 2002 through the vegetation period. The successional development of the area was observed and the changes in the floristic and ecological characteristics of the closest *P. nigra* subsp. *pallasiana* forests were examined (Table 4). For *P. nigra* natural regeneration can only be expected in small patches preserved from fire such as rock outcrops, ridges, discontinuous vegetation mosaics (Escudero *et al*., 1999) and after low severity wildfires (Habrouk *et al*., 1999) because *P. nigra* does not have serotinous cones (Tapias *et al*., 2001; Habrouk *et al*., 1999). For this reason the only way of development of new *Pinus* forest in the area is the migration of seeds of the reforestation.

At the end of the floristic research 133 plant taxa were collected from the burned area in 1999 and compared with the neighbouring forest flora which has 50 plant taxa. Most of these plant taxa are not belonging to the natural forest vegetation; they are the formations of steppe and meadow vegetations which normally do not grow under the forest canopy. After the fire, life forms, having a natural distribution at forest gaps, forest borders and rocky slope of the Sundiken Mountains migrated to the area in different ways and invaded the burned area. The plants growing under forest near to the burned area entered the region and there was a change observed in their relative dominance-coverage and sociability values (Table 2, 3).

According to the observations after the fire and the specimens collected since 1999 showed that between 1999 and 2002 there was a clear development of secondary succession. In 2002, the number of species at the burned area decreased to 75 during the secondary succession.

The primary and secondary succession in any area needs the sequential processes of migration, germination, ecesis, aggregation, competition and reaction (Miles, 1979). The pioneers make the habitat suitable for the settlement of the subsequent plant formation by germinating and developing over the area, after the settlement of subsequent plants intra and inter specific competition start and then this competition results in reaction which leads to the changes in microclimatic and edaphic characteristics of the area. At the end, a community reaches an equilibrium with the climate and form a rather unchangeable state which means climax (Ozturk and Secmen, 1996).

In the study area the annual or perennial pioneers that belong to Poaceae, Fabaceae, Lamiaceae and Asteracaea families competed with other shrub forms like *Cistus laurifolius*, *Genista lydia*, *Juniperus oxycedrus* subsp. *oxycedrus*, *Rhus coriaria*, *Quercus pubescens*, *Crataegus monogyna* subsp. *monogyna*, *Ephedra major* and *Lonicera etrusca*. This successional development can be seen from Table 2 and 3, *C. laurifolius*, perennial chamaphyte, entered the burned area with different ways and eliminated most of the other herbaceous plants and became dominant in 3 years period. *C. laurifolius* is a competitive allelopathic plant and with its roots secrete some chemicals and inhibits the growth of the other plants. After the 3 years observations, there was an obvious increase in the dominance, cover and sociability rates of this species. In the vegetation period of 1999 relative abundance of *C. laurifolius*, projection of its vegetative parts on soil and the power of sociability was determined as 11-23, these values increased to 45 in 2002. In a few years all the dominance characteristics of this species increased and it became a dominant plant over the area.

Although the number of species of 20 sampling area in 1999 was determined as 133, during the succession because of competition, the number of species in samplings at burned areas decreased to 75 and 58 species were eliminated from the area with the changing conditions. Also there was a change through the study period in the dominance, coverage and sociability of each taxa. Although this was an evident positive change for *C. laurifolius* and relatively positive change for *Centaurea depressa*, *Aegilops cylindrical*, *Crupina crupinastrum*, *Verbascum lasianthum*, *Filago pyramidata*, *Bromus sterilis*, *Dorycnium greacum*, *Teucrium polium*, *Cynodon dactylon*, *Phleum exeratum*, *Festuca callieri*, *Eryngium bithinicum* and *Koeleria cristata* and for almost all of the taxa like *Vicia cracca*, *Trifolium caudatum*, *T. pannonicum*, *Thymus sibthorpii*, *Viola kitabeliana*, *Silene armeria*, *Epilobium angustifolium*, *Lotononis genistoides*, *Trigonella fischeriana*, *Achillea biebersteinii*, *Alyssum borzaenum*, *Anthemis tinctoria* var. *tinctoria*, *Cardaria draba*, *Galium verum*, *Papaver rhoes*, *Sisymbrium altissimum*, *Lathyrus czeczottiana* and *Consolida regalis* this change was negative which means that their abundance, dominance and sociability decreased. 58 of the detected species, which was 133 in 1999, eliminated from the region.

At the end of the competition *C. laurifolius* became a dominant species at the study area by eliminating the other herbaceous formations. The density and cover of *Cistus* reached very high values in a short period of time after fire and this can be attributed to increased rates of germination immediately after disturbance (Thanos and Georghiou, 1988; Thanos and Oustrich, 1989; Tavsanoglu and Gurkan, 2005). It is not possible to say that this species formed the climax community of the study area. If there will not be any external impact on the area there should be progress in the successional stage and *P. nigra* subsp. *pallasiana* will probably become the dominant phanerophyte community of the area.

It is known that after the fires that produce high temperatures, many chemical compounds change their phase, melt and because of the oxidation of mould and organic materials food chain changes and the acidity of the soil increases. So, some herbaceous plants whose demand for nitrogen is low become dominant temporarily. In general, it was observed that fires stimulate the flowering and development of not only herbaceous but also woody plants (Bond and Van Wilgen, 1996; Trabaud, 1987). The increase in soil temperature in burned areas cause increase in the population size of fungi and bacteria, which results an increase in amonifikasyon, nitrifikasyon and mineralization processes especially in 12 months period after fire (Ozturk and Secmen, 1996).

Fire has a direct effect on the absorption of available nutrients, the inhibition of nitrogen cycle, the increase in pH and the concentrations of some cations such as K, Ca and Mg. Moreover, senescence of leaves and increase in decomposition rate of these leaves cause entrance of heliophytic herbaceous and woody plant to the area after fire and result in the invasion of the area by these plant specimens with increasing germination, development and population density rates (Table 1).

After the fire the study area only cleared and up to date there was no any reforestation action. If there will be some reforestation activities at this area, according the previous studies conducted in Mediterranean regions *Quercus* species should be used with *Pinus* species. For sustainable reforestation actions in fire-prone Mediterranean landscapes, fast growing pines and broad leaved resprouting species, especially *Quercus* species, should be combined to take the advantage of the complementary features of both species groups (Pausas *et al*., 2004).

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