Soil-Plant Interactions in the High-Altitude Ecosystems: A Case Study from Kaz Dağı (Mount Ida), Turkey

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Chapter 13
Soil–Plant Interactions in the High-Altitude Ecosystems: A Case Study from Kaz Dağı (Mount Ida), Turkey

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13.1 Introduction

Anatolia is one of the richest lands in the world for the natural diversity of its flora and fauna, and has also been a cradle for great civilizations for centuries. The land sustains a unique biological and cultural diversity both in the region as well as on the global scale (Ozturk et al. 1996a, b). It is located at the meeting point of four important floral regions, namely Europe in the Northwest, the Caucasus in the Northeast, Mediterranean in the West and the South, and Mesopotamia in the Southeast (Ozturk et al. 2008, 2010a). Kaz Dağı, known in the history as Mount Ida, is one of the important sites in the country located in the north of Edremit in northwestern Anatolian part within the borders of the states of Çanakkale and Balıkesir. The region has been a center of attraction for the settlers all through the ages because of its fertile soils, wetlands, underground resources, favorable climatic conditions, a premium destination for the ecotourism activities, as a recreation spot, as well as for its floral and faunal richness (Efe et al. 2008, 2011a, b, 2012; Satıl 2009; Uysal 2010; Uysal et al. 2011, 2012). This diversity of the mountain has served and sustained the people around this area for centuries.

In Greek mythology, the region was known as "Mysia" and the people were warriors, originally from Thrace, who settled in Troy around 3000 BC. Later, people from Frig, Mysia, Lydia, Ayonis, and Pers settled in this region (Kelkit et al.

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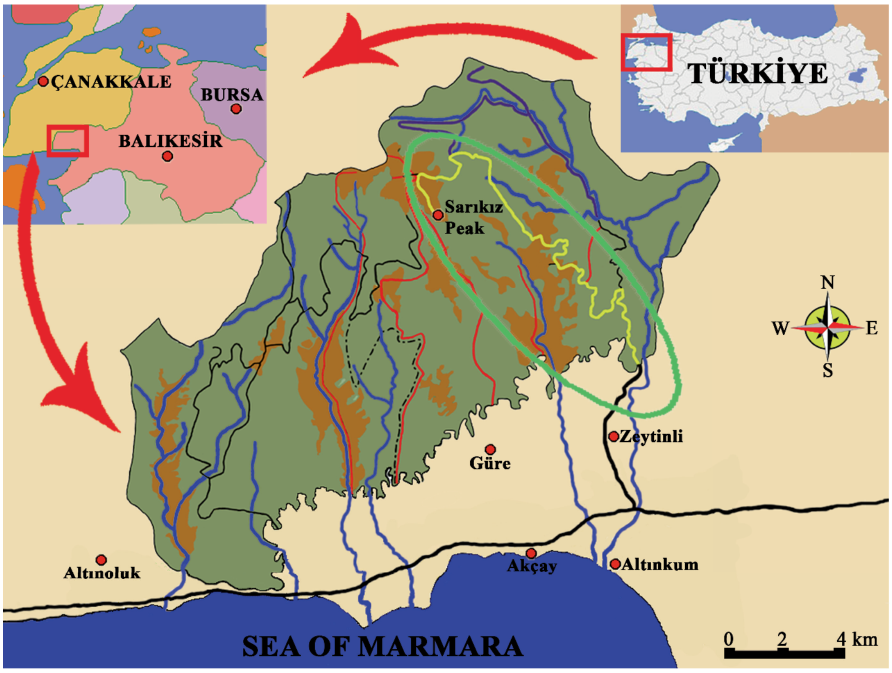

Fig. 13.1 Map showing Kaz Dağı National Park with the study area within the *green circle*

2005). The mountain is known as Mount Ida in the famous epic poem (The Iliad) of Homer (eighth-century BC) (Uysal 2010). According to the legends, the mountain was dedicated to gods and goddess, and all kinds of divine happenings took place on this mountain (Duymaz 2001; Coban 2012).

The mountain is situated at the intersection of two phytogeographically important floral regions; Mediterranean and Euro-Siberian (Uysal 2010), which contributes to its floral richness. The southwestern part of the mountain has been declared as a national park (Fig. 13.1) in 1993, because of its biological diversity, geomorphological features, archeology, cultural resources as well as richness of water resources (Kelkit et al. 2005).

Kaz Dağı has a number of mountain ranges such as Babadağı (1765 m), Karataş (1774 m), Sarıkız (1726 m), Kocatepe (1340 m), Karaçam (1210 m), İnkayası (1180 m), Eybek (1298 m), Öldüren (1060 m), Kocakatrancı (1030 m), and Küçükkatrancı (1015 m) stretching in the east-west direction (Ozel 1999). Zeytinli, Güre, Tuzla, and Gönen wetlands, and Ihlamur and Şahin streams are the main water reservoirs of the mountain (Azatoglu and Azatoglu 2001). These high mountain flowing waters along their way form streams and wetlands; with rich and diverse habitats for numerous plant and animal species; feeding many smaller communities before pouring down into the Aegean and Marmara seas.

13.2 Soils

There are five major types of soils distributed on this mountain (Ozel 1999).

I. *Noncalcareous brown forest soils* are the most common type of soils here, found in almost every aspect and elevation of the mountain. There are A, B, and C horizons with gradual transitions, the B horizon usually at 40–70 cm depth. The A horizon is well formed with porous structure, while the B horizon is not well formed and shows brown or dark-brown granular, or block structure with rounded corners. The organic substances in these soils are generally of acidic character, either separate from the mineral portion or are slightly mixed. The subsoil shows very little or no accumulation of clay. The pH decreases in the lower profiles ($pH < 6$) (Ozel 1999; Uysal et al. 2011).

II. *Brown forest soils* are usually found on the bedrocks containing higher amounts of lime in their structure (Ozturk and Gork 1979). The soil has A, B, and C horizons with gradual transitions, with the B horizon usually at a depth of 50–90 cm. The A horizon is well formed, and shows a porous and granular structure. Organic matter is in the form of mull, thoroughly mixed with mineral substances, the pH is usually basic, rarely neutral, and soil is brown in color. The B horizon shows brown granular or block structure with rounded corners, accumulation of clay is very little but higher than the C horizon. $CaCO_3$ is found at lower layers of this horizon B (Ozel 1999).

III. *Noncalcareous brown soils* also show A, B, and C horizons, the soil is washed, upper parts are brown or light brown in color and easily friable. It shows an acidic character as compared to the subsoil. The B horizon is pale reddish-brown in color. The bedrock is composed of gravel, sand, and clay deposits, especially with the calcareous sandy clay and sandy clay stones exposed to the fragmentation (Ozel 1999; Gregory et al. 2014).

IV. *Red–brown Mediterranean soils* A, B, and C horizons show gradual transition. The A horizon is well formed and contains the organic matter in moderate amounts. It shows red/brown squared blocks or prismatic structures (Verheyen and Rosa 2005). The bedrock is generally composed of hard limestone as well as granite, clay stone, sand stone, various metamorphic rocks, crystalline rocks, flysch, and limestone in the low mountainous regions, and andesitic, dazitic, basaltic rocks, granite clay stone, cemented sand stone conglomerate, marl deposits, various sedimentary rocks, gravel–sandy clay younger sediments, and sandy clay stones in the lower plateaus and plains (Yaalon 1997; Ozel 1999).

V. *Colluvial soils* are the deposit of materials on the weak slopes, carried by the surface flowing waters or streams from short distances. The soil characteristics are more similar to the characters of the surrounding upland soils. According to the degree of slope and rainfall intensity, they contain layers with various particle sizes. These soils have well drainage capacity because of the slope and texture, therefore salt buildup is not observed (Brady and Weil 1996; Ozel 1999; Sumner 1999).

13.3 Vegetation

Forest, shrub, and high mountain are the three main types of vegetation found on Kaz Dağı (Gemici et al. 1998; Uysal 2010).

13.3.1 Forest Vegetation

It is represented by coniferous, deciduous, and mixed forests (Ozturk et al. 1983).

13.3.1.1 Coniferous Forests

Turkish red pine (*Pinus brutia*) forests are typical eastern Mediterranean elements, showing distribution in the western and southern Anatolia as well as on the coast of western Black Sea (Saribas and Ekici 2004; Kurt et al. 2011; Guller et al. 2012). The coverage of this forest vegetation substantially decreased due to anthropogenic factors (Ari 2004; Ari and Kose 2009; Satil 2009). This is especially observed approximately at 250–300 m. The shrub layer is absent or rare under dense forest cover. However, in the areas where the coverage is destroyed, many shrub species in the sub-flora are seen. The following shrub species (0–500 m) are mostly available in the sub-flora on the southern slopes of the mountain: *Anagyris foetida, Arbutus andrachne, A. unedo, Cercis siliquastrum, Cistus creticus, Coridothymus capitatus, Erica arborea, Jasminum fruticans, Laurus nobilis, Lavandula stoechas, Olea europaea, Osyris alba, Phillyrea latifolia, Pistacia terebinthus, Prunus divaricata, P. spinosa, Quercus coccifera, Rhus coriaria,* and *Styrax officinalis* (Uysal 2010; Uysal et al. 2011).

Black pine (*Pinus nigra*) forests are distributed in southern Europe, North Africa, Anatolia, and in Crimea (Scaltsoyiannes 1994; Yucel and Ozturk 2000; Afzal-Rafii and Dodd 2007; Sanchez-Salguero et al. 2013). They begin on the southern slopes at 700–750 m and on the northern slopes of the mountain at about 400 m, and drop down in the Northeast of the mountain to about 270 m. These forests cover the upper part of the mountain and are mostly pure, but in the north and northeastern parts, they are mixed with the fir and broad-leaved beech, oak, hornbeam, and chestnut trees. The following trees and shrubs form mixed communities with the black pine: *Acer platanoides, A. hyrcanum* ssp. *keckianum, Adenocarpus complicatus, Carpinus betulus, Castanea sativa, Chamaecytisus eriocarpus, Crataegus monogyna, Corylus avellana, Cornus mas, Fagus orientalis, Genista lydia, Juniperus foetidissima, Platanus orientalis, Populus tremula, Prunus divaricata, Rubus canescens, Quercus cerris* var. *cerris, Q. frainetto, Q. petraea* ssp. *iberica, Salix pedicellata, Sorbus aucuparia, S. torminalis, Tilia argentea,* and *Vaccinium myrtillus* (Gemici et al. 1998; Ozel 1999; Uysal 2010).

Kaz Dağı fir (*Abies nordmanniana* ssp. *equi-trojani*) is a narrow endemic species (only growing in Kaz Dağı). This endemic species covers an area of 3591.5 ha

(282.5 ha pure fir stands, 3309 ha mixed with *Pinus nigra* ssp. *pallasiana* and *Fagus orientalis*) (Ozel and Simsar 2009). The genetic resource of Kaz Dağı fir is conserved under the national plan for "*In situ* Conservation of Plant Genetic Diversity in Turkey" (Kaya et al. 1997). It is usually occupying the northern slopes of the mountain between 1000 and1400 m, like other fir taxa. Kaz Dağı fir forms mixed communities with following trees and shrubs: *Acer platanoides, A. campestre, Carpinus betulus, Castanea sativa, Crataegus monogyna, Fagus orientalis, P. nigra* ssp. *pallasiana, Populus tremula, Pyrola chlorantha, P. minor, Quercus cerris, Q. petrea* ssp. *iberica, Q. frainetto, Sorbus aucuparia,* and *Sorbus umbellata* (Gemici et al. 1998; Uysal 2010; Uysal et al. 2011).

13.3.1.2 Deciduous Forests

Beech forests (*Fagus orientalis*) have a distribution beginning from the east of Balkans, through Anatolia to Crimea, to the Caucasus and finally reaching northern Iran (Cansaran et al. 2012; Kavgaci et al. 2012). In Turkey, it is found on Amanos Mountains in the South and on Kaz Dağı in the North. They prefer the slopes, which contain more humid and have longer shadowing periods. They are located on the schist bedrock and the soils are noncalcareous brown forest. The following trees and shrubs are associated with the beech species: *Abies nordmanniana* ssp. *equi-trojani, Acer platanoides, Castanea sativa, Carpinus betulus, Corylus avellana, Hedera helix, Pinus nigra* ssp. *pallasiana, Platanus orientalis, Populus tremula, Quercus cerris* var. *cerris, Q. frainetto, Rubus caesius, Rhododendron flavum, Sambucus nigra, Sorbus domestica, Taxus baccata,* and *Tilia argentea* (Uysal 2010; Uysal et al. 2011).

Chestnut (*Castanea sativa*) is mainly distributed in the Black Sea region in Turkey (Ketenoglu et al. 2010). It occupies the elevations between 30 and1500 m and has a scattered distribution in the Aegean and Mediterranean regions. The following species are found as companions in the chestnut forests in Kaz Dağı: *Abies nordmanniana* ssp. *equi-trojani, Alnus glutinosa, Brachypodium sylvaticum, Carpinus betulus, Chamaecytisus hirsutus, Corylus avellana, Euphorbia amygdaloides, Fagus orientalis, Galium verum, Hedera helix, Luzula forsteri, Pinus nigra* ssp. *pallasiana, Pteridium aquilinum, Quercus cerris, Q. frainetto, Q. petraea, Sorbus torminalis, Veronica chamaedrys*, and *Viola odorata* (Ozel 1999).

Hornbeam (*Carpinus betulus*) forests are distributed on the slopes up to 800 m, facing the sea and occupy pebbled areas in northern Anatolia (Gucel et al. 2008). Mostly they are found as mixed communities with following trees and shrubs: *Castanea sativa, Cornus mas, Corylus avellana, Euonymus latifolius, Fagus orientalis, Ilex aquifolium, Malus sylvestris, Quercus cerris,* var. *cerris, Prunus divaricata, Rosa canina, Sorbus domestica, Taxus baccata, Tilia argentea,* and *Ulmus glabra* (Uysal 2010; Kavgaci et al. 2011).

Oak (*Quercus* sp.) forests are located approximately between 300 and 1000 m, and generally prefer sunny and relatively dry southern, eastern, and western slopes. They especially thrive on areas where the black pine forests have been cut or destroyed. Three main species show dominancy here: *Quercus cerris* ssp. *cerris, Q. frainetto,* and *Q. petraea* ssp. *iberica* (Ugurlu et al. 2012; Uysal 2010).

13.3.1.3 Mixed Forests

One of the most important features of Kaz Dağı is that Mediterranean and Black Sea originated species are able to form mixed forests. Black pine–fir, black pine–Turkish pine, black pine–beech, black pine–chestnut, and black pine–oak forests are the main mixed forest types found on Kaz Dağı (Ozel and Simsar 2009).

13.3.2 Shrub Vegetation

The shrub vegetation mainly covers the broad areas between 250 and 600 m elevations in the West and in the Northwest (Ozturk et al. 1983). *Asparagus acutifolius, Amygdalus webbii, Anthyllis hermannii, Cistus creticus, Jasminum fruticans, Juniperus oxycedrus* ssp. *oxycedrus, Olea europaea, Osyris alba, Paliurus spina-christi, Pistacia terebinthus* var. *terebinthus, Prunus divaricata, Quercus infectoria* ssp. *boissieri,* and *Ruscus aculeatus* are the major shrub species distributed on Kaz Dağı (Ozel 1999; Uysal 2010).

13.3.3 High Mountain Vegetation

The species located in 1600 m and over form the high mountain vegetation (Ozturk et al. 1991). *Astragalus idea, Juniperus communis* ssp. *nana, Minuartia juressi* ssp. *asiatica, Nepeta viscida, Narduss stricta,* and *Saxifraga sancta* are the main taxa forming high mountain vegetation in Kaz Dağı (Ozel 1999; Parolly 2004; Nakhutsrishvili 2013).

13.3.4 Flora

Kaz Dağı National Park hosts about 800 plant taxa belonging to approximately 101 families (Uysal et al. 2011). Out of these taxa, 79 are endemic to Turkey and 32 are endemic to Kaz Dağı; 198 are of high ethnobotanical significance (Uysal 2010; Uysal et al. 2012). The endemics and rare species of this mountain have attracted the attention of several botanists (Satıl 2009; Uysal et al. 2011). Most of the endemic species are located at higher altitudes around the Alpine zone (Gungor

2011). Among these endemic taxa, many are of commercial value. Some are important for their secondary metabolites, others have importance for their food values, whereas some are valued for their aromatic and horticultural importance, as well as other purposes (Uysal 2010). The forest areas and the vegetation of this mountain have suffered seriously due to anthropogenic impacts like illegal logging, sulphur dioxide (SO_2) effects from the nearby power plant, acid rains and fires, tourism, festivals, unsustainable agricultural activities, and indiscriminate collection of medicinal plants (Ozturk 1995; Ozel 1999; Satil 2009; Ozel and Simser 2009; Ozturk et al. 2010b, 2011)

13.4 Geomorphometric and Land Cover Relationship

Geomorphometric studies showed that a number of abiotic factors such as altitude, slope, aspect, exposure, latitude, annual average temperature, total annual precipitation, relative topographic humidity, and degree of slope curvature are the primary factors in the formation of rich and diverse flora of Kaz Dağı (Tagil 2006). Especially in mountainous areas, physical environment is an important factor that controls the diversity (Tappeiner et al. 1998; Bolstad et al. 1998; Efe et al. 2011a, b, 2012). In several studies, topography is reported as the main key factor controlling the distribution of vegetation (Barrio et al. 1997). Since topography of a land does not change very frequently, geomorphological formations might be an important indicator in studying ecological classifications and floral productivity of a habitat (Barnes et al. 1982; Host and Pregitzer 1992). In the case of Kaz Dağı, south-facing slopes are exposed to more sunshine than north-facing slopes; therefore, plant communities on the south-facing slopes are subjected to higher transpiration. The areas with higher moisture lead to more sediment movement and erosion as well as causing to form more humid-loving species.

According to Tagil (2006), 8 % of the land on Kaz Dağı is below 300 m, 19 % between 300 and 600 m, 26 % between 900 and 1200 m, 17 % between 1200 and 1500 m, and 6 % is above 1500 m. The agricultural areas are mainly formed by olive groves, which exist between 0 and 600 m. *Pinus brutia* forests are dominant below 900 m and usually concentrated in the areas below 600 m. However, as the elevation increases, *Quercus* sp. and *Pinus nigra* are observed to form mixed formations with *P. brutia*. *Quercus* sp. are widely distributed between 600–900 and 900–1200 m, mixed with *P. brutia* between 600 and 900 m, and with *P. nigra* between 900 and 1200 m. Thirty-seven percent of *P. nigra* is distributed between 900 and 1200 m and 38 % between 1200 and 1500 m. With increasing elevation, *P. nigra* forms mixed formations with *P. nigra–Fagus orientalis–Populus tremula* and *P. nigra–Abies nordmanniana* ssp. *equi-trojani*. The area above 1500 m is made up of stony ground surfaces and covers 82 % of the open ground (Table 13.1).

Table 13.1 Elevation and land cover relationship (%) from Tagil 2006

Elevation (m)	Y	Z	A	Cz	CzM	CzCk	M	MCz	MCk	Ck	CkCzM	CkM	CkCz	CkMKs	CkKnKv	CkG
0–300	0	73	1	15	9	0	4	0	0	0	0	1	0	0	0	0
300–600	100	26	2	56	42	60	32	20	6	1	12	12	18	13	0	0
600–900	0	1	1	27	49	40	36	76	42	16	68	44	61	48	0	0
900–1200	0	0	4	2	1	0	25	4	51	37	20	37	21	37	49	0
1200–1500	0	0	9	0	0	0	2	0	1	38	0	4	0	2	51	74

Y settlement areas, *Z* agricultural areas, *A* open ground and stone surfaces, *Cz Pinus brutia, CzM Pinus brutia—Quercus* sp., *M Quercus* sp., *MCz Quercus* sp.—*Pinus brutia, MCk Quercus* sp.—*Pinus nigra, CzCk Pinus brutia—Pinus nigra, Ck Pinus nigra, CkMKs Pinus nigra—Quercus* sp.—*Castanea sativa, CkCzM Pinus nigra—Pinus brutia—Quercus* sp., *CkCz Pinus nigra—Pinus brutia, CkKnKv Pinus nigra—Fagus orientalis—Populus tremula, CkG Pinus nigra–Abies nordmanniana* ssp. *equi-trojani*

13.5 Soil–Plant Interactions on Kaz Dağı (Mount Ida)

Some soil mineral elements (Al, B, Ca, Cu, Fe, K, Mg, Mn, Na, Ni, and Zn) were studied at different altitudes and their potential effects on distribution of plants in high- altitude ecosystems were investigated. In the present study, 500 g of soil samples were collected from five different localities at every 100 m elevation on the road to the national park and along the path leading to Sarıkız Hill inside the park (Fig. 13.1).

The samples were collected from a depth of about 10 cm with a stainless steel shovel and packed in polyethylene bag; oven dried and treated with 9 ml of 65 % HNO_3, 3 ml of 37 % HCl, and 2 ml of 48 % HF respectively; mineralized in microwave oven at 145 °C for 5 min, at 165 °C for 5 min, and at 175 °C for 20 min. After cooling, the samples were filtered by Whatman filters, and added up to 50 ml with ultrapure water in volumetric flasks and stored in Falcon tubes. Mineral element (Al, B, Ca, Cu, Fe, K, Mg, Mn, Na, Ni, and Zn) measurements were done by inductively coupled plasma optical emission spectroscopy (ICP-OES).

Analysis showed that the concentrations of many mineral elements vary at different altitudes (Fig. 13.2). Al concentration was measured an average of 7345 mg/kg at 100 m. This value decreases to an average lowest value of 2345 mg/kg at 600 m, but reaches its highest average value of 9996 mg/kg at 1700 m. The average B concentration is 1.468 mg/kg at 100 m, reaches its highest value with an average of 6.868 mg/kg at 600 m, but steadily decreases to an average of 1.687 mg/kg at 1200 m. After a slight increase (4.003 mg/kg) at 1400 m, it reaches its lowest value of 1.290 mg/kg at 1700 m. The average Ca concentration is 1484 mg/kg at 100 m, reaches a highest average value (3016 mg/kg) at 600 m, but steadily decreases and reaches its lowest average value of 887 mg/kg at 1700 m. Cu has an average value of 6.297 mg/kg at 100 m. At 1000 m, it reaches its highest value with an average of 23.21 mg/kg and over 1000 m it steadily decreases and reaches its lowest average value of 3.547 mg/kg at 1700 m. Fe has an average value of 3320 mg/kg at 100 m, reaches its lowest average value (1378 mg/kg) at 600 m, slightly goes up to 3342 mg/kg at 1000 m. At 1200 m, this value decreases to 1850 mg/kg and reaches its highest value (5434 mg/kg) at 1700 m. K has an average value of 2545 mg/kg at 100 m, shows highest value at 600 m with an average of 3496 mg/kg, steadily decreases reaching its lowest value (1070 mg/kg) at 1400 m, then it shows a slight increase to 1688 mg/kg at 1700 m. Mg has an average value of 1962 mg/kg at 100 m, value increases to 3069 mg/kg at 1000 m, then decreases to 1973 mg/kg at 1200 m, but shows its highest value (3482 mg/kg) at 1700 m with a sharp increase. Mn has an average value of 238 mg/kg at 100 m, reaches its highest average value of 714 mg/kg at 600 m, begins to decrease and reaches its lowest average value (56 mg/kg) at 1700 m. Na has an average value of 397 mg/kg at 100 m, decreases to 181 mg/kg at 600 m and reaches its lowest average value (160 mg/kg) at 1700 m. Ni has an average value of 6.7 mg/kg at 100 m, reaches its highest average value of 26.3 mg/kg at 1000 m. At 1700 m, it sharply decreases to its lowest average value (2.9 mg/kg). Zn has an average value of 5.9 mg/kg at 100 m. This value slightly

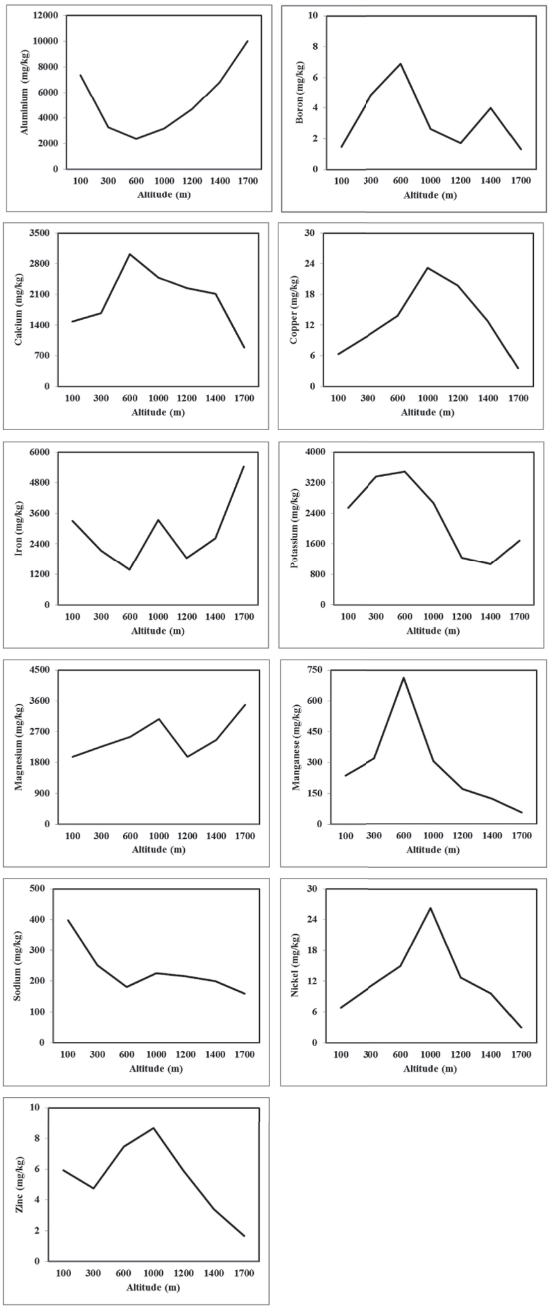

Fig. 13.2 Concentrations of soil mineral elements at different altitudes

Fig. 13.3 Views from different altitudes of Kaz Dağı

decreases up to 300 m, then increases reaching its highest value (8.68 mg/kg) at 1000 m. The average value shows a decrease being inversely proportional to the elevation and reaches its lowest value (1.65 mg/kg) at 1700 m.

Fig. 13.3 (continued)

The mineral element analysis showed that B, Ca, Cu, Mg, Mn, and Ni have lower concentrations at lower elevations; with increasing elevation, the concentrations of these minerals increase to a certain point and then begin to decrease, and reach their lowest values at higher elevations, except for Mg (1600–1700 m). The highest average values for B, Ca, and Mn were measured at 600 m, and for Cu and Ni at 1000 m. Unlike other elements, Al, Fe, and Na represent relatively low values at 600 m. Therefore, 100 m, 600 m, 1000 m, and 1600–1700 m elevations have importance for soil mineralization.

Main plant species observed at different altitudes of the study area follow as (Fig. 13.3):

Between 100 and 200 m, the trees of *Ficus carica* ssp. *carica, Olea europea* var. *europea, Pinus brutia,* and *Punica granatum* are observed. *Adenocarpus compilicatus, Asparagus acutifolius, Cistus creticus, Delphinium* sp., *Micromeria graeca* ssp. *graeca, Pistacia terebinthus, Rhus coriaria, Rubus idaeus, Spartium junceum, Styrax officinalis,* and *Vitex angus-castus* are the other main plant species distributed at this elevation.

Between 200 and 300 m, as the elevation increases, *Pinus brutia* becomes dominant while the density of *Olea europea* var. *europea* decreases. At higher elevations, *Quercus* sp. develop on the degraded *P. brutia* areas. The following species are also observed at this elevation: *Capparis spinosa, Ficus carica* ssp. *carica, Malus sylvestris, Micromeria graeca* ssp. *graeca, Rhus coriaria, Rubus idaeus, Spartium junceum,* and *Styrax officinalis.*

Between 300 and 400 m, *Pinus brutia* is the dominant plant species. *Quercus* sp. has a scattered distribution between *P. brutia* trees, especially on the roadsides. *Digitalis trojana,* which is a Kaz Dağı endemic, is observed at 310 m. Also, in some parts of 390 m *Ficus carica* ssp. *carica* is found.

Between 400 and 500 m, *Pinus brutia* is the dominant species and *Quercus* sp. has a local distribution on some sites of *P. brutia* forests. *Ferulago trachycarpa, Styrax officinalis,* and *Verbascum* sp. are observed on the roadsides.

Between 600 and 700 m, *Echinops* sp., *Micromeria greika, Pinus brutia, Quercus* sp., and *Rhus coriaria* are observed. These species also have an uninterrupted distribution beginning from 100 m up to this elevation.

Between 700 and 800 m, *Pinus nigra* ssp. *pallasiana* first appears at this elevation and becomes dominant at higher elevations. *Pteridium aquilinum* is present under the forest area. *Platanus orientalis, Rosa canina,* and *R. sicula* are locally observed on the roadsides. In addition, up to this elevation, many herbaceous Asteraceae members show continuous distribution.

Between 800 and 900 m, *Pinus nigra* ssp. *pallasiana* is dominant, and *Crataegus monogyna,* and *Platanus orientalis* accompany these forests, especially on the roadsides.

Between 900 and 1000 m, in addition to *Pinus nigra* ssp. *pallasiana, Sideritis trojana* is widely distributed here. *Avena* sp., *Campanula* sp., *Cicer montbretii, Dactylis glomerata* ssp. *hispanica, Dianthus* sp., *Digitalis trojana, Epilobium angustifolium, Euphorbia falcata, E. mrysitenis, Scariola vininea, Scleranthus perennis, Sonchus asper,* and *Verbascum* sp. are the other mainly observed plant species.

Between 1000 and 1100 m, *Epilobium angustifolium* has a wider distribution. *Pinus nigra* ssp. *pallasiana* is the dominant species. Under the forest area, *Pteridium aquilinum* is abundant; beginning from 700 m up to especially 1100 m. *Quercus* sp. is observed to increase at this elevation. *Verbascum* sp. is still observed and *Adenocarpus compilicatus* and *Salvia* species are found abundantly.

Between 1100 and 1200 m, *Pinus nigra* ssp. *pallasiana* is the dominant plant species. *Quercus* species are locally found between *P. nigra* ssp. *pallasiana* trees. In addition, *Heraclium platytaenium* appears as a ruderal.

Between 1200 and 1300 m, in addition to the plant species found between 1000 and 1200 m, *Allium* sp., *Alnus glutinosa, Arabis* sp., *Campanula* sp., *Dianthus arpadianus, Epilobium* sp., *Hypericum kazdaghensis, Juncus* sp., *Scrophularia* sp., *Sideritis trojana, Thymus longicaulis* ssp. *chaubardii* var. *chaubardii,* are observed on the roadsides.

Between 1300 and 1400 m, *Pinus nigra ssp. pallasiana* occurs as a dominant species. *Epilobium* sp., *Pteridium aquilinum,* and *Vaccinium myrtillus* have a wide range of distribution at this elevation.

Between 1400 and 1500 m, *Pinus nigra* ssp. *pallasiana* is the dominant species. Euphorbiaceae and Umbelliferaceae members increase considerably at this elevation. *Achillea frasii* ssp. *trojana* is distributed in a narrow range.

Between 1500 and 1600 m, *Pinus nigra* ssp. *pallasiana* is the dominant species. *Pteridium aquilinum* is very abundant here, whereas *Cirsium* sp., *Inula* sp., and *Quercus* sp. are locally observed.

Between 1500 and 1600 m dwarf *Juniperus* species are widely distributed together with such companions as: *Allium kurtzianum, Anthemis* sp., *Anthyllis vulneraria* ssp. *praepropera, Armeria trojana, Astragalus idaeus, Centaurea odyssey, Chamaecytisus pygmaeus, Cirsium* sp., *Dactylis glomerata* ssp. *hispanica, Dianthus erinaceus, Euprasia* sp., *Galium* sp., *Hypericum kazdaghensis, Lotus corniculatus* var. *alpinus, Paronchia chionae, Pinus nigra* ssp. *pallasiana, Plantago lanceolata, Saxifraga* sp., *Scabiosa* sp., *Teucrium* sp., *Thymus longicaulis* ssp. *chaubardii* var. *chaubardii*, and *Verbascum* sp.

13.6 Climate Change Relations

The scenarios put forward based on the output from four climate models suggest that temperatures are expected to rise by over 4 °C on the inland areas by 2100, and annual precipitation may decrease up to 40 %. Much evidence is now available on a global scale that we “the humans” are influencing our environment to the extent that climate change is going to take place. There will be potentially significant changes at high altitudes. Many valuable ecosystems may vanish because the species may fail to keep up with the shift in climate changes or take to the migration toward safer areas, but such migrations can prove detrimental to these species. Even phonological changes have been reported for many species in particular in the form of early blooming. The temperature warming will push the species to shift to higher elevations where temperatures are favorable for survival. This will in particular endanger the biodiversity at high altitudes. The degraded forests are expected to become vulnerable to erosion if climate change leads to increases in heavy rainstorms. In view of this, particular attention is required to be paid toward the ecosystems at high altitudes before it is too late.

Conclusion

Present study has revealed that up to 600 m altitude in the study area, *Pinus brutia* forests sharply interrupt and replace *Pinus nigra* ssp. *pallasiana* forests. *Juniperus* sp. are widely observed at 1600 m although almost never seen until 1600 m. *P. brutia* and *Quercus* species do not appear at this elevation, but are abundant at lower elevations. Most of Kaz Dağı endemics are observed at higher elevations

(1600–1700 m) (Gungor 2011). The studies done with some narrow endemic species showed that these species, in addition to ecological characteristics of the area, prefer the habitats where mineral element concentrations are either very low or very high (Ozyigit et al. 2013; Altay et al. 2013). If mineral element concentration is very low, some endemic species change their metabolic processes for improvement of accumulation capacity. On the other hand, if mineral element concentration is very high, species develop metabolic modifications where the species either store the elements in vacuoles in order to prevent cellular damage or develop a tendency to wade off these elements. Also, this study showed that concentration of Al, B, Ca, Cu, Fe, Mn and Ni are close to each other between 100-300 m and 1400-1700 m but this is not enough to say a strict relationship between floral distribution and mineral element concentration. If the mineral element distribution became a primary factor for determining floral vegetation of a habitat, then narrow endemic species must have distributed in many areas rather than in particular localities. This also indicates that the plant floral distribution works with many other ecological variables such as temperature, precipitation, slope, wind, sunlight etc. for maximum adaptation but further detailed studies are needed in this connection before climate change scenarios start realizing.

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