

The Effects of Global Warming on the Tree Species Composition in Forests of the Eastern Mediterranean Region in Turkey

- The Vertical Distribution of the Vegetation on the Basin of the Seyhan and Ceyhan Rivers-

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1. Introduction

There are various vegetation types along the climatic and topographic gradient in Turkey (Altan, 2000). Especially in the eastern Mediterranean region of Turkey, they contain a number of differing biotopes such as grassland above the timber line, evergreen and deciduous forests, scrubland, river beds, lagoons, coastal saltmarshes, coastal woodland, and sand dunes. And, the cold climate in the north and arid/semi-arid zones in the south help to enhance the ecological diversity of the Anatolian Peninsula and there is a considerable diversity of flora in the mountainous region (Yilmaz, 1998). If global warming occurred, it will most likely affect the vertical distribution of the vegetation of this region through changing complexly the distribution of each species.

2. Effects of past human activities on the vegetation in this region

It is known that not only the mountainous part of the region but also the present Ceyhan and lower Seyhan plains were covered with dense oak forests in the eighteenth century.

This region has been strongly affected by past human activities since at least the early Neolithic period. In the Ottoman period, people of the region adopted a semi-nomadic life-style. Based on agriculture and pastoralism, people occupied dense settled villages, seasonally utilizing the uplands in their vicinity. Nomadic activities continued until the beginning of the twentieth. After the reform of activities in 1865, there was a transition towards a settled agricultural life-style. At the end of the 1950s the real nomadic life style had disappeared, although some families, for whom subsistence was based on animal

husbandry and who owned limited arable land, still existed.

The most common livestock in this region are goats, which are grazed illegally in the forest. The nomadic groups from western and eastern Anatolia, who graze their livestock also illegally take wood from the forest for daily use and for firewood in the winter. The nomadic activities, which continued between the mountains and the plain, had a detrimental effect on the natural vegetation of the region. However, the change from semi-nomadic to agricultural land use had a far more detrimental effect (Yilmaz, 1998).

Therefore, it is difficult to find natural vegetation, especially in the plains and the low elevation area of the mountains.

3. Study area

The field surveys of vegetation distribution and land use were done on the basin of the Seyhan and Ceyhan rivers in summer and autumn, 2002 and 2003, and 7 permanent plots were set to investigate the stand structure of main forests in the area where natural state comparatively were remained from the Mediterranean coast to the mountain region (ca. 1600m a. s. l.) in 2003 as follow;

(1) Yumurtalik-Dalyan Natural Protection Area
Site-1: Elevation: 0m, N36°45', E35°38'

(*Pinus halepensis*)

(2) Catalan Protection Area

Site-2: Elevation: 151m, N37°12', E35°15'

(*Pinus brutia*)

(3) Karatepe-Aslantas National Park

Site-3: Elevation: 200m, N37°18', E36°15'

(*Pinus brutia*, *Quercus coccifera*)

Site-4: Elevation: 530m, N37°16', E36°14'

(*Arbutus andrachne*, *Quercus coccifera*)

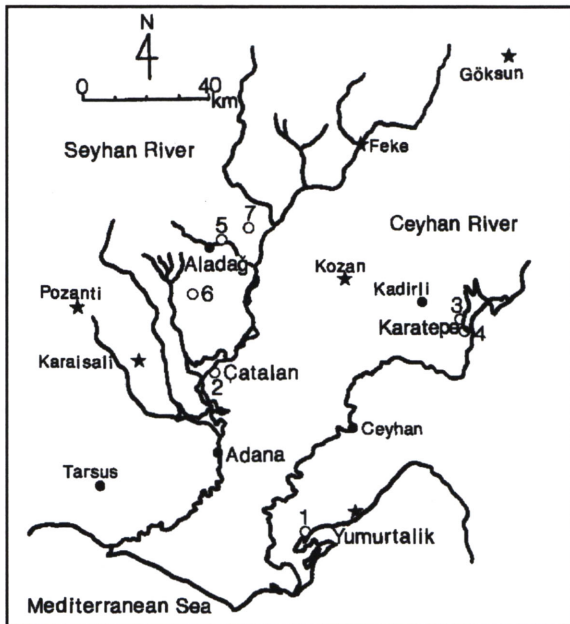


Fig. 1 Study area: permanent plots(○) and meteorological observatory points(★)

(4) Aladag National Forest

Site-5: Elevation: 785m, N37°34', E35°24'
(*Pinus brutia*)

Site-6: Elevation: 1200m, N37°28', E35°19'
(*Abies cilicica*)

Site-7: Elevation: 1530m, N37°36', E35°29'
(*Abies cilicica*·*Cedrus libani*) (Fig. 1)

4. Species composition in each biotope

The existence of the mountain ranges, rivers and coastal plains form several biotopes on the basin of the Seyhan and Ceyhan rivers (Yilmaz, 1998).

Mountainous region consists of three main vegetation belts. Above the timberline, which is at about 2,000m above sea level, sub-alpine grasslands, characterized by thorn-cushion formations of *Astragalus* spp and *Acantholimon* spp, dominate. Between 1,200m and 2,000m, *Cedrus libani* and *Abies cilicica* form a montane-forest type. Below 1,200m various species of deciduous oak, such as *Quercus cerris*, and others like *Fraxinus ornus*, *Carpinus orientalis* and *Sorbus* spp, dominate.

In the region, coniferous forest is to be found up to an altitude of 1,000m. *Pinus brutia*, with a rich understorey, dominates and is replaced by *Pinus nigra* ssp *pallasiana* with altitude in the sub-mediterranean climatic zone. Up to an altitude of 700m, a dense, xerophyll scrubland, called maquis, dominates. This formation consists of several species of evergreen shrub. The most common species in the maquis region is *Quercus coccifera*. *Ceratonia siliqua* and *Pistacia*

lentiscus communities are also prevalent, especially in the coastal zone where they cover a large area. If the maquis is degraded, it is replaced by garrigue formation consisting of several dwarf-cushion species such as *Cistus salviifolius*, *Sarcopoterium spinosum* and *Lavandula stoechas*. Maquis and garrigue formations are common from the coast up to approximately 500m above sea level. This is due mainly to the intensive influence of man in this region.

On the plain, where cultivation is intensive, it is not easy to find any patches of natural vegetation. Few old, solitary trees of *Quercus ithaburensis* spp *macrolepis* from the former oak forest remain.

At the coastal zone of the plain, a complex wetland system is formed. The margins of these wetlands are covered with dense reed beds (*Phragmites australis* and *Typha* spp). Around the river estuaries, salt marshes cover large areas on the hydromorphic alluvial soils. This type of biotope has an almost uniform vegetation aspect, consisting of hallophytes such as *Artrochneum* spp, *Salicornia europa* and *Atriplex portulacoides* in variable dominance.

A patch of coastal woodland, remaining from a former evergreen forest, is located at Yumurtalik Bay. This woodland community, which is surrounded by the saltmarsh, is dominated by Aleppo Pine (*Pinus halepensis*) which is rare in Anatolia. In its natural state the undergrowth consists of the species of the maquis. However, due to intensive grazing, this has largely been degraded to garrigue-type vegetation.

In the foredune zone, which is influenced directly by the sea, *Cakile maritima*-*Salsola kali* communities dominate. Other common species include *Pancreatium maritimum*, *Euphorbia paralias*, *Medicago marina* and *Othantus maritimus*. On the old dunes, maquis remains, e.g. *Pistacia lentiscus*, *Myrtus communis* and other scrubs (Yilmaz, 1998; Yilmaz personal communications, 2002, 2003).

5. Species distribution along altitude

The vertical distribution of vegetation on the basin of the Seyhan and Ceyhan rivers was estimated by dominant species as follow;

(1)(2,000-2,400)-3,000m: Alpinic pastures
(Timber line: 2,000-2,400m)

Astragalus spp., e.g. *A. angustifolius*
Acantholimon spp., e.g. *A. glumaceum*

(2)600-(2,000-2,400)m: Temperate & sub-alpine forest (Aladag, Karanfil Dagi, Kizildag)

Pinus brutia(200-1,000m)
Pinus nigra(1,000-1,600m)
Abies cilicica(1,000-1,600m)
Cedrus libani(1,000-(1,600)m)
Juniperus oxycedrus(600-1,600m)
Quercus cerris(200-1,200m)
Quercus coccifera(0-1,200m)
Quercus libani or *Q.carpininos*(not identified, 1,000m)
Carpinus orientaris(1,200m)
Ostrya carpinifolia(1,200m)
Styrax officifera(200~1,000m)
 **P.brutia* and *P.nigra* change at about 1,200m a. s. l. at southern slope
 (3)up to 600m: Pine forest & Maquis(Karatepe, Catalan)
Pinus brutia
Quercus coccifera
Quercus cerris
Q.infectoria(scattering, 50-150m)
Styrax officifera
Arbutus andrachne(200-600m)
 plus another Maquis
 (4)0m: Maquis & pine forest (partly) (Yumurtalik)
Pinus halepensis
 plus Maquis and halophyte or psammophyte communities

There were some dominant species along the vertical gradient. *Quercus* species were the most abundant, which were followed by *Pinus* species. *Pinus halepensis* was found only on the Mediterranean coast, while *P. brutia* was distributed on the mid elevation to relatively high mountains and *P. nigra* was limited on the high

mountain. In addition, Maquis(scrub) species represented the coastal vegetation and *Cedrus*, *Abies*, *Cupressus*, *Juniperus* species did the high mountain vegetation.

We considered that the vertical distribution of vegetation in the region was generally explained by several species of the genus *Quercus* and the genus *Pinus*, though we have checked only up to an altitude of about 1,600m in this survey.

6. Further research

To estimate species response for the climate change, further researches concerning species composition, community structure, tree physiology and growth patterns are required.

Generally, in order to form the forest which consists of tall tree species, the annual mean temperature up to approximately 20°C and the annual precipitation of 1,000mm or more are required in the warm temperate zone. If this precipitation is less than 1,000mm, the vegetation becomes woodland, scrub, or grassland. When the temperature becomes higher, the climate will go into the subtropical zone and it needs the precipitation of 1,500mm or more to form the forest in this zones.

In the area up to an altitude of 150m on the basin of the Seyhan and Ceyhan rivers, the annual mean temperature and WI (Kira, 1976) are already close to a ceiling of the warm temperate zone, and it is difficult to form the forest because these areas are considered to be the semiarid zone by the precipitation of 1,000mm or less and the value of PEI (Ishizuka, 1977). The area up to an altitude

Table 1. Climate of each observatory point estimated from temperature and precipitation

Location	Elevation	Distance from sea	Temperature			Precipitation		
			Mean	WI	Temperature climate zone	Annual	PEI	Moisture climate zone
	M	km	°C	month·°C		mm		
Yumurtalık	3	0	18.8	165.7(189.7)	warm temp.	835.2	60.6(55.7)	semi-arid
Kozan	150	55	19.3	171.5(195.5)	warm temp.	855.0	59.0(54.4)	semi-arid
Karaisalı	230	50	18.3	159.8(183.8)	warm temp.	929.8	71.2(65.2)	humid
Feke	620	90	15.6	126.6(150.6)	warm temp.	946.5	85.7(77.3)	humid
Pozantı	750	60	13.6	106.5(130.5)	warm temp.	—	—	—
Göksun	1340	115	9.4	74.7(98.7)	cool temp.	595.3	82.2(69.8)	humid

* WI indicates the warmth index by Kira(1976);

cool temperate zone(WI:45~85),warm temperate zone(WI:85~180),subtropical zone(180~240)

* PEI indicates the Thornthwaite' precipitation effectiveness index;

semi-arid zone(PEI:32~64),humid zone(PEI>64)

* () shows the values when temperature rises by 2°C;

change of precipitation accompanied by the rise of temperature is ignored here.

of 750m is estimated to belong to the warm temperate zone and an inland town of Göksun of an altitude of 1,340m to the cool temperate zone. When the temperature rises by 2°C, the climate of an altitude up to 230m will go into the subtropical zone and Göksun into the warm temperate zone as well. The values of PEI at Karaisalı and Göksun become to be close extremely to the semiarid zone (Table 1, Fig. 1).

Moreover, in higher mountainous region, we also found the area where limestone was exposed and soil was not developed in this survey.

Thus, the lower area on the basin of the Seyhan and Ceyhan rivers is already considered to be close to the lower limit of the forest and to be very sensitive to environmental change. We tried to consider by the limited vegetation investigation and few meteorological data this time. In order to analyze the effects of global warming on the distribution of forest species, the field surveys of vegetation of wider area horizontally and vertically and the collection of more extensive and detailed data concerning meteorology, topography and soil conditions also are required

7. Acknowledgments

We would like to thank Dr. K. Tuluhan Yilmaz and his Ph. D. student Hakan Alphan at the University of Cukurova. Also, we would like to thank Dr. Turker Altan and many students at the University of Cukurova. They arranged kindly this field survey and explain about the vegetation and land use in detail.

In addition, this report added the investigation results in 2003 on the basis of the report by Sano et al. in 2003. Identification of plants referred to Baytop (1997, 1999) and Yilmaz (2001).

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