Grazer Schriften der Geographie und Raumforschung **Band 41 / 2006** pp. 17 - 26

The Effects of Mountainous Areas on Biodiversity: A Case Study from the Northern Anatolian Mountains and the Taurus Mountains

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Abstract

The altitude, exposure factors and some landforms and parent materials create different environments and/or habitat for the growth of plants belonging to the several phytogeographic regions in the mountainous areas. The mountain ranges in Turkey bring about the formation of different habitat both in the growing of relic and endemic plant species and the plant communities belonging to adjoining phytogeographic areas. For example, the high part of the Northern Anatolian Mountains, the Mont Ararat, the Erciyes mountains and Nemrut volcanic caldera are the main shelter area of the plants of the Last Glacial period in the Anatolia. Indeed, the high parts, especially northern slopes of the above mentioned mountain areas produce a favourable condition for the growth of Euro-Siberian plants. In other words the plants which spread during the Last Glacial Period appear presently in the high part of mountains.

The karstic depressions, on the other hand, which are found in the Taurus Mountains is rich in terms of endemic and relic plant species and communities such as *Quercus vulcanica* and humid plant species growing in the Euro-Siberian region. Because the thick soil cover which is found the inside of the small karstic depression forms suitable condition for the growth of hydrophytic plants.

There is a considerable difference in the plant communities between on the slopes facing north and south of the Northern Anatolian Mountains. The deciduous forest is common on the lower part of the northern slopes of the Mountain, and the coniferous forest mostly belonging to Euro-Siberian phytogeographic region appears on the upper part of the Northern Anatolian Mountains. But the southern slopes and the tectonic corridors of same mountains are the main occurrence area of the dry forest mostly composed of *Quercus* sp. and xerophytic Mediterranean plants.

The mountain ranges exceeding over 1000 m elevation in the same climatic region cause vertical zonation in terms of ecological conditions. For this reason three orobiomes are found along the vertical distance, in general. For instance, the lower belt of Taurus Mountains extending between seashore and 1000/1200 m is main spreading areas of typical Mediterranean plants composed of red pine (*Pinus brutia*) and maquis. Second belt which is found between 1200-2000 m is the main occurrence areas of the cedar (*Cedrus libani*), Taurus fir (*Abies cilicica*) and black pine (*Pinus nigra*). Third belt corresponds to the sub alpine zone in which some alpine and steppes plants grow.

The tectonic corridors occurring amongst the mountain ranges produce the semiarid conditions in which some xerophytes are common.

Shortly, the Anatolian mountainous areas are very rich in terms of the plant species and communities due to the fact that different habitat which are found both horizontal and vertical direction. The formation of rich biodiversity is related to the existence of rugged mountainous areas.

KEYWORDS: Biodiversity, climatic changes, Anatolian mountains

1. Introduction

The term biological diversity, often shortened to biodiversity, is commonly used to describe the number, variety, and variability of living organisms. Biodiversity therefore embraces the whole of „Life of Earth." Decline in biodiversity includes all those changes that have to do with reducing or simplifying biological heterogeneity-from individuals' members of a species to regional ecosystems (Brown et al., 1993, Environment Facility, www.unibas.ch/gmba).

The Global Mountain Biodiversity Assessment (GMBA) seeks to assess the biological richness of high biota around the world. Our aim in this article is to illuminate biodiversity richness in the mountainous areas of Mediterranean and in Black Sea Regions characterizing the Mediterranean and humid-temperate climatic regions. Indeed the biodiversity richness of Anatolian mountainous areas is related to the altitudinal variation in the short horizontal distance, exposure, the mountain range direction and climatic changes occurred during the especially Last Glacial Period. In order to examine or assessment of the biodiversity and related phoneme the ecological properties of the mountainous areas will be taken into consideration.

2. Geologic and geomorphologic properties of the mountainous areas

Turkey has two orogenic belts: The Northern Anatolian Mountain ranges and the Taurus Mountain ranges (Figure 1).

2.1. Orogenic mountains

The northern and southern parts of the Anatolia were occupied by the Tethys Sea or ocean during the Mesozoic era as the result of sea floor spreading. End of the Cretaceous time, sediments mostly carbonates were subjected to slowly folding and they uplifted as the result of continental collusion. Main orogenic phase in the Anatolia occurred during the Oligocene time, present orogenic ranges formed. During the neotectonic period occurring between Miocene and Early Quaternary, mountain ranges as a whole were underwent to uplifting movements.

The Northern Anatolian Mountains extending as parallel of Black Sea coast have mountain ranges from the north to the south. Coastal belt mountain ranges from the west to the east are the mountains of Akcakoca, Kure, Canik, Giresun, and Eastern Black Sea. The highest summits exceeding 3000 m are found in the Eastern Black Sea Mountains. Second belt of the Northern Anatolian Mountains are Bolu, Ilgaz, Kose, Otlukbeli, Mescit and Yalnizcam mountains. These mountain ranges are separated by the tectonic grabens passing the Northern Anatolian fault lines. Third chain in the west is the Koroglu Mountains.

The Taurus Mountains begin in the southern edge of the Teke Peninsula in the western part of the Mediterranean region and continue along the Mediterranean coast in generally E-W direction. The Taurus Mountains in the Mediterranean Region are called Western and Middle Taurus Mountains. The Western Taurus Mountains are dissected by the vertical tectonic movements providing tectonic graben extending SE-NW direction. These ranges continue in the northern part of the SE Anatolian Region.

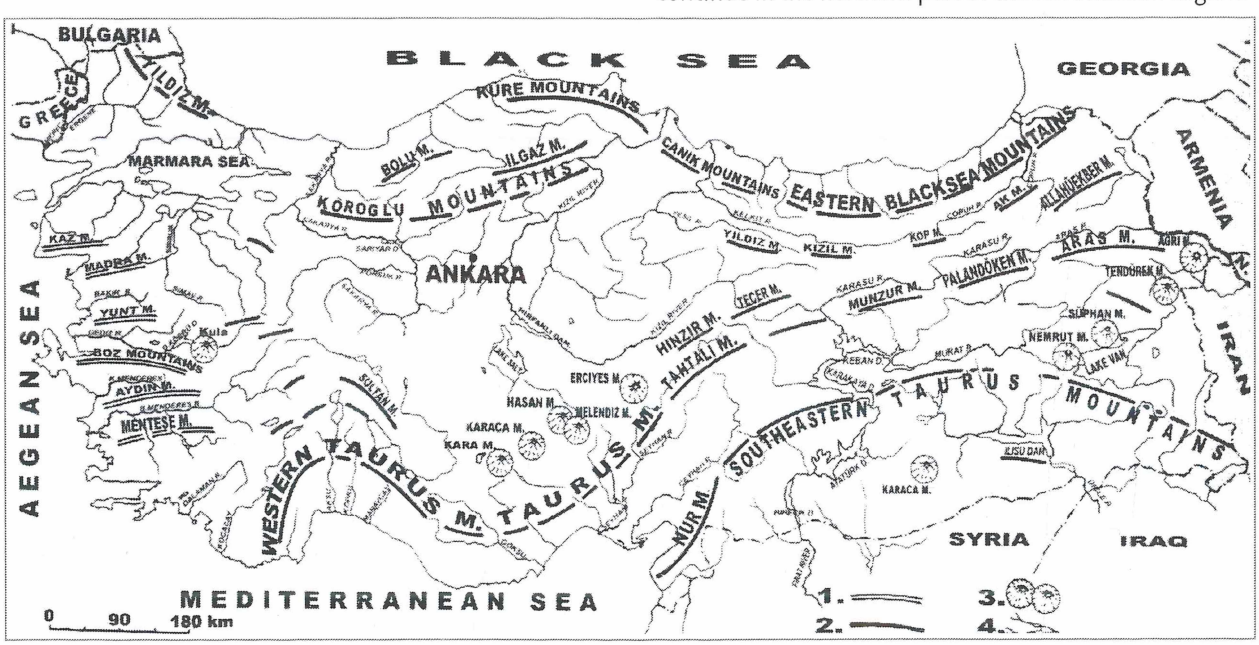

Figure 1: Mountain ranges of Turkey according to formations: 1. Fault-block mountains, 2. Folded Mountains (orogenic ranges), 3. Volcanic mountains, 4. Main rivers.

The summits which are more than 3000 m occur in the western Taurus and the eastern part of the western Taurus. These summits are Yildiz M 3134 m, Medetsiz M. 3524 m in the Bolkar Mountains, and Karanfil M. 3059 m, 3461 m and 3756 m in the Ala Mountains.

The highest summits of Taurus Mountains are found in the eastern parts of the SE Taurus Mountains. Leading summits and their altitudes are the Gok M. 3604 m, Kockiran M (3326 m, Mevzi M. 3446 m, Baskale M. 3668 m, Kara M. 3752 m, Buzul M. 4116 m, Uludoruk M. 4135 m, Ikiyaka M. 3794 m in the Hakkari Subregion.

These orogenic mountains have been cut deeply by the rivers as the result of antecedent and superimpose events. The relative altitude between the talveg and the upper parts of the mountains more than 1000 m, this figure in the Hakkari Subregion is about 2500 m, in the Coruh valley is nearly 3000 m.

2.2. Volcanic mountains

Turkey is one of the volcanic areas within the Alpine orogenic belt. Extrusive volcanic activities were begun in the Tertiary time and continued up to present time. During the Tertiary period, lavas and pryoclastic materials spread almost all part of the Eastern Anatolia and SE part of the Inner Anatolia. During the end of the Tertiary and Early Quaternary central eruption occurred, as the result of these eruptions the volcanic cones were formed both in the Eastern Anatolia, Inner and the South-eastern Anatolia. Young volcanic eruption taken places in Karaca Mountain, Erciyes, Nemrut, Mount Ararat, Kula, and eastern part of Cukurova (Cililian) Plain. Main volcanic cones and their altitude are as follows: Erciyes 3917 m, Melendiz M. 2963 m, Hasan M. 3268 m, Karaca M, Kara M 2288 m. in the Inner Anatolia, Buyuk Agri M. (Big Ararat) 5137 m, Kucuk Agri M. (Small Ararat) 3896 m, Tendurek M. 3533 m, Suphan M. 4058 m, Nemrut 3050 m, Kisir M. 3197 m and Akbaba M. 3040 m in the Eastern Anatolia. Relative altitude between the plateau, plain surfaces and Mountain summits exceed 2000 m.

2.3. Uplifted blocks or horst mountains

Compressional movements in the Eastern Anatolia and tansional movement in the western Anatolia which was occurred during the neotectonic period led to the vertical movements along the fault lines. Best examples can be given in the Western Anatolia. In that region, the mountains E-W trending such as Kaz M (Mount Ida), Madra M, Yunt M, Manisa M, Boz M, Aydin M and Mentese M form the horsts which were uplifted along the fault lines. There are grabens lying between the horsts called Edremit Körfezi, Bakircay, Gediz, Kucuk Menderes (Small Meander) and Buyuk Menderes (Big Meander). Relative altitude between the graben and horst is more than 1000 m.

3. Ecological importance of the mountain areas

In Turkey, the altitude, exposure and the extending direction of the mountains belt plays an important role in the distribution of precipitation and temperature, and sun radiation. Namely, the Northern Anatolian Mountains and the horsts in the western part of the Aegean Region prevent the passing of the front coming from the northern sector to the south. For this reason, the north-facing slopes of these mountains receive abundant precipitation and produce humid environment. The northern slopes of the Eastern part of the Northern Anatolian Mountains cover with the fog. Because the moisture and cool air masses coming from the Black Sea, uplift along the slopes of the mountains. The air circulation leads to both the formation of fog and orographic rainfall. Under the foggy condition oriental spruce (*Picea oriertalis*) and beech (*Fagus orientalis*) forest grow very well. In other words, the existence of oriental spruce is related to the formation of fog. The tectonic corridors or deep valleys extending E-W direction form rain shadow areas in which semiarid climatic conditions prevail. For example the mean annual rainfall is more than 1000 mm in the northern slopes of the Northern Anatolian Mountains, but this figure decrease as low as 400 mm in the southern edges of mountains and the bottom of tectonic corridors and deep valley. For this reason, there is considerable difference in the distribution of precipitation between the north and south facing slopes of the mountains. Although humid forests are widespread on the north-facing slopes, dry forest and shrub vegetation are dominant on the south-facing slopes.

As to the altitude, with the increase of altitude the temperature, relative humidity and air pressure decrease continuously, but solar radiation intense. Depending on these circumstances, the temperature of southern slopes is higher a few degree than the northern slopes. There is a difference of in the ratio of lapse rate between along the north-facing and south-facing slopes. For example lapse rate is about 0.3-0.4°C/100 m along the foggy part of the Northern Anatolian Mountains, but this figure is nearly 0.6°C on the south-facing slopes due to the low relative humidity. Cold-somewhat humid climatic condition prevails on the upper part of the mountainous areas having more than 1500 m. The yearly temperature having more than 18 in the coastal belt of the Mediterranean Sea, and 12-13°C in the coastal belt decrease as low as 6-8°C and 3-4°C respectively at an elevation of 2000 m.

The climatic conditions are considerable different between north-facing and south-facing slopes, and lower and high parts of the mountains.

The factors determining the biodiversity in the mountainous areas

Biodiversity richness is affected by the exposure, altitude, the direction of the mountain range, parent material and the climatic changes.

3.1. Exposure factor

Exposure factor is one of the main responsible for the biological richness in the mountainous areas. There is considerable difference in the distribution of the vegetation communities between the north-facing and south-facing slopes of the mountains. This is related to the both solar radiation and the precipitation. As a general rule, the north-facing slopes of the mountains locating in the northern part of the Anatolia are covered by the humid forest and/or hydrophytic plant species due to the fact that they receive much rainfall and less radiation than that of the southern slopes. That is why the broad deciduous humid forests composed of *Fagus orientalis, Tilia rubra, Tilia tomentosa, Quercus species, Alnus barbata, Alnus glutinosa*, and hydrophytic herbaceous appear along the lover belt of the Northern Anatolian mountains. The upper parts of the north-facing slopes of the coastal belt of the Northern Anatolian Mountains are the main occurrence areas of humid-cold forests composed of *Picea orientalis, Abies nordmanniana, A. bornmulleriana*, and *Pinus sylvestris* (Figure 2).

As to the southern slopes of the Northern Anatolian Mountains, sun radiation intensity is higher on the slopes facing south than the other slopes. For that reason, dry forest and shrubs are common on the south-facing slopes. For example, in the upper part of the Northern Anatolian Mountains *Pinus sylvestris* stands are common due to the high solar radiation and cold-sub humid conditions. The lower slopes are generally covered by black pine (*Pinus nigra*) and oak (*Quercus*) species that are resistant against the drought. Red pine (*Pinus brutia*) and maquis communities are found on the bottom and lower part of the Kelkit Stream (Figure 3).

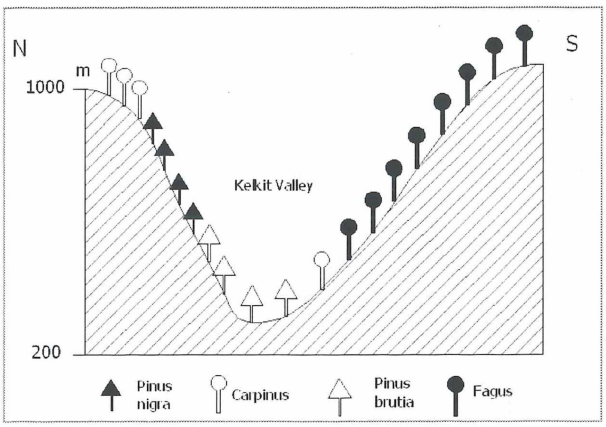

Figure 3: The plant distribution in the Kelkit Valley, NE part of Black Sea Region.

As to the south-facing slopes of the Taurus Mountains belt, the southern slopes of these mountains get more precipitation than the north-facing slopes due to the fact that the fronts coming from the southern sectors are prevented by the mountain ranges. The Taurus Mountains extending along the costal belt of the Mediterranean Sea are the main occurrence areas of the *Pinus brutia* and maquis communities. Towards the upper part of the Taurus Mountains cedar (*Cedrus libani*), Taurus fir (*Abies cilicica*), black pine (*Pinus nigra*) appear. But some red pine (*Pinus brutia*) and oak (*Quercus*) clusters are found on the southern part of the SE Taurus Mountains due to continental influences, in the South-East Anatolian Region.

As a general rule, biodiversity richness of the north-facing slopes of the northern Anatolian Mountains is more than that of the southern slopes.

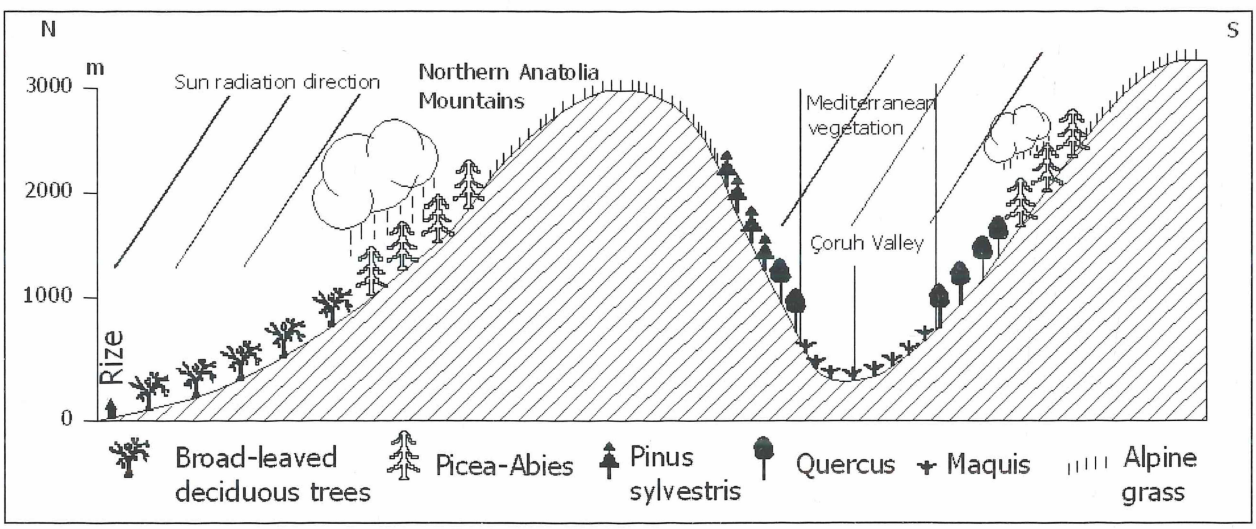

Figure 2: The exposure factor in the plant distribution in the eastern part of Northern Anatolian Mountains.

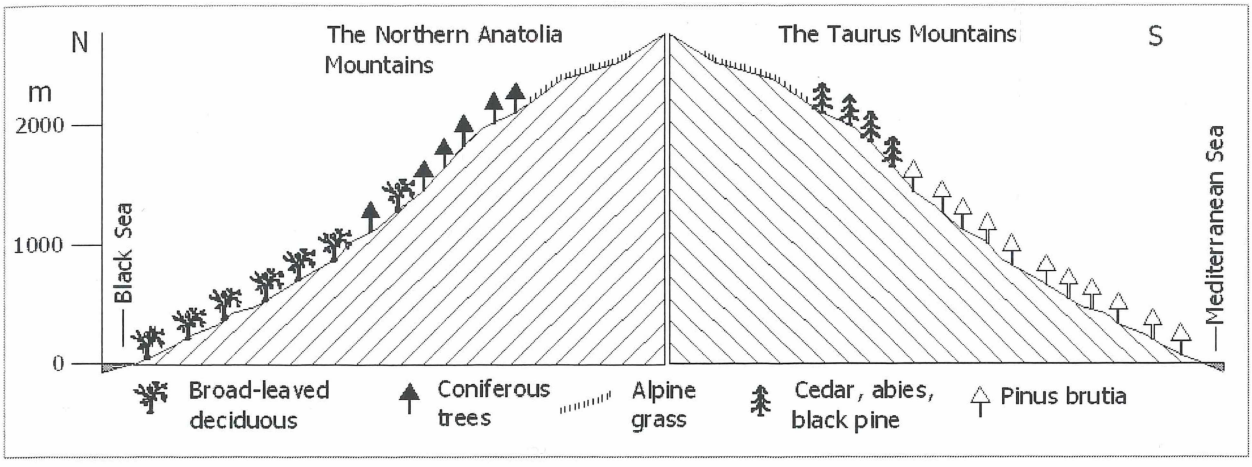

Figure 4: The altitudinal belts in the Northern Anatolian Mountains and Taurus Mountains.

3.2. Altitude

Altitude is an important factor for the biodiversity in the mountainous areas. At least there are three altitudinal belts are found in the mountains that are higher than 2000 m altitude. The altitudinal belts of the mountainous areas are as follows:

3.2.1. Altitudinal belts in the Northern Anatolian Mountains

In the Northern Anatolian Mountains three altitudinal belts are established. First belt begins at the seashore of the Black Sea and climbs up to 1000-1200 m in which broad leaved deciduous forests which are associated with beech (*Fagus orientalis*), *Tilia rubra*, *T. tomentosa*, *Alnus glutinosa*, *A. barbata*, and *Acer species* are common (Figure 4).

Second belt locating between 1000/1200-2000 m is the coniferous forest belts in which oriental spruce (*Picea orientalis*), fir (*Abies nordmanniana*), scotch pine (*Pinus sylvestris*) grow only in the foggy habitat of the eastern section of the Black Sea Coastal Mountains, and fir (*Abies bornmulleriana*), black pine (*Pinus nigra*) and scotch pine (*Pinus sylvestris*) are dominant in the middle and western section of the Black Sea Coastal Mountains. The climatic conditions of the upper part of the northern Anatolian mountains resemble the cold-humid climate prevailing in the northern hemisphere. For this reason, most of the trees and/or forests belonging to the taiga forest of the northern latitude of the European-Asian continent is found in the upper part of the Northern Anatolian Mountains (Figure 5).

Third belt appears after 2000 m of the Northern Anatolian Mountains in which many alpine grasses grow.

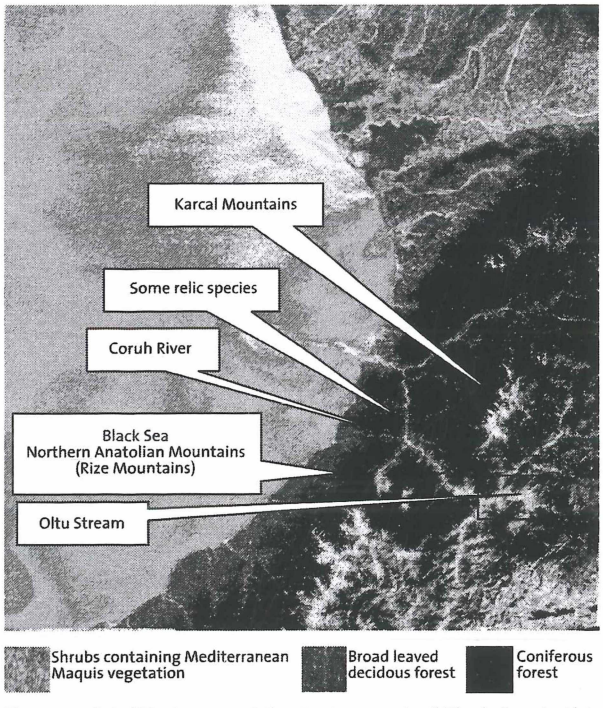

Figure 5: Satellite image of the Eastern part of Black Sea. In this area main forest formations are clearly seen.

3.2.2. Altitudinal belts in the Taurus Mountains

The Taurus Mountains abruptly rising in the coastal belt of the Mediterranean Sea produce different habitats along the vertical direction. The first belt extending between 0-1000/1500 m is the typical Mediterranean plant growing areas in which red pine (*Pinus brutia*) and maquis vegetation is widespread in the places where red pine stands have been destroyed. Second belt is the oromediterranean biome in which cedar (*Cedrus libani*), Taurus fir (*Abies cilicica*) and black pine (*Pinus nigra*) grow. Third belt appearing above 2000 m is the sub alpine herbaceous belt (Figure 4)

3.2.3. Altitudinal belts in the continental part of the Anatolian Mountains

Continental part of the Anatolia is under the semiarid climatic regime. That is why steppe, dry forest and mountain steppe vegetation are found. The spreading of these vegetations is mostly determined by the altitude. For instance, dry forest composed of mainly *Quercus*, *Juniperus* begin at an altitude of 1000-1200 m and rise up to 2000 m in the mountains. In the NE and eastern part of the Eastern Anatolia, lowland or tectonic depressions such as Aras valley are the main spreading areas of steppe, in the second belt *Pinus sylvestris* forest growing under the cold and subhumid conditions is common between 2000-2700 m, and the mountain steppe and grass appear above the 2000 m (Figure 6). Below the glaciated areas of the Eastern Anatolia such as Mont Ararat, are the main occurrence areas of the alpine herbs.

The relic plants are found in the high part of the mountains. This is related to the plant migration of the Last Glacial plants that grown in the lowland areas in the Anatolia. During the Last Glacial period, the upper parts of the Eastern sections of the Northern Anatolian Mountains and high mountains which are found the inner part of the Anatolia were occupied by the glaciers. Under the cold-somewhat dry climatic condition the Euro Siberian plants composed of scotch pine (*Pinus sylvestris*), Birch (*Betula*) widespread below the glaciated areas and migrated as far as the western Anatolia and the southern high part of the Taurus Mountains. During the present climatic condition these trees migrated towards the upper part of the mountains, especially north-facing slopes. Indeed the birch communities are found in the Erciyes volcanic mountain in the Inner Anatolia, Mont Ararat, Nemrut volcanic caldera and the Munzur Mountains in the Eastern Anatolia (Figure 7). The *Pinus sylvestris* clusters also appear in the upper section of Ceyhan river basin in the Taurus Mountains, and the upper part of the Northern Anatolian Mountains. It can be said that the growing of the plants belonging to the Last Glacial Period is related to the existence of high mountainous areas. This situation is lead to increase of biologic diversity or biodiversity richness.

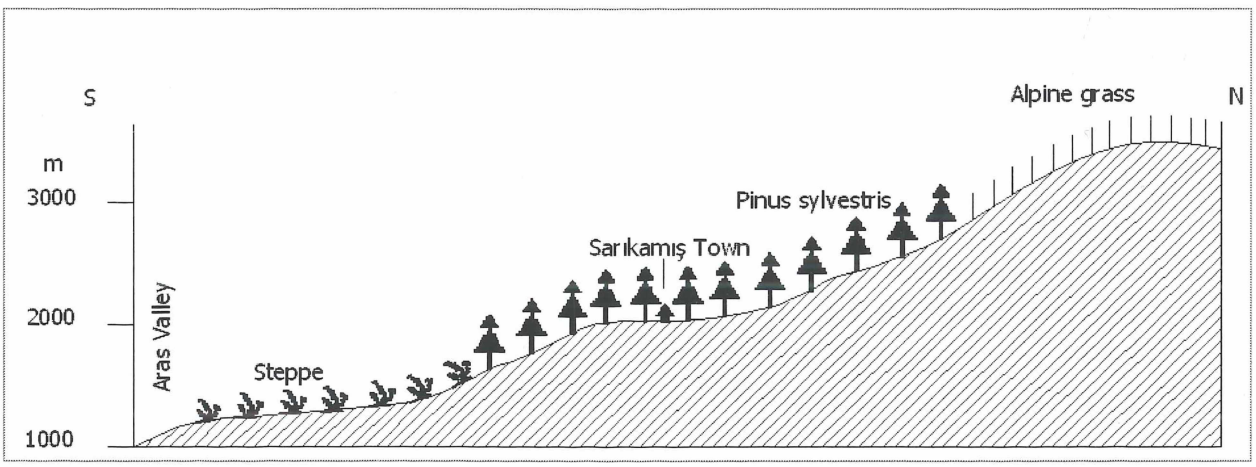

Figure 6: Altitudinal zonation in the NE part of Anatolia.

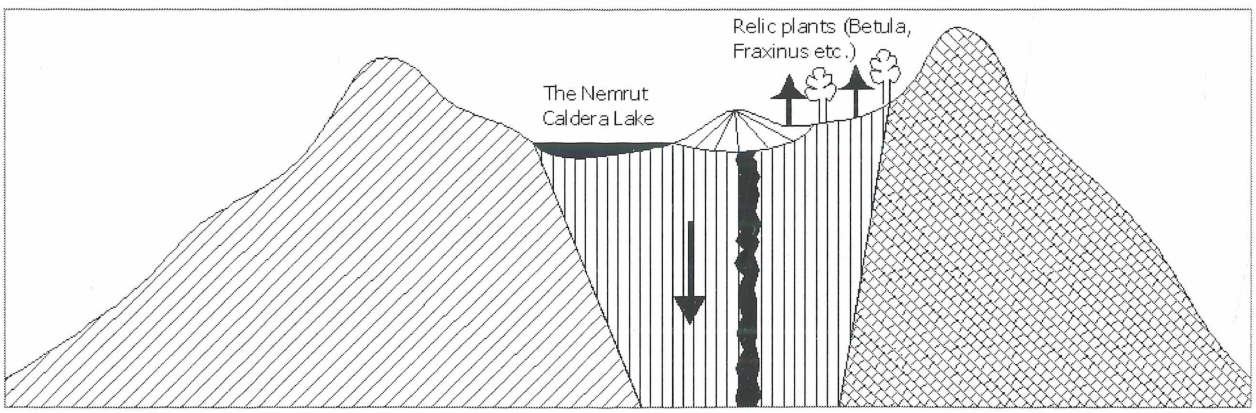

Figure 7: The Nemrut Volcanic Caldera which is the main refuge of some last glacial plants.

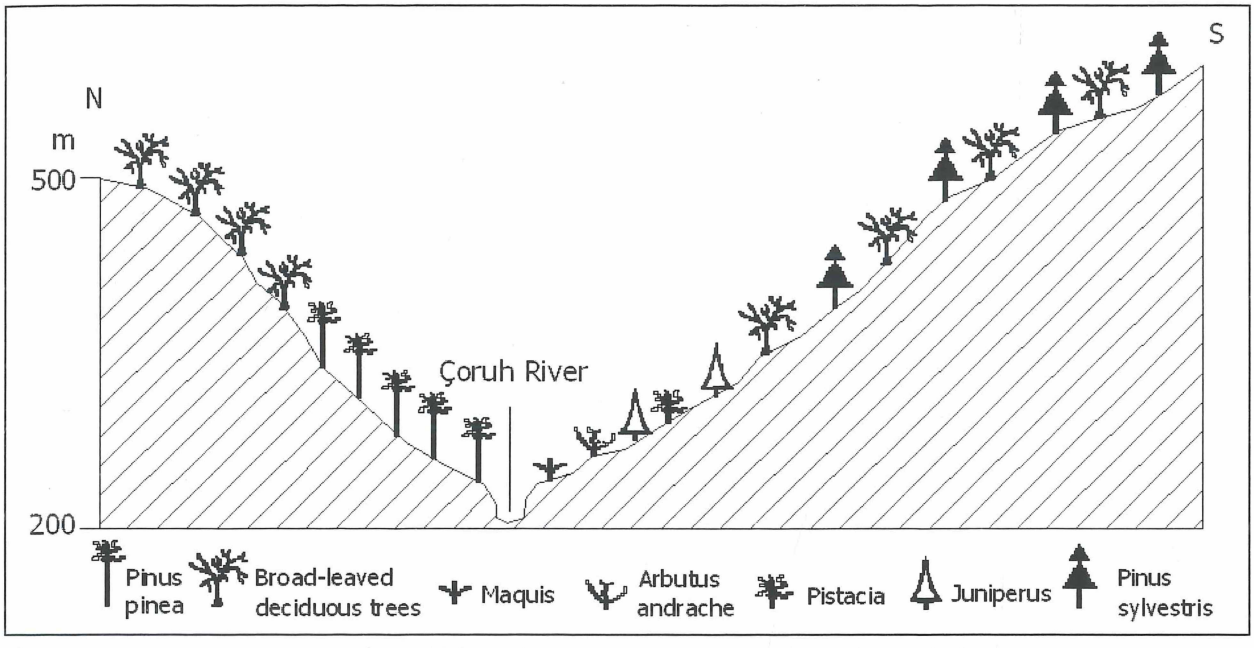

Figure 8: Vegetation profile of the Coruh River Valley. In this valley Mediterranean and Eurosiberian plants are found together.

3.2.4. Landforms affecting of the biodiversity in the mountainous areas

Especially deep and narrow valley and karstic topography in the mountainous areas create special environments or habitats notably for the growth of the some relic and endemic species.

In the Northern Anatolian Mountains, many hydrophytic plants appear along the deep valleys. The exposure factor in the valleys is responsible for the growth of plants belonging to different floristic region. For example the Mediterranean plants are common in the bottom and the south facing slopes of Kelkit, Devrez and Coruh valleys and Erbaa-Niksar depression in the backward section of the Black Sea Region, but broad leaved deciduous forests notably *Fagus orientalis*, *Carpinus* forest are common on the south-facing slopes of these valley and depression. The *Alnus* clusters extend along the valley as high as 2000 m in the eastern part of the Black Sea coastal mountains. In the sunny habitats of the valleys which are the rain shadow places are the main growing areas of the xerophytic plants mostly belonging to Mediterranean vegetation (Figure 8).

In the Taurus Mountains, the Cehennem and Cocak valleys in the near western part of Mersin form shelter areas for the growth of *Alnus sp, Buxus, Corylus* belonging to the Black Sea Region vegetation (Figure 9).

Karstic lands especially depressions are the refuge areas of the some endemic and relict plants and their communities. For example, *Quercus* volcanic which is the endemic *oak* species and *Sambucus*, *Buxus sempervirens* etc. which are the relic species grow inside the dolines in the Davras and Dedegol Mountains in the western part of the Taurus Mountains. Because the protecting of wind by doline walls and thick soil cover in the doline form a favourable habitat for the growth of some hydrophytic vegetation such as *Sambucus ebulus*, *S. nigra*, *Tilia rubra*, *Acer campestre* (Figure 10).

Karstic lands are also rich in terms of vegetation in the Northern Anatolian Mountains. For instance, the karstic

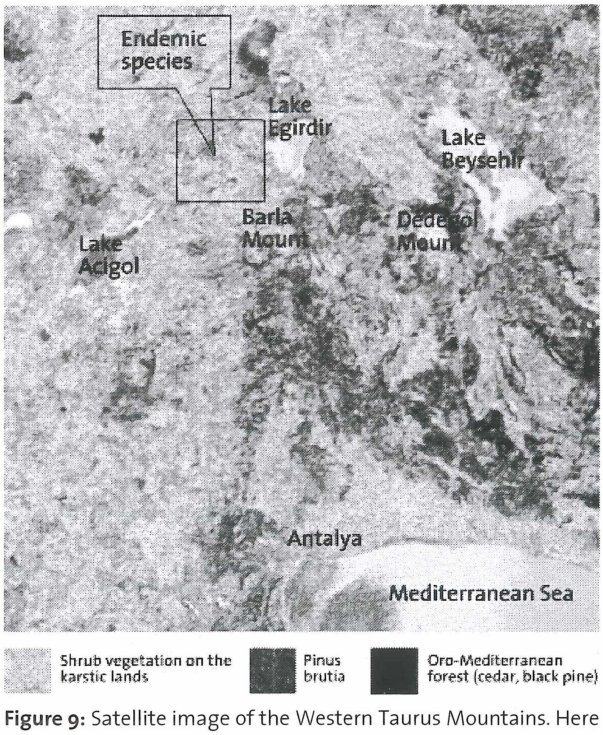

Figure 9: Satellite image of the Western Taurus Mountains. Here karstic depressions of Barla and Dedegol Mountains contain many relic and endemic plants.

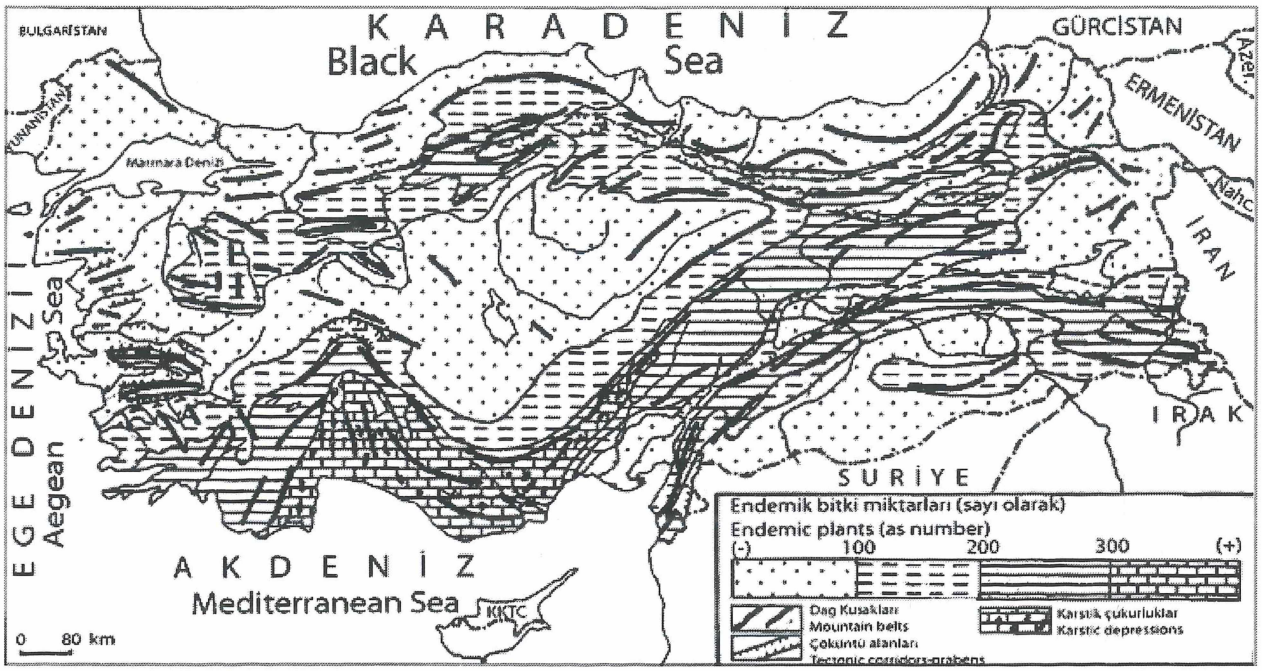

Figure 10: Relationships between the distribution endemic plants and topographic features in Turkey (According to data Davis et al, 1988).

land occurring in the middle and western part of the Northern Anatolian Mountains contains many plant species especially trees.

It can be state that the karstic depressions are also the main refuge areas of the plants belonging to past climatic conditions.

Mountainous areas are also very rich in terms of relict and endemic species. One can found many relic species belonging to the Euro Siberian Phytogeographic Region both in the Northern Anatolian and Taurus Mountains. Indeed during the Last Glacial Period, the mountainous areas more then 2200 m in the western part of the Anatolian and 2500 m in the central and eastern Anatolia were occupied by the glaciers at that time semiarid and cold climatic conditions prevailed on the most part of the Anatolia. The plants Scotch pine (*Pinus sylvestris*) and *Betula* species spread from the North-Eastern Anatolia towards the upper part of the southern slope of Taurus Mountains and western part of Anatolia and the eastern part of Black Sea coast. When present-day climatic conditions prevailed, the plants grown under the semiarid and cold conditions have begun to withdrawal from the lowland areas to the upper part of the mountainous areas. Some of them have survived as clusters on the north-facing slopes of the upper part of the mountainous areas. For instance, *Betula torminalis* which are found on the Mont Ararat, Munzur, Ercies and the Eastern Black Sea Mountains, and *Pinus sylvestris* occurring on the eastern and northern part of Inner Anatolia, on southern slopes of Taurus Mountain in Ceyhan River Basin, on the Western Anatolia especially near Denizli, Kutahya, Usak provinces are in relic character.

When we examined the spread of the relic species, most of them are found in the mountainous areas. Because, the mountainous areas containing several habitats in the lateral and vertical direction. These habitats are suitable for the growth of different species belonging to the different phytogeographical region.

4. Conclusion

The mountainous areas of Anatolia contain abundant plant species and communities belonging to different geographical regions. These are related to following properties:

1. Altitude in the mountainous areas leads to the vertical zonation of plants. There is generally three altitudinal vegetation best in the high mountain ranges.
2. The northern and southern slopes of the Northern Anatolian Mountains and the Taurus Mountains cause the spreading of plants belonging to different habitats and/or climatic regions.
3. Special topographic forms such as karstic depressions, volcanic caldera, wide and deep valleys are the refuge area of the plant that grown in the past climatic conditions.

5. Acknowledgement

Special thanks to Dr. Wolfgang Sulzer due to obtaining satellite photos for this study.

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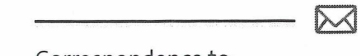

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