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## Impacts of anthropogenic factors on land degradation during the anthropocene in Turkey

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### Abstract

The aim of the present study was to determine the factors that effected the beginning of the Anthropogenic Era (human age) in Turkey and formation of biomes. Destruction of vegetation, soil erosion and land degradation are the most important factors in the formation of anthropogenic biomes in Turkey. For this reason, first of all, a literature review about land degradation, which has been going on for past 300 years in Turkey, and about its causes was made. Changes that have occurred over the last 70 years were studied with the help of aerial photos and satellite images. In addition, studies we have conducted in the last 35 years have contributed substantially to the determination of the extent of the destruction of vegetation and land degradation in Turkey. As a result of research based on literature reviews and fieldwork, the impact of humans on the natural habitat were identified, and the current situation was studied. The findings about the current situation that emerged due to human impact were then transferred to an electronic environment, and a map of anthropogenic biomes was produced with the help of ArcGIS Desktop software. Based on the results obtained, one can say that the natural habitat has considerably changed over the last 200 years; vegetation has been damaged, and land degradation has become faster because of human activities. These results indicate that 97% of natural biomes have become anthropogenic biomes, and this change has become more obvious during 20<sup>th</sup> century in Turkey. The results also show that the change has been more influential after 1950.

### Key words

Anthropocene, Anthromes, Land use, Natural habitat, Turkey

### Introduction

Paul Crutzen, in 1995, was awarded the Nobel Prize in Chemistry for his research on the ozone layer, and Eugene F. Stoermer published the first article saying that a new era called the 'Anthropocene' had begun (Crutzen and Stoermer, 2000). This article led many natural scientists and geologists to become proponents of their view, and the term 'Anthropocene' entered the literature (Crutzen 2002; Crossland 2005; Andersson *et al.* 2005).

Human-natural habitat relations underwent a change about 200 years ago. The impact of humans on natural habitat was not very clear till the end of 17<sup>th</sup> century. Industrialization, population growth and ever increasing human needs have taken control over natural habitats. Human influence on nature has

increased, and humans have come to dominate it since beginning of 19<sup>th</sup> century (Andersson, 2005). Today, human activities have affected a large part of the world. Indeed, 85% of the earth is under human influence (Ozturk *et al.*, 2008, 2011; Sanderson *et al.*, 2002). Only 15% percent of the earth still remains intact.

There are differing opinions regarding the date when the Anthropocene (human age) started, and humans began to change the ecosystem. While some regard Industrial Revolution, which started 200 years ago, as beginning (Crutzen and Stoermer 2000, Crutzen and Steffen 2003; Zalasiewicz *et al.*, 2008), others think that Anthropocene began in 1900 or even in the 1950 (Meybeck, 2001). However, 1784 is important in terms of the beginning of the Anthropocene, as this year James Watt invented steam engine.

It has never been clear when previous geologic times began. Hence, it is wrong to state an exact date for the beginning of the Anthropocene. Besides, human effect has not been same everywhere on the earth, and different events have occurred at different times. In some places, the impact has been greater. The political, economic and cultural structures of regions and countries also affect the start date of the Anthropocene.

It is an undeniable fact that some events have more effect than others. The human effect on the natural environment increased due to mechanization, and this effect spread around the world because of the population growth. Consequently, anthropogenic biomes emerged owing to the human effect on ecosystems (Ellis and Ramankutty, 2008, Ozturk *et al.*, 2002, 2012; Zeist and Bottema 1991, Zalvati and Zitti 2005). Human settlements started 10, 000 years ago and natural vegetation changed due to human activities during Holocene (Eastwood *et al.*, 1999; Bakker 2012).

Compared to Europe and other parts of the world, the situation is different in Turkey. Industrialization and agricultural mechanization started much later in Turkey, while in the west they had started earlier. Despite this, factors such as level of development, population growth rate, lifestyle and cultural features have played a key role in the destruction of natural environment. Although late mechanization and industrialization have delayed anthropogenic effects, the lifestyle of Anatolian people has accelerated them.

### Materials and Methods

The present study, which intends to determine the factors that affect formation of biomes as a result of destruction of vegetation, ecosystem degradation, and destruction of natural habitat, was conducted based on the data obtained from literature reviews, aerial photos, satellite images and land observations. Most of the current data was obtained from satellite images, aerial photos and the previous studies conducted and field trips over the last 15 years in Turkey. Furthermore, historical aerial photos, satellite images, and historical sources proved useful in understanding the extent of land degradation. The effect of humans on the natural habitat and resultant conditions were revealed by analysing the results obtained from practice, observations and literature reviews. In the present study efforts were made determine changes in the natural habitat by comparing the past and present land use data. Analysis of satellite images revealed temporal, spatial, and human-caused changes in factors making up the natural environment. Maps and other drawings were created with the help of ArcGIS Desktop v.9x software.

### Results and Discussion

In Anatolia, relationship between nature and human has mostly been bad so far. Yet, destruction of natural vegetation

triggered by population growth and land degradation in Anatolia has reached a serious degree during the last 150 years. Demographic movements that have occurred in and around Anatolia have increased the population growth rate. People coming from the Balkans, Caucasus, Crimea, Aegean Islands and other regions have caused pressure on land and have brought about permanent changes.

In Turkey, where natural vegetation cannot be protected, and biodiversity is declining day by day, demand for resources due to population growth has increased the pressure on the environment owing to agricultural mechanization. The efforts to augment the amount of material produced have caused more pressure in small areas. While agricultural mechanization has led to increase in the level of income in rural areas, it has also reduced the need for a workforce. The use of agricultural machines such as combine harvesters and tractors has decreased the number of people engaged in agriculture. As a result, hidden unemployment has emerged, and temporary or permanent migration to cities have begun. Rural areas have been damaged, and the naturalness, structure and texture of the cities have been deformed due to migration that has increased since 1950.

As a consequence, the ecosystem of the country has turned into human-supported agricultural ecosystem, ecosystem managed for production, industrial ecosystem, city ecosystem, and natural or nearly natural ecosystem that are either not affected or little affected by people. This has led to the formation of anthropogenic biomes.

It is possible to say that land degradation in Turkey started thousands of years ago. It is known that human settlement in the area where Turkey is located dates back to almost 10,000 years. Agricultural activities have continued for nearly 4000 years in several parts of Anatolia. Prehistoric settlements were established around lakes, rivers, and in valley bottoms. The expansion of residential areas during ancient ages encouraged people living on the edges of steppes to damage nearby forest lands.

The geographical position, climate and topographic and soil characteristics of Turkey has increased public awareness about erosion and land degradation. Agricultural activities and animal husbandry carried out on lands unsuitable for these activities, have caused land degradation and erosion. Also, eroded fertile soil has been carried by rivers. The purpose of creating new residential areas, destruction of forests due to fires and other reasons, lack of land and production planning, inclination of the topographic structure and climate conditions towards erosion, have caused serious erosion and decreased the land quality (Atalay *et al.*, 2008). Migration to cities after 1950 have put pressure on the natural resources in Turkey. Industrialization and population growth after 1980 has further

**Table 1** : Factors causing the natural environmental degradation and their consequences in Turkey

Factor	Consequences
Forest destruction/Deforestation	Erosion and water scarcity
Over/Early grazing	Decrease of biodiversity and erosion
Misuse of land	Erosion, land degradation, loss of fertile land
Migrations to Turkey (Balkans, Crimea, Caucasus, Aegean Islands)	Increase of population, Forest clearing, increase of agricultural lands, change of natural ecosystem especially in lowlands
Fires (human caused and wildfire)	Loss of Biodiversity, land degradation
Machinery increase	Increasing of agricultural lands, easy access to the natural environments, more roads
Industrialization	Invading the natural environment and fertile lands
Construction of dams on rivers	Habitat fragmentation
Population increase	Decrease in land size, more energy consumption, more pressure on agricultural lands
Life style	Land degradation, Degradation of natural vegetation

increased this pressure (Atalay, 1992, 2001). Population pressure has led to the invasion of farmlands by unplanned urbanization and industrialization, and has also paved a way for misuse of land, and irreversible destruction of fertile land and natural habitat (Table 1).

The most striking factors of the natural habitat are vegetation, animals, soil, water and air. The reason for land degradation in Turkey can be divided into two categories: Anthropogenic factors; Socioeconomic, administrative and legal factors. One of the most important factors in ecosystem is vegetation. Vegetation has been damaged due to human interaction with nature, and overgrazing and agricultural activities conducted on sloping lands have led to soil erosion in Turkey.

Some of the factors that started the Anthropocene and caused land degradation were directly related to humans, while some others were indirectly related. Human impact on land degradation was immense. The role of human in ecosystem tends to damage natural habitats and their interference has been on different scales. Forest destruction and misuse of land are unconscious and direct effects, while some effects are indirect. For instance, overgrazing and erosion are indirect human effects which has an adverse impact on ecosystem.

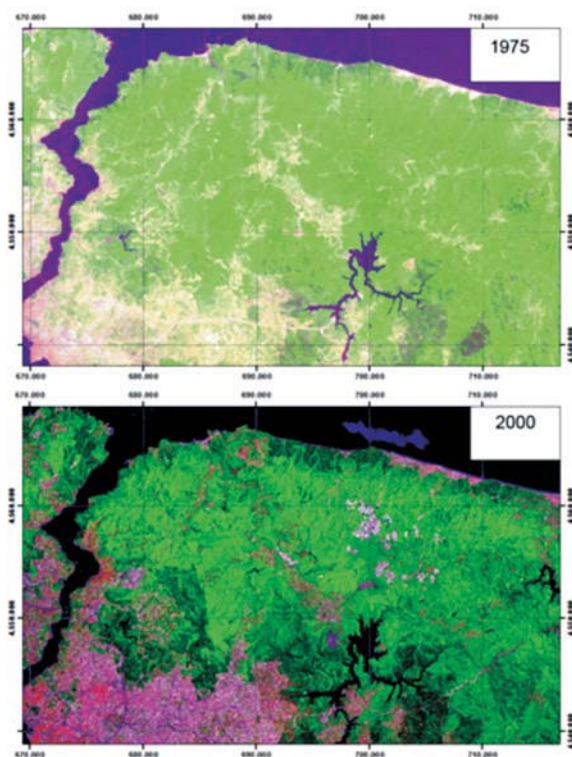
In Anatolia, forests have been destroyed due to illegal tree cutting, fires, efforts to create residential areas and farmlands, overgrazing and production of construction materials. The destruction started with the first human settlements in Anatolia and has continued to grow over time. The constant expansion of residential areas, newly constructed forest roads, mining prospects, and fires had led to further decline in forest areas in 20<sup>th</sup> century (Fig. 3c). The increasing amount of forest and vegetation destruction in Turkey has caused erosion to become severe, expansion of eroded lands, and irreversible farmland losses during last 35 years (Fig. 1 and Fig. 2).

On the other hand, variety of geomorphological characteristics, climate, soil and vegetation, has prevented

destruction from becoming extremely serious for years. However, industrial and agricultural revolutions and population growth have accelerated the destruction. There were about 10,000 plant species in Turkey, and almost 3700 of them were endemic. Turkey has high species diversity, and has forests containing around 450 different types of trees, shrubs and bushes. In addition, 90% of these forests are natural. All these features, including climate diversity and different geomorphic units in Turkey, have a positive effect on forest and vegetation regeneration (Efe 2010; Efe and Atalay, 2012).

Currently, forests cover an area of 20.7 million ha in Anatolia, but if ecological conditions are considered, it can be said that the potential forest land was 50 million ha. Additionally, steppes covered an area of 24 million ha, and based on climatic conditions, this was two times more than the ideal amount. Today, edges of steppes in the Central and south-eastern Anatolia Regions have anthropogenic characteristics. Although the steppe-forest line was 650-700 m, forest trees exist at an elevation of 1000 m or higher today (Efe 1996; Atalay and Efe 2010a, 2010b). As the forest-soil-water balance was at a critical point, fixing balance that was disturbed due to damage is impossible, and this paves the way for severe erosion in sloping lands that are denuded.

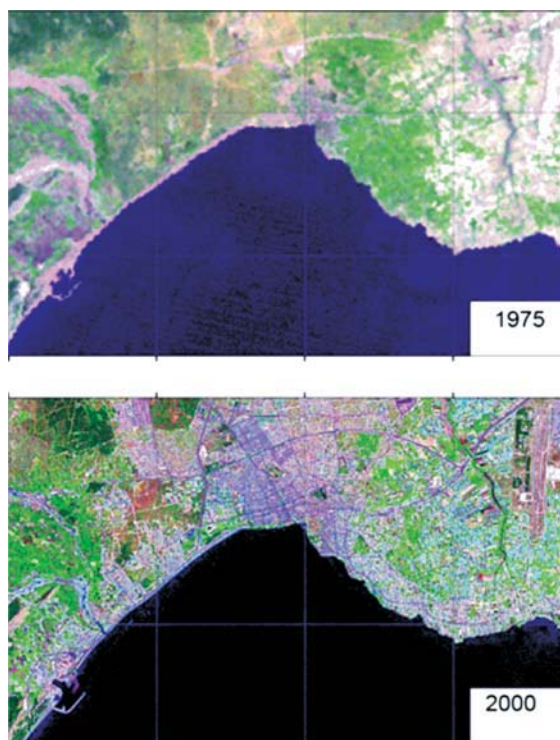
One of the factors that started the Anthropocene in Turkey was destruction of pastures. Overgrazing occurs when more than 60% of fodder produced by pastures during the vegetation period is consumed by animals. Overgrazing on pastures and plateaus destroyed vegetation, and led to biodiversity decline. The most important factor in vegetation decline and loss of species in particularly arid and semi-arid areas was overgrazing. Plateaus were severely damaged in the Aegean and Mediterranean regions, where the Mediterranean climate prevailed. Herds of goats and herbaceous plants have damaged bushes and shrubs in these regions. Overgrazing in sloping fields have not only destroyed vegetation, but also caused erosion. Even though pastures in Turkey remained intact in terms of surface area, their quality was impaired during the historical periods. Pastures,



**Fig. 1 :** Satellite image of the Eastern part of Istanbul. Forest and bushlands on south-western part replaced with settlements

which comprised 58% of the total area of Turkey in the beginning of the Republican period, reduced to 35.5% in 1965, to 28% in 1982, and to 25% in 2008. During this period, pastures not only became smaller in size, but their quality also declined. Natural floristic diversity of pasture was disturbed; fodder plants and nutritious plants were destroyed as a result of overgrazing, and they were replaced by thorny, poisonous, and bulbous plants which are not eaten by animals. Pasture degradation can be observed around Kaz Mountain (Mt. Ida) Mt.Yunt, Mt. Boz, Mt. Menteşe, Mt.Saphane, Mt.Murat, Mts. Taurus Mt. Erciyes, and Mt. Davraz (Atalay 2006; Efe 1996,1998, 2004, 2005, 2006, 2007; Ozturk *et al.*, 2008;Unaldi, 2003).

Another problem about pastures and grasslands was early grazing. Plant species that composed pasture vegetation were severely damaged due to early grazing in early spring. During this time, plants began to grow and were vulnerable. Early grazing slowed plant development and reduced the quality of grass (Fig.3a, b).During spring, soil humidity increases after rain. During this period, grazing had a negative impact on aeration of soil and soil permeability. Additionally, areas where animals were in large number and where they grazed, soil was extremely compact and vegetation was damaged. The area covered by fodder plants growing in field soil comprised not more



**Fig. 2 :** Satellite images of Antalya region. There is big difference between the years 1975 and 2000 in terms of natural biomes on Mediterranean coast

than 1% of these lands, while in Europe it composed more than 25% of land.

Turkey has a total land area of approximately 78 million ha. 70 million ha of the total land area is affected by water and wind erosion to some extent. In Turkey, only 6.5% of soil is grade 1, and this type is not under threat of erosion. 93.5% of land, which is equal to 71.6 million ha, suffers from erosion. 83% of the total area of Turkey is composed of land that has an incline of 10% or more (Atalay, 2011). Thus, all physical land characteristics, ecological features, and the socioeconomic structure make it easier for erosion to occur (Fig.3a,3b).

The annual amount of soil loss caused by erosion nearly equals to 24 billion tons. In Turkey, almost 1.5 billion tons of fertile soil and 9 million tons of plant nutrients are lost each year. This feature of erosion is most important factor in ecosystem and water pollution because plant nutrients, chemical fertilizers, and pesticides carried by surface runoff contaminate water resources. The average amount of soil loss in Turkey is 9.5 times more than that of Europe, 2.9 times more than that of Australia, and 1.6 times more than that of America. 54% of forests, 64% of pastures, and 59% of farmlands are still exposed to erosion (Winfried and Eswaran, 2004).



Fig. 3: (a) Severe degradation is very common in Taurus mountains due to overgrazing and forest cutting (left). (b) Animal husbandry is the main activity in rural areas in western Anatolia (middle). (c) Stubble burning is one of the hazardous practices that damage the agricultural lands (right)

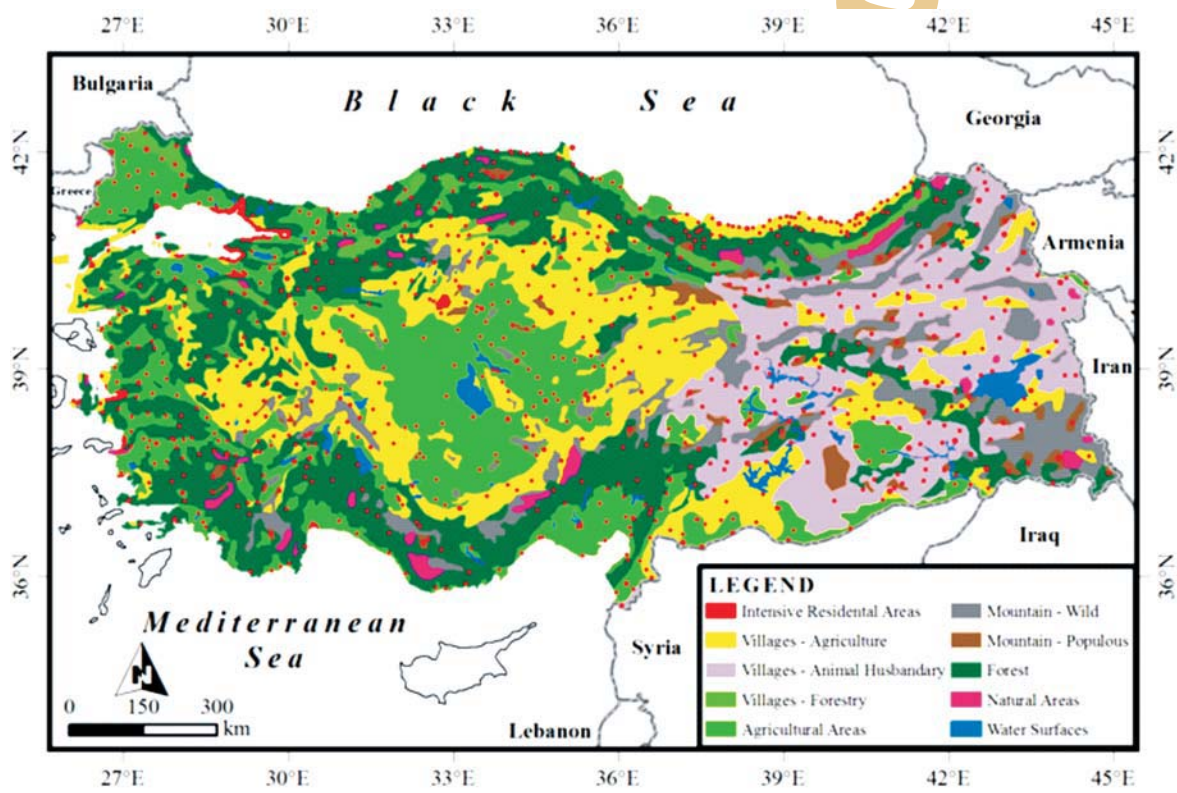


Fig. 4 : Anthropogenic Biomes in Turkey

Soil pollution is one of the environmental problems becoming more serious day by day. Furthermore, destruction of forests by people, open field burning, misuse of farmland, overuse of pastures and meadows, and overgrazing lead to soil erosion, and it is now one of the most important environmental problems in Turkey and several other countries (Atalay, 2011; Efe *et al.*, 2008).

The misuse of land is one of the most important factors that leads to land degradation and to the formation of anthropogenic land. The primary cause of land degradation is

utilization of forest lands for agriculture and use of farmlands and pastures as settlement and industrial areas.

The total area of land is divided into eight classes based on features such as soil thickness, degree of inclination, and other factors. The first four classes have low inclination degree and sufficient soil thickness. These classes are present in fields that do not suffer from problems such as saltness and rockiness. These fields are considered "farmlands". Fields that are incorporated into this group because of their topographic features generally include plain and plateau surfaces. The total area of

plains in Turkey comprises only 8% of the country (Atalay, 2008; Tunçdilek, 1985; Çolak and Rotherham, 2006). In Turkey, population and migrations from rural areas to urban areas have rapidly increased since 1970s. As a consequence, cities established on the Marmara, Aegean and Mediterranean plains have attracted large masses of people, and urban areas expanded into plains at the expense of farmlands. Concrete buildings have begun to invade soil, and soil has been lost. Examples for this situation can be seen in cities such as Adana, Bursa, Mersin, İzmir, İzmit, İstanbul, Gaziantep, Balıkesir, Manisa, Tekirdağ, Çerkezköy, Çorlu, etc. The grade 1 soil of Bursa Plain, a plain within the south-eastern Marmara Region, is now almost completely used for non-agricultural purposes. Balıkesir Plain has a total area of 140 km<sup>2</sup> and has grade 1 soil. 75% of Balıkesir Plain is used for settlement and industry. The situation is same for plains in the Aegean and Mediterranean regions.

Misuse of land is not only limited to plains, but can also be observed in lands with grades 5, 6, and 7. These lands are naturally covered with forests, bush formation, or herbage and are inclined. As farmlands on Turkish plains are lost, cultivated lands expand, while forests, shrubberies, and meadows decline. This has two important consequences. The first is that soil is lost due to erosion and land becomes totally infertile. The second is that many plants begin to grow outside their natural limits; these plants experience decline in quality and quantity (Efe, 1997; Efe et al., 2008).

Grade 5, 6, and 7 lands should actually be covered with forests and pastures. Yet, these lands are used for agricultural purposes. These lands cover an area of 46.7 million ha in Turkey and constitute 61% of the total area of the country. When grade 8 land, which covers an area of 3.5 million ha were also taken into account, this rate rose to 65%. Sloping lands, which have a capacity of 50 million ha of forest and pasture areas, have been eroded due to misuse of land and agricultural activities. Tourism urbanization of coastal areas is also a common example of degradation (Efe, 2005; Efe et al., 2008).

The fact that some farmlands consist of many parts, affects the financial income of rural people. In addition, this condition has an impact on migrations. Parcels of land are much smaller in Turkey compared to those in European countries. The total percentage of land bigger than 50 million hectares within the total area of the country is 82% in England, 46% in France, 34% in Italy, 44% on average in the European Union, while it is only 17% in Turkey.

The primary function of wetlands are to provide drinking water, control floods and climate changes, feed underground waters and purify water. Wetlands provide living space for birds, plants, fish, insects and many other species. Drying of wetlands would lead to extinction of all species adapted to these lands.

Most of wetlands in Turkey were destroyed, particularly during the second half of 20<sup>th</sup> century. During this period, wetlands and swamps were considered as useless lands. The fact that mosquitoes causing malaria, a widespread disease in the first years of the Republican period, live in swamps and wetlands can not be ignored. Over the last 40 years, half of the wetlands in Turkey have lost their ecological and economic features due to drying, filling, interference with water systems and pollution. Excessive agricultural irrigation, illegal use of ground water, chemical pollution caused by water used in agricultural activities, and pollution caused by water that is used by industrial plants and households and that returns to wetlands without being purified, have played a key role in these loss.

Lake Amik (Hatay), Gâvur (Kahramanmaraş), Kestel (Burdur), Suğla, and Samsam (Konya) are important water resources that have dried, in the last 50 years, for the purpose of creating farmlands. Malaria is one of the reason for the destruction of natural habitat in Turkey. In 1950, however, Turkey changed strategies against this disease on the advice of World Health Organization, and started taking precautions against *Plasmodium* instead of mosquitoes. Although malaria was completely eradicated by 1960, drying of wetlands continued in Turkey. After Turkey signed the Ramsar Convention on Wetlands in 1994, drying process slowed down.

The key factors in land degradation and destruction of vegetation are the cultural values, lifestyle and habits of Anatolian people. The impact of environment on lifestyle, settlement types and economic activities cannot be denied. Additionally, the role of culture is also significant. Traditional Turkish nomadic culture was transported from steppes of Central Asia to Anatolia from 11<sup>th</sup> century onwards. Nomadism and semi-nomadism, part of Turkish culture, continued in Anatolia till the end of 19<sup>th</sup> century. Some Yörükhs (nomadic) living in the Taurus and south-eastern Anatolia regions maintained this lifestyle till 20<sup>th</sup> century. Even today, there are people sustaining a nomadic lifestyle. When Turks settled, they still followed their lifestyle (Gökpınar, 2003; Gürbüz, 1997).

Nomadism took a very long time. During the Ottoman rule, nomads were forced to settle down, and the government passed some laws about this matter during 18<sup>th</sup> and 19<sup>th</sup> century.

Animal husbandry, the most important factor in the nomadic lifestyle, had a great impact on the destruction of vegetation in Anatolia. Turks arriving in Anatolia tried to come up with a new lifestyle based on the geographical characteristics of land, where they had settled down. Turks mainly depended on animal husbandry and goat feeding for their livelihood. Intense presence of goat in these areas is not coincidental; there is a close relationship between the way goats grow and feed, and the structure of land, climate and vegetation. Both nomadism and goats were important factors in destruction of vegetation and land

degradation in Anatolia (Bates, 1971). After migrations to Anatolia ended and people settled down, agricultural activities have increased, and forest lands were used for agricultural purposes, particularly during last 100 years (Halaçoğlu, 1997). Destruction started right around villages and continued by spreading from one village to another. In Anatolia, one can spot the traces of destruction around villages located in or near forests. Only in cemeteries the natural vegetation of a residential area can be seen.

Human pressure on the natural environment increases as population grows. Migration to Anatolia, which started during second half of 19<sup>th</sup> century and continued intensively up to first quarter of 20<sup>th</sup> century, substantially increased the pressure on land (Demir, 2002). As a result of total new political condition, many people migrated from Crimea, the Caucasus, and the Balkans to the Ottoman Empire from second half of the 19<sup>th</sup> century onwards. The empire had a population of 12 million at the end of 19<sup>th</sup> century. In 1914, this number reached 16 million. About 5 million people from Yugoslavia, Bulgaria, Crimea, Romania, Greece, Romania and Caucasus migrated to the Ottoman Empire and Turkey between 1826 and 1990. The Ottoman Empire divided masses of refugees into small groups and settled them at different places (Halaçoğlu, 1997). They mostly settled on lands that were still natural and arable, but not cultivateable. After transition to a multi-party system, use of tractors began in 1950s and the common property regime entered a new phase. Anatolian people, who led a nomadic lifestyle, caused damage to the vegetation since they were engaged in animal husbandry. Emigrants were engaged in agriculture for thousands of years. Thus, they maintained this lifestyle in Anatolia. As agricultural activities gained importance, conversion of forestlands to farmlands became faster, and land degradation started increasing again in 1890.

Results show that the natural environment in Anatolia changed significantly over the last century. Due to human impact on ecosystem, anthropogenic biomes emerged in Turkey as well as many other countries. Anthropogenic biomes (i.e. anthromes) that emerged as a consequence of long-term human impact on ecosystems spread over a wide area. In two centuries, large habitats became fragmented because of forest destruction, illegal cutting of trees and land clearing (Fig.4). The study suggested that the rate of natural biomes in Turkey was 3%. The remaining 97% was determined to be composed of anthropogenic biomes.

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