

# Causes of land degradation and rehabilitation efforts of rangelands in Turkey

## Türkiye’de arazi bozulmasının sebepleri ve mera ıslahı çalışmaları

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### ABSTRACT

Turkey, which is located in an ecological transition zone between subhumid Southern Europe and the arid Middle East, has a long history of land use and civilization. Pressure from expanding human populations, intensified animal production, and transhumant movements in particular, are leading to the complete denudation of many areas of central Turkey (Central Anatolia), with soil erosion emerging as the primary concern. A mountainous topography and semiarid climatic conditions exacerbate the threat of soil erosion and have limited the success of efforts to restore degraded lands. Although afforestation efforts have increased, rangeland areas dominated by shrub and grass species have decreased. Remnant rangeland areas continue to experience overgrazing and severe losses in productivity. Forest remnants and archeological studies indicate that, due to human use, Central Anatolia has lost its original native vegetation, including pine and oak species, and has assumed anthropogenic steppe characteristics. For this reason, the restoration emphasis has been on tree species, without any consideration for shrub or grass species that could help to stabilize soils in denuded and degraded landscapes. In this article, we discuss the socioeconomic and environmental limitations of the natural revegetation of rangeland areas, and the need for restoration efforts with a focus on shrub and grass species in areas vulnerable to high rates of soil erosion.

**Keywords:** Land degradation, Anatolian steppe, rangeland rehabilitation, overgrazing

### ÖZ

Çok uzun ve eski bir arazi kullanım tarihine ve uygarlaşmaya sahip Türkiye, yarı nemli güney Avrupa ile kurak Ortadoğu arasında geçiş zonunda yer almaktadır. İnsan nüfusu ve hayvansal üretim artışının yarattığı baskı, özellikle yayla yaklaşımı, erozyona sebep olarak İç Anadolu’da vejetasyonun kaybına ve arazinin çıplak kalmasına yol açmaktadır. Dağlık topoğrafik yapı ve yarıkurak koşullar toprak erozyonu tehdidini hızlandırmakta ve bozuk alanların restorasyonunun başarılı olmasını kısıtlamaktadır. Ülkemizde ağaçlandırma faaliyetleri artarken, otsu ve çalı türlerinin baskın olduğu mera alanları azalmıştır. Mevcut mera alanları sürekli otlatılmaya maruz kalmakta ve verimlerinde kayıplar meydana gelmektedir. Orman kalıntıları ve arkeolojik çalışmalar, İç Anadolu’nun insan kullanımından dolayı içerisinde çam ve meşe türlerinin de yer aldığı doğal vejetasyon örtüsünü kaybettiğini ve antropojen step özelliği kazandığını göstermektedir. Restorasyon çalışmalarında ağırlık, bozuk ve çıplak alanlardaki toprakları stabil hale getirecek çalı ve otsu türler yerine ağaç türlerine verilmektedir. Bu makalede, mera alanlarının doğal çalı ve otsu türlerle bitkilendirilmesini kısıtlayan sosyo-ekonomik ve çevresel faktörler açıklanarak yüksek derecede erozyona uğrayabilecek alanlardaki otsu ve çalı bitki türlerine restorasyon faaliyetlerinde duyulan ihtiyaç konusu tartışılmıştır.

**Anahtar Kelimeler:** Arazi bozulması, Anadolu stebi, mera ıslahı, aşırı otlatma

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### INTRODUCTION

#### Location, Topography and Land Use

Turkey is located between Latitudes 35°50’-42°06’N and Longitudes 25°40’-44°48’E and covers an area of 77797127 ha (Balci and Uzunsoy, 1980). The larger part of the country, called Anatolia or Asia Minor, lies in Asia while the smaller part, called Turkish Thrace, lies in Europe. Both land parts meet at two important straits, the Bosphorus and the Dardanelles connecting the Black sea with the Mediterranean sea. Very di-

verse climatical, topographical, sociological, geological, and historical conditions dictate the management of soil and vegetation resources. The topography of Turkey can be defined as rugged, apart from the highly mountainous coastal region and Eastern part. The Northern and Southern chains of the mountains running along the coast meet in Eastern Anatolia and form the highest plateau of Anatolia. The mean elevation is 1132 m which is 3.5 times greater than that of the European Continent (GDSHW, 2015). The country has more than twenty peaks with elevations higher than 3000 m above sea level and elevation varies from 0 m at sea level to 5165 m at Ararat Mountain. (Balci and Uzunsoy, 1980). As seen in Table 1, 62% of the total area has a slope of over 12% and “very steep” or “extremely steep” slopes cover 47% of the total land area. These values show the significance of topography in land use and soil erosion as one of the main reasons for land degradation.

According to land capability classification, 34.6% of the land area is suitable for cultivation while 65.4% is not and should be under permanent vegetation cover such as range or forest (Table 2). Although the amount of arable land almost coincides with the actual amount of cultivated land (31.10%), it is believed that there is a significant difference between current land use and the capability classes because several studies conducted around the country showed that some range and forest areas are presently being used for agricultural purposes (Balci and Uzunsoy, 1980; Gülersoy et al., 2015).

**Table 1. Distribution of land area in relation to slope degrees (MAFRA, 1987)**

Slope degrees (%)	Ratio to total land area (%)
Flat or almost flat (0-2)	12.80
Gentle slope (2-6)	11.18
Moderate slope (6-12)	13.87
Steep slope (12-20)	14.17
Very steep slope (20-30)	17.63
Extremely steep slope (>30)	30.35

**Table 2. Distribution of total land area according to land capability classes (MAFRA, 1987)**

Land use suitability	Land capability classes	Ratio to total land area <sup>1</sup>
Suited for cultivation	I	6.53
	II	8.81
	III	9.88
	IV	9.39
Not suited for cultivation	V	0.22
	VI	13.35
	VII	47.32
	VIII	4.50

<sup>1</sup>Lake areas are excluded from the land area.

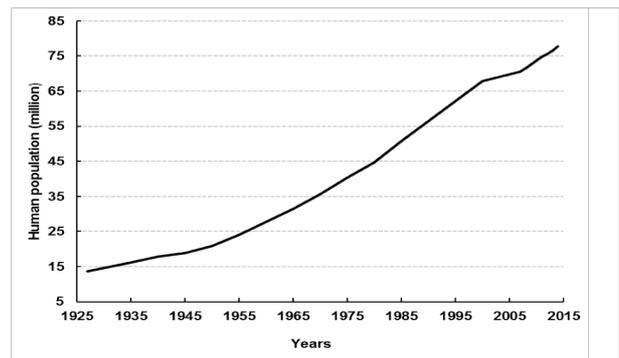
## Demography

Turkey has a high annual population growth rate of about 2% and the population increased from 13.6 million in 1927 to approximately 77.7 million in 2014 (Figure 1) (TSI, 2015). Due to rapid migration from rural areas to urban areas, the rural and urban populations changed from 75.8% and 24.2% in 1927 to 8.2% and 91.8% in 2014, respectively (Figure 2).

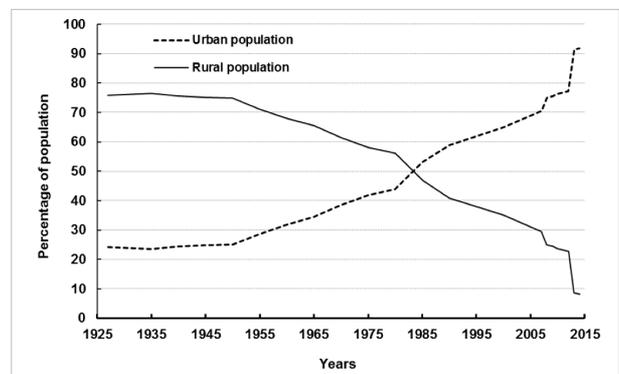
Migration of people from rural to urban areas also affected livestock population. Similar to human population, the total number of livestock including cattle, sheep, and goats was approximately 26.5 million in 1929, in the early years of the Turkish Republic and increased to 85.5 million in 1981 and then dramatically decreased to 37.7 million in 2009 (Figure 3) (TSI, 2015). However, livestock population has started to increase in recent years due to changes in the rural development policies of the Turkish government and increases in subsidies paid to farmers for encouraging farming, livestock production, and preventing rural migration.

## Actual Land Use

Although the size of cultivated land was used to coincide with the size of arable land with respect to land capability classification in the mid 1900's, the amount of cultivated land decreased to 31.10% over the last decades (Figure 4). Decreases in the size of the cultivated land can be attributed to abandonment of ar-



**Figure 1. Trend of human population increase by years in Turkey**



**Figure 2. Trend of changes in the urban and rural populations by years**

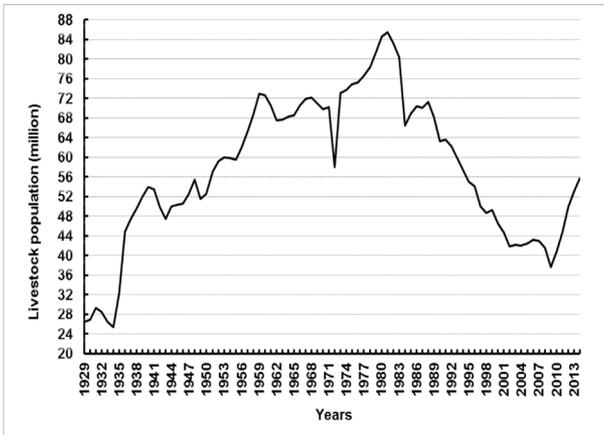


Figure 3. Livestock population changes with respect to years

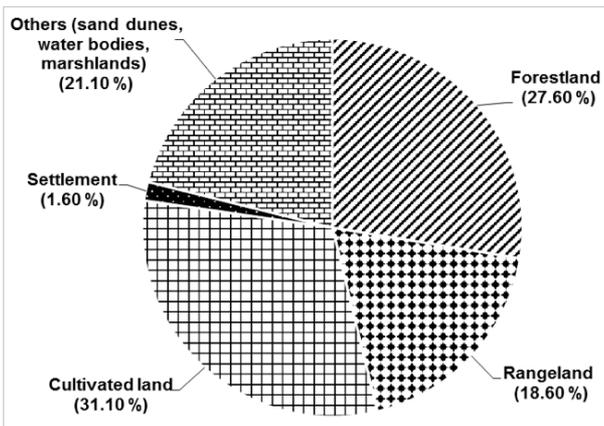


Figure 4. Actual land use in Turkey (GDCDE, 2015)

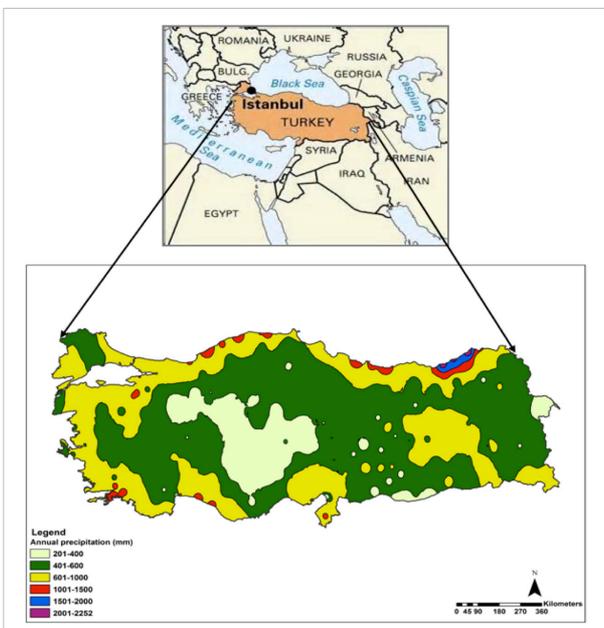


Figure 5. Distribution of annual precipitation in Turkey

able lands due to migration of people from rural areas to urban areas, and allocation of arable lands for new settlements and industrial plants. According to present land use classification, almost one third of the country is used for agricultural purposes while 27% is covered with forest vegetation and about 19% is rangeland (Figure 4).

### Climatic conditions

According to the General Directorate of State Hydraulic Works (GDSHW, 2015), mean annual precipitation is around 643 mm with a runoff coefficient of 37% and most of it falls in winter months (Özhan, 2004). Precipitation regime is uneven and its annual amount varies from 200 mm in Central Anatolia to 2250 mm along the Northeast Black Sea coast. About half of Turkey (53%) receives annual precipitation of less than 600 mm and 12.5% receives less than 400 mm (based on 41 years of Turkish State Meteorological Service data covering a period from 1970 to 2011 years (TSMS, 2012). This means that semi-arid conditions prevail in an area equal to greater than half of the country (Figure 5). Mean annual temperature is around 13.1°C and varies from 2.2°C to 24.3°C. Also, temperatures can drop as low as -45.6°C in January and reach 48.6°C in July months in Southeastern Anatolia which is one of the warmest and driest regions on the Anatolian peninsula (TSMS, 2015).

### RESULTS AND DISCUSSION

Anatolia has a long history of land use and civilization. Several civilizations flourished and disappeared in Anatolia. The History of cultivation goes back to 7000 years ago, particularly in upper Mesopotamia and some other parts of the country (Brice, 1968). Some wheat, barley and leguminous species were already being cultivated by about 6000 BC (Balci and Uzunsoy, 1980). Due to this long history of cultivation and conflicts among the civilizations, vegetation cover was destroyed and soil was lost due to erosion. Two erosion periods have been identified in Anatolian soils. The first period is between 300 years BC and 300 years AD. During this 600 year period, some ports like Ephesus and Miletus were destroyed and abandoned because of siltation (Balci and Uzunsoy, 1980). There is also evidence showing that Turkey has been experiencing a second period of serious erosion in the last 50 to 100 years. Even though annual soil loss was decreased by afforestation and land rehabilitation studies from some 500 million tons in the 1970's to 168 million tons in 2014 (GDCDE, 2015), soil loss is still greater than in many countries around the world (Wallington, 1988). Therefore, soil erosion still remains a serious threat for natural resources in Turkey. Currently, 86% of the total area has experienced soil erosion problems to varying degrees and approximately 59% has severe to very severe erosion problems (Table 3). Wind erosion appears only in a small portion of the country, especially in the sand dune covered areas. Because of soil loss, soil depth has decreased and about 67% of the country has shallow and very shallow soils (Table 4). Moreover, erosion threatens water resources and some reservoirs were shut down and are no longer used due to siltation.

Over grazing and land use tradition are some of the main factors responsible for land degradation and affect the success of restoration works in addition to mountainous topography, semiarid conditions in large areas, extended land use and civilization histories, land misuse, and rapid human and animal population growth. The vast majority of livestock depends on rangelands. Livestock are grazing as long as climatic conditions are suitable without considering the basic principals of range management such as grazing season and systems, and carrying capacity (Koc et al., 2015; Anonymous, 2015a). In rural parts of Turkey, rangelands are allocated to villages and villagers have the right to own as much livestock as they want. All livestock from the villages graze together and no fees are required for the grazing rights. Regardless of region, most livestock owners have long continued to practise their traditional transhumance system,

creating heavy and uncontrolled grazing pressure - especially on most of the steppe rangelands (Cornelius, 1962; Tukul, 1984). Additionally, although regulation of the grazing conditions are specified in the rangeland act of 1998, grazing seasons are not controlled (Koc et al., 2015). Transhumance style grazing has traditionally taken place in Anatolian soils as a lifestyle of Turkish people living in rural areas (Koc et al., 2015). As weather conditions and forage growth becomes suitable, livestock herds are moved to highlands for grazing and shepherds apportion livestock grazing at will, without considering the principals of grazing management. Therefore, some rangelands have been overgrazed and degraded, especially in the Eastern Anatolia (Figure 6). Moreover, with developments in the mechanization of agricultural systems in the last century, conversion of Anatolian steppe rangelands to cultivation lands has increased. This has meant that the size of grazing lands has decreased and grazing pressure on rangeland increased (Tukul, 1984; Firincioğlu et al., 2007; Anonymous, 2015a). Hence, increases in human and livestock population, especially in the early 1900s, are another factor causing degradation and productivity losses in the rangelands. Alper et al. (2010) reported that rangeland was 45 million ha seventy years ago yet has decreased to 21.7 million ha today, and while grazing land was 2.2 ha per animal in 1935 it has dropped to 0.76 ha today.

**Table 3. Distribution of total land area with respect to erosion severity (MAFRA, 1987)**

Intensity of erosion	Ratio to total land area (%)
None	6.64
Slight	7.22
Moderate	20.04
Severe	36.42
Very severe	22.32
Rock surfaces	3.77
Wind erosion	0.65

**Table 4. Distribution of land area in relation to soil depth (MAFRA, 1987)**

Intensity of erosion	Ratio to total land area (%)
Very shallow (<20 cm)	37.2
Shallow (20-50 cm)	30.5
Moderately deep (50-90 cm)	11.90
Deep (>90 cm)	14.30



**Figure 6. A general view of degraded rangelands in Turkey (GDCDE, 2015)**

Although Turkey is considered as a rich country in terms of vegetation diversity with over 15,000 plant species, 13 species have become extinct as a result of severe land degradation (Ekim et al., 2000). Due to heavy and continuous grazing and over carrying capacities, some plant species were removed from range vegetation composition in Turkey (Firincioğlu et al., 2007). Vegetation composition changed and annual vegetation became dominant in some range sites e.g. the ranges of Aegean Turkey (Pringle and Cornelius, 1968). A grazing enclosure study conducted in the Central Anatolian steppe ranges showed that protection of a range site from grazing for 27 years increased species richness and 32 more plant species were identified in the enclosure site compared to grazed sites (Firincioğlu et al., 2007). Several studies are available indicating how the composition of both woody and herbaceous vegetation in Turkey's grasslands have been changed or disturbed because of land degradation and overgrazing. Therefore, present plant composition is totally different from what was seen in the past. In fact, palynological studies on sediment samples collected from different regions of Anatolia showed that forest vegetation had covered a larger area than what is seen in Anatolian steppe today (Boydak and Çalişkan, 2015). Firincioğlu et al. (2009) reported that the range vegetation of the Anatolian steppe changed from tall-grass dominated grassland to *Artemisia santonicum* dominated shrubland, and a sod forming short grass, *Festuca valesiaca* and a prostrate shrub, *Thymus sipyleus* ssp *rosulans* became the dominant plant species due to heavy grazing in the rangelands. Several examples of similar changes in the vegetation compositions of the rangelands can be seen in different parts of the country. In these regions, dominant species are generally either spiny and noxious shrubs like *Astragalus* sp. and *Acantholimon acerosum* or other plant species like *Achillea wilhelmsii*, *Salvia* sp.,

and *Stipa lessingiana* that have relatively little forage value (Gökbulak, 1999; Firincioğlu et al., 2010). In another study conducted in the herbaceous vegetation covered Anatolian steppes, some woody and shrub species such as pine, oak, juniper, oriental hackberry, hawthorn, sumach, and common white beam were identified from forest remnants indicating that the region was once dominated by forest vegetation but this is no longer the

case. (Uslu, 1959) Moreover, an archaeological study on pollen analysis of soil samples from a Central Anatolia region which is currently forest absent, proved that forest existed in the region in the pre-historic period and that this forest cover used to consist of some native tree species such as pine, cedar, fir, chesnut, birch, poplar, willow, lime, as well as some shrub species like maquis, and herbaceous species like plantago, and fern (Aytuğ, 1970). All this evidence indicates that the majority of Central Anatolia was covered with a totally different vegetation composition in the past but this region later gained steppe characteristics. In fact, Uslu (1959) claimed that 50% of Central Anatolia is anthropogenic steppe due to human intervention. Moreover, besides overgrazing, browsing and fodder leaf utilization are further problems in maquis covered rangelands and forestlands dominated by oak trees. There are about 10 million goats in Turkey today (TSI, 2015) and the majority of them utilize the maquis vegetation covered areas of Southern Turkey and the oak forest dominated areas of South Eastern Turkey. Browsing was a serious threat in the past and it still continues to create a negative impact on shrub and woody vegetation covered rangelands (Acatay et al., 1978). In some regions in Southeastern Anatolia, tall oak forests have been replaced with pseudo-maquis covered rangelands. Acatay et al. (1978) estimated that 58 million ha of forestland were trampled annually by goats and each of these browsed areas was trampled at least three times per year. In order to meet forage demand (especially that of goats) in the harsh winter conditions, and to cover the shortage of forage production in relation to herd sizes, oak trees are pruned and fresh leaves and twigs are stored in summer for use in winter and other times when forage availability is limited due to the end of growing season and herbaceous plants die or senesce. The use of leaves as fodder is still a common tradition applied in South Eastern Anatolia and causes degradation of lands dominated by shrub and oak trees. It can be said that browsing, together with the pruning of oak trees for leaf fodder have replaced forest cover with pseudo-maquis cover composed of shrub species such as *Artemisia* spp., *Thymus* sp., *Astragalus* spp., and *Acanthalimon* spp. in the South and Southeastern Anatolia steppe ranges. In fact, Mol (1982) studied the effect of pruning on tree growth and found that trees lost regrowth and regeneration capacities and they were dwarfed due to repeated pruning for leaf fodder. Also, East and Southeastern Anatolian rangelands are invaded by shrub species such as *Peganum* spp. and *Genista* spp., *Artemisia* spp., *Thymus* sp., *Astragalus* spp., and *Acanthalimon* spp. due to overgrazing (Koc et al., 2015).

Both the Ministry of Food, Agriculture and Livestock (MFAL) and Ministry of Forestry and Water Affairs (MFWA) are responsible for land rehabilitation works in Turkey but most of the range rehabilitation works have been carried out by MFAL. MFAL rehabilitated 506,560 ha of land (MFAL 2015) while MFWA rehabilitated 76,512 ha of rangeland (GDCDE, 2015) between the years 2000-2014. As seen from Figure 7, the area of land rehabilitated only by MFWA is increasing from year to year but these efforts are not enough and land degradation still remains a big issue in Turkey. For instance, the areas of rangeland rehabilitated and land protected from erosion by MFWA was 880 and 7,458 ha respectively in 1993.

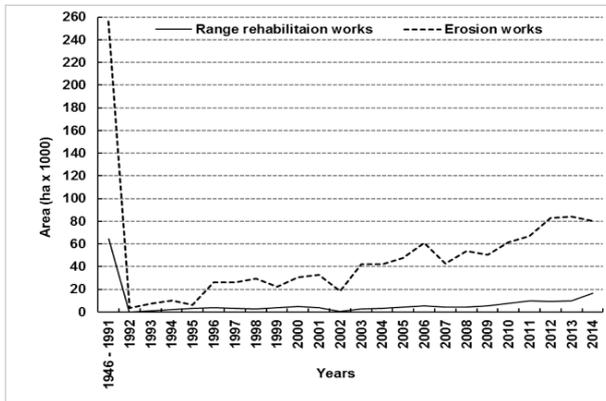


Figure 7. Sizes of rehabilitated rangeland, and the land erosion control works performed per year



Figure 8. a, b. Contour terracing for erosion control (a) and improving soil moisture recharge and forage production (b) (GDCDE, 2015)

These areas reached 16,383 and 80,517 ha in 2015 (Figure 7). Erosion control works are also mostly carried out on lands that were



Figure 9. A combination of afforestation and contour terracing works in range rehabilitations (GDCDE, 2015)



Figure 10. a, b. Sand dune stabilization works along the Black Sea coast of Northeast Thrace: (a) fence as a combination of herbaceous vegetation and woody material, (b) same site after afforestation (Anonymous, 2015b)

formerly rangelands but which lost their vegetation cover and soil due to heavy grazing. In comparison, MFAL has rehabilitated an area of 586,682 ha for the last fifteen years but all these works are small scale experimental studies carried out by research stations and universities (MFAL, 2015). Range rehabilitation works in general include weed control by mechanical methods (Pringle and Cornelius 1968), construction of new watering facilities to provide a better distribution of grazing animals, and contour terracing for increased soil moisture and protection from erosion. Seeding or revegetation are not commonly applied rehabilitation strategies in degraded rangelands. Most of the range areas are located in East, Central, and Southeast Anatolia and 75% of the range rehabilitations works were conducted in Central and Eastern Anatolia and Black Sea regions where the most degraded rangelands exist and overgrazing takes place (MFAL, 2015).

In most of the rehabilitation works in rangelands, in contrast to MFAL, MFWA prefers contour terracing and planting these terraces with local native tree species to increase species diversity, range productivity, and minimize soil and vegetation disturbance by maintaining native vegetation in the areas between terraces (Figures 8a, b) (GDCDE, 2015).

Depending on site conditions, MFWA carries out afforestation on contour terraces with the saplings of drought tolerant native tree species in some rangelands with the purpose of protecting them from human intervention and soil erosion (Figure 9). In general, herbaceous vegetation and shrub species are not preferred in large scale range rehabilitation works. Afforestation of rangelands in some regions of the country is an effective strategy in Turkey for protecting the lands from misuse, occupation and human interventions because the lands with tall trees are much more valuable and respected by people and receive less disturbance than herbaceous vegetation covered rangelands in Turkey. That is why, the Turkish forest service prefers to rehabilitate some rangelands by afforestation.

Additionally, a lot of wildfires occur every year in the hot dry summer months, especially in the southern and western parts of the country where the Mediterranean climate type is common. As ruled in Turkish Forest Law, the forest service has to afforest burned sites immediately after wild fires. Consequently, Turkey is the leading country in the world for increasing forest covered land due to intensive afforestation works in forest lands and partially in rangelands. Forest areas increased from 20.7 million ha in 1972 to 21.7 million ha in 2012 (GDCDE, 2015). In contrast to forestlands, rangelands covered about 56% of the country in 1940 (Karagöz, 2006) but have decreased to below 20% today (Figure 4). Decreases in the rangelands can be attributed to encroachment of urbanization, conversion of rangelands to croplands, deficiencies in the application of agricultural policies and laws (Sayar et al., 2015). Even though wind erosion affects a small portion of the country (Table 3), the forest service has made some successful sand dune stabilization works and Figure 10 shows one such example from Black Sea coast of Northeast Thrace (Anonymous, 2015b). In these works, fences either as a combination of herbaceous vegetation such as *Ammophilla*

**Table 5. Some laws enacted for environmental issues**

Name of the acts	Law number	Enactment date
Forest law (MGYGM, 2015a)	6831	September 8, 1956
Environment law (MGYGM, 2015b)	2872	August 11, 1983
National park law (MGYGM, 2015c)	2873	August 11, 1983
Mining law (MGYGM, 2015d)	3213	June 15, 1985
Rangeland act (MGYGM, 2015e)	4342	February 28, 1998
Soil conservation and land use law (MGYGM, 2015f)	5403	July 19, 2005
Agricultural law (MGYGM, 2015g)	5488	April 25, 2006

*breviligulata*, *Isatis arenaria*, and *Allicum spp.* and wood material together or alone were established and sand dunes were stabilized and then planted with saplings of tree species such as *Pinus maritima*, *Pinus pinea*, *Pinus brutia*, *Cupressus pyramidalis*, *Alnus glutinosa*, *Robinia pseudoacacia* (Figure 10).

The degradation of soil and soil resources exceeds the progress of land rehabilitation efforts because of lack of administrative regulations as well as insufficient budget, expertise, and labour. The Great Assembly of Turkey has enacted several acts relating directly to environmental issues such as forestry, the environment, national parks, mining, pasturelands, soil conservation and land use, and agriculture at various times (Table 5) All of these laws regulate the major issues of forests, rangeland, agriculture, mining, and national parks in order to minimize degradation of environmental resources such as soil and vegetation. However, poverty is still a serious threat for land resources and forest trees are still cut illegally for fuel and for creating spaces for cultivation, rangelands are repurposed as cropland - especially in low income rural areas where the laws are not properly applied and their results are not monitored effectively enough due to insufficient labour, expertise and finance. For instance, mining law holds the forest service responsible for reclamation and revegetation of mining sites, and mining enterprises for paying all reclamation expenses after mining activities completed - but these actions do not generally take place in Turkey. Another example is the rangeland act. Articles in the act dictate that people who cause the degradation of rangelands are responsible for meeting the expenses for rehabilitating the rangelands, but the law is not implemented or executed properly. In addition to forest law, there are other environment related laws which were enacted 4-5 decades ago as well as amendments which are made time to time depending on the demands of the country and prerequisites for European Union candidacy.

## CONCLUSION

Harsh topographical land characteristics, semiarid conditions in large areas, traditional habits, rapid increase in population and livestock, a long history of civilization and land use in Anatolia have made lands fragile and vulnerable to land degradation and - in the case of misuse of land - have caused vegetation distur-

bance Because of human interference, some woody and herbaceous plant species have become extinct, especially in central Anatolia and these areas have gained anthropogenic steppe characteristics. Restoration efforts have increased since the early years of the Turkish republic in forest, range, and mining areas but soil degradation and limited restoration activities remain important issues. Even though some laws regarding the regulation and organization of land resources have been enacted recently, their applications are not effective. Land abuse such as occupation of state forest and range lands by individuals is still continuing and amnesty laws are issued time to time by the government for those who illegally use or occupy these state lands. In rangeland rehabilitation, herbaceous plants species and shrub species are not commonly preferred and mostly tree species are used for land rehabilitation works. It seems that range rehabilitation studies will not reach a satisfactory level and will not be successful for a long time in Turkey unless at least the basic principles of range management strategy are properly applied.

**Ethics Committee Approval:** This study does not contain an approach involving humans or animals as a subject. Based on this, ethics committee approval was not necessary for this study.

**Informed Consent:** No patients participated in this study so written and verbal informed consent was not needed for this study.

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