



The effects of karstic areas on agriculture and forestry in the Western Mediterranean Region of Türkiye

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ABSTRACT: Karst landscapes, composed of limestone, present distinct habitats and/or karst biomes in terms of landforms, land use, land capability classification, forest growth and regeneration, soil formation, water sources, and settlements. At the end of the Alpine orogenic period, the Taurus Mountains region rose by more than 3000 m and was dissected along fault lines. Large basins were formed as a result, and some of the tectonic depressions were occupied by lakes in which marl materials accumulated in the Korkuteli, Elmalı, and Bucak depressions. In the Taurus Mountains, the bottoms of karst depressions where clayey calcareous lake sediments and terra-rosa soils are found correspond to areas where cereals, fruits, and vegetables were produced and where settlements were established. Most greenhouses and citrus orchards have been established on karst depressions containing Mediterranean soils along the Mediterranean coast. In sloping karst areas, red Mediterranean soil (alfisol and luvisol) is found in cracks and between layers rather than on the surface. Karst areas are of particular importance from a forestry perspective. In karstic lands, the seeds of cedar trees, in particular, germinate easily in the upper parts of cracks containing soil. After one vegetation period, the seedlings' roots grow to more than 1 m in length. For this reason, the karstic areas of the Taurus Mountains are covered in productive forests of Taurus cedar (*Cedrus libani*), black pine (*Pinus nigra*), and Calabrian pine (*Pinus brutia*). Reforestation and afforestation activities in karst areas involve scattering cedar seeds in karst regions. Conversely, maquis vegetation is common in the understory of Calabrian pine forests, particularly in areas where Calabrian pines have been cleared or destroyed. Maquis vegetation regenerates with root suckers along limestone cracks. The main aim of this article is to shed light on the relationship between agriculture and forestry in the western part of the Taurus Mountains.

Keywords: Limestone, karstification, agriculture, forestry, Taurus Mountain

Türkiye'nin Batı Akdeniz Bölgesi'ndeki karstik alanların tarım ve ormancılık üzerine etkileri

ÖZET: Kireçtaşıdan oluşan araziler, yer şekilleri, arazi kullanımı, arazi kapasitesi sınıflandırması, orman büyümesi ve yenilenmesi, toprak oluşumu, su kaynakları ve yerleşmeler açısından kendine özgü bir yaşam alanı ve/veya karst biyomu sunmaktadır. Alp orojenik döneminin sonunda, Toros Dağları bölgesi 3000 m'den fazla yükselmiş ve fay hatları boyunca parçalanmıştır. Korkuteli, Elmalı, Bucak gibi bazı tektonik çöküntüler, içinde marn malzemelerinin biriktiği göllerle dolmuştur. Killi kireçli göl tortullarının ve terra-rosa topraklarının bulunduğu karstik depresyonların tabanları, tahıl, meyve ve sebzelerin üretildiği ve yerleşmelerin kurulduğu sahalara karşılık gelir. Akdeniz kıyı şeridi boyunca seraların ve narenciye bahçelerinin çoğu, Akdeniz toprakları içeren karstik çukurlarda kurulmuştur. Kayalık eğimli karstik arazilerde topraklar yüzeyde değil çatlak ve tabakalar arasında oluşmuştur. Ormancılık açısından karstik sahaların ayrı bir yeri ve önemi vardır. Karstik arazilerde orman yenilenmesine gelince, özellikle sedir ağaçlarından düşen tohumlar, toprak içeren çatlakların üst kısımlarında kolayca çimlenmektedir. Bir vejetasyon döneminden sonra fidanın kökleri 1 metreden fazla uzar. Bu nedenle, Toros Dağları'ndaki karstik alanlar verimli Toros sediri (*Cedrus libani*), karaçam (*Pinus nigra*) ve Kızılçam (*Pinus brutia*) ormanlarıyla kaplıdır. Karstik alanlardaki ormanlaştırma ve yeniden ağaçlandırma faaliyetleri tohum serpilmesiyle uygulanmaktadır. Öte yandan, Kızılçam ormanlarının alt katmanında yetişen makilik bitki örtüsü, ağaç kesimi yapılmış veya tahrip edilmiş kızılçam alanlarında yaygındır. Makilik bitki örtüsünün yenilenmesi, kireçtaşı çatlakları boyunca kök sürgünleri ile gerçekleşir. Bu çalışmanın temel amacı, Toros Dağları'nın batı kesiminde tarım ve ormancılık arasındaki ilişkiyi aydınlatmaktır.

Anahtar kelimeler: Kireçtaşı, karstlaşma, tarım, ormancılık, Toros Dağları

INTRODUCTION

The term 'karst' is generally given to limestone areas with topographically distinct, rocky scenery, including karstic depressions, caves, springs and dolines (Thomas and Gouide, 2000; Atalay, 2017). The term originates from a narrow strip of limestone plateau in Serbia, Slovenia, and the adjacent Italian region bordering the Adriatic Sea, where a remarkable array of features dependent on subsurface dissolution can be found (Thornbury, 2004). Limestone containing calcium carbonate (CaCO_3) and clay dissolves in the presence of carbonic acid (H_2CO_3). Karstic landscapes are widespread in many areas of Turkey. The most extensive karst area is found along the Taurus Mountain range, particularly in the western part (Figure 1). Karst landforms in the study area contain two main topographic features formed by the dissolution of limestone and the accumulation of calcium carbonate in the form of travertine deposits resulting from the evaporation of calcium bicarbonate waters.

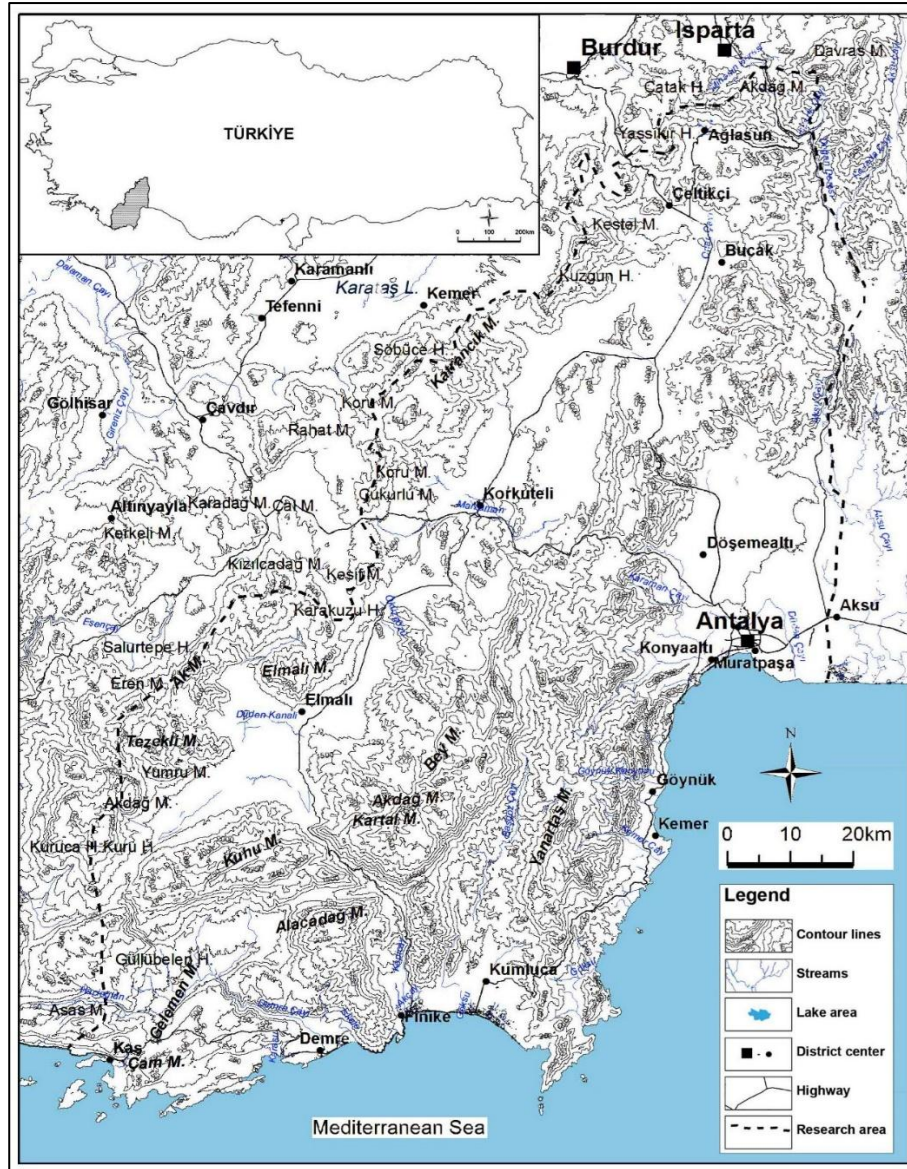


Figure 1. Location and topographic map of the study area

The first karst study was started by Prof. Alagöz in the Taurus Mountains (Alagöz, 1943). The topographic landforms were mentioned in the geomorphological textbook of the Geographical Institute (Erinç, 1971; Yalçınlar, 1969). Geomorphologists have worked on the subject of karstic landforms and karstic sources in the MTA Institute. The first karstic ecology is taken into consideration by Atalay (1988; 1995; 1999; 2011). The forest growth and regeneration in the karstic area were mentioned by Atalay and Boydak (Atalay 1987; Boydak & Çalikoğlu, 2008). State Hydraulic Working is interested in the groundwater and karstic sources for dam constructions. From the forestry perspective, the effects of afforestation on karst areas in terms of carbon and nitrogen sequestration were studied by Babur et al. (2025). Long-term effects of land use transition on SOC stocks in Adana Karst Ecosystems by Dindaroğlu et al. (2024). The soil characteristics in the Andırın-Karasu basin were studied by Reis and Dindaroğlu (2023). The habitat classification in the Sarımsak Mountains between Kahramanmaraş and Andırın was studied by Dindaroğlu et al. (2019; 2023).

Karstic lands ecologically created a distinct habitat called karst biome mainly cover in most part of the Taurus Mountains (Atalay, 1987; 2014; 2017; Atalay et al., 2024; Siler 2016). First

time karstification processes on the limestone belonging to Paleozoic had started and continued during the period of Mesozoic and Senozoic Era in Türkiye. Karstification intensity has occurred depending on the vertical faulting movements occurred in Miocene neotectonic period. In this neotectonic period some part of the karstic area have depressed and uplifted along the faulting movements leading to the formation high altitudinal differences. On the uplifted area karstification process has shifted from the surface to deep part of limestone (Atalay 1987; 1995; 1996; 2003; Atalay et al. 2008; Nazik, 2008; Nazik et al. 2015; Erinc, 1971).

Karstic areas are the responsible for the formation of different karstic environments in terms of soil formation, forest growth and agricultural lands (Atalay 1995; 1996; 1999; Atalay et al. 2024a; 2024b; 2008). For example, productive forests are common in the rugged and/or sloping areas of Taurus Mountains. Agricultural lands are found on the marly deposits that accumulated on the collapsed karstic lands like Burdur-Bucak, Korkuteli, Elmalı depressions.

In this study, the formation of karstic depressions, and their shapes depending on the inclination of limestone layer, soil formations and importance of karstic depression on the agricultural fields in western part of Taurus Mountains will be assessed.

MATERIAL AND METHOD

During the fieldwork carried out between 1980 and 2024, the geological parent materials, soil formation and karstification processes were examined. The spreading areas of geological parent materials and the geomorphological evolution of the landscape, particularly in karstic areas, were considered to explain the topographic forms and soil properties. Geological cross-sections and topographic profiles were also created to illustrate the evolution of karst topography and soil formation in the study area, which covers the western part of the Taurus Mountains (Fig. 1). Many photos were used for illustrative purposes. The importance of regenerating forests and maquis vegetation on karstic land is also examined and explained.

The texture, CaCO_3 , pH, organic matter, cation exchange capacity (CEC) and organic matter content of the soil and plant nutrients in the samples of parent materials were determined in the soil laboratory of the Department of Soil Science and Plant Nutrition at Akdeniz University. The soil texture was determined using the hydrometer method of Bouyoucos (1955) and Black (1965). The CaCO_3 content was determined using the Jackson (1967) method. The exchangeable cations were determined using the 1N ammonium acetate method according to Kacar (1995). The cation exchange capacity (CEC) was determined using the sodium acetate method according to the USDA (1975) and Kacar (1995) methods, respectively. Soil pH was determined using the Evliya (1964) and Jackson (1967) methods, respectively. CEC was determined using Kacar's method (1995).

RESULTS and DISCUSSION

Geologic Structure and Geomorphological Evolution

As a whole, present-day Taurus Mountain area was occupied by Tethys Ocean with the splitting between Anatolian micro-plate and African-Arabian plate during the early Mesozoic period. This ocean bottom was covered by the ultrabasic and/or ultramafic volcanic rocks mainly

composed of peridotite-serpentine that erupted along the mid-oceanic ridge as the result of sea floor spreading process (Figure 2 and 3).

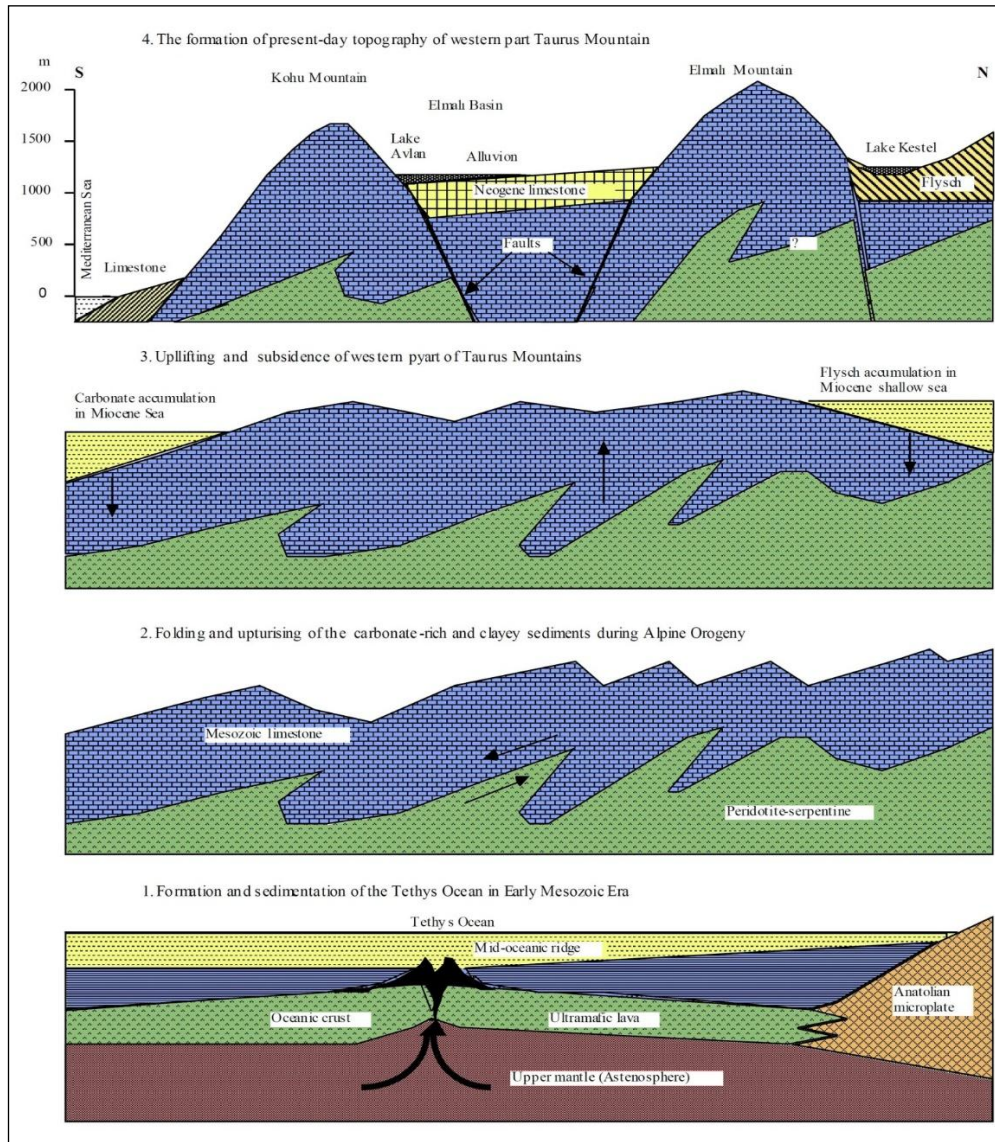


Figure 2. Simplified geomorphological evolution of western part of Taurus Mountains

So, calcareous and clayey materials accumulated on the oceanic crust during the Mesozoic Era. At the end of the Mesozoic the accumulated materials were subjected folded and uplifted by the Laramian orogenic movements occurring at the end of Mesozoic era. Thus, the mainland of the Taurus Mountains was emerged from shallow parts of the Tethys Ocean. The early Senozoic period, the lowlands of the Taurus Mountains were occupied by the shallow sea in which nerithic limestones, marl and flysch deposits were accumulated. During the Alpine orogenic movements occurred in the Upper Oligocene Taurus Mountain range was formed as a whole (Şengör, 1980; Şengör et al., 1983; Atalay 2017). In the neotectonic period occurred between the Upper Miocene and Early Pleistocene period Taurus Mountains range was uplifted as a whole and was dissected by the vertical faulting movements contributing the formation of present-day grabens and/or depress; thus, the tectonic depressions such as Bucak-Celtikci, Elmalı, Söğüt, Burdur and Korkuteli were formed (Figure 2 and 3).

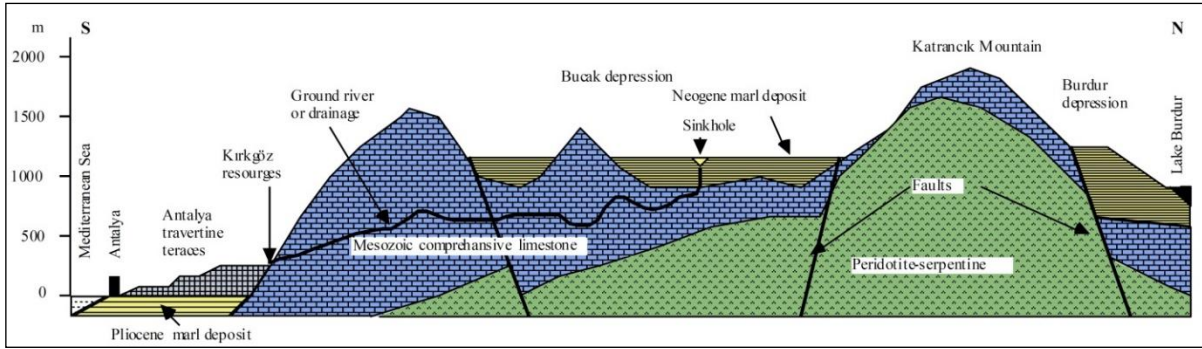


Figure 3. Geological cross-section between Antalya and Burdur depression.

Figure shows Bucak tectonic-karstic depression containing marl deposit that suitable for agriculture. These depressions were occupied by the upper Neogene Lake in which mostly clay-rich calcareous materials were accumulated (Atalay 1988; 1995; 2002; 2017; Güldalı, 1972; 1976). Travertine deposits have formed on the lower slopes especially in the vicinity of Antalya Gulf, as the result of evaporation of the calcium bicarbonate waters coming from the upper karstic areas of Taurus Mountains (Atalay et al. 2008).

Topographic Properties of Taurus Mountains

The Taurus Mountains belonging to the Alpine-Himalayan orogenic belt beginning from the coast of Mediterranean Sea and abruptly raising up to 3500 m altitude have very rugged topography due to intense karstification process and vertical faulting movements. The rising of Taurus Mountains forms a barrier between Mediterranean Sea and Central Anatolia (Figure 4).



Figure 4. A general appearance of Taurus Mountains

This situation led to frequently changes of ecologic conditions especially air circulation. In fact, the south facing slopes of Taurus Mountains is covered by fog due to the coiling of the humid air mass during the summer period. Besides, the preventing of front coming from the Mediterranean Sea lead to increase of precipitation on the south facing slope of Taurus Mountains. Rocky appearance is dominant. Slope inclination changes frequently. Deep and

large depressions that encircled high land are the main reason of the temperature and precipitation changes. For example, temperature drops as low as -20°C on the bottom of deep and large depression due to the moving of cold air mass on the upland areas. This temperature inversion leads to the forest spreading areas. As is seen the bottom of the deep and large depression is covered by Taurus fir growing resistant cold condition, while Calabrian pine forest growing in the hot Mediterranean belt is found on the encircling high area near Akseki town (Figure 5 and 6). Figure 6 clearly shows the importance of temperature inversion during the winter season, near Akseki.



Figure 5. A canyon karstic valley in vicinity of the eastern slopes of Bey mountains



Figure 6. The Taurus fir on the bottom of karstic depression and calabrian pine on its high slope

The inversion taking place between the chemical erosion is dominant in the places where along the streams and cracks in the karstic lands. Indeed, U- shaped canyon valleys are found on the slopes facing to the Mediterranean Sea in the Taurus Mountains.

Some wetlands which are remnant of the old Neogene lake are found on lowlands of the karstic-tectonic depressions. On the other hand the blockage of the sinkholes lead to the formation of temporary lake as is Çeltikçi and Bucak depression.

The travertine deposits containing three terrace levels were formed with the evaporation of the water containing rich calcium bicarbonate that originated from the karstic sources named Kırkgöz springs in vicinity of Antalya plain in the southern edges of Taurus Mountains (Efe et al., 2008) (Figure 3).

Karstification Process and Formation of Karstic Landforms

Karstification is a dominant chemical erosion and depositional process on limestone which is one the chemical rocks. Initially, karstification process has occurred in Paleozoic, Mesozoic and Senozoic limestones in the Taurus Mountains. Karstic land forms can be classified according to the shapes that are seen on the surface and occurrence of ground of limestone.

Small karstic depressions

These karstic landforms on the surface are small depressions and covering a few acre agricultural lands and encircled high land mountains. Dolines which are small karstic depression are only formed the weathering of limestone (Figure 7).



Figure 7. Doline (small karstic depression) with dry farming field formed on the travertine deposit in the north of Antalya

The inclination of the limestone strata is mostly determined the shape and inclination of the bottom. Namely, the flat bottom of the doline is common on the horizontal strata, while V-shaped doline bottom appears on the thick comprehensive limestone reflecting continual sedimentation process. Depressions which are found on the old or misfit valley are the result of the seepage of the river water to the deep part of limestone with the enlarging of cracks (Figure 5, 8 and 9) Besides, deep canyon valley have been formed on the thick limestone due to the fact that the chemical erosion of the rivers. These canyon valleys are found along the river courses flowing into Mediterranean Sea.

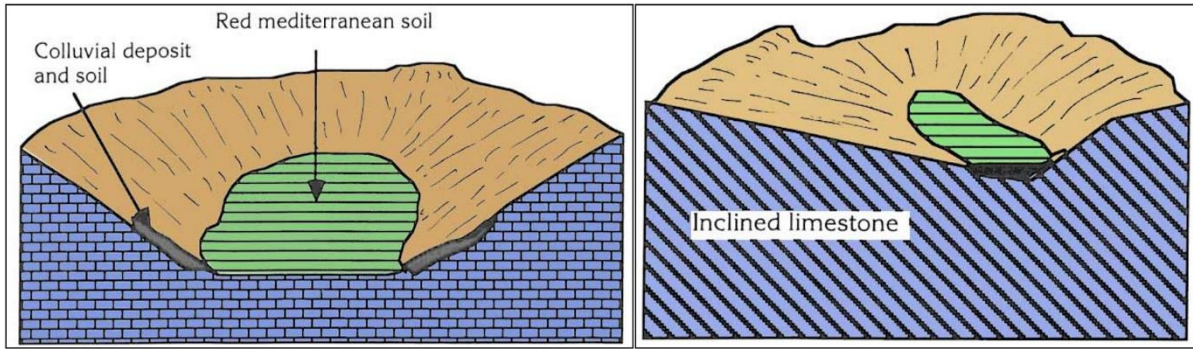


Figure 8. The shapes of the karstic depressions (dolines) depending on the inclination of limestone layers. The circular shaped doline in the horizontal layers (left), and dissymmetric shaped doline on the inclined strata (right).

The enlarging of these depressions has occurred by the chemical erosion limestone, and large karstic depressions were formed the mainly collapse along the fault line of the karst area. These depressions widespread are in plain appearance, and cover an area of more than 20 km².

Karstic plains (poljes) are mainly found on the bottom of the tectonic-karstic depressions and wide and deep misfit valley bottoms (Figure 8-9b). Vertical tectonic movements are responsible for the formation of tectonic depressions in the karstic lands, and additionally they have been enlarged by the solution of limestone. These plains can be divided into two groups in terms of soil and altitude.

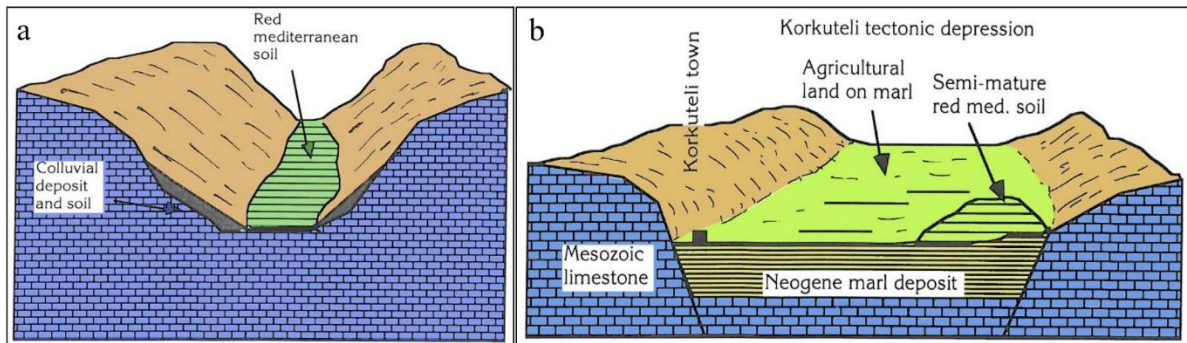


Figure 9. a) Agricultural land on the Korkuteli valley Antalya and Korkuteli town, b) a karstic depression formed along the old karstic-tectonic depression.

The poljes (karstic plains) on the upland area

These depressions are in tectonic origin which formed in the collapse of the area between the two main fault lines. In other words, their shapes are controlled by the structure of limestone and geomorphological evolution of valley. The depressions with steep slopes correspond to the tectonic line, for example. The large depression containing sinkholes on the upland areas is found at an elevation of more than 700-800 m. At the same time, these depressions are also found along the old wide stream valley that formed along the fault line. These depressions with red Mediterranean soil are widespread between Antalya-Korkuteli and Bucak-Çeltikçi (Burdur province). The bottoms of upland part of these depressions contain Red Mediterranean soil which formed in situ conditions.

Some of the poljes contain marl deposit that accumulated in the lake environment. Marl deposit at the same time is suitable for agricultural practises due to easily plough and enough plant

nutriment content. Korkuteli and Bucak plains are one of the main apple growth areas of the Mediterranean region. Non irrigation areas of these plains are the dry farming areas on which mostly wheat is harvested.

Besides, some of these depressions are found along the deep and wide valleys corresponding to the tectonic basin and the misfit valleys (Figure 9a). The circular shaped depressions have probably formed in the collapsed areas. These depressions with red Mediterranean soil are widespread between Antalya and Korkuteli. Red Mediterranean soil which formed in situ conditions is the main production areas of cereals. On the other hand, settlements especially towns were set up on the big karstic depression such as Korkuteli, Bucak, Çeltikçi and historical town Elmalı (Figure 10).



Figure 10. Tectonic-karstic depression that contains marl deposit named Söğüt in the W of Korkuteli town

Karstic depressions on the Mediterranean coastal belts

These depressions which are covered with red Mediterranean soil (Alfisol / Luvisol) are found both in the coastal belt of Mediterranean and upland areas of Taurus Mountains (Altunbaş et al., 1998, 2009, IUSS, 2014; Soil Survey Staff, 2014; Sarı et al., 2018; Kaymak, 2018, Atalay 2014). Fertile agricultural lands are seen along the coastal belts of western part of Antalya Gulf and the between Finike and Kalkan town in the southern part of Teke Peninsula (Figure 9). Green houses and agricultural land are established to produce cash crops vegetables and fruits on the some parts of these karstic depressions (Figure 11).

As to land capability classification, sloppy and rocky areas are covered by productive forest belonging to VII. Class; the agricultural land on the karstic depression is class IV on which dry farming carry out. The land along the coastal belt of Mediterranean plains is in the class of I and II due to the suitable climatic conditions. Coastal belt agricultural lands are among Türkiye's important citrus, vegetable and fruit production areas due to no climatic limitations.



Figure 11. A karstic depression named Kale plain in the coastal belt of Mediterranean Sea and the greenhouses on this plain.

Underground Features of Karstic Land

Karstic area also contains cave, underground rivers and holes. Underground rivers were formed as the result of established rivers on the surface of Paleozoic, Mesozoic limestones shifting from surface to the deep parts. Other words, with the uplifting of Taurus Mountains surface drainage networks have shifted from the surface to the deep part of limestone. At the same time underground rivers imply the enlarging of the limestone cracks with chemical erosion of limestone. The existence of misfit and/or dry wide valleys on the surface is the residue of old rivers. The collection of the infiltrated water in the ground has feed underground river. The emerged ground river and seepage of the rain water forms prominent the karstic resources as is Kırkgöz springs. Generally the shortage of the water is common on the in the karstic land. Most of the caves correspond to the old ground river. Collection of the karstic resources maintains some rivers such as Manavgat, Aksu, Alakır streams flowing into Mediterranean Sea.

Soil formation in the karstic land

There is no soil cover on the surface of rugged and/or rocky lands due to precipitation water easily infiltrates along the cracks. Soil is only found along the cracks and among bedding surface where water is holds in the sloping areas (Figure 12). Here carbonates (CaCO_3) transport as calcium bicarbonate ($\text{CaH}(\text{CO}_3)_2$) via water and clay particles remain as clay. So, mostly clayey texture soil has formed in the karstic lands of Taurus Mountains. Good air and water circulation within the cracks of limestones produce the reddening of soil. Soil reaction is generally neutral and weak alkaline reaction, CEC (Cation Exchange Capacity) is the very high category in terms of plant nutriments (Atalay 1997, 2016; Kaymak, 2018, Sarı et al 2018; Atalay et al, 2024a, b). For this reason karstic land in the sloppy areas is the productive is covered by the forest especially cedar.



Figure 12. Red Mediterranean soil formed along the cracks and among the layers

On the flat land on the tectonic karstic, karstic plain (poljes) and old valley red Mediterranean soil (Alfisol/Luvisol) are found (Figure 5, 13, 14). These areas are the main agricultural producing grains for local settlement people. There is no mature soil profile on the marl deposit and it shows clay texture (Table 1).



Figure 13. Red Mediterranean soil on the polje that is found between Antalya-Korkuteli



Figure 14. Sub-mature red Mediterranean soil

Figure 14 shows that sub-mature red Mediterranean soil has formed on the firstly submerged Neogene marl deposit in the southern edge of the Korkuteli depression and abandoned agricultural field and dissected with large gullies on the Neogene deposit in the background. On the other hand the soil developed on the flat surface transports due to the enlarging of the crack. Limestone surface turns into rocky land. Here trees and olive oil trees go on grow (Figure 15).



Figure 15. Transformation of limestone surface into rocky land

Figure 15 shows olive trees grove on the rocky flat area formed the vertical transportartation of Red mediterranean soil along the wide cracks in the near of Meditteranean Sea, and maquis vegetation area that completely cut of Calabrian pine forest in the background.

Table 1. Laboratory analysis of red Mediterranean soils, marly deposit on the limestones in the study area

Soil sample places	pH	CaCO ₃ (%)	Organic matter (%)	CEC (cmole/ kg ⁻¹)	Exchange cations (cmole/ kg- 1)				Sand (%)	Clay (%)	Silt (%)	Texture
					Mg	Ca	Na	K				
Beldibi tunnel entrance limestone	7,1	17	2,8	45	0,5	20	0,1	0,45	35	40	25	Loam
Red med soil Elmalı-Korkuteli basins	7,2	6,5	0,6	44	0,5	23	0,01	0,39	30	45	25	Clayey loam
On the slope of Elmalı Çamkuyusu locality	7,2	9	6,5	44	0,5	27	0,03	0,45	39	46	15	Clayey loam
Soil on limestone at Çamkuyusu locality	7,4	9	6,5	44	1,1	25	0,05	1,38	41	46	13	Sandy clayey loam
Soil on bottom of Çamkuyusu locality	7,2	9	6,4	44	1,1	25	0,04	1,35	40	50	10	Sandy loam
Çiğlıkara 1400 m altitude	7,1	14	6,5	55	0,6	27	0,02	1,27	38	57	5	Sandy clay
Red Med. Soil under Cedar forest at Dokuz göl locally Elmalı basin	7,4	13	7,9	57	0,6	26	0,02	1,25	35	63	2	Clay
Red med. Soil on the slope and monument of Koç cedar	7,0	16,5	7,3	50	0,6	28	0,01	1,95	27	55	18	Sandy clayey loam
A horizon of red med. Soil at locality of altınkaya, Kumluca of	7,5	14,5	2,8	56	1	33	0,00	1,42	32	46	22	Silty clay
Kumluca Altınyaka kireçtaşı	7,3	14,4	5,7	51	1,9	36	0,00	1,46	30	42	28	Clayey loam
Kumluca red mediterranean sol at Altınyaka locality	7,6	14,9	3,1	47	1,6	34	0,01	1,45	29	39	32	Clayey loam
Red med. Soil formed along the crack. of limestone at Altınkaya loc.	7,5	8,7	2,0	57	1,6	34	0,01	1,45	34	60	6	Sandy clay
Red med. Soil developed on limestone at Alanya Söğüt high plateau	7,4	15,7	5,8	43	0,05	0,20	73	25	34	40	26	Loam
Red med soil on Paleozoic limestone at Mahmutlar loca. of Alanya	7,4	9,7	3,6	47	0,04	0,21	73	23	73	25	2	Loamly sand
Red med soil under Calabrian pine Mahmutlar of Alanla locality	7,2	10,5	3,8	46	4	29			73	23	4	Loamly sand
Bucak marly deposit	7,5	27	8,5	16	143	247	0,4	15	28	32	40	Clay

Soil formation has continued to develop all karstic lands that formed from Paleozoic to Quaternary. The existence of bauxite deposit composed of alumina silicate in the Mesozoic limestone is clearly reflects to have been developed red Mediterranean soil.

Agricultural lands

Agricultural lands are widespread on four main areas:

1. Karstic-tectonic depressions that formed the collapse of the karstic areas along the fault lines and the enlarging of the karstic erosion are the biggest depression as are Bucak (Burdur)-Korkuteli and, Elmalı Basins. These depressions contain marl deposit that formed the accumulation of the marl material in the lake environment. These depressions covering at least an area of c. 50 km² is the main agricultural area on which apple gardens and dry farming fields are found (Figure 7, 10-14).

2. Karstic depressions have been formed by the chemical erosion of the limestone. Red Mediterranean soils that are formed on the bottom of these depressions are the small dry farming areas.
3. These areas are mainly corresponding to abandoned old river valleys. In these valley is one of the small agricultural on which wheat fields are common.
4. Mediterranean coastal belt plains that formed both the collapse and the karstic erosion process are the main greenhouse lands. Due to the favorable Mediterranean climatic condition citrus, fruits, vegetables are grown in the coastal plains, where agriculture is carried out year-round. These areas, like Kemer, are also among the developing areas of major seaside tourism centre (Figure 11).

Agricultural lands provide a significant portion of the grain needs of the population living in the karstic region. The Elmalı and Korkuteli-Burdur basins are among the largest apple production areas nationwide. On the other hand, small cities as is the Korkuteli, Bucak and historical town Elmalı were set up on the big karstic lands.

Forest growth in the karstic land

As a general rule karstic land is one of the productive forest growth areas of Türkiye. Almost of all forests which are associated with Calabrian pine (*Pinus brutia*), cedar (*Cedrus libani*), Taurus Fir (*Abies cilicica*), black pine (*Pinus nigra*) grow on the karstic lands. Calabrian pine (*Pinus brutia*) forest begins at an elevation of near Mediterranean coast and rise up to 1200 m, Cedar forests are found on the between 800-2000 m, Taurus fir (*Abies cilicica*) forest both pure and mixed with cedar is commonly seen on the foggy and orographic rainy areas on the slope facing south (Figure 17). Black pine (*Pinus nigra*) forests common on the inside part of the Taurus Mountains. Pure cedar forests are only seen in the Elmalı Basin located NW of the Taurus Mountains (Figure 16, 17).



Figure 16. A pure cedar forest and monumental cedar tree named Koç Sedir (Ram cedar) growing on the karstic land of Elmalı Basin

Karstic land forms a suitable ecological condition on the growth of forests. The seeds falling within cracks containing red Mediterranean soil easily germinate, and their roots follow the seepage of water along the cracks attains a meter long after a vegetation period (Fig. 19-21). Presently regeneration cedar forest on clear cut cedar forest areas cedar applies the scattering of cedar seeds on the karstic area. This application carries out especially in Mersin Forestry Directorate (Figure 20). For this reason, karstic lands are the good habitat for the growth of forests. While poor stand Calabrian pine and cedar forests are common on the unweathered serpentine areas as is seen in the western part of coastal belt of Taurus Mountains.



Figure 17. Pure Taurus fir (*Abies cilicica*) forest growing foggy area on facing south slope the karstic land (north of Mersin)



Figure 18. Good stand of cedar forest on the karstic land in Taurus Mountains

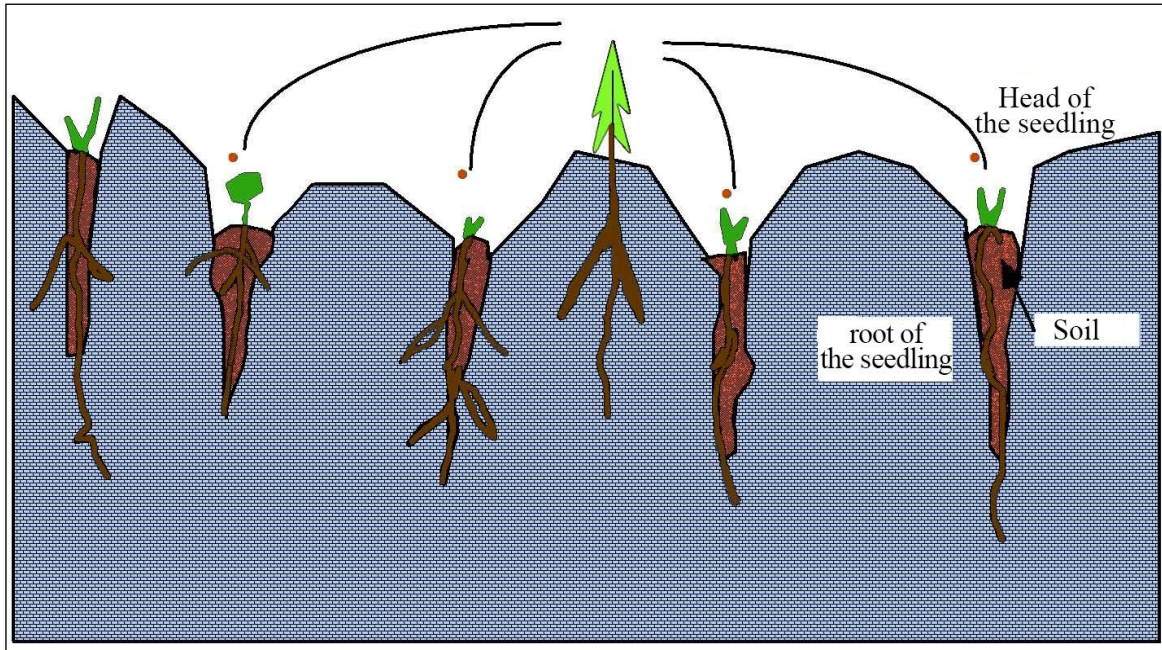


Figure 19. The regeneration falling of the tree seeds within the cracks containing soil on the karstic land.



Figure 20. Cedar regeneration areas applying the cedar seed scattering on the karstic land.



Figure 21. Nature cedar regeneration areas in karstic land in the vicinity of Armutkırı locality

Maquis vegetation naturally growing on the lowerstory of Calabrian pine spread fast with root sucker where clear cutting of Calabrian pine. Maquis vegetation areas are the main grazing areas of goat flocks along the year. After fire and clear cutting areas maquis again spreads. Because maquis root easily develops along the cracks of limestone (Figure 23). It can be stated that Maquis is stabilized vegetation on the karstic land.



Figure 22. Maquis vegetation covering destroyed Calabrian pine (*P. brutia*) forest areas

Regeneration of maquis vegetation takes place with clear-cutting methods. This method leads to increase of the biomass production of maquis. Every cutting a period 3-4 year increases magus production three fold. The milk and meat production of goat also rises.

Presently maquis areas have been degraded by the over grazing, it these areas especially kermes oak (*Quercus coccifera*) are converted into cone shape. In order to maintain of maquis vegetation over grazing should be controlled.



Figure 23. Root sucker regeneration of maquis vegetation after fire

1. The Taurus Mountains extend like a barrier and were formed mainly through the folding and uplifting of carbonate-rich sediment that was deposited in the Tethys Ocean.
2. Vertical tectonic movements that occurred in the Middle Miocene contributed to the formation of grabens, or depressions, and the surrounding uplifted areas were subjected to depression. Some of the large depressions were occupied by lakes, in which marly deposits were formed. The karstification process, involving the chemical dissolution of limestone, led to the formation of rugged and rocky topography.
3. The high altitude of the Taurus range, which rises to 3,000 m, gives rise to different vegetation belts. The lower belt, found at altitudes of 0–1,200 m, is the main area of Calabrian pine. The second belt, found at altitudes of 1,200–2,000/2,200 m, is the main area of pure and mixed Taurus cedar (*Cedrus libani*), black pine (*Pinus nigra*) and Taurus fir (*Abies cilicica*) forests.
4. Preventing a humid air mass and front from the Mediterranean Sea leads to increased precipitation on the south-facing slopes of the Taurus Mountains. Additionally, the rising humid air originating from the Mediterranean Sea contributes to the formation of fog and orographic rain on the high southern slopes. For this reason, the south-facing slopes are more humid than the northern part of the Taurus Mountains.
5. Soil formation has only developed along the crack and bedding surface of the sloped land, while the bottom of the soil is common on the flat land of the depressions.
6. Agricultural areas are widespread across the flatlands of the depressions. Meanwhile, good, productive forests are common on karstic land because tree roots can easily develop along

cracks in the soil. Native forest regeneration occurs through the germination of seeds in the cracks in the red Mediterranean soil.

7. Reforestation and afforestation activities can be applied using seed-scattering methods.

8. Maquis vegetation grows in the lower story of Calabrian pine forests and in areas that have been completely clear-cut. These areas are then covered again due to the root suckers of the maquis.

Ecological data and/or knowledge, including geological evolution, topography, the physical and chemical properties of the parent material and climate, are very important in agricultural and forestry research. However, most research does not adequately consider ecological data. Forest productivity mainly depends on climate and the degree of weathering of parent materials. Karst ecology is not well understood by scientists interested in erosion. For this reason, the Taurus karstic land in Turkey is mapped as an area of intense soil erosion. In fact, soil transportation by surface flow does not occur in sloping karst areas. This is because rainwater infiltrates along the cracks in the limestone. On the other hand, most of the solar radiation is reflected due to the pale white color of the limestone, which decreases evaporation. The boundary layer climate, which explains the topographic importance of the formation of the local climate, is very important in forest ecology in the rugged Taurus Mountains.

CONCLUSION

The importance of land for agriculture and forestry can be explained and defined through an understanding of the different topographical forms, climatic conditions and parent materials. Each topographical form is shaped by the erosion and deposition of parent material over a long period of time - reaching millions of years - under the influence of climate, and soils are formed accordingly. For example, flat topography formed on sedimentary rocks creates a flat surface, and all the horizons of the soil can be seen.

Hard rocks like granite have a very rocky appearance. Here, the destruction of vegetation leads to the formation of rocky areas, as seen in the Kaçkar Mountains. In mountainous areas, agricultural land is found in depressions formed by collapsed fault lines, whereas forest growth depends on the lithological properties of the parent materials. In such places, the parent material plays a crucial role in forest growth and productivity. For instance, in the Taurus Mountains, low-density forests grow on serpentine slopes, whereas productive forests grow on deeply weathered serpentine. In the Black Sea coastal mountains, productive forests are found on nutrient-rich flysch where tree roots can penetrate deeply. In all research depending on the natural environment, ecological data is very important.

The physical and chemical characteristics of the parent material should inform land preparation and regeneration activities for afforestation and reforestation. Only trees that have completed the felling cycle should be cut down in forests located on hard rock where the natural balance has been disrupted. Regeneration activities should involve removing the litter. Flat areas containing sedimentary rocks, especially marls and serpentines, should be deeply ploughed. This will encourage root development in saplings and the decomposition of the parent material. When afforesting or reforesting sloping karst land or flat areas, avoid using bulldozers or

tractors for ploughing, as this disrupts the karst ecosystem and brings rocks to the surface. Instead, afforestation should be carried out by scattering seeds.

AUTHORS CONTRIBUTION

İbrahim Atalay: Ensured the preparation of the research plan, visiting all the sites, determining the main materials, taking photographs, drawing the figures and writing the report. **Muzaffer Siler:** Coloured the figures and partially participated in the fieldwork.

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The author declares no conflict of interest.

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This study does not require any ethics committee approval.

REFERENCES

- Alagöz, C. A. (1943). *Türkiye’de Karst Olayları Hakkında Bir Araştırma* (Türk Coğrafya Kurumu Yayınları No. 1). Ankara.
- Altunbaş, S., & Sarı, M. (2009). The Relationships of Iron Contents Between Red Mediterranean Soil and Its Parent Material in Antalya Province, Turkey. *Mediterranean Agricultural Sciences*, 22(1), 15-21.
- Atalay, İ. (1987). *Sedir Ormanlarının Yayılış Alanlarının Ve Yakın Çevresinin Genel Ekolojik Şartları ve Sedir Tohum Transfer Rejyonlaması* (TÜBİTAK TOAG/571). Ankara.
- Atalay, İ. (1988). Toros Dağlarında Karstlaşma ve Karstik alanların Ekolojisi. *Jeomorfoloji Dergisi*, 16, 1-8.
- Atalay, İ. (1995). Pedogenesis And Ecology of Karstic Lands in Turkey. *Acta Carsologica*, 24, 54-67.
- Atalay, İ. (1996). Karstification And Karstic Landforms In Turkey. J-J. Foros & A. Gines (Eds.), *Karren Landforms* içinde (ss. 325-334). Palma: Universitat de Les Balears.
- Atalay, İ. (1997). Red Mediterranean Soils in Some Karstic Regions of Taurus Mountains, Turkey. *Catena*, 28, 247-260.
- Atalay, İ. (1999a). The ecology And Importance of Prevention of Land Degradation in The Karstic Lands. A. L. Singh (Ed.), *Resource Management* içinde (ss. 227-237). Aligarh: Aligarh Muslim University.
- Atalay, İ. (1999b). Land Use In Karstic Lands in The Mediterranean Region. *International Journal Of Speleology*, 28B(1/4), 111-118.

- Atalay, İ. (2003). The effects of tectonic movements on the karstification in Anatolia. *Acta Carsologica*, 32(17), 195-203.
- Atalay, İ. (2011). *Türkiye’de Karstlaşma ve Karst Ekolojisi. Fiziki Coğrafya Araştırmaları Sistematik ve Bölgesel* (Türk Coğrafya Kurumu Yayınları Sayı 6, ss. 202-222). İstanbul.
- Atalay, İ. (2014). *Türkiye’nin Ekolojik bölgeleri (Ecoregions of Turkey)*. İzmir: Meta Press.
- Atalay, İ. (2016). *Toprak oluşumu, Sınıflandırılması ve Coğrafyası* (5. baskı). İzmir: Meta Basım.
- Atalay, İ. (2017). *Türkiye Jeomorfolojisi* (3. baskı). İzmir: Meta Press.
- Atalay, İ., Altunbaş, S., Coşkun, M., & Siler, M. (2024a). *Taşlarının Ekolojisinin Tarım ve Ormancılık Açısından Önemi* (2. baskı). Ankara: Palme Yayınları.
- Atalay, İ., Efe, R., & Soykan, A. (2008). Mediterranean ecosystems of Turkey: Ecology of The Taurus Mountains. R. Efe, G. Cravins, M. Öztürk, & İ. Atalay (Eds.), *Natural Environment and Culture in The Mediterranean Region* içinde (ss. 3-38). Cambridge Scholars Publishing.
- Atalay, İ., & Gündüzoğlu, A. G. (2015). *Türkiye’nin Ekolojik Koşullarına Göre Arazi Kabiliyet Sınıflandırması*. İzmir: Meta Basım.
- Atalay, İ., İrdem, C., Altunbaş, S., Siler, M., & Coşkun, M. (2024b). *Türkiye’de Ana Materyaldeki Bitki Besin maddelerinin Orman Ağaçlarının Verimliliği Üzerindeki etkileri* (OGM Yayınları). Ankara.
- Atalay, İ., & Mortan, K. (2023). *Türkiye Bölgesel Coğrafyası* (8. baskı). İstanbul: İnkılap Yayınları.
- Atalay, İ., Saydam, C. K., Selahattin, & Kadir, M. (2018). Pedogeomorphology. *The Soils of Turkey* içinde (ss. 75-104). Springer.
- Babur, E., Yalçıntaş, B., & Ünsal, Y. T. (2025). Impact of Cedrus libani afforestation on Soil Carbon and Nitrogen Stocks in The Upper Mediterranean Basin. *Turkish Journal of Forest Science*, 9(1), 75-88.
- Boydak, M., & Çalikoğlu, M. (2008). *Toros Sedirinin (Cedrus libani A. Rich.) Biyolojisi ve Silvikültürü* (GDGEM-Vak). Ankara.
- Dindaroğlu, T., Boran, B., Babur, E., & Menshov, O. (2024). Long-Term Temporal Variation of Land Use Transition on Soil Carbon Stocks in Mediterranean Karst Ecosystems. *Forestist*, 74(1), 94-101.
- Dindaroğlu, T., Tunguz, V., Babur, E., Menshov, O., & Battaglia, M. L. (2023). Determination of The Relationship Among Compound Topographic Index (CTI), Soil Properties and Land-Use in Karst Ecosystems. *Physical Geography*, 44(3), 307-329.
- Dindaroğlu, T., & Vermez, Y. (2019). Classification and Mapping of Some Site Features of Karst Ecosystems (Sarımsak Mountain Andırın-Kahramanmaraş). *Turkish Journal of Forest Science*, 3(1), 60-83.
- Efe, R., Atalay, İ., Soykan, A., Cürebal, İ., & Sarı, C. (2008). The formation of Antalya Travertine Deposit and Ground Water System. R. Efe, G. Cravins, M. Öztürk, & İ. Atalay (Eds.), *Natural Environment and Culture in The Mediterranean Region* içinde (ss. 93-108). Cambridge Scholars Publishing.
- Erinç, S. (1971). *Jeomorfoloji cilt II* (2. baskı). İstanbul: İ.Ü. Coğrafya Enstitüsü Yayınları No. 27.
- Ford, D., & Williams, P. (1989). *Karst Geomorphology and Hydrology*. London: Unwin Hyman.
- Güldalı, N. (1972). Korkuteli ve Bucak Çevresinde Lapyta ve Dolin çeşitleri ve bunların Gelişmeleri. *Jeomorfoloji Dergisi*, 4, 81-98.
- Güldalı, N. (1976). Akseki polyesi: Torosların Karstik Bölgelerinde Dağlararası Ovalarının Oluşumu ve Gelişimi. *Türk Jeoloji Kurumu Bülteni*, 19(2), 143-148.

- IUSS Working Group WRB. (2014). *World Reference International Soils Classification for Naming and Creating Legends for Soil Maps* (3. baskı). Rome: FAO.
- Kaymak, H. (2018). *Dim Çayı Havzası'nın (Alanya) Karst ekosistemi* (Yayımlanmamış doktora tezi). Afyon Kocatepe Üniversitesi, Afyonkarahisar.
- Nazik, L. (2008). Türkiye'de Güncel Karst Jeomorfolojisi ve Karstik Parametrelerin İncelenmesi. *Jeomorfoloji Dergisi*, 14, 65-78.
- Nazik, L., & Poyraz, M. (2015). Türkiye'de Karst Jeomorfolojisinde Neotektoniğin Rolü. M. Bahadır, A. Uzun, & Zeybek (Eds.), *IV. Ulusal Jeomorfoloji Sempozyumu Bildiriler Kitabı* içinde (ss. 203-213).
- Reis, A., & Dindaroğlu, T. (2023). Karasu Deresi Karstik Yağış Havzasında Toprakların Bazı Özellikleri ve Aralarındaki İlişkilerin Belirlenmesi. *Turkish Journal of Forest Science*, 7(1), 73-90.
- Sarı, M., Kurucu, Y., Akça, E., Eren, M., Kadir, S., Günal, H., ... FitzPatrick, E. (2018). Luvisol. S. Kapur, E. Akça, & H. Günal (Eds.), *Soils of Turkey* içinde (ss. 231-250). Springer.
- Siler, M. (2016). *Anamur Çevresinin Karst Jeomorfolojisi* (Yayımlanmamış doktora tezi). Fırat Üniversitesi Sosyal Bilimler Enstitüsü, Elazığ.
- Soil Survey Staff. (2014). *Keys to Soil Taxonomy* (12. baskı). Washington, DC: USDA-Natural Resources Conservation Service.
- Şengör, A. M. C. (1980). *Türkiye Neotektoniğinin Esasları* (Türkiye Jeoloji Kurumu Konferanslar Serisi No. 2). Ankara.
- Şengör, A. M. C., & Yılmaz, Y. (1983). *Türkiye'de Tetis'in Evrimi: Levha Tektoniği Açısından Bir Yaklaşım* (Türkiye Jeoloji Kurumu Yerbilimleri Özel Dizisi No. 1).
- Thomas, D. S. G., & Goudie, A. (2000). *The Dictionary of Physical Geography* (3. baskı). Basil Blackwell.
- Thornbury, W. D. (2004). *Principles of geomorphology*. CBS Publisher and Distributions PVT.
- Yalçınlar, İ. (1969). *Strüktürel Jeomorfoloji Cilt II* (2. baskı). İstanbul: İ.Ü. Coğrafya Enstitüsü Yayınları No. 24.