

## An Analysis on the Distribution of Maquis-Shrubland: Karabük-Safranbolu Basin (Turkey)<sup>1</sup>

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**Abstract:** Karabük-Safranbolu basin is located in the Western Black Sea Region in the northwest of Turkey. The basin lies within 100 km from the coastline and is an important area, as it hosts Euro-Siberian and Mediterranean plants species. The focus of the study is maquis formation. Occupying a large place on the earth, Maquis communities are commonly distributed over the regions where the Mediterranean climate prevails. These regions are the Mediterranean Region, California, Chile, the Cape and Australia. Distribution of the Mediterranean plant species in the Euro-Siberian phytogeographic region, and vice versa, is related to climate changes and plant migration in the past. Karabük-Safranbolu basin sets a model for such distribution. The study aims to determine the maquis shrubland formation within the Karabük-Safranbolu basin and examine the vertical-lateral distribution patterns. The methodology is based on a regional approach. ArcGIS 10.3 was used for preparing cartographic materials. Within the scope of the study, certain maps of the region such as topographical, physical, slope, aspect, soil, geological, geomorphological and forest management maps were examined as the materials of the study as well as using some meteorological data. The elements of maquis shrubland in the region were detected through field surveys and their distribution patterns were addressed.

**Keywords:** Maquis Shrubland, Maquis Formation, Maquis Distribution, Karabük-Safranbolu Basin, Turkey

### 1. Introduction

Maquis formation spreads on a large area of the world surface. Maquis are located along with coniferous plant communities on Subtropical zone with prevailing Mediterranean climate. Maquis grow in bush form under Calabrian Pine (*Pinus brutia*) forest areas, expand rapidly in forest cleared land and turn into trees when preserved. Maquis are widely distributed in areas with seasonal and daily thermoperiodism, seasonal and limited precipitation and reduced plantation due to water stress. Therefore, maquis generally give rise to the dominant type of vegetation that is characterized by stiff, leathery and plumose leaves. (Schwarz, 1936; Dönmez, 1968, 1979; Peşmen ve Oflas, 1971; Atalay, 1987, 1988a, 1988b, 1992, 1994, 2008, 2014; Aydınöz, 2008; Efe, 2010; Allen; 2014, Atalay and Efe, 2015, Türkeş, 2015). Mediterranean climate is prevailed in the areas of Mediterranean basin, Australia, Chile, California and the Cape region of South Africa.

There are different names used to refer Maquis shrubland in different countries of the world. French

word Maquis or congested bush is used for this shrubland biome in Corsica, while in Chile and Spain it is known as Matorral in South Africa as Renosterveld, in California as “Chaparral” and in Turkey as Maki while in Mediterranean basin it is called as Maquis or Macchia. Dominant vegetation types in Mediterranean ecosystems include Temperate needleleaf forests broad leaf deciduous forests, maquis, garrigue and herbaceous.vegetation types. Maquis is wide spread under coniferous forests or underdeveloped soil profile of limestone parent rock.

The purpose of present research is to determine the elements of maquis formation that is widely distributed in Karabük-Safranbolu basin and to evaluate its horizontal and vertical distribution in the basin. It is found that no single research has been done on distribution of maquis in Karabük-Safranbolu basin before, making the present study significant. Besides, this study will contribute in providing new and contrasting evidences about types of maquis and their elevations on black sea

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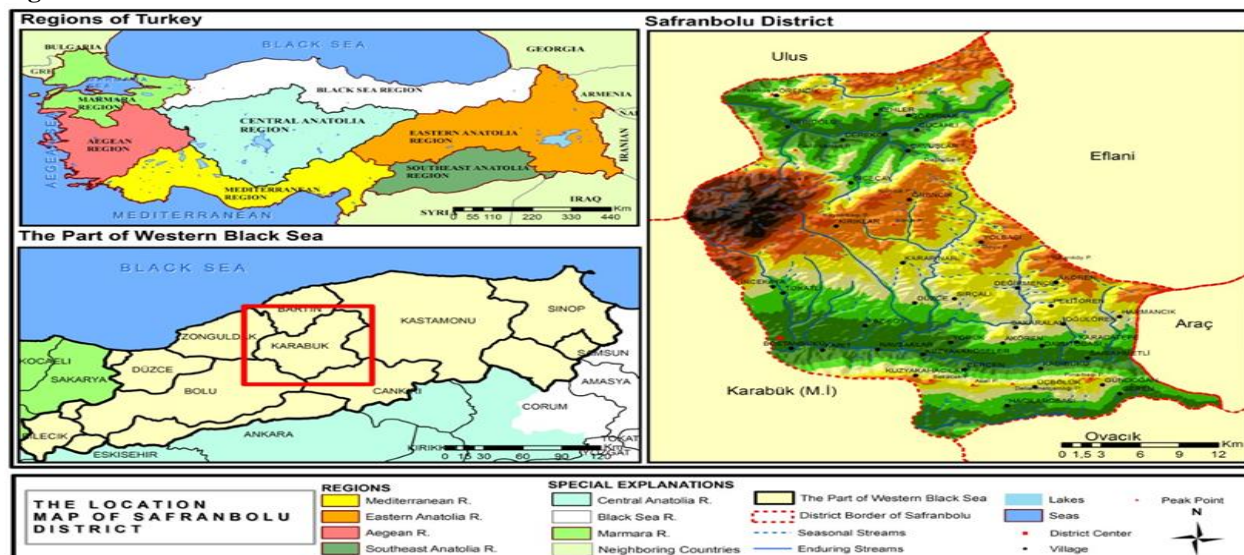
hinterland and thus strengthening the previous literature on the subject.

## 2. Field of study

Karabük-Safranbolu basin is located in in western part of Black sea region in northern Turkey. The

basin lies within the boundary of Karabük province. The area of study extends from Araç district to Karabük central district in the east and from Ovacık district in the south to Eflani district in the north. The basin lengthens from northeast to southwest and widens from west to east (Figure. 1).

Figure.1 The Location of Safranbolu.



## 3. Material and Method

This study is conducted in three stages. First stage involves desk study that includes review of existing literature and preparation of tables, graphs, climographs and maps. ArcGIS 10.3 software was used in preparation of maps.

Second stage includes field survey of the study area. Samples from six different points in Karabük-Safranbolu basin were taken during the study and evaluations were made. The areas excluded from samples were also observed to determine any possibility of differences. Third stage includes desk study again where results were compiled after analysis of samples and field notes. Systematic and regional approach principles with method study were used in research methodology.

## 4. Findings and Discussion

### 4.1. Geological and Geomorphological features

Safranbolu-Karabük basin lies in the west of north Anatolian mountains, between Küre mountains in north and Koroğlu mountains in south, at a distance of 110 km from Black Sea. Height of mountains does not exceed more than 2000 meters. Whole of the basin lies in first degree seismic zone and located in south of North Anatolian Faultline. Secondary Karabük Faultline (southwest-northeast directed) lies to the north of basin.

Karabük-Safranbolu basin was formulated in tertiary period thus known as “Karabük-Safranbolu tertiary basin”. Coşkun (2015) has described that Safranbolu tertiary basin comprises of sedimentation area with important lithologic structures like limestone and flysch. Moreover, it is also mentioned that stone stacks belonging to 2nd and 3rd geological periods like shale, marl, claystone, siltstone, sandstone, conglomerate are also observed in the basin. The bases of basin were formed of flysch and metamorphite before the Eocene period. It is also mentioned that the inner part of the basin was formed by Nummulite accumulated limestone and clastic sedimentary rocks belonging to Lutetian period, quaternary alluvium and slope debris. Karabük-Safranbolu basin is a place surrounded by mountains with deposits of colluvial on foothills within which lies the wave like pattern of flat surfaces and even mesas cut off by the canyons in a monolithic appearance, with a view of terraces and river planes around Araç stream and antecedent valleys. Gradient of basin shows a descent from west to east. Moreover, gradient is more steep in the north and south of the basin while it shows descent towards Araç stream that flows through the basin. North of Araç stream watercourse has southern aspect while south of the stream has northerner aspect. There are two big settlement areas within the basin that are Karabük and Safranbolu that is why the basin is known as Karabük Safranbolu basin. Settlement of

Karabük located in valley, while Safranbolu is located at a higher point of basin than Karabük.

#### 4.2 Soil Characteristics

Alluvial soil is found around streams and stream beds while colluvial soil occurs in down slope the highlands in the basin. The other dominant soil group of the basin is brown forest soil which is widely spread. In their research on Atalay and Coşkun (2015) have mentioned about occurrence of red Mediterranean soil that is formed on calcareous colluvial storages. After the analysis of soil profile samples taken from Safranbolu part of the basin it has been found that red Mediterranean soil and paleosol red Mediterranean soil are also present in this part of the basin. According to them the reasons of this type of soil formation include prevailing Mediterranean climate characterized by warm and arid summer and mild, moist winter season with less rainfall along with widespread presence of limestones in the area.. In addition, they have also described that occurrence

of red Mediterranean soil in the region is not a sign for climatic change and both Paleosol and red Mediterranean soil profiles have same physical and chemical characteristics. and. It is argued that rock material carried from steep slopes by flood covered the red Mediterranean soil which transforms into soil profile similar to already occurred profile with the passage of time.

#### 4.3. Climatic Characteristics

The climate of Karabük-Safranbolu basin is neither as rainy and humid as of Black Sea coast nor does show harsh continental climatic characteristic like Central Anatolian region of Turkey. According to Emberger climate classification, Mediterranean type of climate with dry and warm summer and cold winter is prevailed in the basin. The presence of red Mediterranean and Maquis and Calabrian pines vegetation type also serve as evidence for dominant Mediterranean type of climate (**Chart.1**).

**Chart.1.** Karabük climatic type according to Emberger climate classification.

#### Karabük (Turkey) According to Emberger Climate Classification

<b>PE:</b> Precipitation Total of Summer	97,3
<b>M:</b> Mean Maximum Temperature of Hottest Month (°C)	32,2
<b>S:</b> Value	3
<b>Result</b>	Mediterranean climate
<b>P :</b> Annual Rainfall Total(mm)	488,5
<b>m:</b> Mean Minimum Temperature of Coldest Month (°C)	-0,5
<b>Q Value</b>	51,7

#### Climate Types of Karabük According to Emberger Methods

Q= 32-63; P= 300-400 mm	Semi-dry Mediterranean Climate
m= (-3)-(0) °C	Cold in Winter Mediterranean Climate

Karabük central meteorology station is the only station which has been regularly measuring and recording the meteorological condition in the region for many years. According to meteorological statistics of the station mean temperature over a 65-year time period (1950-2015) was recorded as 13.4 °C. The highest recorded temperature till date is 44.10 °C that was recorded on 11th August 1970. while the lowest recorded temperature is -15.1°C that was recorded on 25th January 1974. Moreover, daily total amount of rainfall was recorded on 10<sup>th</sup> June, 2008 as 79 kg/m<sup>2</sup> and the fastest recorded wind speed was 118.8km/per hour recorded on 16<sup>th</sup> August, 1972, while record maximum snow fall was 38 cm recorded on 10<sup>th</sup> January, 2013.

In Karabuk central district the annual rainfall is 488.5 mm while average temperature is 13.4 °C. The rate of

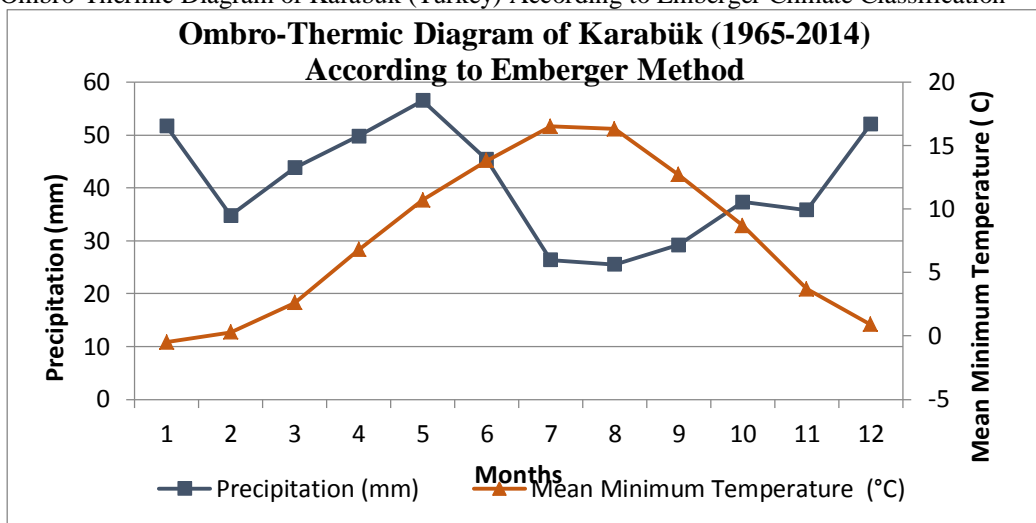
Rainfall becomes lesser during the months of July, August and September. Most of the dry season is observed during months of July and August. while spring season is associated with more rainfall. Average maximum temperature is recorded 32.4°C in August and the lowest one is observed in January as -0.5 °C.

In terms of climatic conditions the Karabük-Safranbolu basin shows characteristic of area that lies in rain shadow due to barrier of Sarıçiçek mountain that blocks the passage of rain-producing system from Black Sea., causing low rainfall in the area. Keeping in consideration the precipitation index given in Thornthwaite climatic classification, the basin has an arid climate (C1) characteristic. On the other hand, the basin has climate characteristic of mesothermal climate (medium warm climate - B2) in

terms of temperature index while, according to precipitation index, it shows characteristics of

medium secondary climate. (Chart.2-3; Graphic.1-2).

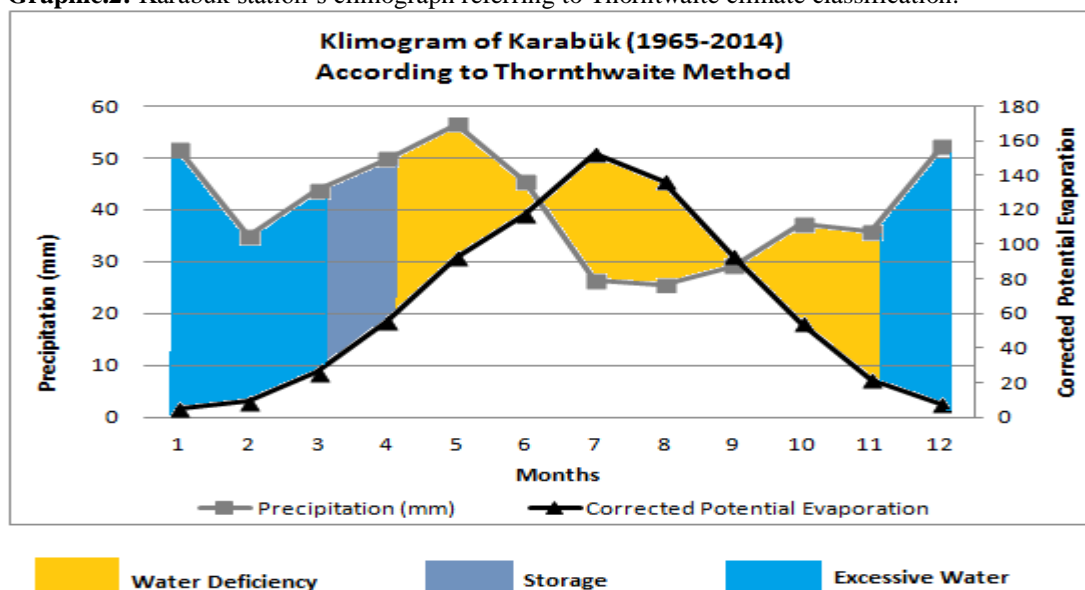
**Graphic 1:** Ombro-Thermic Diagram of Karabük (Turkey) According to Emberger Climate Classification



**Chart.2.** Thornthwaite Water schedule of Karabük station.

Elements of the balance	Months												Annual Total
	1	2	3	4	5	6	7	8	9	10	11	12	
Air Temperature (°C)	3	4,7	8	12,8	17,4	20,9	23,9	23,6	19,5	14,3	8,3	4,3	13,4
Temperature Index	0,4	0,9	2,0	4,1	6,61	8,72	10,6	10,4	7,8	4,9	2,1	0,8	59,8
Uncorrected Potential Evaporation	6	11	25	50	74	93	120	115	90	57	27	9,5	677,5
Corrected Potential Evaporation	5	9,1	25,8	55,5	92,5	117,2	152,4	136,9	93,6	54,7	22,1	7,6	772,4
Precipitation (mm)	51,7	34,8	43,8	49,8	56,5	45,4	26,4	25,5	29,2	37,3	35,8	52,1	488,3
Storage Change	0	0	0	5,7	94,3	0	0	0	0	0	13,7	86,3	200
Storage	100	100	100	94,3	0	0	0	0	0	0	13,7	100	508
Real Evapotranspiration	5	9,1	25,8	55,5	150,8	45,4	26,4	25,5	29,2	37,3	22,1	7,6	439,7
Water Deficiency	0	0	0	0	58,3	71,8	126	111,4	64,4	17,4	0	0	449,3
Excessive Water	46,7	25,7	18	0	0	0	0	0	0	0	0	44,5	134,9
Runoff	36,2	31	25	12,5	6,3	3,2	1,6	0,8	0,4	0,2	6,9	25,7	149
Moisture Ratio	9,3	2,8	0,7	-0,1	-0,4	-0,6	-0,8	-0,8	-0,7	-0,3	0,6	5,9	15,6

**Graphic.2:** Karabük station's climograph referring to Thornthwaite climate classification.



**Chart.3.** Climatic type of Karabük-Safranbolu basin referring to Thornthwaite climate classification

Rainfall Efficiency Index                      **C1:** Semi dry-Less humid  
 Temperature Efficiency Index                **B'2:** Mesothermal (Middle Hot Climates)  
 According to Rainfall Regime                **s:** Secondary climate type which in winter and moderate of excessive water

Erinç rainfall effectiveness index of Karabük-Safranbolu basin is calculated. Prof. Dr. Sırrı Erinç has considered the average highest temperature and total amount of rainfall in formulation of drought index. According to this index the climate of basin shows characteristics of subhumid climate based on the annual temperature and rainfall data. The weather

is very humid in 2 months of the year (January-December), only one month is wet (February) and 4 months are subhumid (March-April-May-November). In this basin, months of July, August and September have arid characteristics while June and October have subarid climate properties (**Chart.4**).

**Chart.4.** Monthly rainfall effects in Karabuk-Safranbolu basin based on Erinç index

MONTHS	Janua ry	Febru ary	Mar ch	Apri l	May	Ju ne	Jul y	Aug ust	Septem ber	Oct ober	Nove mber	Dece mber	Annual Total
Mean Maximum Temperature (°C)	7,5	10,4	14,8	20,3	25,5	29, 0	32, 2	32,4	28,3	21,9	13,4	8,6	20,4
Mean Rainfall (mm)	51,7	34,8	43,8	49,8	56,5	45, 4	26, 4	25,5	29,2	37,3	35,8	52,1	488,3
Aridity Index Value	82,7	40,2	35,5	29,4	26,6	18, 8	9,8	9,4	12,4	20,4	29,8	72,7	23,9
Climate Type	Very Wet	Humi d	Sem i Hu mid	Sem i Hu mid	Sem i Hu mid	Se mi Ari d	Ar id	Arid	Arid	Sem i Arid	Semi Humi d	Very Wet	Semi Humid

**Climate Type of Karabük: Semi Humid**

In Karabük-Safranbolu basin, summer and autumn seasons have characteristics of dry and subarid climate while considering the seasonal drought conditions of the area. of. The climate of the basin remains very humid in winter and subhumid in spring (Chart.5). Imbalances in distribution of precipitation and temperature are observed in Erinç's climograph. Summer drought conditions extends towards Autumn and continue in decreasing fashion.

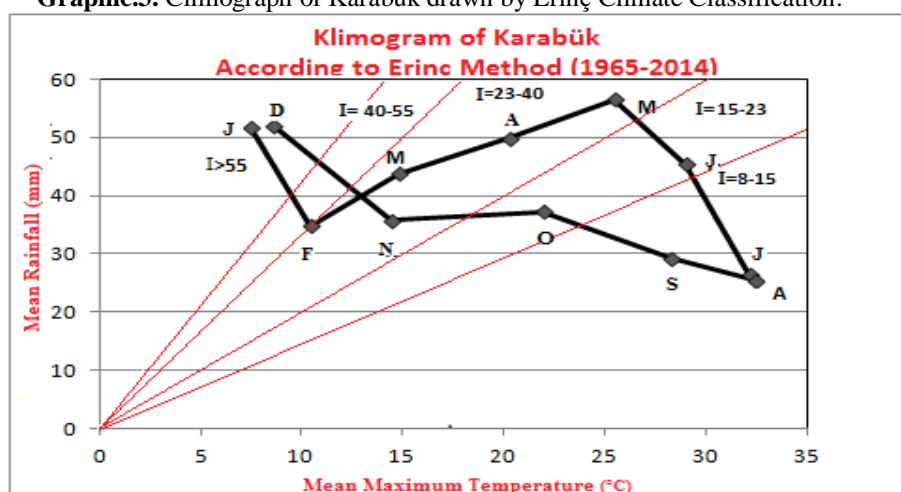
The winter season, in contrast to summer, shows charecteristics of very humid and rainy climate. No

transition climate characteristics are found in the basin, instead, as observed in Emberger classification system, a Mediterranean type of climate with dry and hot summers and rainy cold winters is prevailed in the region. Considering the rainfall distribution, the rainfall pattern is determined as spring-winter-autumn-summer. This condition shows that the type of precipitation pattern of the basin is placed in second type of Eastern Mediterranean pattern. (Graphic.3).

SEASONS	WINTER	SPRING	SUMMER	AUTUMN
Mean Maximum Temperature (°C)	8,8	20,2	31,2	21,5
Mean Rainfall (mm)	554,4	600,4	389,2	409,2
Aridity Index Value	63	29,7	12,5	19
Climate Type	Very Wet	Semi Humid	Arid	Semi Arid

Chart.5. Seasonal rainfall effects in Karabuk-Safranbolu based on Erinç index.

Graphic.3. Climograph of Karabük drawn by Erinç Climate Classification.



#### 4.4. Characteristics of vegetation

The soil, climate and vegetation cover of Karabük-Safranbolu basin have the characteristics of Mediterranean climate. The basin provides a different habitat range for living organisms with its unique environment properties as compared to other areas of Turkey. In context of vegetation geography, it is argued that development of localized climate properties other than Mediterranean climate is evident from variation in plant species of the area. The characteristics of Euro-Siberian phytogeographical region become more dominant in part of the basin close to Black Sea.

It is surprising to observe that in some areas of the basin, plant species associated to Mediterranean, transitional and Black sea climate are found within 2-

3 km stretch.2 The development of vegetation remains limited in central area of the basin because of presence of Karabük and Safranbolu settlements. The areas with more vegetation destruction are also located around these settlements. The natural vegetation cover is more prominent in areas of the basin include highlands and canyons with no human interference and rugged terrain. Most widely spread plant species in the basin include Calabrian Pines (*Pinus brutia*), Terebinth (*Pistacia terebinthus*), Phillyrea (*Phillyrea latifolia*), Prickly juniper (*Juniperus oxycedrus*), Sandalwood tree (*Arbutus andrachne*) and Blackthorn (*Paliurus spina-christi*). Uludağ Fir (*Abies nordmanniana subsp. bornmulleriana*), a plant species from Euro-Siberian phytogeographical region, grown together with local scots pine (*Pinus sylvestris*), forms vegetation

combinations in the area other than the Mediterranean component of vegetation. However, the number of scots pines have decreased and fir have replaced them in combination growth as in some places forests only contain fir trees. In the basin's touchpoints with transitional climate, there could be seen Local natural black pines (*Pinus nigra*) and oaks (*Quercus*) are also found in the basin in the pockets of prevailing transitional climate. Hydrobiome plants are found around stretches of Araç and Soğanlı streams like Salix, Poplar (*Populus nigra*- *Populus alba*) and Sycamore (*Platanus orientalis*).

#### 4.5. Maquis Components

After the analysis of samples taken from six different places during fieldwork, the maquis species are found widespread in the Karabuk-Safranbolu basin despite of the fact that it is located about 110 km from Black Sea coast. It is observed that maquis component is widespread on slopes with southern aspect in terms of species and density, while, on the slopes with northern aspect its occurrence found decreased and replaced by Euro-Siberian phytogeographical type of vegetation. The reason of the maquis growth on slopes with southern aspect is availability of long duration sunlight, as this plant require more sunlight for its growth.

First sampling area was located in northern part of the basin near Mencilis cave. This area is almost 700 m above sea level while bedrock is composed of limestone. The most widespread maquis type in this area is Sage leafed cistus (*Cistus salviifolius*), following are, Daphne leafed cistus (*Cistus laurifolius*), Phillyrea (*Phillyrea latifolia*), Juniperus (*Juniperus oxycedrus*), Sandalwood, Black pine (*Paliurus spina-christi*) and Sumac (*Rhus coriaria*). Presence of densely grown Cistus in down slopes of the area provides evidence for a past forest fire. Phillyrea latifolia and Arbutus andrachne are more common species in the upper side of the area. Sandalwood trees with a height of 5 meter are found more densely grown at elevation of 820 meter are also identified in the area which are extended up to 1200 m., Types of plants are grown along with maquis components in bush form include White flowered hawthorn (*Crataegus monogyna*), Çoruh colutea bush (*Colutea armena*), Yellow flowered cornel wood (*Cornus mas*) and Daphne pontica.

The second sampling area was also located in northern part of the basin near Mencilis cave with southeast aspect. The area lies about 700 m above sea level with upper and lower part consisting of limestone and sandstone respectively. Most widespread kind of maquis in the area is Salvia leafed cistus (*Cistus salviifolius*) following Daphne leafed

cistus (*Cistus laurifolius*), phillyrea (*Phillyrea latifolia*), Juniperus oxycedrus, Sandalwood (*Arbutus andrachne*) and Blackthorn (*Paliurus spina-christi*). Juniperus oxycedrus with 3.5 meter length are also found at 800 meters along with sandal trees extended up to 1000m. Blackthorns (*Pinus nigra*) and Encinas (*Quercus virgiliana*) are also partly spread in the area.

Third sampling site was located in north of the basin with southwest aspect in north of Safranbolu district. The area is located about 800 m above sea level. The maquis is found under the unnatural Blackthorn plant community (*Pinus nigra*) and open areas. Bedrock of the area has limestone property. Pines (*Quercus*) and Hornbeams (*Carpinus betulus*) are found on high slopes. Maquis types in this area include Salvia leafed cistus (*Cistus salviifolius*), Phillyrea (*Phillyrea latifolia*), Sandalwood tree (*Arbutus andrachne*), Sumac (*Rhus coriaria*) and Black pine (*Paliurus spina-christi*). The bush species grown together include Fructus cynosbati (*Rosa canina*), Rubus (*Rubus spp.*), Çoruh colutea bush (*Colutea armena*) and Daphne pontica.

The fourth sampling site is located on upper part of Balıklar Rock. The height of area is 350 m with northeast aspect. Bedrock is formed by mudstone and marl. Species of trees in the area include blackthorns (*Pinus nigra*), oaks (*Quercus*), and calabrian pines which are found at 500 meters leaping forward from southern west slope. The maquis types on the area include terebinth (*Pistacia terebinthus*), sumac (*Rhus coriaria*), blackthorns (*Paliurus spina-christi*) and Juniperus oxycedrus. Maquis components are not widespread in this region. Other bushes grown in the area include fructus cynosbati (*Rosa canina*), rowanberry (*Sorbus*) and hawthorns (*Crataegus monogyna*) with widespread hawthorns. The fifth sampling site is located around the canyon of Tokath. Elevation starts from 500 metres and bedrock is limestone. Maquis types include terebinth (*Pistacia terebinthus*), sumac (*Rhus coriaria*), blackthorn (*Paliurus spina-christi*), sandalwood tree (*Arbutus andrachne*), hackberry (*Celtis australis* L.) and Phillyrea latifolia. Terebinths are widespread and with large trunks. Most wide spread component of maquis is terebinth in this field. Maquis components is more diverse and dense because of variations in natural environment in and around the canyon. Bushes include fructus cynosbati (*Rosa canina*), rubus *Rubus spp.*), Çoruh colutea bush (*Colutea armena*), scarlet firethorn (*Pyracantha coccinea*), sorb (*Sorbus*) and hawthorn (*Crataegus monogyna*). Additionally, some fruit types are also existing including wild pear, walnut and almond. Acer

campestre (*Ulmus campestris*) is generally seen as small tree form.

The sixth sampling site is located in the village of Sırçalı and around the canyon of Sırçalı. The elevation of the area is about 650 meters with bedrock type of limestone. Trees are not grown densely because of unimproved soil profile. The tree forms include swamp oaks (*Quercus pubescens*) and encina (*Quercus virgiliana*), Calabrian pines (*Pinus brutia*), black pine (*Pinus nigra*), Greek juniper (*Juniperus excelsa*) and fragrant juniper (*Juniperus foetidissima*). This pattern has shown that trees have not developed communities, but spreading sparsely on places where bedrock allows. The height of pine is not more than 3 meters, therefore maquis components dominate vegetation cover in the area. Types of maquis include terebinth (*Pistacia terebinthus*), sumac (*Rhus coriaria*), blackthorn (*Paliurus spina-christi*), Juniperus oxycedrus, salvia leafed cistus (*Cistus salviifolius*), woolly cistus (*Cistus creticus* L.) and Phillyrea (*Phillyrea latifolia*).

## 5. Results

Samples from six different places were taken and evaluated during the field survey in Karabük-Safranbolu basin about maquis vegetation. It has been found that 10 different maquis components are widely spread in the area in spite of its distance from coast about 110 km. These types of maquis include terebinth (*Pistacia terebinthus*), sumac (*Rhus coriaria*), salvia leafed cistus (*Cistus salviifolius*), daphne leafed cistus (*Cistus laurifolius*), woolly cistus (*Cistus creticus* L.), Phillyrea (*Phillyrea latifolia*), sandalwood tree (*Arbutus andrachne*) and hackberry (*Celtis australis* L.).

Sandalwood and Phillyrea are mostly widespread in the areas with low elevation and more humidity. Juniperus oxycedrus grows taller more than 2 metres in open areas but becomes shorter in the places dominated by pines and reduced sunlight duration. Blackthorn is also a widespread maquis component. It is propounded that Karabük settlement has received its name from this plant. The word Karabük is made up of Kara (Black) and Buk (Bush). Terebinth is a widespread maquis component in the area. Natural terebinths found in Safranbolu cemetery are never destructed and are grafted to turn them into pistachio garden nowadays. Safranbolu municipality provides bids every year to collect these nuts. However, there is a need to replace old pistachio plants with new ones. Besides many regrown terebinth plants also awaiting grafting. It is determined that cistus can

spread fast on destructed or burned forest places but on other areas it accompanies with maquis.

It is observed during the field work that maquis are being replaced by black pine in the areas where the trees are unable to sustain lithology. Therefore, it is suggested that it is better to preserve such area naturally instead of interfering in. Moreover, it is also suggested to educate the local people about grafting and promote the pistachio agriculture, thus contributing to local economy.

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