The ecosystems of north - eastern Anatolia

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1. INTRODUCTION

The study area which is named north-eastern Anatolian region is bounded by the Black Sea on the north, the Rize-Erzurum line on the west, the southern section of the Aras river watershed basin on the south, and by the USSR border with Turkey on the east. In other

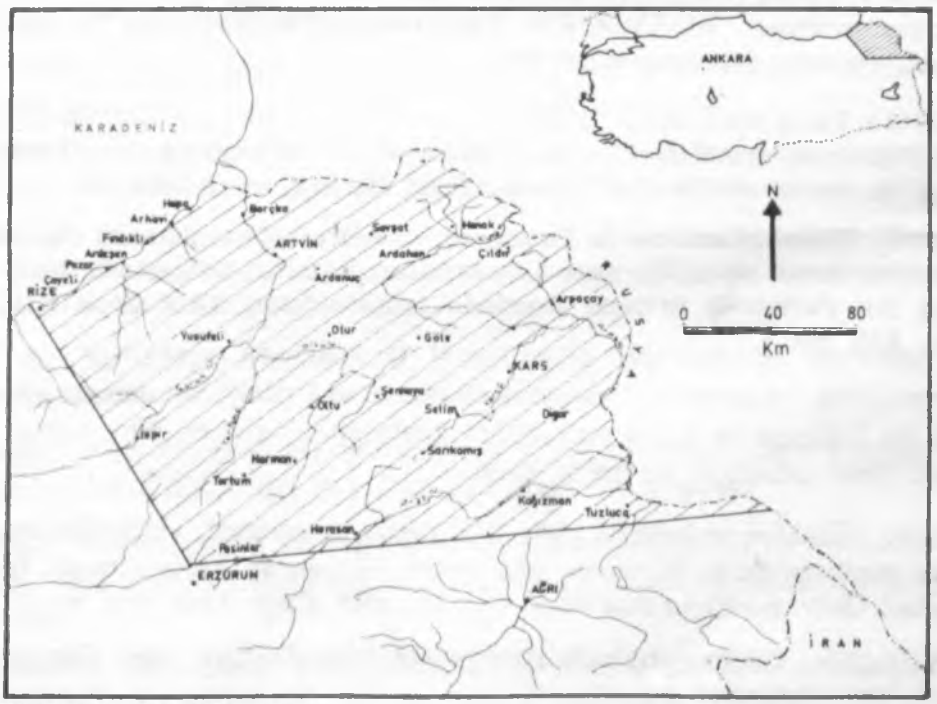

Figure 1 : Location map.

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words, the study area covers the north-eastern region of Turkey. The region also covers both the subregion of the Eastern Black Sea of Black Sea Region and the subregion of Erzurum Kars of the Eastern Anatolia Region (Figure 1).

The given area, generally, has very rugged topography and great changes in altitude within short distance.

The orogenic mountain ranges which are cut as deep as 500-1500 m by the rivers and their main tributaries, extend in a NE-SW direction. In the south and the southeastern part of the region volcanic plateaus and mountains, tectonic corridors and/or basins are located among the orogenic belts, and there are also volcanic rigid masses. Elevation differences between the mountains and river valleys and tectonic basins are great.

The climatic conditions of the study area vary greatly from the north to the south and the southearstern sections of the area. Namely, humid- perhumid climatic conditions prevail in the Eastern Black Sea subregion, whereas continental cold and semiarid-subhumid climates dominate in the south and southeastern part of the region.

Acide brown forest soils and reddish-yellowish podzolic soils are common in the northern section, while brown forest soils which one of the major soils occur especially in the scotch pine forests found between 1400-2500 m. High mountain and grassland soils are widespread above the natural timberline. Chernozem soils are found in the Erzurum-Kars plateau at altitudes between 1800-2200 m. Brown and chestnut soils occur within the Erzurum-Aras tectonic depression and the southern section of the Narman Basin.

The flora of the northern section of the study area belongs to Colchic floristic subregion of the Euro-Siberian region. The flora of the highland and mountains containing herb vegetation, include the elements of Euro-Siberian region, whereas the most of the herb species of the Erzurum-Kars tectonic basin within the Irano-Turanian flora region. Remaining flora which are found some localities especially in the lower section of Çoruh River basin and in the NE part of the area belong to Mediterranean, Hyrcano and Caucasica.

The economic activities of the inhabitats include cattle-breeding, agriculture and forestry. These economic activities based on natural potential of the area have caused the deterioration of the natural balance. Namely, forested lands have been converted into agricultural land in order to obtain cereals and/or grains; natural grass-

land and potential forested areas have been completely destroyed due to heavy grazing and excessive cutting. Natural plant species and communities have been lagely degenerated and replaced by species of spiny and poisonous plants. The natural potentials of the region reduced due to incorrect land-use, heavy grazing and destruction of natural vegetation.

The aims of the study is to classify and to evaluate the ecosystems and/or habitats, and is to recognize the afforestation and reforestation activities, and to realize the optimum growing habitats for trees and some shrubs.

Two important issues from the standpoint of forestry are: 1- to establish afforestation areas and to reveal the ecological conditions of these areas, and to choose and/or select the plant species that should be planted according to ecological condition, 2- to examine the evolution of the vegetation cover and to establish whether the present plant communities are suitable or unsuitable to the habitats The aim of the study related to forestry activities was classified according to the ecological and vegetation formations.

2. MATERIAL and METHOD

2.1. MATERIAL

In order to determine the ecosystems the fallowing data were collected and maps were prepared :

— a geological and litological map at the scale of 1/ 500 000,

— a geomorphological map at the scale of 1/ 500 000,

— a soil map at the scale of 1/ 500 000 based on the collection of more than 100 soil profiles,

— a vegetation map at the scale of 1/500 000 according to the scale of 1/25 000 forest management maps and field observetion and collected plant samples,

— a distribution of mean annual temperatures map, a distribution of July and january temperatures map and a distribution of mean annual precipitation maps at scale of 1/ 2 500 000.

In addition climatic conditions of the region were evaluated based on the data at the meteorological station in the area.

Meanwhile in order to clearly show the distribution and dividing of the ecosystems the topographic profil series, geologic cross-section

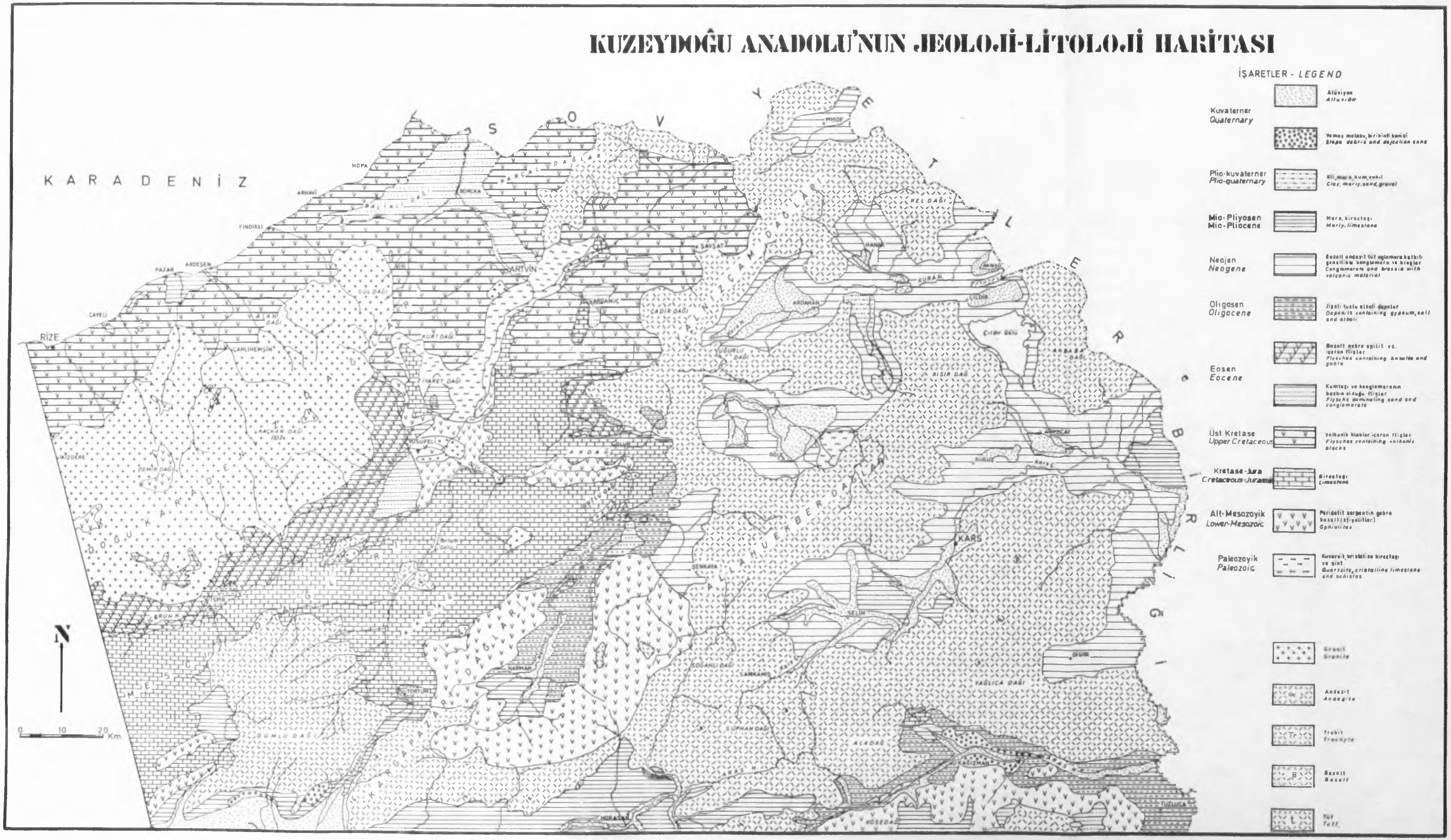

Figure 2 : Geological - lithological map of NE Anatolia.

in direction of E-W and NE-SE are drew. In these profiles, the parent materials, and vegetation cover are shown on the topographic profiles; and addition to this the sunny days, cloudly days, and overcast / closed days during the growing or vegetation period representig from April to Nowember are presented above the topographic profiles; and then the total precipitation and mean temperature and relative humidity of the growing season are taken into consideration and these figures are put on the profiles. So, in term of these profiles, it is possible to show and to examine relationships between the geomorphic, plant cover and climatic conditions in the determining of the ecosystems and/or habitats (Figure 4, 5, 6 and 7).

2.2. METHOD

Field work was carried out between 1976 and 1983. During the period, parent material and general geologic structure were examined, the soil profile horizons were opened especially on the different parent materials, altitude, exposition and vegetation cover. Soil profile observations were done in the field and soil samples were taken in order to determine the physical and chemical properties. Plant samples that were unknown in the field were collected and their floristic determinations were made. Also, geomorphological observations were done.

Relationships between the biotic or alive factors such as soil, vegetation and human activities and abiotic compenents such as topography, parent material and climate were examined in order to classify the ecosystems.

3. DATA: THE FACTORS DETERMINING ECOSYSTEMS

In order to evaluate the ecological conditions of NE Anatolia the ecological factors such as geomorphology (or topography), parent material, soil, vegetation, and biotic factors affecting the habitat, will be viewed in the following sections.

3.1. GEOMORPHOLOGIC FACTORS

The study area can be divided into two units in the geologic and geomorphologic sense. 1- The norther Anatolia orogeniç belts which consitute Alpine orogenic ranges, extend in direction of NE-SW in the norhern section of the area, 2- the volcanic mountains, basaltic plateaus, and the tectonic depressions or basins occur in the S and SE part of the area. The northern Anatolia orogenic belts which are composed of ultrabasic rocks, limestone, flysches and volcano-sedi-

mentary strata constitutes the highest mountain ranges which rise as high as 3900 m and form the most striking barrier between the Black Sea and the inner section (Figure 2 and 3).

The tectonic depressions or basins extending especially on the S and SE part of the region were formed due to vertical tectonic movement which occured in the early Miocene and Pliocene era. These depressions bounded by fault scarps were occupied lake and shallow sea and in these basins coarse detritic material and dissolved material were accumulated. After the lakes had regressed and captured by the rivers, the depression areas became terrestial areas.
The mountains running in an E-W direction and NE-SW and a deep valley cutting the high mountain ranges extending in direction of N-S and E-W and the tectonic depressions extending roughly parallel in direction to the mountains, and isolated volcanic mountains rising on the high plateaus are most important topographic features. The main geomorphological units from the north to the south are as fallows:

— Doğu Karadeniz (Eastern Black Sea), Mescit-Yalnızçam, Kargapazarı-Allahüekber, Süphan-Alaca, Yağlıca and Karasu-Aras mountains.

— Oltu-Narman, Göle, Ardahan, Çıldır lake, Sarıkamış, Arpaçay, Erzurum and Igdır-Kağızman basins,

-- The volcanic plateaus on the Yalnızçam-Mescit, Kargapazarı-Allahuekber mountains located between the Sarıkamış and Kars provinces.

The effects of topographic factors such as height, exposition, orographic ranges and continentality play the most important role in the classification of the habitat and ecosystems. For example, local climatic changes and the distribution of the vegetation both in vertical and in horizontal distance, are lagely controlled by topographic factors. The mild and per-humid climatic condition prevails on the lowland part of the Black Sea, because air masses are often protected by Doğu Karadeniz Mountains. On the otther hand, air masses and fronts are mostly stopped by the outer slopes of Eastern Black Sea Mountains which often leads to orographically caused occlusions, while deeply cut Çoruh Valley area which is located on the inner section of the mountains is hot and dry due to a rain-shadow effect. Meanwhile, dry and hot air masses (continental tropical) coming from the sauthern sector are obstacled by the mountain ranges which extend in the northern section of the Aras watershed ba-

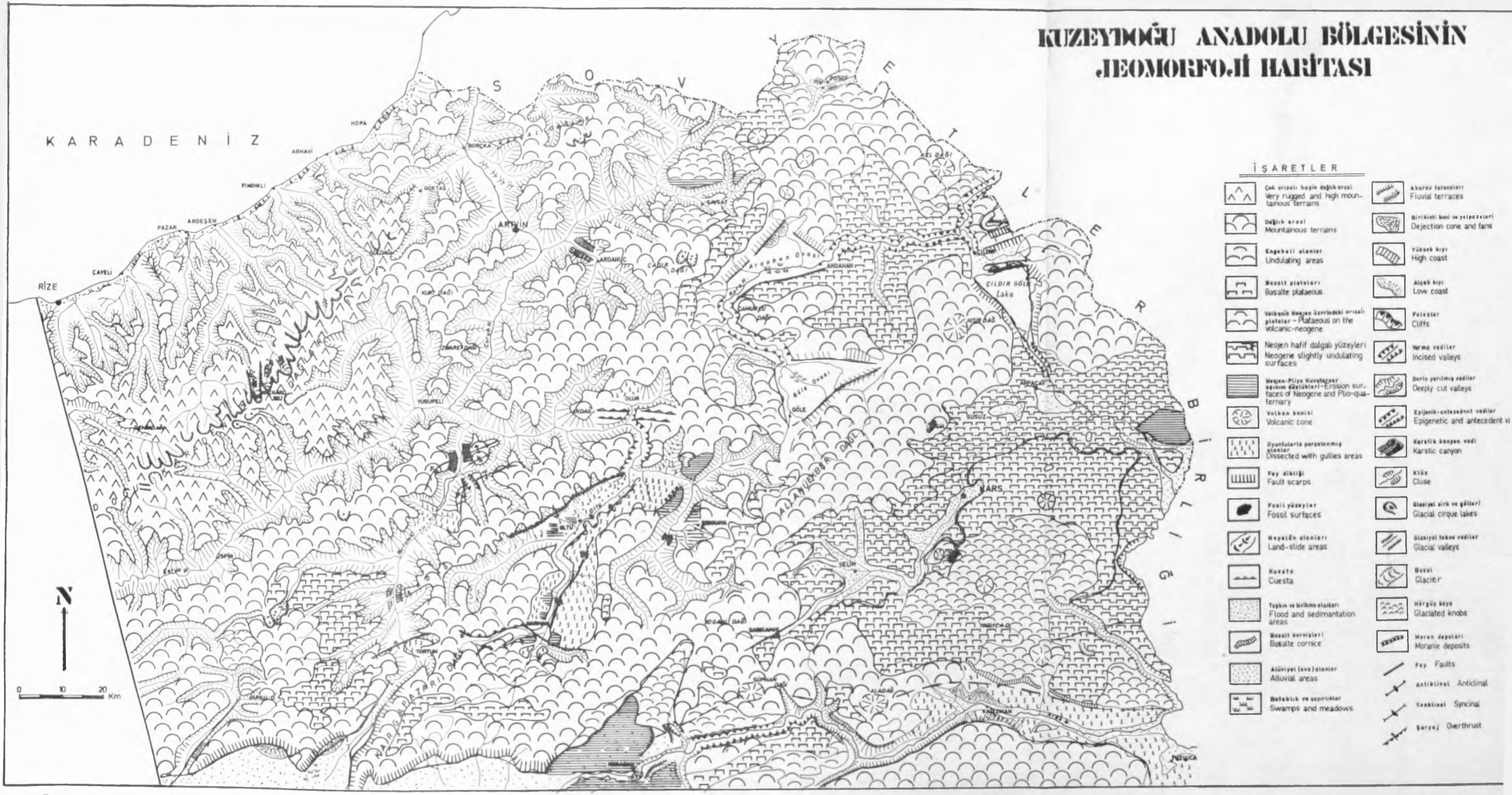

Figure 3 : Geomorphological map of NE Anatolia.

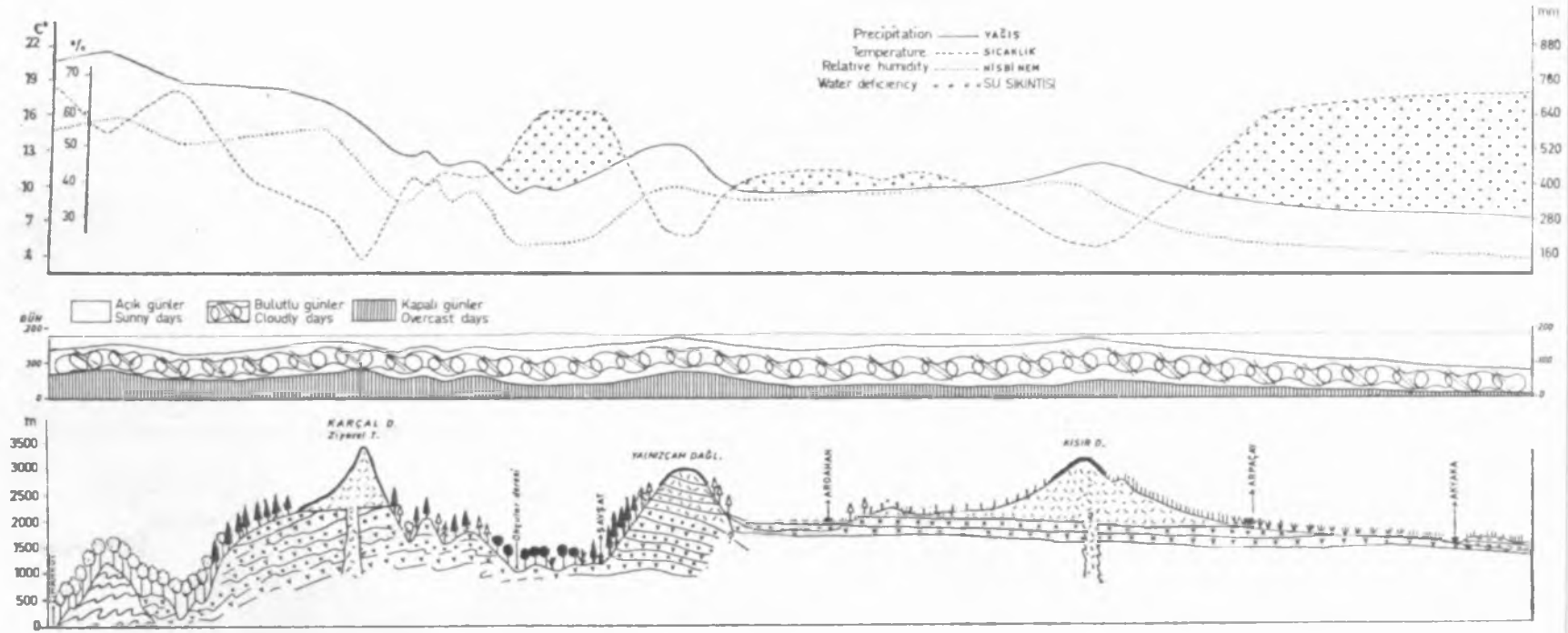

Figure 4: Profile showing topography, vegetation distribution, geologic cross-section and climatic data between Limanköy and Akyaka in direction of W-E (Conventional signs as in fig. 7).

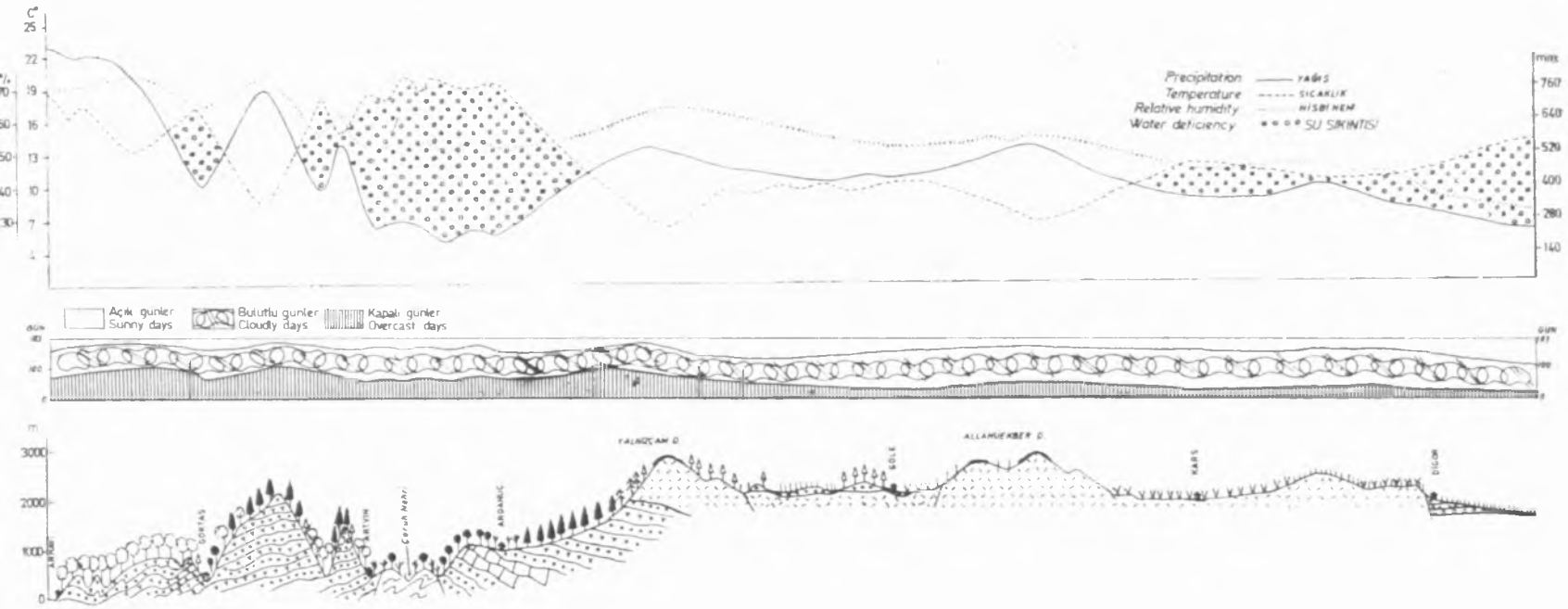

Figure 5: Profile showing topography, vegetation distribution, geologic cross-section and climatic data between Arhavi and Digor in direction of NW-SE (Conventional signs as in fig. 7).

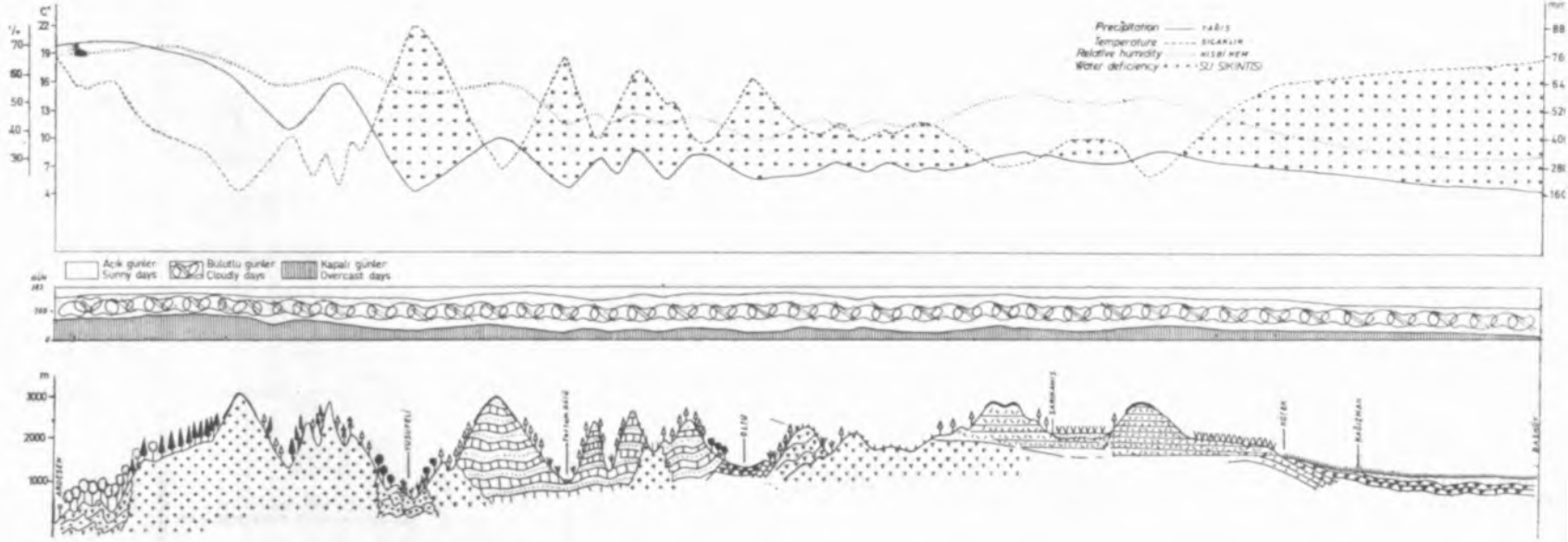

Figure 6: Profiles describing topography, vegetation distribution, geologic cross-section and climatic data between Ardeşen and Başköy in direction of NW-SE (Conventional signs as in Fig. 7).

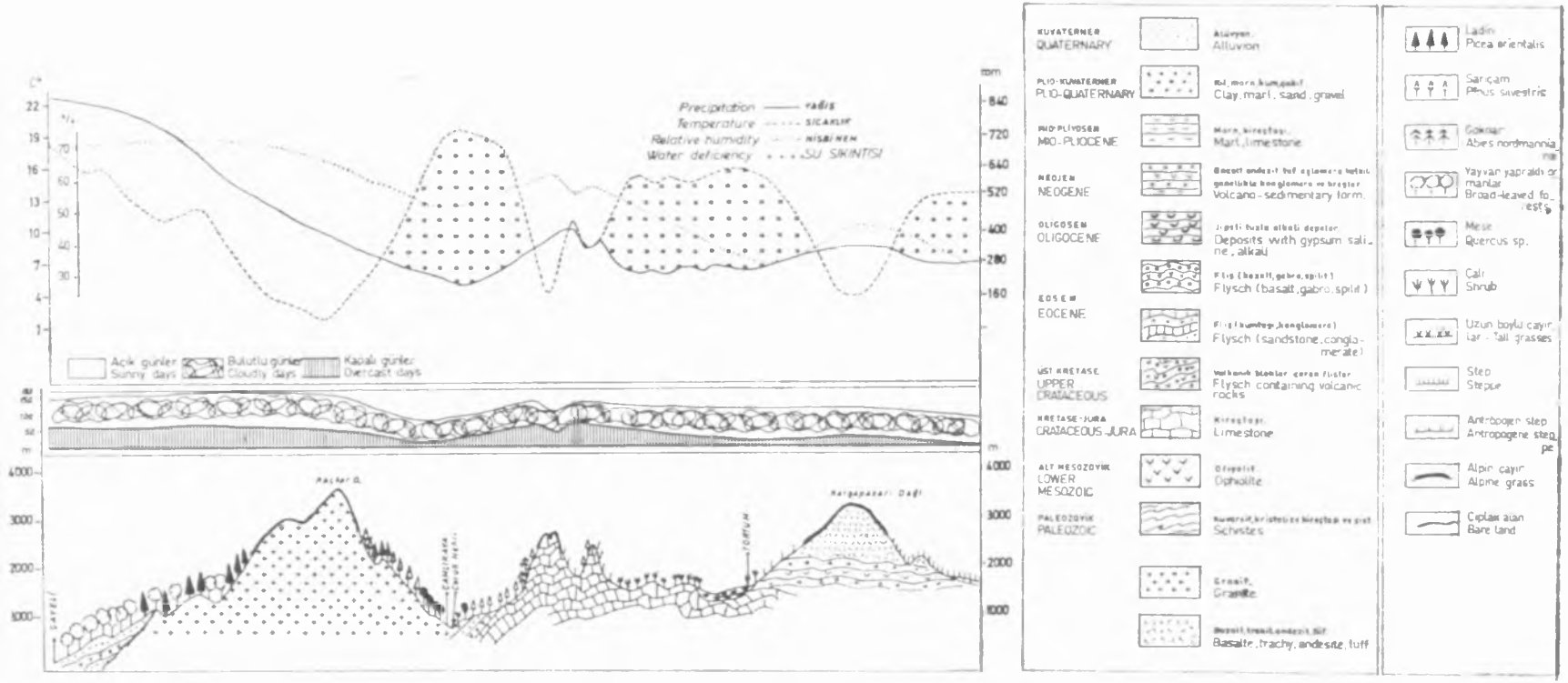

Figure 7: Profile explaining topography. vegetation distribution, geolcgic cross-section and climatic data between Çayeli and Kargapazarı dağı in direction of NW-SE

sin. For this reason the arid-semiarid climate prevails in the southern and the southeastern sector of the area whereas the humid-per humid condition dominates in the northern part of the area.

In the distribution of plant species and communuties in the vertical and lateral direction is generally controlled by topographic factors, (Figure 4, 5, 6 and 7). For example, hygrophyll and hygrophilous plant communities are found on the northern slopes of the Eastern Black Sea Mountains, while on the slopes facing south and within the deeply cut Çoruh Valley xerophytes and dry forest and shrubs are widespread. Although the upper limit of the timberline is about 2000 m in the Eastern Black Sea region, it is abcut 2700 m in the southern sectors due to continentality. The upper limits of agricultural activities change from 2000 m in the southern sector to 1000 m in the Black Sea region also due to continentality influences.

3 2. CLIMATIC FACTORS

From the macro-climatic point of view, the study area is situated in a zone of transistion between the source regions of different air masses. In other words, the study area is under different airmasse influences. In the winter period, especially inner sections of the area are generally occupied by polar air, whereas in the summer continental tropical air mass settle in the southern section of the region. But the general air circulation and weather types are greatly changed by the physical geographical factors. Long and severe cold conditions prevail during the winter period in the highlands and depressions of Eastern Anatolia when because inner sections of the area are occupied by polar air, but cool and rainy conditions generally prevail on the coastal section of the Black Sea because the coastal lowlands are often protected by the Doğu Karadeniz Mountains from cold air invasion. On the other hand, snowfall occurs when frontal activites begin in Eastern Anatolia. Foehn events occur in the cold season from November till April due to topographic conditions Cold polar air masses covering the Doğu Karadeniz Mountains flow either towards the Black Sea coast or the Çoruh River Valley. During the Foehn, the temperature of the Black Sea coastal areas and even the Çoruh River Valley increases considerably as a result of adiabatic processes. For this reason, mild climatic conditions prevail in the winter period.

During the summer period the S and SE parts of the area are largely occupied by continental tropical air coming from the southern sector. In this season the Black Sea is under high air pressure while

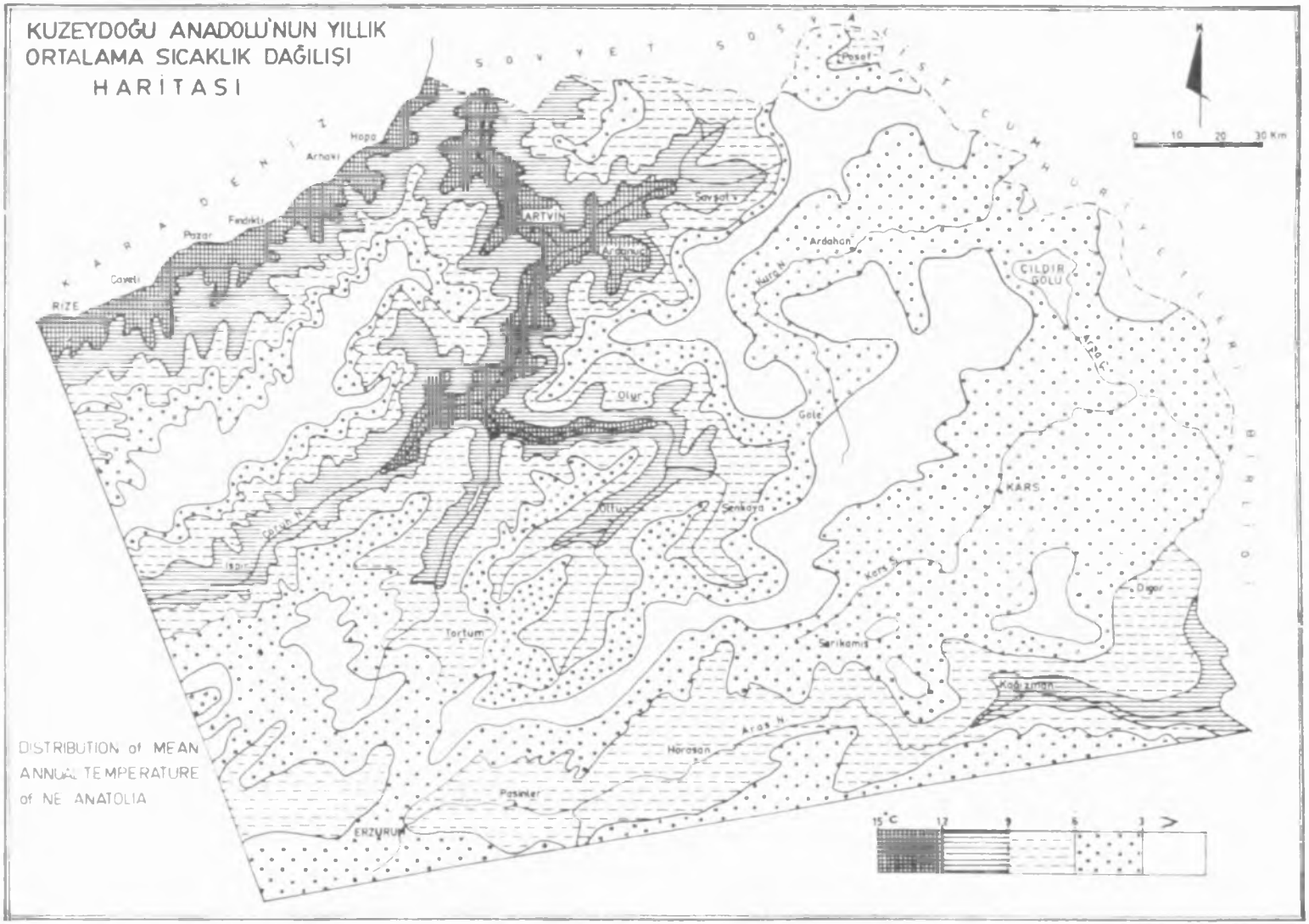

Figure 8: Distribution of mean annual temperature of NE Anatolia region.

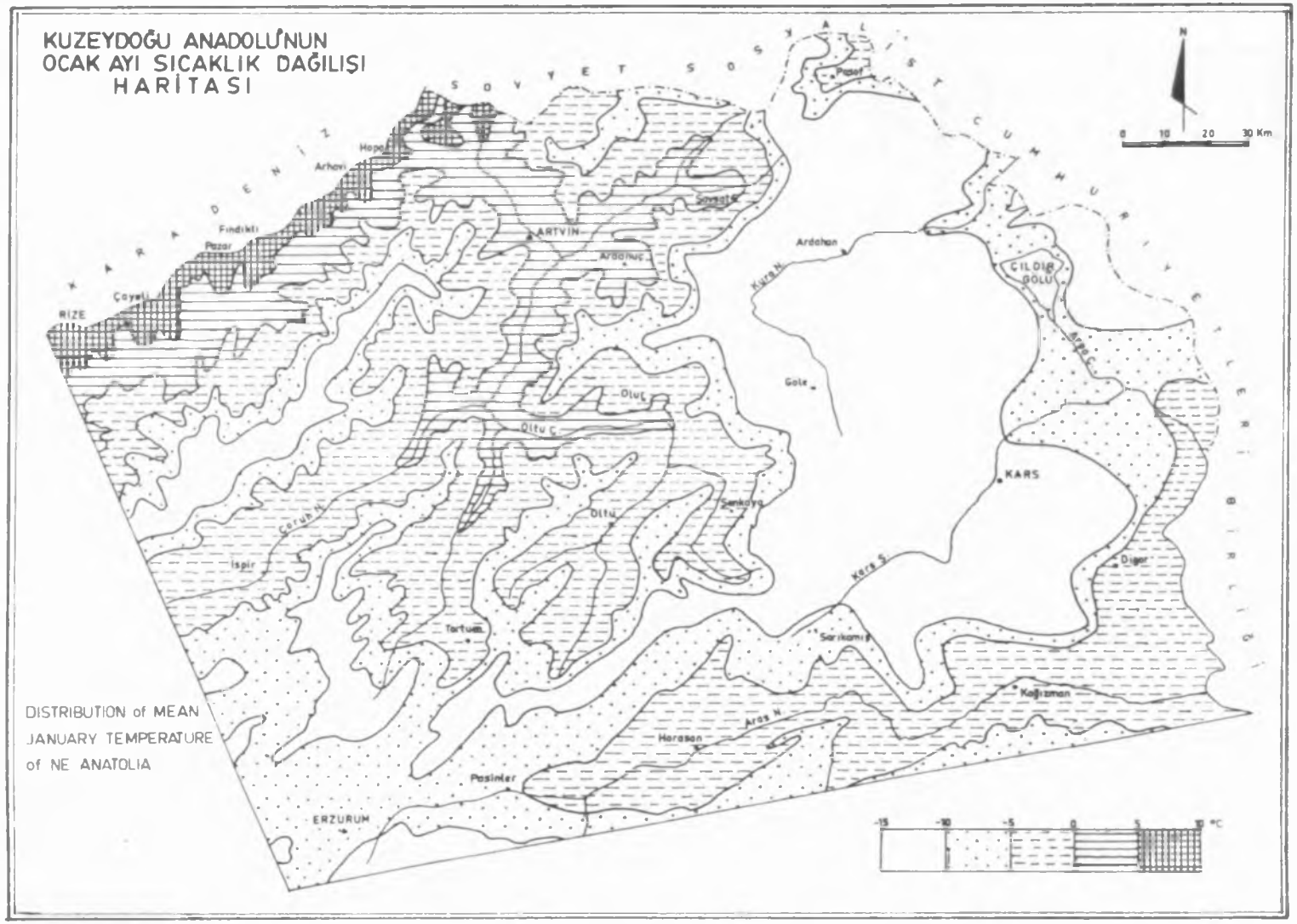

Figure 9: Distribution of mean January temperature of NE Anatolia region

the inner section of Eastern Anatolia is subject to low air pressure due to thermal conditions, For this reason, the dominant wind direction is from the north to the south. The air mass, the moisture content of which is increased by the evaporation from the Black Sea, is forced to climb the high Eastern Black Sea Mountains especially where the mountains are exposed to the west and northwest. The upslope movement of relatively moist air mass causes the fogs that cover the northern slope and the considerable amount of summer rainfall. The plateau areas of East Antatolia receive summer convectional rainfall due to daily thermal conditions.

As to the thermal conditions, mean annual temperatures range between 14 and O°C. Maximum values are observed both on the East Black Sea coastal section and in the vicinity of Yusufeli in the Çoruh River Valley. The second hottest areas are the upper Black Sea region and the lower section of the main Çoruh Valley and its main tributaries. (Artvin 12°C, Ardanuç 13°C, Şavşat 10.2°C, Oltu 9.5 °C, Tortum 8.3°C). The coldest areas both of the study area and of Turkey are the high plateaus extending between Sarıkamış-Kars-Ardahan, There mean annual temperature varies between 3- 6°C. At the highest part of the Eastern Black Sea Mountains the temperature decreases to as low as O°C (Figure 8).

In January, temperatures vary between 6 and —10°C. The most striking characteristic of winter is the sharp contrast between the coastal lowlands of the Black Sea region and the inner section of East Anatolia where the largest negative anomalies and lowest temperatures occur (Figure 9).

As to the July temperatures, in the warm season generally thermal differences decrease. The warmest part is in the vicinity of Yusufeli and Ardanuç and in the SE part of the area. Here mean July temperature is over 20°C (Figure 10).

Mean annual precipitation exceeds 2000 mm in the Eastern Blacksea coastal belt, whereas it is below 300 mm in the Tuzluca basin and in the Çoruh River Valley extending from Artvin towards Lake Tortum and the vicinity of Yusufeli. (Figure 11). The plateaus receive considerable rainfall, There mean annual precitipation varies between 400-600 mm. On the other hand horizontal distribution of annual precipitation varies largely because of the effects of the extremely diverse relief features.

As to the seasonal distribution of precipitation, there are great differences in the seasonal distribution. In the study area two rather

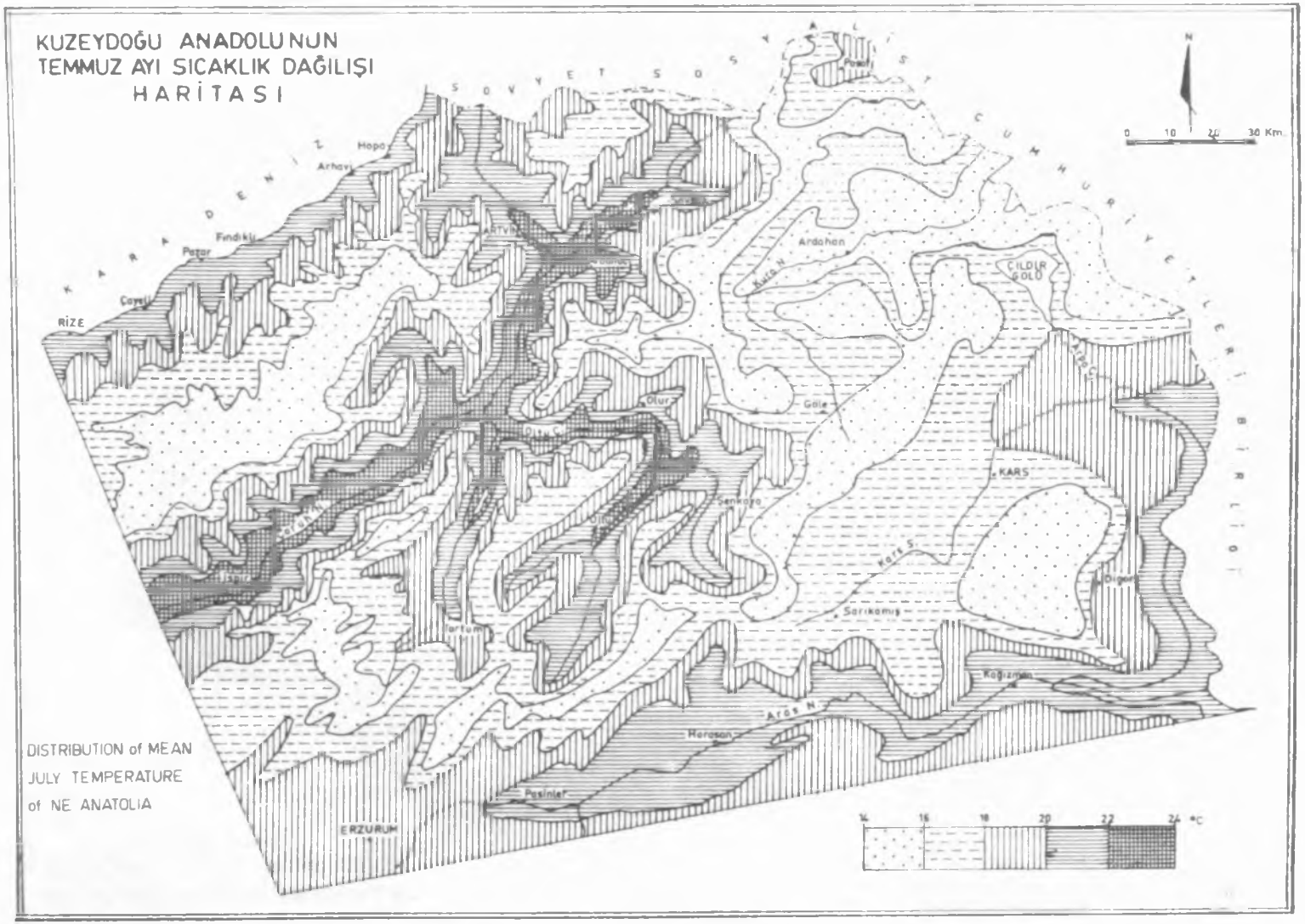

Figure 10: Distribution of mean July temperature of NE Anatolia.

Figure 11: Distribution of mean annual precipitation of NE Anatolia

different in the seasonal distiribution. In the study area two rather established:

1— the Black Sea type or cceanic type: having a high amount of rainfall, sufficent precipitation at all seasons. with the maximum occuring in autumn and the minumum in spring.

2— the continental type: having maximum rainfall in the first month in summer or late spring with winter being the driest season.

3— The Çoruh valley sub-type: having Maximum rainfall in spring and early summer and minumum in fall and in winter.

A few regional and local climatic types can be seen by taking into consideration of precipitation, cloudiness, relative humidity and temperature:

1— a very humid cool climate between o- 1000 m on the northern slope of Black Sea Mountains and lower watershed area of Çoruh.

2— a Humid and perhumid cold climate on the high part of the Eastern Black Sea Mountain and the high parts of the Çoruh River vatcrshed.

3— a humid subhumid cold climate on the high plateaus of NE Anatolia between 1800-2500 m.

4— a sub humid continental climate on the Erzurum plain, the western section of the Aras basin, and on the southern part of the Çoruh basin at altitutes of 1500-2000 m.

5— a semiarid- mild climate in the vicinity of Artvin and Yusufeli at altitudes of 400-1000 m.

6— a cold, snowy continental climate in places between 2000-4000 m on the Eastern Black Sea Mauntain and in places higher than 2500 m in the inner section of the mountains.

7— a semiarid-cold continental climate on the lower section of the Aras River basin and on the SE part of the area.

The distribution of vegetation, tree species and communities, agricultural systems and soil forming are largely determined by the prevailing climatic conditions in the study area. Namely, broad-leaved mild forests are stabilized in the perhumid-humid climate of the Eastern Black Sea Region, and the lower watershed area of the Çoruh River. Oriental spruce (**Picea orientalis L.**) forests are growing in the foggy and/or cloudy environments of the north-facing slopes

of the mountains. Pure scotch pine (**Pinus silvestris L.**) forests are widespread on the high plateau of NE Anatolia where sunny days are dominant in the vegetation period. In the sunny and semiarid locations of the Çoruh River Valley xerophyte shrubs and dry forests are dominant. Irano-Turanian steppic plants, especially herb species, are widespread on the depression areas located in the S and SE part of the study area having a continental semiarid cold climate. Also, climatic conditions are largely determine the dividing up of the ecosystems. (Figure 3, 4, 5, 6, 7, 8, 9, 10 and 11).

3.3. SOIL and PARENT MATERIAL

In the region ithere are zonal, azonal and intrazonal soils as defined by the U.S. soil classification system, in 1949. The zonal soils occur under dense vegetation cover located in the Eastern Black Sea Region, and beneath the slight undulating areas having good drainage found at the bottom of the tertonic depression and the plateaus of Eastern Anatolia. Brown forest soils and reddish-yellowish soils showing acide reaction are widespread in the broadleaved deciduous forests and conifer and mixed forests. Limely brown forest soil, brown steppe soil and chestnut, colored soils are common on the plain and undulating areas of the tectonic basins and their immediate surrounddinges (Figure 12).

Azonal soils containing alluvial, lithosol, regosol and colluvial soil are common on the floodplain and flood areas and on the old and new dejection fans and cones on the plain of Horasan, Hasankale and Erzurum. Regosols are formed on the volcanic tuffs and sands in the vicinity of the town of Sarıkamış, Lithosols or skeleton soils are common on the steep slopes where vegetation cover is partly and completely destroyed.

Intrazonal soils cover most of the region. As is known soils reflect the physical and chemical properties of the parent material.

The climatic soils of the semiarid areas which have rugged terrains have been eroding due to the destruction of the natural vegetation. So, the parent material exposed and outcropped due to severe erosion. In these areas the growing of the plant growth has been greatly affected by the parent material because the natural equilibrium has been greatly disturbed.

The saline and alkaline soils occur on Oligocene evaporitic deposits. Sandy and coarse textured soils are common on the flysches and on the Neogene sedimentary strata containing conglomerate, and

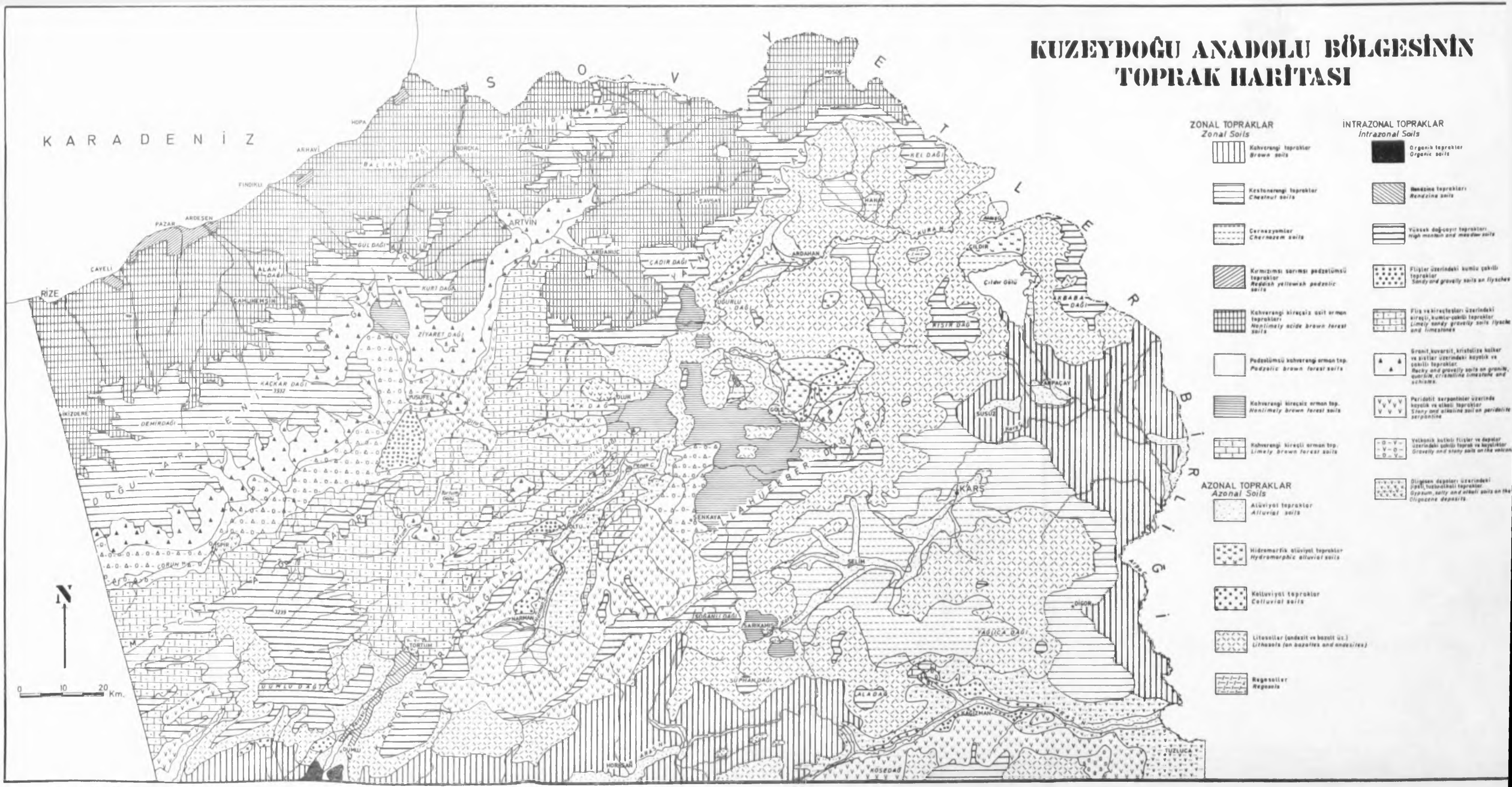

Figure 12 : Soil map of NE Anatolia.

sandstone. Strong alkalen soils are also found on the weathered ophiolite complex containing ferro-magnesium silicate.

In the research area the depth of the solum, soil reaction and the horizon of lime ($CaCO_3$) accumulation supports the dividing of the ecosystems and/or habitats where the normal soil profile has been developed.

3. 4. VEGETATION FACTORS

The distribution and formation of vegetation communities and forest undergrowth reveals clearly both climatic conditions especially where meteorological station do not, and habitat types. In other words some plant communities and forest vegetation are indicators of the climatic character (Figure 13).

Broad leaved decidouos forests associated with **Alnus barbata, A. glutinosa, Fagus orientalis, Tilia rubra, Castanea sativa, Ulmus montana, U. glabra, Acer platanoides, A. cappadocicum, A. campestre** etc. are most common on the northern section of the Black Sea region and on the lower watershed of the Çoruh River between 0-1000 m. Both the northern slopes of Black Sea Mountains and the Yalnızçam-Mescit Mountains which are located in inner section of the Black Sea region in places extending (800) 1000-2000 (2400) m are mostly covered by conifer forests containing pure oriental spruce **(Picea orientalis L.)**, Scotch pine **(Pinus silvestris L.)** and oriental fir **(Abies nordmanniana)**. The shrub layer of the forests contain **Rhododendron ponticum, Rh. luteum, Rh. caucasica,** and **Rh. smirnovii,** In the lower section there is **Buxus sempervirens** and in the upper level **Rosa montana, Ribes bebersteini, Sorbus torminalis, S. aucuparia** etc.

Dry forests which are composed of **Quercus iberica, Q. dschorochensis, Juniperus excelsa, J. oxycedrus, J. foetidissima,** and xerophyte shrubs containing **Rhamnus pallasii, Paliurus spina-christi,** and **J. oxycedrus** are found along the Çoruh River Valley between İspir, Artvin,, Lake Tortum, and the Oltu district.

Pure scotch pine **(Pinus silvestris)** forests are widespread on the plateau surfaces where the vegetation is sunny and subhumid-humid At the same time these forests are rich in undergrowth flora.

The bottom section of the depression in the southern section of the study area is largely covered by steppe herb species belonging to the Euro-Siberian flora region. Mountain steppe vegetation is wide-

spread on the slope of the mountains that surround the depression in the south. Tall grasses similar to prarie vegetation are found between the steppe and scotch pine forests in the eastern part of the study area.

Above the natural timberline alpine and sub-alpine meadows and/or grasses belonging to the Euro-Siberian floristic region are common.

Antropogene steppes and bare lands are seen where natural vegetations have been severely destroyed.

3.5. BIOTIC FACTORS

The population of the region is about 1,700,000 according to the 1980 census. 70 percent of the population live in rural areas and the remaining 30 percent in the cities and provinces. Major cities have developed along the Black Sea coast, on the edge of the plains or depressions and near the main river or streams.

As to the settlement of the rural areas, scattered rural settlements containing a few house groups or one home are common in the Black Sea region whereas villages have developed on the edge of the mountains, along the valley, and on the plain surfaces of the whole of the inner section. In the inner section the upper limit of settlements rise as high as 2400-2450 m due to continentality.

The main livelihood of the rural population is dependent on agricultural activities and cattle-breeding. In the inner sections, agricultural lands are devoted to the production of cereals. Especially the semi-arid steppe areas are suitable for wheat farming, but in the mountainous lands agricultural activities, carried out to obtain food are generally done on unsuitable lands where land capability classification is V., VI. and VII. In these areas forested lands have been converted into agricultural lands. And cattle-breeding activities have been carried out in forest lands and meadows. At the same time, in these areas over grazing systems are dominant.

Due to over grazing and incorrect land-use, the natural vegetation of the mountainous areas has been greatly destroyed and degenerated. Destroyed lands are generally occupied by herb species named antropogene steppes where semiarid-subhumid climatic condition prevails. Meanwhile, in the Black Sea region, forest lands between 0-1000 m are mostly converted into agricultural lands in order to grow tea, hazelnuts, and maize. Since forest destruction leads to

the changing of the vegetation composition in the Eastern region a destroyed area of beech forest was lagely occupied by alder (**Alnus barbata**) in short time.

In the same way, completely destroyed oriental spruce (**Picea orientalis**) areas have been occupied by **Rhododendron** species.

Further the oriental spruce forests of the Artvin-Şavşat and Posof regions are suffering due to insect and mushroms. For example, in 1974 20 000 hectares of oriental sprucewere mostly destroyed by the insect **Dentroctonus micans** Kug.

The most important effects of the destruction of natural plant cover are seen on the evaporitic sediments which contain salt, potasium, gypsum, carbonate. After the natural vegetation has been destroyed in various ways, the soil cover is eroded especially on the steep slopes, and the parent material is exposed. In the Oltu basin, the northern section of the Narman basin and the eastern part of the Aras basin were classified as a geosystem due to the fact that parent material is dominant factor in these habitats.

4. ECOSYSTEMS

In the previous section the general ecological conditions of the region have been explained briefly. In this section, the divinding of the ecosystems will be examined. Based on the ecological conditions, the study area was divided into three main ecosystems (Figure 14).

4.1.FOREST ECOSYSTEMS

A forest ecosystem cover most parts of the Black Sea region at heights between 0-2000 m and covers the high part of the eastern mountains and plateau at heights between 1200-1300 and 2500-2600 m. The tree species, of these forests are different from one another. For this reason, the forests were classified into forest habitat types. (Figure 13, 4, 5, 6 and 7).

4.1.1. ECOSYSTEM OF THE PERHUMID-HUMID BROAD LEAVED DECIDUOUS FOREST

This forest ecosystem is found on the coastal belt of the Black Sea in places rising up to 1000-1100 m and on the lower watershed basin of the Çorun River.

Geomorphology : From the standpoint of geomorphology the

topograhy of the ecosystem encompasses the northern Anatolia orogenic belt which is composed mostly of Mesozoic volcano-sedimentary complex containing gabro, basalt, spilit, granite and other ophiolitic rocks. In addition flysches have been cut by the streams flowing into the Black Sea. The slopes of the mountains are very step due to positive epirogenic movement which occured during Tertiary and early Quaternary time. The mean slope inclination of the mountainous areas is more than 20 %. The slope degree and exposition varies frequently in shortt distances (Figure 2, 3, 4, 6 and 7).

Climate : The Mean annual temperature ranges between 8-14°C. January temperature is about 7°C, the lowest temperature recorded was - 7°C. July temperatures vary between 18-22°C The highest temperature recorded was 42.2°C. During the foehn days in winter the mean daily temperature increases to as high as 25°C on the Black Sea coast.

Mean annual precipitation varies between 1500-2300 mm. The amount of mean annual precipitation decreases from the coastal belts to the higlands or mountains, The maximum occurs in autumn, the minumum in spring and in winter. There are great changes in the amount of annual precipitetion. There is no dry month, mean annual relative humudity is over 70 percent, During the summer period, relative humidity is more than 80 percent at night in the mornings. Dominant wind direction which was calculated by Rubinstein formula is S 36°W and N 19°E.

Soil : There are two zonal soils : 1- Reddish yellcwish podzolic soils are widespread on the coastal belt attaining 500 m. The soils show strong acide reaction, The carbonates are carried away from the soil profile and the soils are rich in organic content. 2- Acide brown forest soils are generally seen in the upper part of the ecosystem. The organic content is more than 3 %. A strong acide reaction is-dominant due to transportation of carbonates. The soil surface is covered with hydrophytic species especially where the forest cover was destroyed (Figure 12).

Vegetation : The dominant vegetation of the ecosystem is generally pure broad leaved deciduous forests which are associated with **Alnus barbata**, beech (**Fagus orientalis**), chestnut (**Castanea sativa**), linden (**Tilia rubra**), birch (**Acer campestre, A. platanoides**), elm (**Ulmus montana, U. glabra**), **Carpinus betulus**, etc. The leading shrub species of the shrub layer of the forests are: **Ulmus carpinifolia, Cornus mas, Ilex europerasus, Fraxinus oxycarpa**, Clematis vitalba,

Prunella vulgaris, Sorbus torminalis, Frangula alnus, Mespilus germanica, Smilax excelsa, Corylus avellana, Buxus sempervirens, Ostrya carpinifolia, Prunus laurocerasus etc.

Alnus barbata forests constitute the major forest of the region especially along the valleys. The natural vegetation composition of the forests are generally degenerated due to severe destruction of the forests. Forest lands destroyed by human activites and torrent are being occupied by alder trees in a short time.

Small communities of **Rhododendron, Buxus sempervirens** and **Ostrya carpinifolia** are seen along the valleys.

The undergrowth flora is rich in floristic composition. Approximately half of the plant species found in Turkey are found in this ecosystem.

Biotic factors : Approximately 100,000 people are living in the rural settlement of the Black Sea region has occured within the broadleaved forest lands. Scattered settleemnt types are dominant because agricultural lands are very limited. Farmers build their homes near their own arable field due to the rugged terrain. This settlement types and the used agricultural system bas caused the degeneration of the natural vegetation and/or forest composition. Areas that are suitable for the cultivation of hazelnuts and tea are being opened in the ecosystem.

4.1.2. ECOSYSTEM OF COLD HUMID CONIFER FOREST

This ecosystem covers the slope facing north of the Eastern Black Sea region at heights between 1500-2000 m and the Artvin-Şavşat basin, and the high part of the main Çoruh River Valley from Artvin to the Çamlıkaya (İspir) district, located inner section of the Black Sea region. This ecosystem is the suitable habitat for pure and mixed oriental spruce forests. As is known the oriental spruce forests are only found in the above mentioned areas.

Geomorphology : The ecosystem that is within the Northern Anatolia orogenic belt has a rugged and dissected topography. This topography was formed as a result of fluvial erosion. The orogenic belt has been cut as deep as 500-1500 m by the Çoruh River and its main tributaries. Granite, quartzite, quartzite schists and clayed schists which are found in the core of the mountains are exposed from place to place along the deep cut valley. The slope inclination of the deep valleys is more than 100 %. The slope gradient of the Ardanuç basin

exceeds 34 %. The mean slope inclination of the mountains found in the northern sector exceed 20 %.

The area is so dissected by the streams that there are 26 stream basins in the 67 km horizontal distance of the Çoruh River basin between Yusufeli and Artvin. The position reflects the degree of fluvial erosion in the area (Figure 3, 4, 5, 6 and 7).

Climate : The Mean annual temperature varies varies between 11-6°C. January temperatures range between 2 and -5°C. The average montly temperature of July and August is about 15-22°C. The lowest temperature recorded was - 17°C at Şavşat, but the temperature was estimated to be -20°C at an elevation of 1800-2000 m.

The mean annual precipitation in the Şavşat basin is about 700 mm. This figure is nearly 1000 mm in the Easter Black Sea region. The maximum rain fall occurs in spring, the minumum in winter. There are great derivation in the amount of annual precipitation.

The mean annual relative humidity is about 61 %. This figure decreases during the summer and increases in the winter. The northern slopes of the Şavşat Ardanuç basin are covered with fog and clouds during the summer season.

Soil : Acide brown forest soils are dominant. The soil profile generally has A and C horizons because of the very steep slopes. In this ecosystem the podzolic soil is only found in the vicinity of Karagöl is located in the NW part of Şavşat. Soils shallow and poor in organic content are seen on the slopes facing south.

Vegetation : In this ecosystem, pure oriental spruce forests and mixed conifer forests composed of **Picea orientalis, Pinus silvestris** and **Abies nordmanniana** are widespread, but in the lower section and in some localities mixed forests which associated with **Fagus orientalis, Quercus dschorochensis, Alnus barbata**, and **Picea orientalis** are seen. In the study area oriental spruce (**Picea orientalis** L.) begin here and there near the Black Sea, and above an elevations of 1000 m are seen within the broad-leaved forests, the trees generally establishes the pure oriental spruce forests in the Black Sea region, while this forests are found between 800-2200 m in the backward section of the Black Sea region. The leading tree and shrub species found within the orientale spruce forests are: **Fagus orientalis, Sorbus aucuparia, S. torminalis, Vibirnum orientale, V. lantana, Lonicera caucasica, Cornus sanguinea, Abies nordmanniana, Pinus silvestris, Ribes beibersteinii, Populus tremula, Ribes orientale, Taxus bac-**

cata, Acer cappadocicum, Carpinus betulus, Tilia rubra, Vaccinium arctostaphylos, Acer trauvetteri, Ulmus glabra, Juglans regia, Euonymus europeasus, Rhododendron luteum, Sambucus nigra, Daphane pontica (Anşin 1979). Alnus barbata trees are dominant along the valley and Rhododendrons are widespread on destroyed forest land in the oriental spruce forest belt.

Biotic factors : In the northern section of this ecosystem extending between 1000-2400 m in vertical distance there are no parmanent settlements There are only temporary population which settle during the summer. However in the inner section all of the rural populations have generally settled within the forests. The forest lands found near villages have mostly been turned into agricultural land to meet the needs of the people livings. Cattle-breeding activities are carried out in the forest lands and on the alpine-subalpine grasslands. All of the houses that have been built in the villages and on the grasslands are made of timber or wood materialls obtain from the forests. For this reason, productive forest lands are severely destroyed and degenerated from place to place. The upper natural timberline is lowered as low as a few hundred meters.

The oriental spruce forests are being destroyed by the **Dentroctonus micans** insects, while the mixed and pure oriental spruce forests have been run out by the gases with SO2 which are coming from a copper factory in the town of Murgul.

4.1.3. ECOSYSTEM OF HUMID- SUB HUMID CONTINANTAL COLD CONIFER FOREST

This ecosystem comprises the whole southeastern section of the study area, especially the northern slopes of the Mescit, Yalnızçam and Allahüekber mountains and the high plateaus and mountains at heights between 1200 and 2400 m. The dominant plant cover of the ecosystem is pure scotch pine (**Pinus silvestris** L.) forests (Figure 13 and 14).

Geomorphology : The high mountains extend in direction of NE-SW in the northern part of this ecosystem are composed of clayev limestone, flysche and volcano-sedimantary strata belonging to Mesozoic and Eocene era. The mountains and high plateaus located in the southern and the southeastern part of the area are made up of ophiolites containing peridotite, serpantine, radiolarite and limestone; green schistes, and volcanic material such as basalts and volcanic sands, and tuffs. The upper part of the mountains are mostly

covered by the volcanic rocks. There are tectonic depressions and/or basins between the mountains. The main tectonic depressions are Oltu, Narman, Ardahan, Göle.

High smooth plateaus at heights between 1800-2200 m were formed because of basaltic eruption which occured during Pliocene, Plio-quaternary, and early Quaternary, and early Quaternary time. The orogenic belts and basalt plateaus have been dissected and cut by to the base level of the tectonic depression and the lower level of the Çoruh River. Meanwhile, the Kura river and other rivers suremposed and incised their own valley due to positive epirogenetic movement which occured during the Quaternary time. So the canyon valley and meandering valleys have formed.

Climate : The mean annual temperature varies between 3 and 8°C. The temperatures are about 3-5°C where the Pinus silvestris forests are in good condition and productive. (Mean annual temperature is 3.0°C at Ardahan, 3.2°C, at Sarıkamış. The mean January temperature is about -10°C at Ardahan and 10.8°C at Sarıkamış The mean August temperature ise 13.4°C at Sarıkamış and 14.6°C at Ardahan). As to extreme temperatures, the lowest recorded temperature was -35.6°C at Ardahan, and - 31.5°C at Sarıkamış. The highest temperature was 32.6°C at Ardahan and 32.9°C at Sarıkamış. These figures clearly reflect the continentality of the region (Figure 8, 9 and 10).

Mean annual precipitation ranges between 500-700 mm (Ardahan 512 mm, Sarıkamış 608 mm, Göle 626, Hanak 535 mm). There is great variation in the distribution of precipitation. For example, the amount of yearly precipitation is between 393 mm and 900 mm at Sarıkamış.

Mean annual cloudiness is about 5. Maximum cloudiness occurs during the winter season and minumum cloudiness in the summer. Mean annual relative humidity is over 70 %. The lowest relative humidity is more than 15 % during the summer months. Relatire humidity is high on the slopes facing north because of the northern slopes of the mountains get moisture coming from the northern sectors during the summer season.

The dominant wind direction is about S 81°W and S76.5°E at Sarıkamış and S 76.5°W at Ardahan. The winds blowing from the NE and NW sector are become dominant in the summer.

Soil : The main soil types of the ecosystem are limely brown and

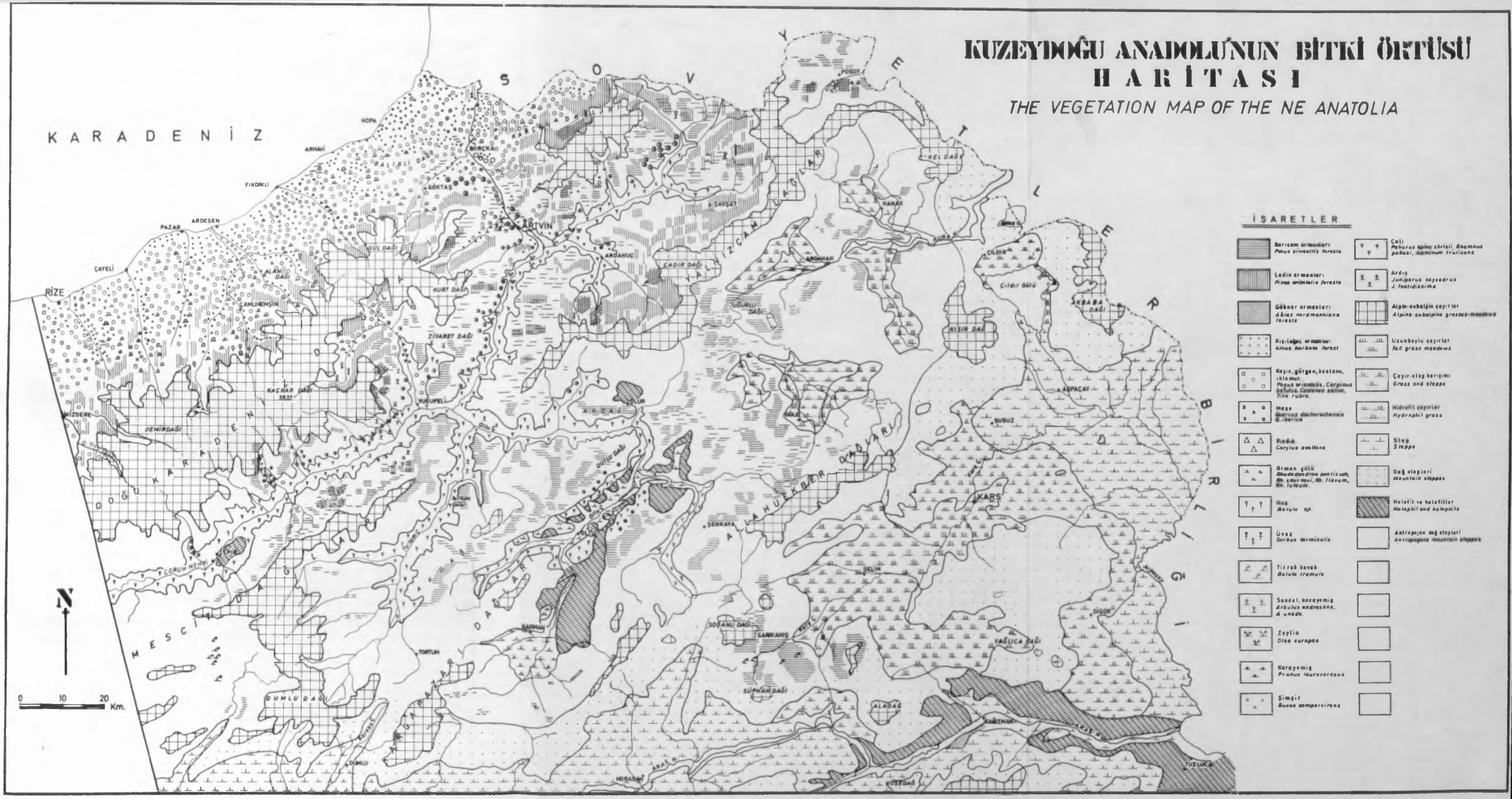

Figure 13 : Vegetation map of NE Anatolia

non-limely brown forest soils. Non limely brown forest soils have been formed in the humid habitat of the scotch pine forest. The carbonates are completely leached away from the soil profile due to sufficient precipitation.

Limely brown forest soils have developed under the dry scotch pine forests, which are located between 1500-2000 m. Accumulations of clay and carbonates are seen in the lower soil profile especially at the Bca and Cca horizons. The general texture of these soils is loam, sandy loam and clayey loam, granular structure is dominant at A horizons and coarse and blocky structure is dominant at B horizons due to clay accumulations.

Lithosols are widespread on the slopes where natural vegetation cover has been destroyed. In these areas sandy soils are common on the flysche formations, whereas clayey soils occur on the clayey limestones.

Vegetation : The natural forest vegetation of this ecosystem is generally pure forest of **Pinus silvestris**. In the forest areas located in the inner section of the Black Sea region or back section of Black Sea region, **Quercus iberica, Juniperus oxyeedrus**, and **J. foetidissima** are found. Mixed forests which contain **Abies nordmanniana** and **Pinus silvestris** are common on the northern northern slopes of the Meccit Mountains. In the vicinity of Oltu-Olur some shrubs such as **Berberis vulgaris, Juniperus foetidissima, Prunus** sp., **Ostrya sarpinifolia, Vibirnum lantana, Quercus iberica., Lonicera caucasica, Pyrus eleagnifolia** and **Acer platanoides** are found in the **Pinus silvestris forests.** Different underground flora is seen in the different forests, Namely, Irano-Turanian herb species are common in the dry scotch pine forests, whereas Euro-Siberian hydrophyll species occur within the humid scotch pine forests in the vicinity of Sarıkamış and Göle areas.

Biotic factors : Both rural and urban settlements begin along the streams and rise as high as 2500 m. The population of the ecosystem is about 150,000. The upper limits of agriculture reaches over 2000 m due to continentality. The main livelihold of the population is agriculture and cattle-breeding. Agricultural activities are carrying out on the forest lands and animals are being grazed in the forests and on the subalpine grassland. There are some yayla settlements in the forest areas. These economic systems lead to the destruction of the natural vegetation. In fact most of the scotch pine forests have been destroyed in order to provide construction materials and to grow grains.

4.1.4. DRY FOREST- SHRUB ECOSYSTEM

This ecosystem encompasses the lower section of the middle Çoruh basin between Artvin and İspir provinces. Shrubs along the Çoruh River and its valley slopes and trees found in the upper part of the valley form the natural vegetation of the ecosystem (Figure 13 and 14).

Geomorphology : Çoruh Valley which deeply cuts the northern Anatolia orogenic belt causes the ecosystem. Namely, the northern Aratolia orogenic ranges have been cut by the Çoruh River system probably after the Oligocene era. Different parent material has been exposed vhich consists of schistes, gabro, ophiolites, and quarzites along the deep Çoruh Valley. The depth of the valley varies between 500-1500 m and the slope of the valley is more than 30 percent.

Climate : This ecosystem is the driest of the study area. The mean annual temperature is between 15-8°C. Winter temperatures are generally over O°C on the lower section of Çoruh River, whereas temperatures decrease gradually towards the upper section of the valley, In these areas the mean January temperature is about -5°C. The highest temperature recorded was 37°C at İspir and 42°C at Yusufeli. The lowest recorded temperature was -24°C at İspir, -8°C at Yusufeli. Mean annual rainfall varies between 300-45 mm. There is great variation in the amount of yearly precipitation. Namely, the amount of yearly precipitation at Yusufeli is recorded at between 206 mm and 403 mm. Summer droughts are severe in the lower section of the Çoruh River.

Mean annual cloudiness varies between 4.6-5.0. This figure is under 4 during the summer season. Mean annual relatiye humidity is about 60 %. The lowest relative humidity of the vegetation period ranges between 5-15 percent. Winds blowing from the northern sector are dominant during the summer season.

Soil : Intrazonal soils reflecting the physical and chemical properties of the parent materials are common due to severe soil erosion and very rugged topography. In other words, the soils of the ecosystem were determined by the parent material. Strong alkaline soils are found on the ophiolites containing ultra-basic material. Sandy and stony soils occur on the Tertiary flysches extending between İspir and Yusufeli. On the undulating and smooth surfaces that are covered with dense oak stans limely brown forest soils are seen. Carbonate accumulation is dominant at B horizons due to insufficient precipitation.

Vegetation : In This ecosystem xerophytic vegetation is widespread between 400 - 1000 m and dry forests containing oak and juniper occur between 1000 - 1500 m. The leading shrub species are **Paliurus spina - christi, Jasminum fruticans, Berberis integerrima Berberis vulgaris, Rhamnus pallasii, Cotinus coggyria, Prunus spinosa, Pyracantha coccinea, Rhus coriaria,** and **Rosa canina** etc. The dominant shrub species of lower section of the Çoruh Valley is **Paliurus spina-christi** of the Mediterranean flora region, while **Olea europea** communities are seen along the Çoruh Valley between Yusufeli and Artvin.

Mixed dry forests composed of **Quercus iberica, Quercuss dschorochensis,** and J. **foetidissima** are located between shrub belts and conifer forests containing **Pinus silvestris, Abies nordmanniana,** and **Picea orientalis.**

Biotic factors: The population of this ecosystem is about 130,000; 100,000 of whom are living in the rural areas while the rest live in suburban centers. Most part of the population is centered along the Çoruh River Valley because of natural transportation. The irrigated Çoruh valley is the natural fruit and vegetable garden of the ecosystem. Goats are grazed in the shrub and dry forest areas. Since the young plants are eaten by the goats, the growth of shrubs and trees is prevented. Most of the area nas undergone severe soil and parent material erosion because the natural vegetation is severly degenerated and the topography of the area is very rugged.

4 2. ECOSYSTEMS OF HERB VEGETATION

The areas covered by natural herb vegetations are divided into four ecosystems according to ecological conditions (Figure 13 and 14).

4.2.1. STEPPE ECOSYSTEM

This ecosystem extending between 1000-2000 m encompasses the southeastern and southern section of the study area where tectonic depressions are located.

Geomorphology : The tectonic depressions lying in direction of E-W in the southern part of the area formed during the Oligocene and Miocene eras. The basins were occupied by the Oligocene shallow lake and Miocene shallow sea in which clayey, sandy and evaporite sediments accumulated Then these depressions were converted into land as a result of the regression of the lakes during the pliocene, Plio-quaternary eras. The central part of the basins were dis-

sected and and eroded by running water due to lowering of the base level. Dejection fans and cones have developed on the edges of mountains. The elevation of these tectonis depression is between 1100-2000 m.) the Erzurum plain 1700-2000 m, the Pasinler-Horasan basin 1600-2000 m, the Iğdır-Kâğızman basin 1100-1600 m, and the Arpaçay basin 1100-2000 m.) (Figure 4, 5 and 6).

Climate : The Mean annual temperature ranges from 11°C in the SE to 6°C in the W. The mean January temperature varies between - 3 and - 8°C. The mean July and August temperature varies between 19- 30°C. The coldest recorded temperature was -42°C at Erzurum, and -45°C at Horasan. The number of frosty days is between 116 and 153 days.

Mean annual precipitation varies between 300-450 mm. More than half of the precipitation falls during the late spring and early summer. The amount of yearly precipitation shows great variation from year to year. The derivation of the precipitation based on several meteorological stations is as fallows: Kâğızman 243-719 mm, Iğdır 114-501 mm, and Pasinler 196-527 mm. As to cloudiness, yearly cloudiness is about 4.5-5.0, but this figure decreases to as low as 3.0 during the summer. Mean yearly relative humidity is about 60 per cent. Relative humidity decreases to as low as 1 and 2 % in August and October, because relative humidity is very low in the summer, evaporation and transpiration is high. Yearly dominant wind direction is S 68°E and S49.5°W. Dominant wind direction of July is about S 36°W, and second dominant direction is also N 63°E.

Soil : The climatic soil types of this ecosystem are brown soil and chestnut soil develloped on the plâin surfaces of the tectonic depdession. The soils which have granular texture show alkalen reaction due to insufficient leaching. Although calcium carbonate accumulation level of the brown soil occur just below the A horizon, the level is found in the subsoil of the chestnut soils. Hydromorphic alluvial and hydromorphic soil are seen where groundwater level is high and near the river. Internal soloncak soils are found on the central part of Erzurum plain. The torrential areas of the plains have the alluvial soils.

Vegetation : This ecosystem has rich herb species and communities. Most part of the herb species belong to Irano-Turaniar steppe vegetation. Plain surfaces of the tectonic depression are covered by the steppe vegetation. By the first week of April generally geophytes start blossoming and form their seeds in a short period. Perennials

also start developing by mid June. During the mid and the end of the spring and first month of summer the steppe has a beatiful appaerance and is covered with coloured flowers. After June only some deep rooted perennials such as the species of **Astragalus, Acantholimon, Verbascum, Euphorbia** are green while other salalow rooted species of steppe become yellow or dried.

The leading herb species largely restricted to this ecosystem inolude **Glaucium corniculatum, Alyssum linifolium, A. desertorum, Isatis glauca, Holosetum umbellatum, Silene armena, Polygonum aviculare Rumex crispus, Astragalus** species, **Coronilla orientalis, Lotus corniculatus, Trifolium pratense, Valeriana cymbicarpa, Anchusa italica, Mentha tomentosa, Salvia syriaca, Thymus fallax, Achiella biebersteini, Anthemis trictoria, Artemisia caucasica, A. austriaca A. absinthium, Centaurea depressa, Cichorium intybus, Cirsium arvense, Crepis foetida, Senecio vernalis, Xeranthemum annuum, Euphorbia** species, **Agropyron repens, Bromus erectus, B. tectorus Poa bulbosa, Vicia sativa, Galium verum, Phleum hirsitum, Cynodon dactylon, Euphorbia** and **Stipa** species etc.

Biotic factors : More than 200 settlement centers are found in the ecosystem. The population of rural and suburban settlement is about 250,000. The city of Erzurum situtated on the southern section of Erzurum plain has 200,000 population. Most of the villages are settled on the plain near the streams and rivers and on the edge of river valleys opening towards the plains. Main livelihood of the population depends on agricultura and cattle-breeding. On the other hand a few prehistoric settlements were discovered on Erzurum Plain, the dates of the these settlements are estimated to be 7000-8000 year B.P.

The steppe ecosystem area has been cultivated and animals have been grazed For this reason, the natural steppe vegetation species had been decreased or extinct. So in some areas spiny cushion and bitter species which are not eaten by animals are widespread due to over grazing.

4 2.2. TALL GRASS (STEPPE-GRASS) ECOSYSTEM

This ecosystem extends between the steppe and cold-humid conifer forest ecosystem and extending between 1800-2000 m in the SE part of the study area (Figure 14).

Geomorpholcgy : The volcanic mountains and plateaus form the main geomorphic units. The basaltes which covered the old fouudation especially Mesozoic ophiolites form the smooth and sliglt un-

dulating relief. The plateau surfaces were being eroded by the young streams, and the canyon like valleys have been opened. Some isolated volcanic peaks or hills are seen on the plateaus (Figure 2 and 3).

Climate : Mean annual temparature is about 3—4°C according to Sarıkamış and Kars meteorological station. Mean July temperature is nearly 16-17°C and Mean January temperature is about -10°C. The number of frost days generally change between 180 to 200 days. The number of the snow covered- days is more than 120 days. Mean annual precipitation varies between 500-600 mm. There are great variation both the amount of yearly and monthly precipitation. For example the amount of yearly precipitation of Kars is recorded between 293-718 mm. Mean annual relative humudity is nearly 68-70, mean monthly figure is not less than 60 percent. Lowest figures happen during August and December and this relative humudity decrease as low as 2 per cent.

Dominant wind direction is calculated as S 40°W and N 35°E. Dominant wind direction of July is N 36.5°E.

Soil : Climatic soil of the ecosystem is chernozem developed on the basalt plataeus and Plio-quaternary sandy and clayey sediments. The depth of A horizon is about 25-40 cm and has granular, furda structure, and loam, clayey loam texture and it shows notral, sligly alkalen and acide reaction and rich in organic content. B horizon of the soil is deep, and clayey texture is dominant, the coarse granular and block structure is common. Carbonate accumulations are seen at the lower section of B horizon.

B horizon which is rich in carbonate content is seen where A horizon has been eroded

Vegetation : Tall meadow grasses are widespead in the ecosystem due to sufficient ecological properties. The Leading herb species are **Salvia** sp., **Cichorium inthybus, Cirsium hypoleucum, Eryngium campestre, glomerata, Onosma sp., Vicia sp., Galium verum, Alyssum** sp., **Daucus carota, Bromus,** sp., **Festuca** sp., **Salvia amasiaca** etc. By the firs week of july geophytes and perennials start blossoming, after August greenish apparance become yellow.

Biotic factors : More than 60 centered rural settlements or inhabitats contain 500.000 population. Agriculture and cattle-breeding are main economic activities. Tall grass vegetation is an important factor in respect of cattle-breeding. For this reason main livelihood of

the population depends on animal grazing and animal husbundry But some tall grasse areas have been converted into agricultural or arable land in order to grow cereals. The natural composition of grassland deteriorated because of heavy grazing and agricultural activities. In fact some areas that have undergone heavy grazing are covered by spiny species.

2.3. ECOSYSTEM OF ALPINE GRASSES

This ecosystem located over the natural timberline begins over 2000 m in the Eastern Black Sea Mountains, 2200-2400 m in the backward section of Blacksea region and 2500-2700 m in the inner section. The lower boundary of the ecosystem is determined by the continentality (Figure 13 and 14).

Geomorphology : The topography of the area except for basalt plateaus is very rugged and very high. The summuits of the mountains are generally over 3000 m (Karçalı M. 3334 m, Demirdağı 3425, Kaçkar M. 3932 m. Altıparmak M. 3562 m.) Especially the northern slopes of the mountains were occupied by the Pleistocene and early Holocene glaciation. The Pleistocene olimatic snow line had descented as law as 2500 m. The upper watershed basins of the streams were covered by the glaciers and so in these areas glacial cirques, glacial valleys had been formed. The topographic features belonging to glacial topography are seen on the northern slopes of the Eastern Black Sea Mountains, Yalnızçam and Mescit Mountains.

Climate : Mean annual temperature is below 3°C, the temperature is probably below O°C on the highest peaks or hils of the Eastern Black Sea Mountains. Frost days are in excess of 250 days. Mean annual precipitation is estimated to be 600-1000 mm.

Soil : Developing of the normal soil profile is absent due to short vegetation period. High rangeland soils which have acide reaction and rich in organic content have been developed only on the flat and slight undulation surfaces and under hygrophyll species. Litho sol or coarse texture soil occur in steep slopyıcareas.

Vegetation : Vegetation period of the ecosystem varies between two and four months and most of the herbs belong to Euro-Siberian floristic region. There is vertical zonation in the high rangeland vegetation. Namely, dense and rather tall grasses are found on the flat basalt plateaus extending between 2500-3000 m whereas sparse and short grasses or herbs are common both on the steep slopes and highlands over 3000 m. For example the higher parts of the Kaçkar mo-

untains are generally bare in appaerance.

The leading species which are restricted to the Eastern Black Sea mountains are : **Helychrysum graveolens, Geranium cinereum, Trifolium polyhyllum, Gagea** sp., **Lolium rigidum, Jassionne pontica, Vicia balansae, Campanula tridentana, Hypericum pruniatus, Festuca alpina, Geranium sylvaticum, Sedum spurium, Prinula elatior, Astragalus vicifolius, Ranunculus caucasicum, Potentilla ruprechtii, Thymus polytrichus, Draba polytricha Daphane pontica** etc.

On the other hand in the Eastern Black Sea mountains **Festuca violacea-Cerastium lazicum** and **Daphane glomerata-Veronica gentianoides** communuties are found out (cf. Düzerli, 1982). Grasse communities belonging to high mountain grasses are : **Anthemis marchalliana** subsp. **pectinata, Androscea villosa-Secorzonera soidlitzii** and **Potentilla overiniana-Aster alpinus.**

Biotic factors : The natural range meadows of the ecosystem, except for Eastern Blac Sea mountain, are generally deteriorated due to unusual or irregular and heavy grazing. For this reason the natural and or climax herb species of the rangeland of the inner section are extinct to a great extent. These areas are generally bare in appaerance and soil erosion events are active.

1.2.4. ECOSYSTEM OF MOUNTAIN STEPPE

This ecosystem encompasses mountainous areas located on the southern and southeastern part of the study areas in places extending between 1800-2700 m. It can be stated that these mountainous areas formerly had been occupied by the scotch pine and oak forests during the cold and humid climatic condition of the Pleistocene. But these forests had been completly destructed, and so these areas were mostly occupied by the steppes. It is found that the present ecological conditions are not suitable to grow the oak and pine forests. In fact, during the Pleistocene time on the northern section of the Erzurum plain and Aras river basin would probably have been occupied by the **Pinus silvestris**, and oak species (Figure 13 and 14).

Geomorphology : As mentioned before the tectonic depressions extending generally in direction of E-W are settled. The fault line and fault sharps aslo extend parallel to the tectonic depression arranges. The slopes of the mountains facing to the plains or the depression are very steep and had been cut by the faults. In other words, the steep slopes of the mountains fit the fault sharps. The old and

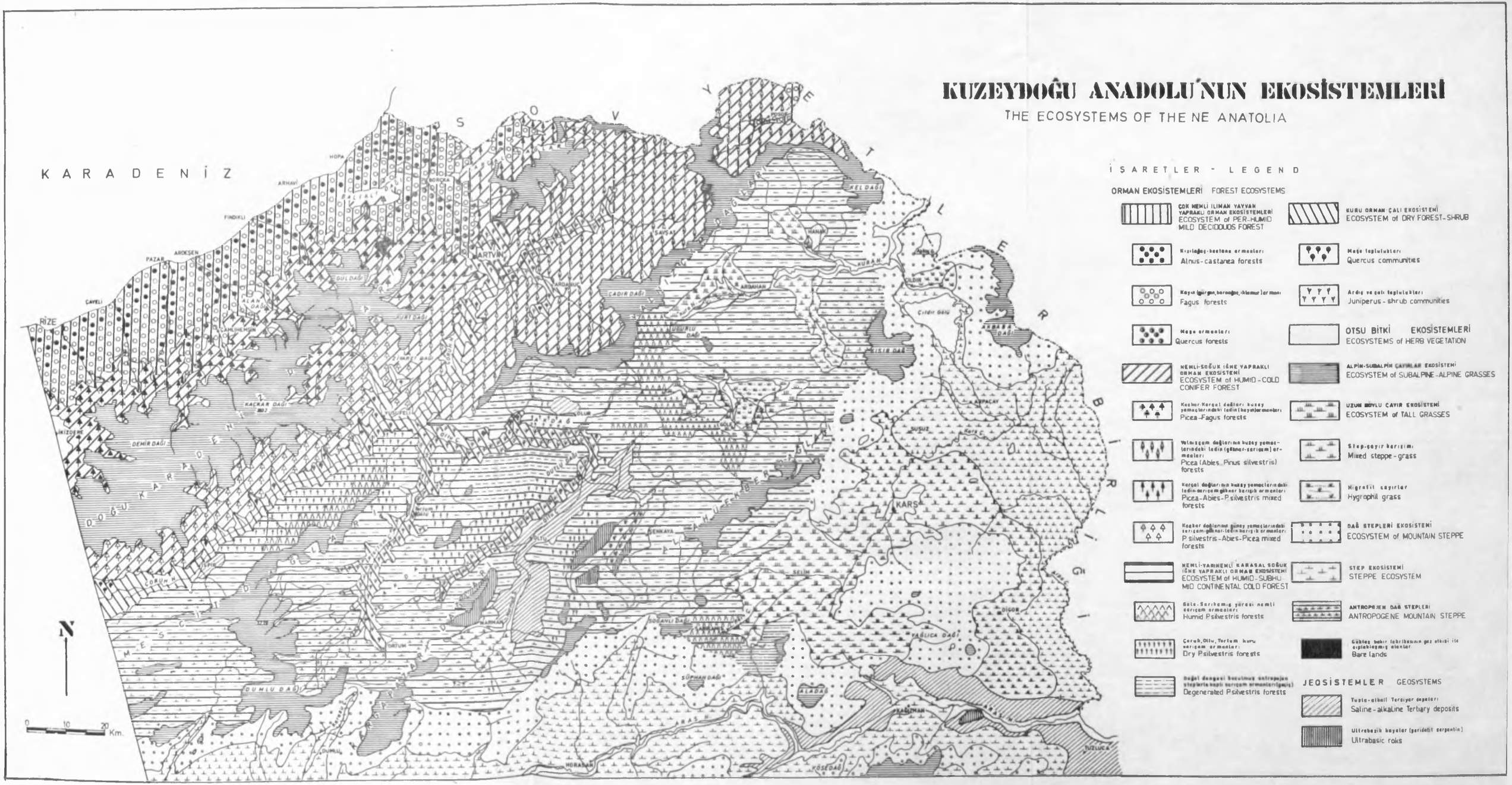

Figure 14 : Ecosystem map of NE Anatolia.

the new fault sharps were dissected by the streams that drain the mountains.

Climate : It can be said that the mean annual temperature of the ecosystem varies between 3 and 6°C. Mean annual precipitation is estimated to be 500-800 mm. Most of the annual precipitation falls as snowfall. Winters are generally dry and very cold but are not as severe as those in the Alpine ecosystem. Relative humuidity is very low especially during the vegetation period, but cloudiness and moisture increases when the frontal and convectional activities occur.

Soil : The normal soil profile developing and/or pedogenesis is not complete because of strong slope, sparse vegetaion cover, and erosion. For this reason, lithosols are widespead on the steep slopes facing towards the plain. The soils have A and C horizons developed on the densely vegetation cover and undulating topography. Although the soil reaction is notral and weak alkalen on the lower part of the mountains, the reaction becomes sligly acide and acid on the upper part of the mountains due to increase of precipitation and organic matter content.

Vegetation : From the standpoint of animal husbundry or animal grazing the herb vegetation of the mountain is very important. Herb species are rich is floristic composition. In spite of some Euro-Siberian elemants found on the slopes facing north, Irano-Turanian steppe elements are common on the slope facing south. As a general rule, the mountain steppes which are widespread between 1800-2500/2600 m are taller and richer in floristic composition than that of the steppes which are found on the plain of Erzurum and Horasan, Pasinler and Tuzluca. The Leading mountain steppe species are **Astragalus** species, **Festuca ovina, Bromus tomentalus, Medicago papillosa, Asperulla aspera, Bromus erectus, Veronica austriaca, Thymus** sp., **Silene spergulifolia, Dianthus erythoroleus, Helichrysum plicatum, Koleria cristata, Campanula** sp., etc. Mountain steppe communuties found out are as fallows : 1—**Astragalus eriocephalus**, 2—**Thymus fallax-Galium verum**, 3—**Poa longifolia.**

Biotic factors : Within the mountain steppe vegetation grazing is so much that the natural composition of the vegetation is generally run out. The species of **Astragalus, Euphorbia** and **Verbascum** are dominant where animal grazing is very excessive.

4.3. ANTROPOGEN ECOSYSTEM

Except for the broad-leaved forests the most part of the study area

is occupied by the herb species called antropogen steppes. In other words, antropogen steppes are widespread where scotch pine and oaks forests had been completely destructed and degenerated. The ne time are reflected by the glaciated topograhy, paleosol and relict plant species and communities. The glacial cirques and lakes, «U» shaped glacial valleys which are found between 2000-3200 m in the Eastern Black Sea Mountains, Mescit and Yalnızçam mountains ref- natural equilibrium of the destructed areas was deteriorated. For this reason the destructed forest areas were largely occupied by the xerophytic species mostly belonging to Irano-Turanian floristic region. Present ecological condition of the deteriorated areas are suitable to grow the herb vegetation. It could be said that it is very difficult to grow the scotch pine again in places where natural equilibrium is completely deteriorated.

Antropogen ecosystem extends over all the upper watershed area of Çoruh river and the northern section of Allahüekber Mountain and the most part of the Karadağ.

Geomorphology : From the standpoint of geological structure the northern section of the ecosystem enters the northern Anatolia orogenic belts that were deeply dissected by the fluvial agents, whereas the southern part of the ecosystem comprises the ophiolitic foundation and basaltes lying on the Tertiary and Mesozoic strata. The flysche formations which are generally found in the Oltu and Tortum atershed basin are being dissected by the gullies due to less cohesin. Ophiolites containing gabro, peridotite and serpantine and other submarine volcanics were exposed or outcropped along the deeply cut valley, And the slope degree of the valley is more than 20 % (Figure 3).

Climate : The climatic condition of this ecosystem is very different because of the fact that there are great changes with regard to topographic pericularities both in vertical and lateral direction. The mean annual temperature ranges from 14°C to 3°C. The mean January temperatures varies between -10°C and 5°C. The mean July temperature is about 20-25°C. Mean annual precipitation is about between 300 500 mm. Deviation of annual precipitation varies between 200-600 mm. Maximum rainfall occur in the spring and in early summer, and water deficiency occurs during the summer period. The mean yearly relative humudity is about 50-60 per cent, lowest figure decreases as low as 5-15 per cent.

Soil : Intrazonal and azonal soils are widespread due to natural equ-

ilibrium deteriorated. Neogene coarse deposits and flysches derived soils have sandy and coarse texture. Lithosol covering large part of the ecosystem is the main soil group which has (A) C horizons. Normal soil profiles are not developed because of the creeping of decayed and dissolved materials on the slopes.

Vegetation : Perenial steppe vegetation and xerophyte shrubs form the large part of the flora of the antropogen ecosystem. In some localities there are Euro-Siberian and Irano-Turanian elements reflecting former ecological condition especially climatic changes. For example, Irano-Turanian steppe communities discovered within the Tortum valley extending between 1300-2000 m are: 1—**Artemisia austriaca-A.marschalliana**, 2—**Lepidium graminifolium-Centaurea simplicicaulus**, 3—**Rumex scutatus-Centrathus longifolius**, 4—**Caragana grandiflora-Minuartina lineata**, 5—**Astragalus microcephalus-Atraphais grandiflora**, 6—**Astragalus erinaceus-achiella schischkinii**, 7—**Campanula betuliflora-Saxifraga paniculata. Veronica anagallis-aquatica, Inula oculus-christi, Erigeron acer, Fillipendula vulgaris, Fragaria viridis, Campanula betuliflora, Myosotis arvensis** and **Solanum indivisium** belonging to Euro-Siberian is found out secluded places especially facing north in the Tortum valley (Aksoy 1981). On the other hand there are some Mediterranean shrub species within same valley.

Biotic factors : It is clearly said that antropogen steppe ecosystem is caused by the human activities representing forest destruction, heavy grazing and wrong land-use.

4.4. GEOSYSTEMS

In the study area, exposed saline-alkaline parent material where the natural plant cover was completely destructed form the geosystems. So the habitats are mostly determined by the geological and geomorphic factors. Namely, the growing of the plants are mostly obstacled by exposed or outcropped Oligocene saline-alkaline and weathered ophiolites located in the Oltu-Kömürlü basin and in the northern part of Narman basin and the eastern part of Aras river basin especially between Tuzluca and Kağızman. These habitats are called as geosystems (Figure 2).

Geomorphology : The Oligocene deposits composed of clay, marly, sandstone, limestone and gypsum were accumulated under the dry-hot climatic condition in the closed basin of Oltu- Narman and eastern part of Aras basin. After the lakes had been occupied by above

mentioned basins, and had been regressed by the Alpine tectonic movement, these closed basins were generally captured by the rivers and so the saline and alkaline deposits covering the basins were dissected and moved by the fluvial agents. Gully erosion has been formed on the deposits. On the other hand active mass movement and slope creeping are also seen on the steep slopes of the Oligocene reddish-brownish and yellowish deposits. When the deposits saturated with water especially weathered deposits are dissolved like sugar and salt and the deposits are easily eroded by the running water after showers.

Climate : Mean annual temperature is about 6-10°C, the number of frost day is nearly 90-120 days. Mean annual precipitation varies between 285-450 mm. Maximum rainfall happes in May, June and July, minumum is in winter and summer. Relative humudity is estimated to be 55-60 per cent, lowest figure is recorded as 2 per cent. Summer drought prevails.

Soil : Pedogenes events are absent due to active chemical and physical erosion occuring on the steep slopes. But there are only slight weathered and leached C horizons reflecting the physical and chemical properties of the parent material.

The physical and chemical properties of Oligocene weathered zone are as fallows : pH varies 8.7-9.9 and lime content ranges from 0.99 % to 29.3 %, soluble degree of Ca÷Mg, K and Na varies 0.9-2.53 m. e./100 g, 0.03-0.22 m.e./100 g, and 0.05-11.9 m.e./100 g, respectively. Soluble (Cl), (HCO_3) and (SO_4) occurs 0.11-3.56 m. e./100 g, 0.05-0.70 m. e./100 g, and 0.28-32.4 m.e./100 g respectively. Electrical conductivity ($EC \times 10^3$ at 25°C) ranges between 0.27-56.7 milimhos/cm And Oligcene deposits contain 14-82 per cent clay,6-44 per cent silt, and 6-66 percent sand. These values indicat that the sediments are both saline and alkali.

Vegetation : Saline and alkaline Oligocene deposits are generally bare in apperance. Some halophytes, halophyll plant species are only found sparsely. The leading species which are growing on the saline and alkaline deposits are : **Onosma sercaum, Dianthus erythocoleus, D. balasae, Camphorosma monspeliacum, Linaria** sp., **Coronilla orientalis, Hedysarum elegans, Helichrymus plicatum, Gypsophylla cappadccicum, Astragalus ornithopodioides, Lepula barbata. Cynodon dactylon, Onobrychis huetiana** etc.

Biotic factors : The ecosystem called geosystem found within the hu-

mid-cold conifer forests, dry forests and natural steppe region, are results of the soil and parent material erosion. It can be clearly stated that most part of the present geosystem areas must have been coverd by the dry forest and scotch pine forest aproximately 4000-5000 years ago. These areas have been converted into geosystem due to the result of the destruction of natural plant cover and so the Oligocene and alkaline deposits are exposed after soils had been completely eroded on the steep slopes.

5. EFECTS OF CLIMATIC CHANGES ON THE ECOSYSTEMS: PALEOECOSYSTEMS AND THEIR EFFECTS

Climatic changes which had occured during Pleistocene and Holocene time are reflected by the glaciated topography, paleosol and relict plant species and communities The glacial cirques and lake, «U» shapea glacial valleys which are found between 2000-3200 m in the Eastern Black Sea mountaihs, Mescit ana Yalnızçam mountains reflect to have been glaciated. Marine terraces extending along the shore of the Black Sea at different levels show the fluctuation of the sea, level. Reddish deposits and reddish-yellowish soils found under the brown forest soil at the coastal belt of Black Sea had been developed under hotter climatic condition than present climate. Vegetation evidence iş relict species and communities belonging to a few floristic region and sub region. For example, **Pinus silvestris** stands found at the several localities on the Eastern Black Sea region show to have prevailed cold and humid climatic condition in the area. On the other hand, **Olea oleaster, Paliurus spina- christi, Rhus coriaria, Juniperus oxycedrus, Arbutus unedo, A. adrache** shrubs showing within the lower part of the Çoruh river valley indicated that the area had undergone to Mediterranean climate.

During the glacial periods of Pleistocene and early Holocene some Euro-Siberian elements were moved to the inner section as far as Sarıkamış town and Aras river corridor; whereas during the interglacial periods which is hotter than present day, Irano-Turanian and Mediterranean plants were intruded towards the inner section especially Çoruh river valley and tectonic depressions So the natural ecosystem of the study area had been changed with regard to climatic changes and relict communities had been placed. For this reason, it can be said that climatic plant communities and/or natural vegetation formation or ecosystems are not yet stabilized. In spite of

this, natural equilibrium of the study area was greatly deteriorated by human activities the natural occurence of plant communities and natural boundary of the definite ecosystems can not be truely determined.

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Özet

Kuzeydoğu Anadolu'nun Ekosistemleri

Ormancılık Araştırma Enstitüsü tarafından desteklenen bu araştırmada, Kuzeydoğu Anadolu'nun önce genel ekolojik şartları değerlendirilmiş ve bilâhare bu ekolojik şartlara göre bölgedeki ormanlar çok nemli, nemli ılıman yayvan yapraklı nemli soğuk iğne yapraklı, nemli-yarınemli karasal soğuk iğne yapraklı (sarıçam) kuru orman-çalı olmak üzere dört ayrı ekosisteme, ot örtüsü ile kaplı alanlar da step, dağ stepi, uzun boylu çayır (step çayırları), subalpin ve alpin çayırları halinde dört ekosisteme, orman örtüsünün tahrip edildiği alanlar antropojen step ekosistemine dahil edilmiştir. Doğal dengenin genellikle tamamen bozulması sonucu yüzeye çıkan tuzlu-alkali Oligosen depolarının bulunduğu sahalar ve kuvvetli alkalen reaksiyon gösteren ayrışmış ultrabaziklerin ve/veya ofiyolitlerin bulunduğu alanlar, jeosistemler olarak ayırt edilmiştir.

Ayrıca, bu araştırma ile Kuzeydoğu Anadolu'nun vejetasyon formasyonları ana çizgileri ile sınıflandırılmış, orman ekosistemlerine tekabül eden orman yetişme bölgelerinin tesbit edilmesi ile de ormancılık faaliyetlerine özellikle ağaçlandırma ve erozyonu kontrol çalışmalarına ışık tutulmuştur.