Turk J Bot
25 (2001) 131-136

Research Article

A Description of the Vegetation Mosaic of the Forests of Yirce and Muratdere (Bilecik-Bursa, Turkey) by Satellite Remote Sensing

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Received: 24.02.2000
Accepted: 08.12.2001

Abstract: The aim of this study is to describe the cut-off borders and the structure of vegetation mosaics of existing plant communities in the area, using traditional flora and vegetation methods and satellite remote sensing (Landsat satellite pictures and Geographical Information System (GIS) data). The results indicate that *Pinus nigra* L. subsp. *pallasiana* (Lamb.) Holmboe and *Fagus orientalis* Lipsky plant communities together with *Quercus pubescens* Willd. and *Quercus cerris* L. var. *cerris* could be differentiated. The coverage rates of dominant plant communities in the research area were as follows: *Fagus orientalis* (92%), *Pinus nigra* subsp. *pallasiana* (73%), *Quercus pubescens* and *Quercus cerris* var. *cerris* (55%).

Key Words: Remote Sensing, GIS, Vegetation, Ecology.

Yirce ve Muratdere Ormanlarının (Bilecik-Bursa, Turkey) Vejetasyon Mozayiğinin Uydu ile Uzaktan Algılanarak Tanımlanması

Özet: Bu araştırmada klasik flora ve vejetasyon yöntemlerinden yararlanarak arazi çalışmalarıyla alınan sonuçlarla birlikte, uzaktan algılama yöntemlerinden (Landsat Uydu görüntüleri ve Coğrafik Bilgi Sistemleri (CBS) proğramlarından) yararlanarak mevcut bitki topluluklarının vejetasyon mozağininin yapıları ve sınırları tanımlanarak ortaya konulmaya çalışılmıştır. Buna göre *Pinus nigra* L. subsp. *pallasiana* (Lamb.) Holmboe *Fagus orientalis* Lipsky. topluluklarıyla, *Quercus pubescens* Wild ve *Quercus cerris* L. var. *cerris* in karışık olarak toplulukların ayırtedilebildikleri görülmüştür. Araştırma alanındaki dominant bitki topluluklarının örtüş yüzdeleri şu şekildedir: *Fagus orientalis* (% 92), *Pinus nigra* subsp. *pallasiana* (% 73), *Quercus pubescens* ve *Quercus cerris* var. *cerris* (% 55).

Anahtar Sözcükler: Uzaktan algılama, CBS, Vejetasyon, Ekoloji.

Introduction

Because Turkey is located at the intersection of three phytogeographical regions, it has a rich vegetation. However, this potential, without scientific description, lacks meaning.

Because of this, we need detailed scientific information about the country's plant life and vegetation. This need has led to the development of botanical science to make up for the previous lack of information on plant community development, plant variation, geographical distribution and environmental relationships. Consequently, this science has gained interdisciplinary status as, irrespective of its biological base, it started making use of investigative methods specific to other scientific areas (Benedetti, 1994). The Remote Sensing System, which has been used by various disciplines, has recently been introduced to botanical science studies. This system can be used to determine distribution maps of plant species (Schreirer, 1994), mapping vegetation and relevant mosaic determination (Güleryüz et al., 1998; Arslan et al., 1999), as well as environmental factors and anthropogenic effects, either positive or negative (Okçu et al., 1997).

In order to account for the reliability of the data and confirm the data, vegetation study has been conducted using both the Remote Sensing System and area studies (Yıldırım et al., 1997).

In the study, area investigations have been performed using both traditional flora system and vegetation research methods (Türe and Tokur, 2000). At the end of the study, specific reaction values of the plant communities were determined using the Remote Sensing

Method, which resulted in maps showing the structure of plant communities and their cut-off borders.

The method of investigation has created a new dimension in the study of vegetation. Thus, it is believed that in the study of large areas, with respect to vegetation cut-off borders, and the reasons for changes in natural vegetation, this method will prove efficient.

Defining the Area of the Study

The study area, in the A2-B2 squares according to Davis (1965), is within the border of Bilecik-Bursa. The area is surrounded by four plateau including Pazaryeri in the north, Bozüyük in the east, Domaniç in the south and the İnegöl plateau in the north-west (Davis, 1965), (Figure 1).

The Yirce-Bürmece-Kömürsu Forest Series is located at 39°41'-39°55' N and 29°42'-29°50' E and the location of the Muratdere forest series is located at 39°47'-39°58' N and 29°45'-30°17' E (Orman Bakanlığı, 1994). The Bursa-İnegöl highway runs through the Bursa-İnegöl forest series. The Aksu river also runs parallel to the highway and through the Mezit valley and İnegöl plateau.

Geographical characteristics of the area

The Muratdere Forest Series consists basically of volcanic rock. On the other hand, the Yirce-Bürmece-Kömürsu Forest Series consists of granite, blue-schist and marble. Micaschist and diorite on the marble have also been observed on the south part of Aksu Dere (Atalay, 1982).

Soil Types of the Area

Besides being covered by brown forest soil, colluvial, alluvial and red-brown soils were also seen in the area (Topraksu Genel Müdürlüğü, 1983).

Climate of the area

The climate of the area was described according to the meteorological data of Bozüyük, İnegöl and Bilecik. The average temperature of Bilecik is 12°C with and annual precipitation of 436.4 mm. These figures are 10.4°C and 484.2 mm and 12.3°C and 568.4 mm for Bozüyük and İnegöl, respectively (Meteoroloji Genel Müdürlüğü, 1995). When all the climate data is evaluated, it can be seen that part of the study area belongs to the semi-arid Mediterranean and the rest of the area belongs to subhumid Mediterranean climate regions. The precipitation regime is Eastern Mediterranean (Akman, 1990).

Methods

Data from the field studies using traditional flora and vegetation methods and the Remote Sensing Method were used. Satellite data available at the Anadolu University Research Institute of Satellite and Space Sciences was evaluated. The September 1997 Landsat TM bands were used for satellite imaging. Micro Station and

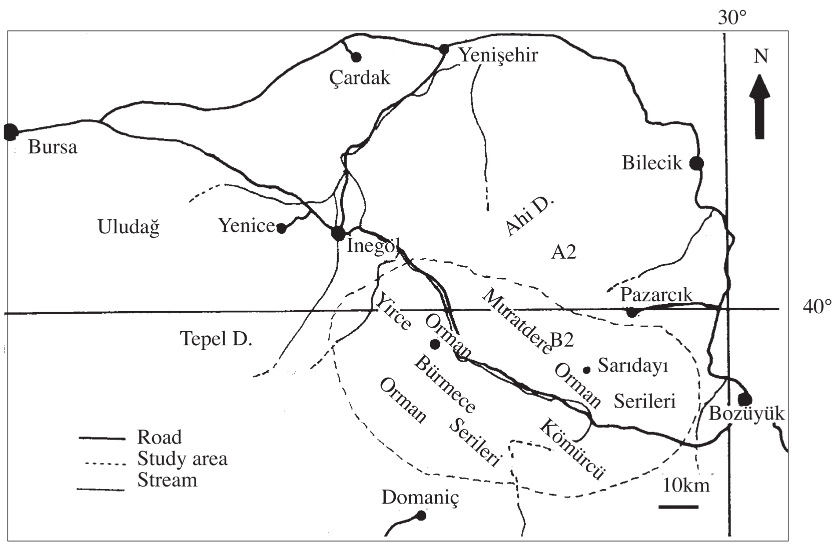

Figure 1. The geographical location and boundaries of the study area.

Advance Imager Models, part of the MGE (Modular GIS Environment), were used in the analyses of the images. The TM5, TM4 and TM3 were considered applicable bands for this study. By using a TM543/RGB combination, artificial colour imaging of the investigation area was achieved. Using a band ratio method (Figure 2), the images were made more concrete and clear. The Transformed Vegetation Index Formula was used for plant differentiation (Figure 3).

TVI=SQRT((TM4-TM3)/(TM4+TM3)+0.5)

Using the new band dense slide method, different plant communities were differentiated. As there is information about the area from the area investigation, the information about the location of plants and reflection values of those places have been determined. These values were used in the dense slide method. Pixels in specific dimensions of distribution were eliminated using a 3 x 3 convolution matrix lowpass filter (Figure 4).

Findings

In this study, the findings of the area investigation have been evaluated together with the data from the Remote Sensing Method. The area investigation carried out to identify the area's flora and vegetation characteristics was conducted by Türe (1992-1995) and Türe and Tokur (2000). A look at the area's vegetation indicates that the majority of the area has a forest formation. However, most of the plant taxa belongs to the Euro-Siberian phytogeographical region. *Fagus orientalis* Lipsky and *Pinus sylvestris* L. *Carpinus betulus* L. were plant taxa found in the area. In addition, plants belonging to the montane Mediterranean prepontic bioclimatic zone, and *Fagus orientalis* towards the north-west combination of *Abies nordmanniana* subsp. *bornmuelleriana* (Mattf.) Coode & Cullen were also observed in the mountainous prepontic bioclimatic zone.

At a 600-1100 m altitude, towards the east, where the humidity level is higher, *Pinus nigra* Arn. subsp. *pallasiana* (Lamb.) Holmboe and *Quercus cerris* L. var. *cerris* plant communities were found. In the eastern part,

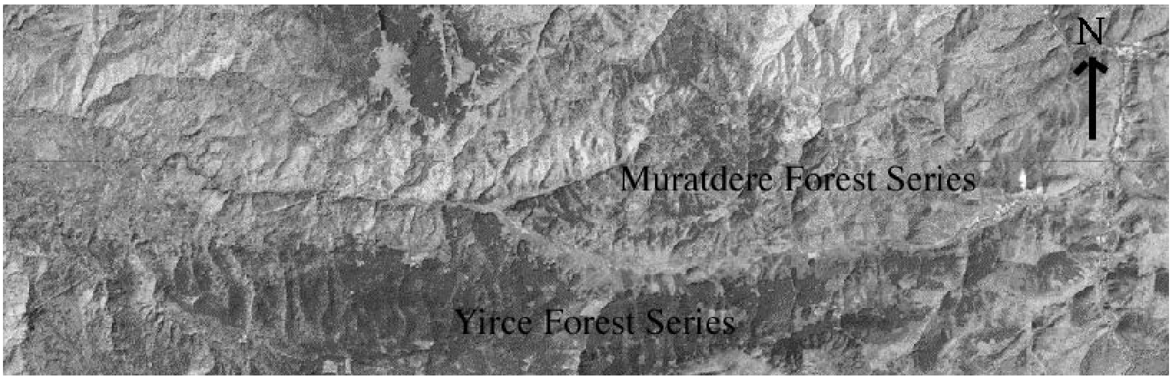

Figure 2. The artificial colour image of the investigation area via TM543/RGB from satellite (Scale: 1/200,000).

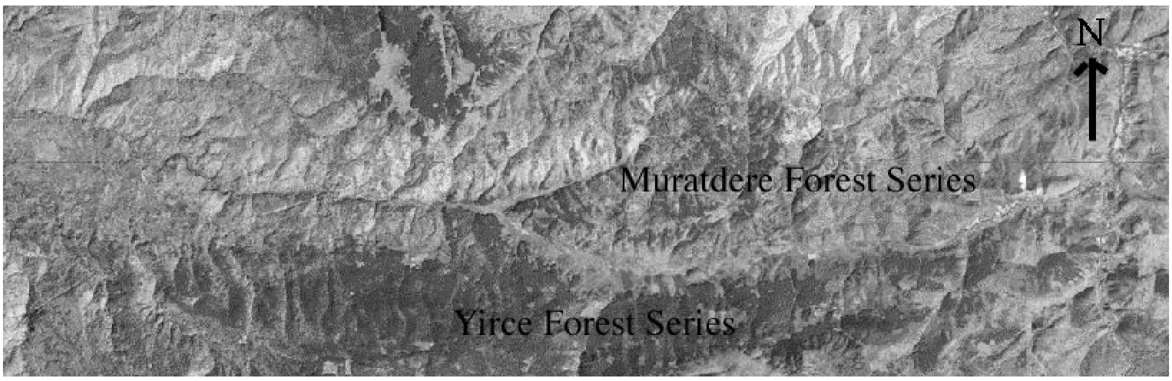

Figure 3. Single band image showing plant differentiation by Transformed Vegetation Index from satellite imaging (Scale: 1/200,000).

Pinus nigra subsp. pallasiana

Fagus orientalis

Quercus pubescens-Quercus cerris van cerris

Figure 4. The plant community distribution from saatellite imaging in the area using the dense slide method (Scale: 1/200,000).

at an altitude over 1000 m with less humidity, *Juniperus excelsa* L. and *Juniperus feoditissima* Willd. plant communities were observed.

In terms of shrub formation, the study shows that plant community developments, such as *Quercus pubescens* L. and *Quercus cerris* L. var. *cerris*, were located in the transition area of the Central Anatolia and Marmara region.

Because of anthropogenic effects, such as agricultural activity, it was impossible to identify and determine humid stream or meadow formation.

The main characteristic species of the dominant plant communities and vegetation types were chosen according to Türe and Tokur (2000).

Shrub vegetation

The *Quercus pubescens* community

Quercus pubescens Willd.
Juniperus oxycedrus L. subsp. *oxycedrus*
Osyris alba L.
Rhamnus oleoides L.
Coronilla varia L. subsp. *varia*
Rosa canina L.
Campanula lyrata Lam. subsp. *lyrata*
Teucrium polium L.
Onobrychis armena Boiss. and Huet.
Vicia cracca L. subsp. *stenophyhlla* Vel.

The *Quercus cerris* subsp. *cerris* community

Quercus cerris L. var. *cerris*
Crataegus monogyna Jacq. subsp. *monogyna*
Argyrolobium bieberstenii Ball.
Hypericum calycinum L.
Lathyrus laxiflorus (Desf.) O. Kuntze subsp. *laxiflorus*
Thymus longicaulis C. Koch subsp. *longicaulis*
Euphorbia stricta L.
Poa bulbosa L.

Forest vegetation

The *Juniperus excelsa* community

Juniperus foeditissima Willd.
Jasminum fruticans L.
Cistus creticus L.
Lonicera etrusca Santi
Teucrium chamaedrys L. subsp. *chamaedrys*
Psorealea bituminosa L.
Holosteum umbellatum L.
Torilis leptophylla (L.) Reichb.

The *Pinus nigra* subsp. *pallasiana* community

Pinus nigra Arn. subsp. *pallasiana* (Lamb.) Holmboe

Cistus laurifolius L.

Colutea cilicica Boiss. and Ball.

Dryopteris felix-mas (L.) Schott

Stellaria holostea L.

Helleborus orientalis Lam.

Campanula glomerata L. subsp. *hispida* (Witasek) Hayek

Fragaria vesca L.

The *Fagus orientalis* community

Fagus orientalis Lipsky

Coryllus avellana L.

Sambucus ebulus L.

Quercus petraea (Mattuschka) Liebl. var. *iberica* (Steven ex Bieb.) Krassiln.

Trachystemon orientalis (L.) G. Don

Galium rotundifolium L.

Campanula rapunculoides L. subsp. *cordifolia* (C. Koch) Damboldt

Lathyrus aureus (Stev.) Brandza

Cardamine bulbifera (L.) Crantz

The *Abies nordmanniana* subsp. *bornmuelleriana* community

Abies nordmanniana (Stev.) Spach subsp. *bornmuelleriana* (Mattf.) Coode and Cullen

Carpinus betulus L.

Fagus orientalis Lipsky

Pinus sylvestris L.

Ilex colchica Polj.

Salvia forskahlei L.

Cardamine bulbifera (L.) Crantz

Epilobium montanum L.

By using Remote Sensing satellite images of a resolution value of 30 x 30 m, the plant community's reflection values have been determined. These reflection values are given in the Table.

In this study, it can be seen that the *Pinus nigra* subsp. *pallasiana*, *Quercus pubescens*, and *Quercus cerris* var. *cerris* plant communities can be clearly determined. The reason for the ease of the determination of these communities can be explained as follows:

Table: Characteristic reflection values of plant communities

Plant community	Reflection Value
Pinus nigra subsp. pallasiana	96-159
Fagus orientalis	170-211
Quercus pubescens Quercus cerris var. cerris	17-64
Abies nordmanniana subsp. bornmuelleriana	101-135

Fagus orientalis and *Abies nordmanniana* subsp. *bornmuelleriana* are located in mixed from in transition zones in the north-western highland regions. Because the *Abies nordmanniana* subsp. *bornmuelleriana* is needle-leaved and the *Fagus orientalis* is broad-leaved, they were sensed in the satellite images in a heterogenous structure.

The coverage ratios of dominant plant communities in the research area were as follows: *Fagus orientalis*, 92%; *Pinus nigra* subsp. *pallasiana*, 73%; *Quercus pubescens* and *Quercus cerris* var. *cerris*, 55%.

As the *Quercus pubescens* and *Quercus cerris* var. *cerris* plant communities are similar in their physyonomic structure and are located close to each other, the reflection value that they each give is the same. That is why there is one area specified for *Quercus* L. communities in general.

Within the investigation area, *Pinus nigra* subsp. *pallasiana* and *Fagus orientalis* make up the largest coverage and distribution area. Consequently, their cut-off borders could be specifically identified.

In differentiating plant communities, leaf characteristics play an important role because it determines and affects the reflection value. It has been emphasized that needle-leaved and broad-leaved plants can be easily differentiated.

Juniperus excelsa L., being located in low and high mountain steppes, *Cistus laurifolius* L. gains a dominant status in areas where *Pinus nigra* subsp. *pallasiana* has been destroyed and having a low coverage ratio in the area, does not reflect a dense distribution. That is why it has not been feasible to differentiate this plant via 30 x 30 resolution satellite imaging.

In areas where *Abies nordmanniana* subsp. *bornmuelleriana* is located homogeneously, the reflection values of *Pinus nigra* subsp. *pallasiana* interfere with the satellite images because *Pinus nigr*a subsp. *pallasiana* covers the reflection value of *Abies nordmanniana* subsp. *bornmuelleriana*. Although these communities have similar reflection values, they can be differentiated by locating layer altitudes. However, with the support of area investigations, these drawbacks could be eliminated.

Results

All needle-like and broad-leaved plant species were determined in the area. *Pinus nigra* subsp. *pallasiana*, *Fagus orientalis*, and *Quercus pubescens-Quercus cerris* var. *cerris* communities in the area were identified by using the Remote Sensing Method. *Cistus laurifolius* and *Juniperus excelsa* having a low coverage ratio and narrow distribution in the area could not be determined specifically by the Remote Sensing Method.

By applying a TVI function to the TM4 and TM3 bands, certain plant communities could be specified.

For recognizing the undetermined plant associations, wide-scale aerial photography or satellites with high resolution power having the characteristics for use in the vegetation analyses can be used to describe the plant species of the study area in future (Güleryüz et al., 1998; Arslan et al., 1999).

At the end of the study, the following suggestions can be made:

Using the Remote Rensing Method reduces the cost of the field studies and saves time in vegetation determination and could be suggested as a means of study especially with larger areas. However, the value of area investigation cannot be underestimated. A similiar study could be carried out in different areas for the same plants to highlight the suitability of the method. For reliability of findings, the results of the satellite imaging should be checked by results of field studies.

These data can be used in monitoring environmental and anthropogenic effects that lead to positive or negative effects in vegetation structure in future.

Acknowledgement

I thank Dr. Aynur Baysal and expert Edward McQuaid, Anadolu University, School of Foreign Languages, for translating and editing the English manuscript. I also want to thank to Prof. Dr. Can Ayday and Metin Altan, Anadolu University Research Institute of Satellite and Space Sciences, for their contributions.

References

Akman Y (1990). *İklim ve Biyoiklim*, Ankara: Palme Yayınları.

Arslan H, Güleryüz G, Gökçeoğlu M, Rehder H (1999). Vegetation Mosaic around the Second Center of Turism Development in the Uludağ Mountain, Bursa-Turkey, *Turk J Bot* 23: 233-239.

Atalay İ (1982). *Türkiye Jeomorfolojisine Giriş*, İzmir: Ege Üniversitesi Sosyal Bilimler Fakültesi Yayınları.

Benedetti P, Rossini P, Taddei R (1994). Vegetation Classification in the Middle Mediterranean Area by Satellite Data, *Int J Remote Sensing* 15(3): 583-596.

Davis PH (1965). *Flora of Turkey and the East Aegean Islands*, Vol. I, Edinburgh: Edinburgh University Press.

Güleryüz G, Arslan H, Gökçeoğlu M, Rehder H (1998). Vegetation Mosaic around the First Center of Turism Development in the Uludağ Mountain, Bursa-Turkey, *Turk J Bot* 22: 317-326.

Meteoroloji Genel Müdürlüğü, (1995). *Meteorolojik Veriler Bülteni*, Ankara.

Okçu D, Yağız E, Maktav D, Aslan Z (1997). Uydu Verileri ile Türkiye'de Bitki Örtüsü Analizi, III. *Uzaktan Algılama ve Türkiye'deki Uygulamaları Seminer Bildiriler Kitabı*, 16-18 Mayıs 1997, Bölüm X, Sf. 45-50, Uludağ-Bursa, Ankara: Tufuab yayınları.

Orman Bakanlığı (1994). *Bilecik Orman İşletme Müdürlüğü*, Orman Amenajman Planları Bülteni.

Schreirer H, Brown S, Schmidt M, Shah P, Shresta B, Nakarami G, Subba K, Wymann S (1994). Gaining Forest but Losing Ground: A GIS Evaluation in Himalayan Watershed, *Environmental Management*, 18(1): 139-150.

Topraksu Genel Müdürlüğü (1983). Bilecik ve Bursa İlleri Toprak Envanter Planları, *Toprak Envanter Planları Bülteni*, Ankara.

Türe C, Tokur S (2000). The flora of the Forest Series of Yirce-Bürmece-Kömürsu and Muratdere (Bilecik-Bursa, Turkey), *Turk J Bot* 24:47-66.

Yıldırım H, Alparslan E, Aydöner C, Elitaş S (1997). Bitki Örtüsü ve Yoğunluğunun Uzaktan Algılama ile Bulunması, *III. Uzaktan Algılama ve Türkiye'deki Uygulamaları Seminer Bildiriler Kitabı*, 16-18 Mayıs 1997, Bölüm X, Sf. 22-26, Uludağ-Bursa, Ankara: Tufuab yayınları.