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A methodical approach to the mapping of biotope types by using GIS based remote sensing techniques (Köprülü Kanyon National Park Case / Turkey)

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Abstract

The objectives of nature conservation focused on the protection of selected animal and plant species and individual ecosystems through conservation. The basic components of nature conservation are flora and fauna including their habitats, biodiversity, performance and functionality of the natural environment. These can be directly linked to the goals for ecosystem, species and biotope protection. The main objective of this study is the development of an efficient nation-wide procedure for biotope type mapping. This requires the methodical development of a systematic biotope type mapping. In preparation an exemplary region was chosen the Köprülü Canyon National Park, which covers an area of 35,672.72 ha, The biotope types in the area were recorded, classified and mapped using GIS-supported remote sensed technology. Methods of digital classification were utilized in determining forest types and maquis. The remotely acquired information and the classes had to be combined with other information in order to be processed via GIS. The analysis and evaluation using GIS was the basis for establishing the biotope types. The GIS analysis served to place the polygon and object classes which were classified by visual or digital image evaluation on the biotope type layer. Thus the biotope type layer is a final layer for all biotope-forming shape files that serves the transferring of adjoining polygon classes. The biotopes were classified by coding the homogenous biotope surfaces according to their characteristics. This made it possible to address the biotope types via their properties in various hierarchical levels. The typification and description of biotopes achieved through hierarchic classification. Thereafter, the biotope types were presented as a list together with their descriptions, which contained information used during classification. The characteristics for classification are distinguished by hierarchical level which entails a discreet description of the particularities and characteristics. The biotope types were mapped for each layer in a hierarchical level.

Keywords: Biotop types, mapping, GIS, Remote Sensing, Turkey

Introduction

The basic components of nature conservation are "flora and fauna including their habitats and habitats in the aspect of biodiversity" and "performance and functionality of the natural environment". These can be directly linked to the goals for ecosystem, species and biotope protection. Initially, the tasks and objectives of nature conservation focused on the protection of selected animal and plant species and individual ecosystems through conservation and conservation strategies (Erz 1980, Plachter 1991). The tasks of nature conservation in new approaches were no longer described as merely conventional, conservative and protective, but also as preservative and planned-formative. Such approaches have been

published in terms of country level (Deixler 1982) and forest biotope mapping (Ammer and Utschik 1982). This required a broader definition of nature conservation. It was from Plachter (1991) formulated as follows: "All measures for the conservation and aid of plants and animals of wild species, their communities and natural livelihoods as well as for protecting landscapes and landscape parts under natural conditions". According to Plachter (1991), with biotope mapping has been provided for the first time a thorough overview of the existence and condition of certain biotope types in Germany. This initial biotope mapping indicated the status and distribution of the most valuable and vulnerable habitats, and as a result, a regionalized evaluation was carried out to derive differentiated protection and development objectives. In recent years, biotope mapping has no longer concentrated solely on natural or semi-natural habitats, but also on the systematic inventory of semi-natural or land-use cultural landscapes serving a purpose-based integrated nature conservation. The mapping of the biotope types allows a nature conservation evaluation of the Wildlife habitats as a planning basis for habitat protection. The protection of biotopes is a central task of nature conservation, which results from the synthesis between the two fields of species and site protection (Erz 1980), Thereafter, the preservation and development of life opportunities for the flora and fauna throughout the landscape (from the natural to the urban and industrial landscape) must be ensured. The term of biotope in this definition is usually not strictly used in the sense of ecology as "habitat of a biocenosis of a certain minimum size and uniformly distinguishable from its environment", but according to Erz (1980) more or less in the sense of the location term as "the totality of the environmental factors acting on the place of residence of an organism". By mapping the biotopes, a sufficiently flexible database can be provided for the needs of the specific conservation plans relevant to nature conservation in order to fulfill legal mandates (Hmuelv 1995). The fields of application of biotope maps are distinguished on the basis of the methodological procedures for mapping the biotopes from a nature conservation point of view. It is important to mention three practical procedures for detecting biotope types:

a) The selective biotope mapping, which includes a targeted collection of protected or legally protected biotopes and forms the basis for (Lanuv 1982, Drachenfels 1993, Ssymank et al. 1993, Hmuelv 1995, Knickrehm and Rommel 1995, Lua 2002):

- the collection of the protected or legally protected biotopes of the countries

- the designation of valuable nature conservation areas

- the preparation of decisions on protected area designations and the Development of protected area systems and their monitoring in the context of the implementation of the Habitats Directive

b) Representative biotope mapping is based on a selective or area-wide biotope mapping and provides a more detailed picture of this through studies on the flora, vegetation or fauna and on site and habitat qualities on selected test areas in a random sampling theory (Hondong, 2002). Representative biotope mapping is used in urban biotope mapping, conservation and development planning for protected areas, landscape and landscape planning, conservation projects and in the context of EIA and Environmental Impact Assessment projects (Hondong 2002, Wächter 2003).

c) In the comprehensive biotope mapping all landscape components of a study area are completely assigned to a specific biotope type (Knickrehm and Rommel 1995), without first determining what is to be regarded as protection required (Lanuv 1982). The comprehensive biotope type maps are a complete survey of all biotope types in a processing area and are mostly used as the basis for the creation of ecological contributions to landscape- and site development plans, the development and implementation of a comprehensive conservation area system of graded intensity (as an inventory system with regard to the conservation and monitoring of biological diversity), the assessment of interventions in the context

of environmental impact studies and the regional and national red list of endangered biotope types (Drachenfels 1993, Ssymank et al. 1993, Knickrehm and Rommel 1995, Hondong 2002, Lua 2002):

According to Bastian (1997), nationwide biotope mapping provides the value-determining criteria for the assessment of landscape functions with regard to their habitat functions. The comprehensive biotope mapping, which is realized through a uniform survey and assessment of all natural and cultural habitats, has a great importance for the creation and implementation of regional and national species and biotope protection programs (Plachter 1989, Erz 1994), the Red List biotopes (Ssymank et al. 1993, Riecken et al. 1994, Drachenfels 1993), the biotope network (Jedicke 1990) and the integrated protected area system (German Councıl for Landespflege 1983), landscape and intervention planning (Knickrehm and Rommel 1995, Brinkmann 1997, Ott 1997). An another requirement placed on biotope mapping is the consideration of the hierarchical arrangement of the organizational levels of living beings. This results in a gradation of differently complex habitats, which must correspond to the respective organizational levels of life. When typing biotopes it is therefore important to consider this hierarchy (Haeupler 2002). Finally, biotope type indexes or mapping keys that are created nationwide or used for large-scale planning of the landscape units must be available as a standardized type formation in a hierarchically uniform structure (Ssymank et al. 1993, BfN 1995, Knickrehm and Rommel 1995, Lua Brandenburg 2004), while a distinction or treatment of regionally and locally important biotopes is to be respected.

Although the mapping of the biotopes in Turkey as a planning tool for nature conservation-oriented tasks finds no place, it was carried out as part of scientific research and externally funded projects exemplified. It can be differentiated in urban and rural areas. The first biotope mapping in the urban area was carried out in the city of İzmir (Köseoğlu 1981 and 1983, Yılmaz 1986). The first biotope maps, which were created in the rural area, are from Uzun et al. (1995) and Altan et al. (2001) in the Çukurova region. There are need new strategies, working methods and instruments based on nature conservation according to Turkey's species-specific and habitat-typical richness. They should primarily enable the planning and management of protected areas based on the biological, geo-ecological and socio-economic conditions of the country. The main objective of this study is the conception of a nationwide efficient procedure for biotope mapping. The main content of the study consists in the development of a nationwide systematic inventory and exemplary mapping of the biotopes in a protected area.

Material and Methods

Site Properties

The study area covers 35,672.72 ha. The area belongs to the counties of Manavgat (about 30,000 ha) with the provincial town of Antalya and Sütcüler (about 5,000 ha) with the provincial town of Isparta. It was declared to the National Park "Köprülü Kanyon" in 1973. The area is located about 90 km northeast of the city of Antalya in the western part of the Taurian mountain range in southern Anatolia, where the Köprü Çayı (river) forms a basin from north to south into the Mediterranean Sea. The study area is located in the central area of Köprü Irmağı Valley (Fig. 1).

Methods

Procedures for data collection and analysis

The determination of biotope properties is an important step in the identification of biotope types. The characteristic values for the identification of the biotope and land use types in the study area were determined by the analogue and digital processing of the data sources (Fig. 2) The analogue data was divided into printed maps, bibliographical references and authorities. The characteristic values for the identification of the biotope and land use types in the study area were determined by the analog and

digital processing of the data sources. A procedure has been developed to develop data collection and processing methods for the comprehensive mapping of biotopes (Fig. 3)

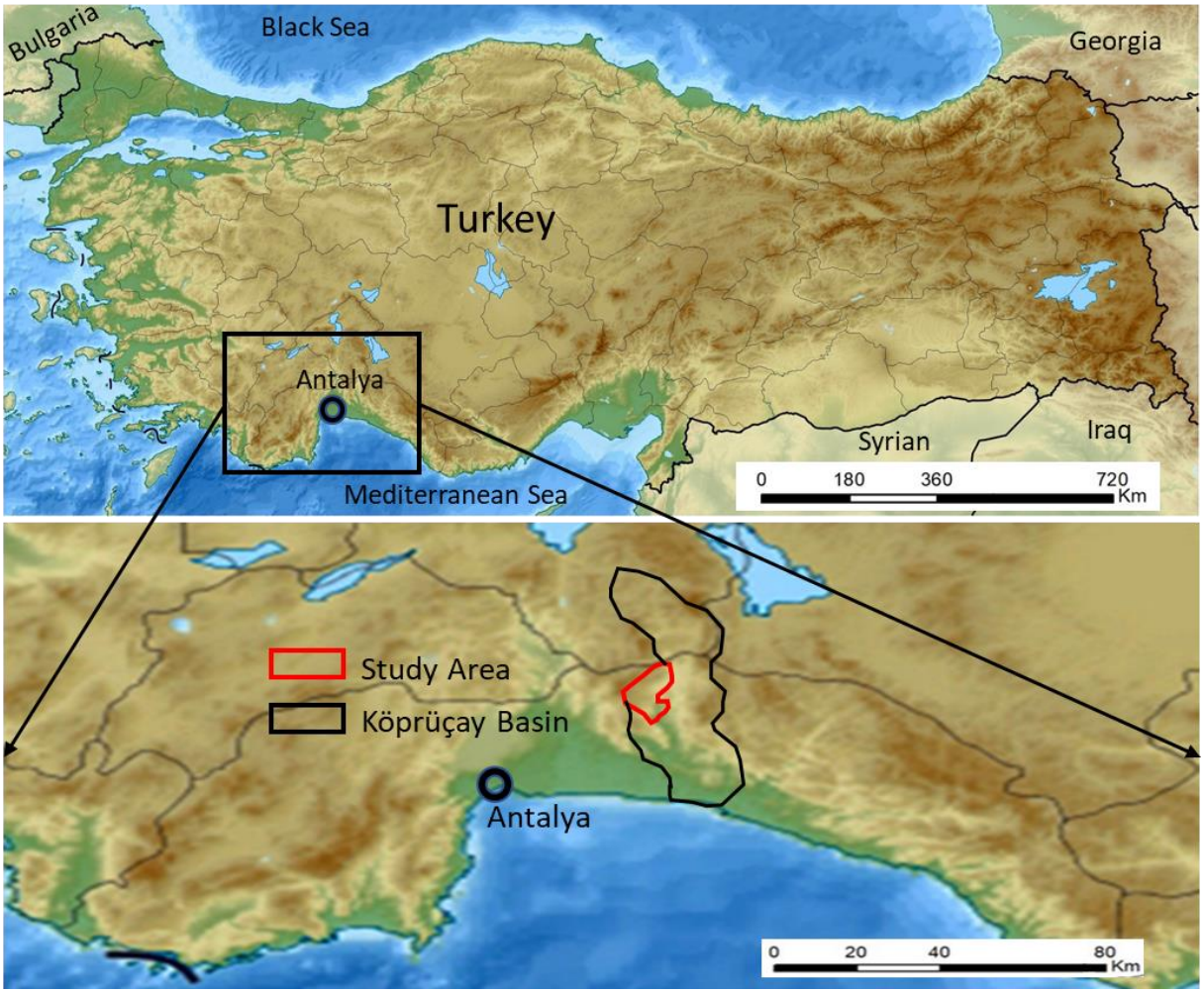

Figure 1. Location of study area

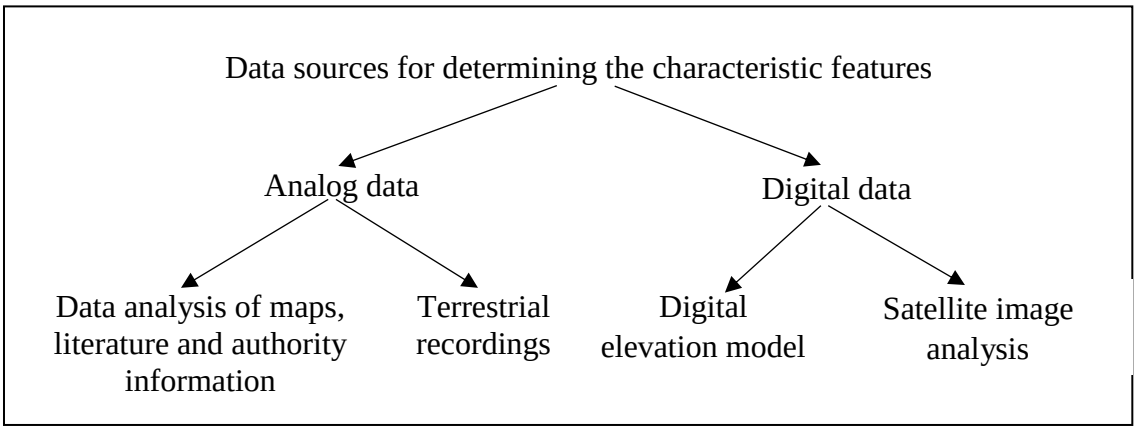

Figure 2. Data collection for the characteristics of the biotopes

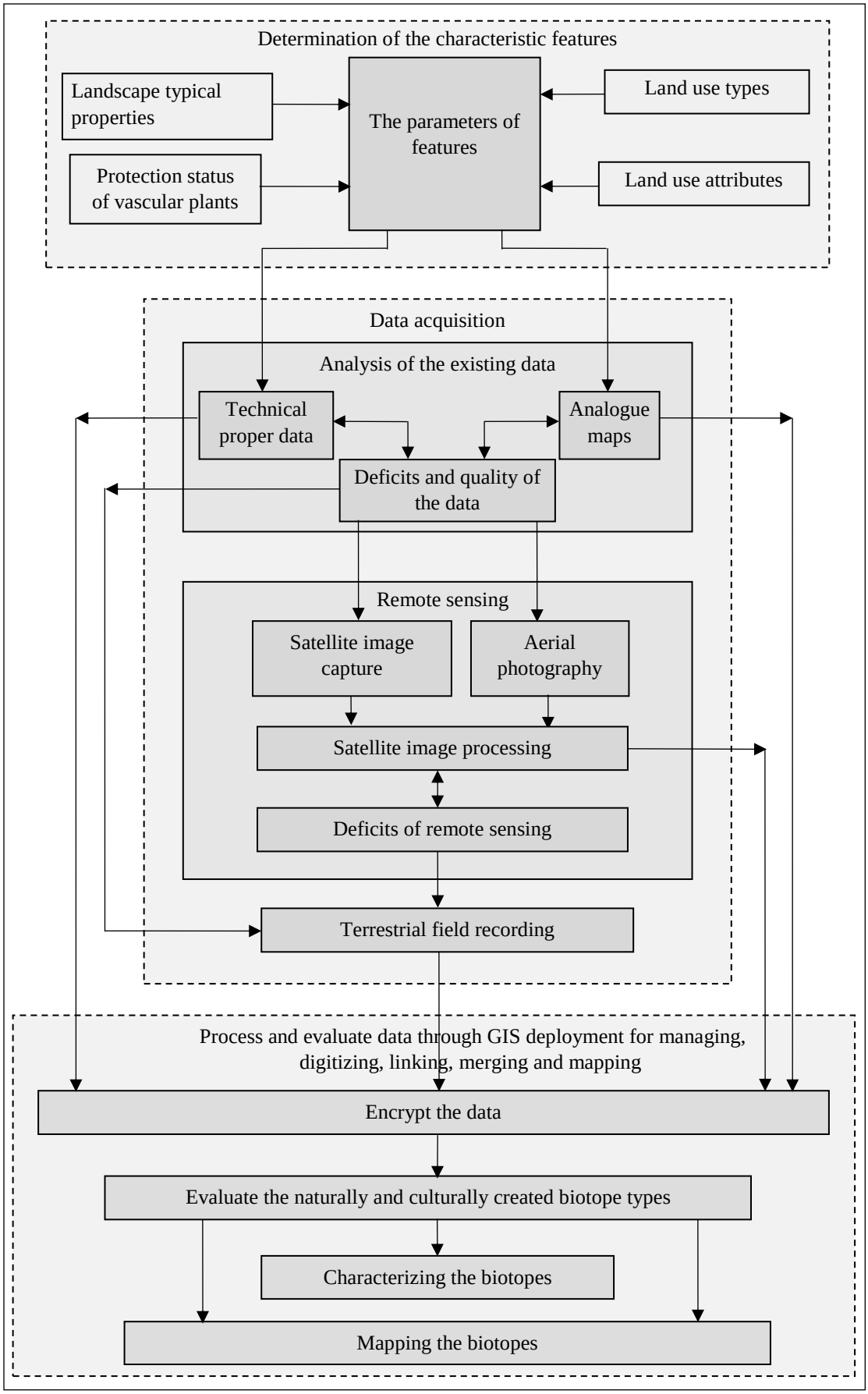

Figure 3. Procedure for recording biotope types

Assessment of the vegetation and land use properties

The vegetation characteristics for ecology and vegetation distribution, phytosociological and physiognomic characteristics and human influence provided the data for the characterization of biotope characteristics with regard to vegetation expression and land use. In addition, the vegetation types described in vegetation tables and their species were used to identify the biotopes (as a sample class of vegetation). Ayaşlıgil (1987) 's vegetation survey was used to obtain this information. The data on stratification, species-specificity and sociability of individual species were compared with location of characteristics such as slope, exposure and altitude as well as the bedrock and degree of vegetation in order to determine the spatial differentiation of characteristic plant species in the biotopes. The studies published by Kantarcı (1982 and 1990) on the relationship between the distribution of natural tree and shrub species and the regional site characteristics of the Turkish Mediterranean provided important information for the site identification of the biotopes. From the forest inventory maps, the data on the tree species composition, the degree of cover, the layering and stock development phase as well as the distribution of the tree species for the characterization of the forest biotopes are obtained. From these data, especially the tree species composition, the degree of cover and the distribution of the tree species were used as additional data in the evaluation of the satellite imagery. The rock types were digitized from the geological map (MTA 1995) to be used as a layer for classification. The significance of determining the types of land use for this study lies in distinguishing the natural given from the man-made structures of the landscape (Walz et al. 2001) and spatially delineating and typifying the land uses that occur. Only then can the naturally and culturally created structure of the landscape be comprehensively recorded on the basis of the biotope type mapping and the human influence with its consequences on the landscape elements and the structuring of the landscapes recognized. For the impact of human impact on the landscape, land use attributes are used to identify land use types.

Encryption of the homogeneous feature classes

The coding of the biotope types follows the hierarchical classification system and translates this into a numerical code. This gives the properties relevant to the biotope type at the various hierarchy levels. The goal of encryption of the biotope types is to record the hierarchical assignment category of landscape units at the various levels. The biotopes are encoded by the plane-by-plane homogeneity of their specific properties, which is a characteristic that is clearly different from others. Each level has a special significance for the labeling of biotope types. It was planned to limit the level number, because otherwise the classification into the sublevels will make it too confusing. Encryption has only formed three levels so far, but the encryption concept provides four or five levels to allow further differentiation where needed (Fig. 4).

Data preparation and processing using remote sensing techniques

To collect and analyse of data was used remote sensing and GIS techniques. Remote sensing played an important role in the storing of extensive area information. The results of the satellite image analysis were used to address vegetation types. The topographical map sheets on a scale of 1:25000 standard topographic maps of Turkey, produced by the General Directorate of Mapping for Turkey and with the geodetic reference system (UTM 1950 ED) are georeferenced according to the geodetic projection of the IKONOS 2 (geometrically corrected one frame, Pan+MSI 4 channel image type, acquisition Date/Time: 2003-06-13 08:59 GMT, pixel resolution 1 m) satellite imagery (UTM WGS 1984). Subsequently, they were used as a basis for the map applications of vegetation, geology and forest stands as well as for the geocoding of the GCP (Ground Control Points) for referencing the objects from IKONOS satellite images. In addition to satellite imagery, the 1/15000 CIR aerial imagery available was

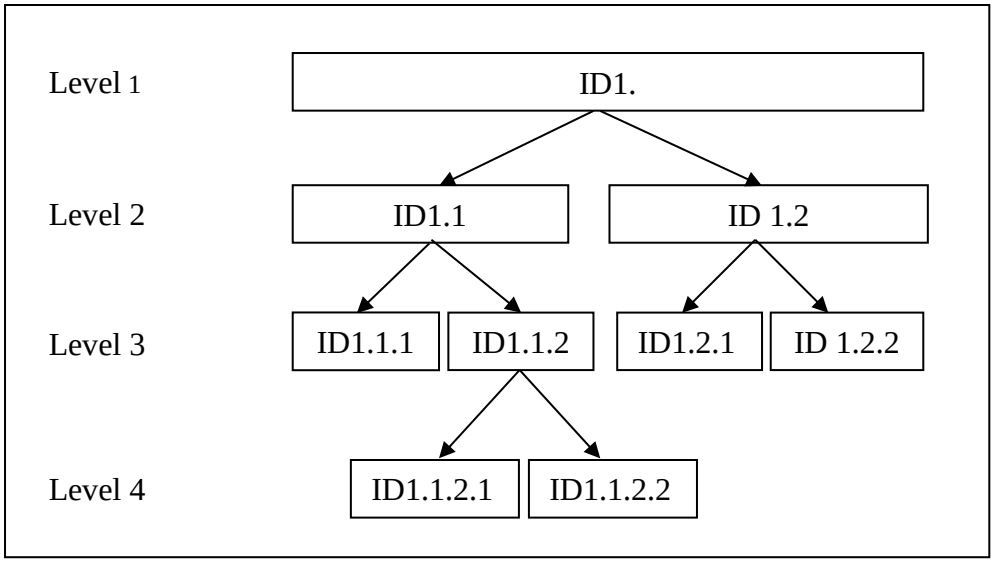

Figure 4. Encryption of biotope types in a hierarchical classification system

used for visual interpretation to identify forest tree species. The digital data was derived from the digital elevation map and the satellite image interpretation. The data basis for creating a digital elevation model were the files in e00. ARC/INFO coverage formats on a scale of 1/25000. Parameters such as slope, exposure, altitude classification and large-scale relief shapes were generated from the digital elevation model. The areas for the vegetation units and land use types were obtained by applying the digital image analysis methods. The terrestrial methods were mainly used to eliminate uncertainties or to increase the quality of remote sensing data. The content and methods of terrestrial recording are determined by the quality of the IKONOS images.

Using GIS in the hierarchical classification of the biotope types

The feature classes obtained by evaluating the image data were used in GIS together with other data for the characterization and classification of the biotope types. The role of GIS was very important in classifying the biotopes, using various software tools for operations or implementations such as converting, exporting, importing, storing, editing, querying, intersecting, georeferencing, selecting, extracting and mapping the data. A digital elevation model was created in grid cells. This was important for the site-morphology-related local features and further in the coding and typing of the biotope types. The advanced GIS analyses used to transfer of homogeneously characterized feature classes, encryption of homogeneous feature classes, hierarchical classification of encrypted biotope types. The determination of the biotope properties by using GIS serves both to distinguish homogeneous units which are characterized by certain features or feature groups, and to develop a classification system which follows a hierarchical arrangement of the homogeneous units at different levels. These features must be coded according to the GIS data foundation. The classification of the biotopes follows a hierarchical demarcation and classification of homogeneous spatial units with regard to different characteristic values of the respective biotope type (Fig. 5).

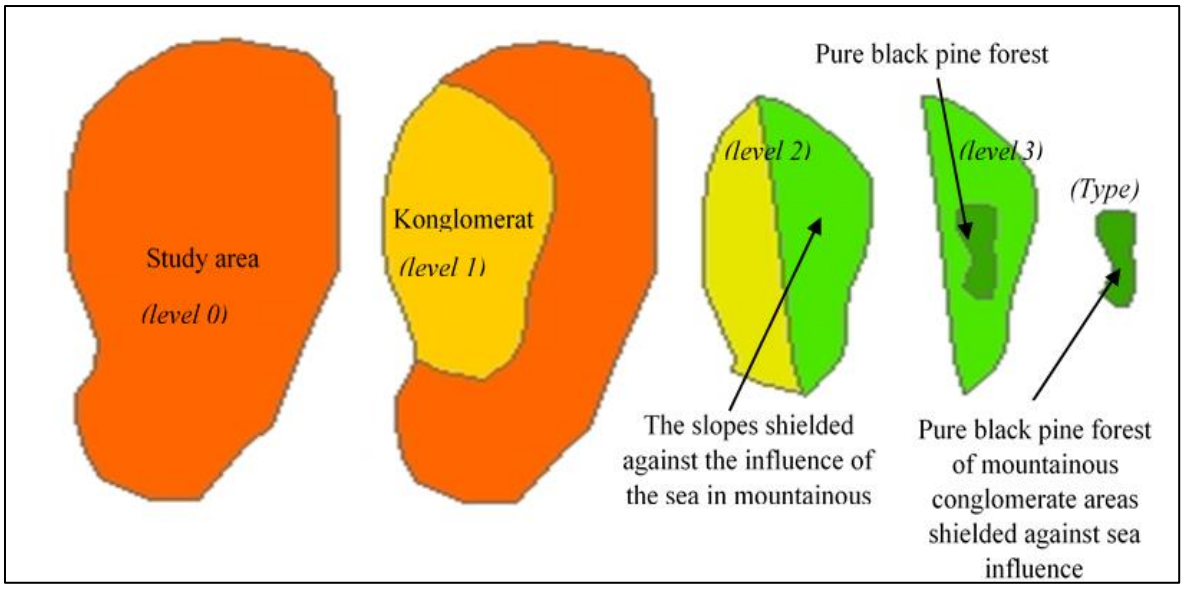

Figure 5. Exemplary representation for the GIS classification and typing of the biotopes in the study area

Data collection and analysis using remote sensing and GIS techniques

The topographical map sheets on a scale of 1 / 25000 and with the geodetic reference system (UTM 1950 ED) are geo-referenced according to the geodetic projection of the IKONOS satellite images into the geodetic projection UTM WGS 1984. Subsequently, they were used as a basis for the map applications of vegetation, geology and forest stands as well as for the geocoding of the GCP (Ground Control Points) for the referencing of objects from IKONOS satellite imagery. In addition to these satellite imagery, the 1/15000 CIR aerial imagery available was used for the visual interpretation of some objects taken for the identification of forest tree species. The digital data was derived from the digital elevation maps and the satellite image processing. Parameters such as slope, exposure, altitude and large-scale relief forms were generated from the digital elevation model. The areas for the vegetation units and land use types were obtained by applying the digital image analysis methods.

Results

The following biotope properties were determined by data collection and analysis method including satellite imagery analysis and GIS techniques (Table 1).

Vegetation units and their bioclimatic characteristics in relation to the altitude levels determined for the study area which was important to characterise the special features for individual vegetation types (Table 2).

Remote sensing techniques have been used intensively in the separation of forest types. One of the techniques applied for this is to distinguish the spectral reflectance values of tree species (Fig. 6). Supervised and unsupervised classification techniques are frequently used in forest areas where forest types cannot be visually classified (Fig. 7). ISODATA-Clusteranalyse was used for uncontrolled classification. Depending on the density of the vegetation, the areas were cut from the image. 15 classes and 20 iteration are used for each cutted image. A supervised classification was performed for all objects that could not be assigned to any class by ISODATA cluster analysis. Such classes have been classified used to the maximum likelihood classifier by spectral signature analysis. The visual interpretation was performed by the scale changes and band changes. Accuracy assesment procedures were applied to test the accuracy of these classifications (Fig. 8).

Table 1. List of determined biotope properties

Characterized features	Classes
Land uses	afforestation, utilization of wood, grazing, forest fire, recreation, tourism, dry crop cultivation, irrigated field crops, fallow fields, traffic circulations, residential areas, others
Frequency of encroachments by land usages	regularly, irregularly, not any
Daily usage time	permanently, only by day, only in the evening/at night
Yearly usage time	permanently, seasonally
Accessibility	good, moderate, low, none
Special features for individual vegetation types	Forest (pure coniferous or deciduous, mixed coniferous or deciduous, mixed deciduous and coniferous forest, mixed coniferous and sclerophyllus shrubs, mixed deciduous and sclerophyllus shrubs, mixed deciduous and coniferous forest with sclerophyllus shrubs) Woody plants (shrubs and dwarf shrubs) Montane to subalpine xeromorphic open dwarf shrublands and grasslands in the mountains (montan and subalpin, moist or dry) Riparian vegetation (river, stream, siltation areas) Cleft vegetation (mediterranean, montane, high montane-subalpine), Areas degraded by rural uses (abandoned farmland, burnt areas, lands degraded by deforestation, by overgrazing degraded areas, strong to very strongly or little to moderately eutrophicated areas, intervened very strongly, strongly, moderately and little) Agricultural land (cereals, vegetable growing, fruit production, mixed cultivation, non-wood products, beekeeping, carob, thyme, sweet chestnut) Settlements and streets (village, hamlet, massive use, single or group use, continuous use, discontinued use, official use, two or one lanes and traffic-tight or low)
Characteristic plant species	Coding of the characteristic plant groups, for example: 182 *Pinus brutia* and *Glycyrrhiza asymmetrica* formation
Canopy closure degree	closed %70-100, half closed %40-70, light closed %10-40, open %0-10
Canopy closure degree of the shrub layer	closed %70-100, half closed %40-70, light closed %10-40, open %0-10
Layering of the vegetation	two or more, one, not layered
Other features of the vegetation	rich in lying and standing deadwood, rich in young growth, rich in herbs, rich in chasmophytes, geophytes, thermophytes, rich in anthropogenic plant species, rich in fire sensitive species, rich in shrub and herbaceous species, rich in tree and wood species.
Climate zone of plant society	*Oleo-Ceratonion* Zone: hot and rainy winters *Quercion calliprini* zone: mild and rainy winter *Querco-Cedretalia libani* zone: cold to very cold and moderately rainy winter *Astragalus Brometea* Zone: cool to frosty, winter with little rainfall
Stand development phase	Older, young, mixed
Structure of the surface	uncovered soils, soils and loose gravel and debris, mostly stones and gravel, partly soils, mostly loosened blocks, partly with gravel and soil, rough stones, Boulders and rock wall, rockfill
Rock formation	Holocene deposits in valleys and polders, sedimentary areas, Beşkonak Formation, Köprüçay Conglomerate, Mesozoic-Old Tertiary Formations, Radiolarites and Upper Triassic Sandstones
Geologically and geomorphologically important areas	Valleys (canyon- and deep-shaped, inliers), karst forms (poljen, sinkholes, barrow), half karst formations, cirques, snow erosion pans, firn patch)
Slope classes	plane, slightly inclined, moderately inclined, inclined, strongly inclined, steep, very steep
Slope exposure	plane, north, east, south and west exposed
Waters	perennial, periodic, standing, spring, gravel and sand banks in the flooded bank area

Table 2. Vegetation units of the study area and their bioclimatic characteristics in relation to the altitude levels

	Vegetation units	Altitude (m.)	Bioclimatic characteristics
	Astragalo-Brometea	2500 m	Mediterranean-subalpine / high-montane vegetation stage, with cool to frost-rich and rain-poor winter
	Querco-Cedretalia libani	2000/2100 m	Mediterranean-montane vegetation, with cold to very cold and rainy winter
Quercetalia ilicis	*Quercion calliprini*	1100/1250 m	Upper Mediterranean vegetation with temperate and rainy winter
	Quercion calliprini	500/600 m	Meso-Mediterranean vegetation with warm / mild and rainy winter
	Oleo-Ceratonion	200/300 m	Thermo-mediterrane Vegetationsstufe mit warmem und regenreichem Winter
	Oleo-Ceratonion	100/110 m	

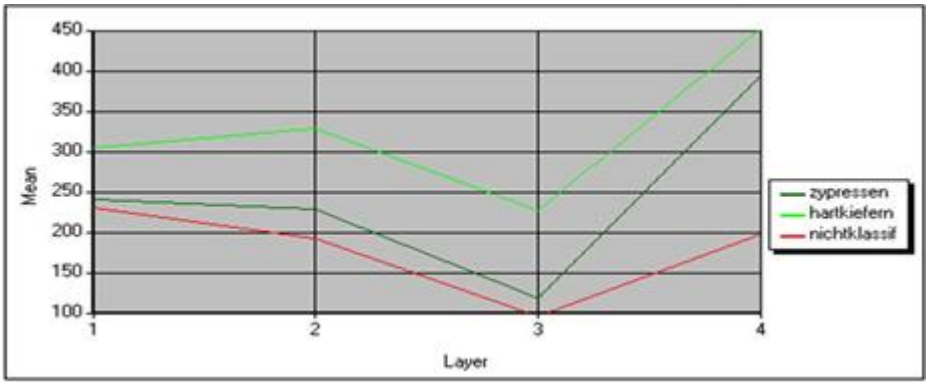

Figure 6. The distribution of spectral signatures of IKONOS images according to tree species (cypress: dark green, Turkish red pine: light green and unclassified: red)

For the coding of the biotope types, a hierarchical subdivision and classification of the biotope types initially classified in the first level was carried out. This required different GIS operations that required a different approach for each characteristic in terms of its raster or vector format. The class-related database attributes had to be prepared before, or after, entered, or transmitted according to the type of operation (→ overlay intersect). The following figures were used to illustrate the hierarchical classification under the level 1 (forests). Here, the layers of characteristics were selectively retrieved after the first-level biotope classes in a new layer and then categorized according to their unique feature classes. By intersecting two vector layers, the result classes were extracted to other new layers. Here in (Fig. 9), the rock types and forests (level 1) are combined in one layer to determine which rock types are important for the area-wide forest distribution. Then the rock types were selected and extracted with the forest types (special features for vegetation) by the clip operation. This marked the forest types that only exist on conglomerate, which is the first step in the classification for level 2.

Then the forest types (special features for vegetation) were selected on this layer. The different types of forest within conglomerate mountain forests have been specified. Therefore, a classification template for forest types still had to be designed. The forest types were selected by the main tree type via characteristic plant species and blended by overlay intersect with the previous layer. Then the pure mountain black pine forests occurring on conglomerate and dry and cold slopes were classified (Fig. 10).

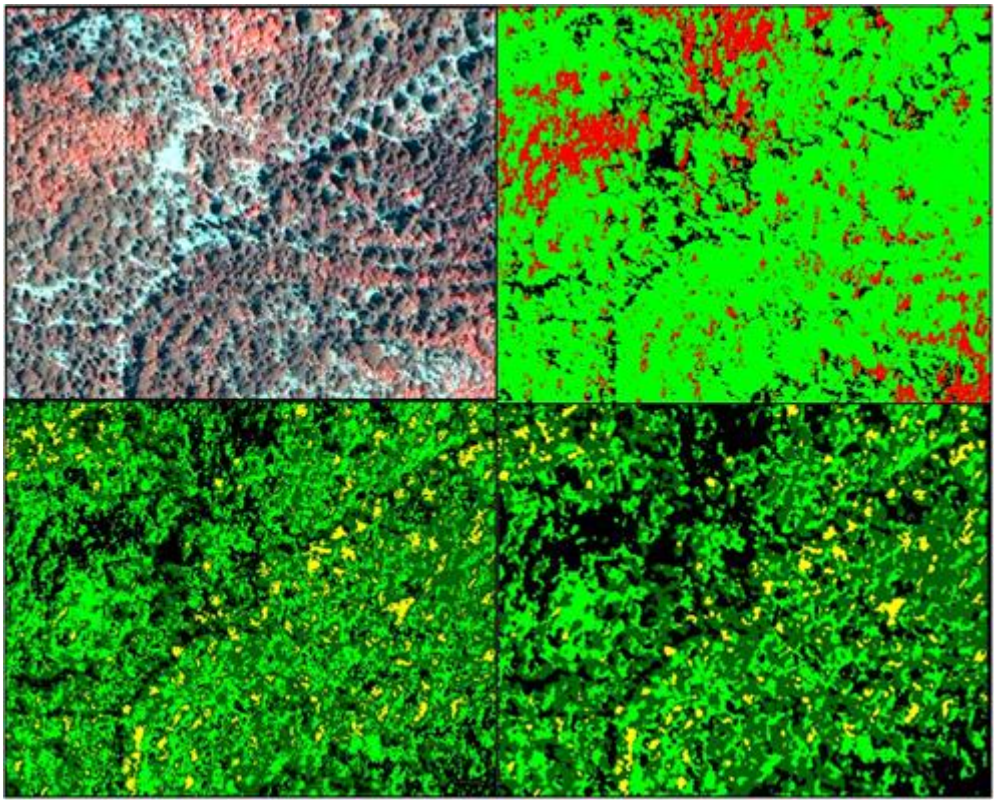

Figure 7. Top left, IKONOS image data in RGB true color representation; top right, the classes of ISODATA cluster analysis; bottom left, results of the Maksimum-Likelihood classification; bottom right, classes related to neighborhood relationships in block structures

CLASSIFICATION ACCURACY ASSESSMENT REPORT

Image File : d:/cumhur/rec101/101_alt/101alt/yeni/ne3recisobtk.img

ACCURACY TOTALS

	Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
1)	Hartkiefern	60	68	57	95.00%	83.82%
2)	HLGebüsche	66	54	50	75.76%	92.59%
3)	HLG-Laubb	21	25	20	95.24%	80.00%
4)	Laubbaum	3	3	3	100.00%	100.00%

	Totals	150	150	130		

Overall Classification Accuracy = 86.67%

----- End of Accuracy Totals -----

Figure 8. The accuracy assessment report for an unsupervised classification (1: Turkish red pine, 2: sclerophyllous bushes, 3: sclerophyllous bushes and deciduous forest, 4: deciduous forest)

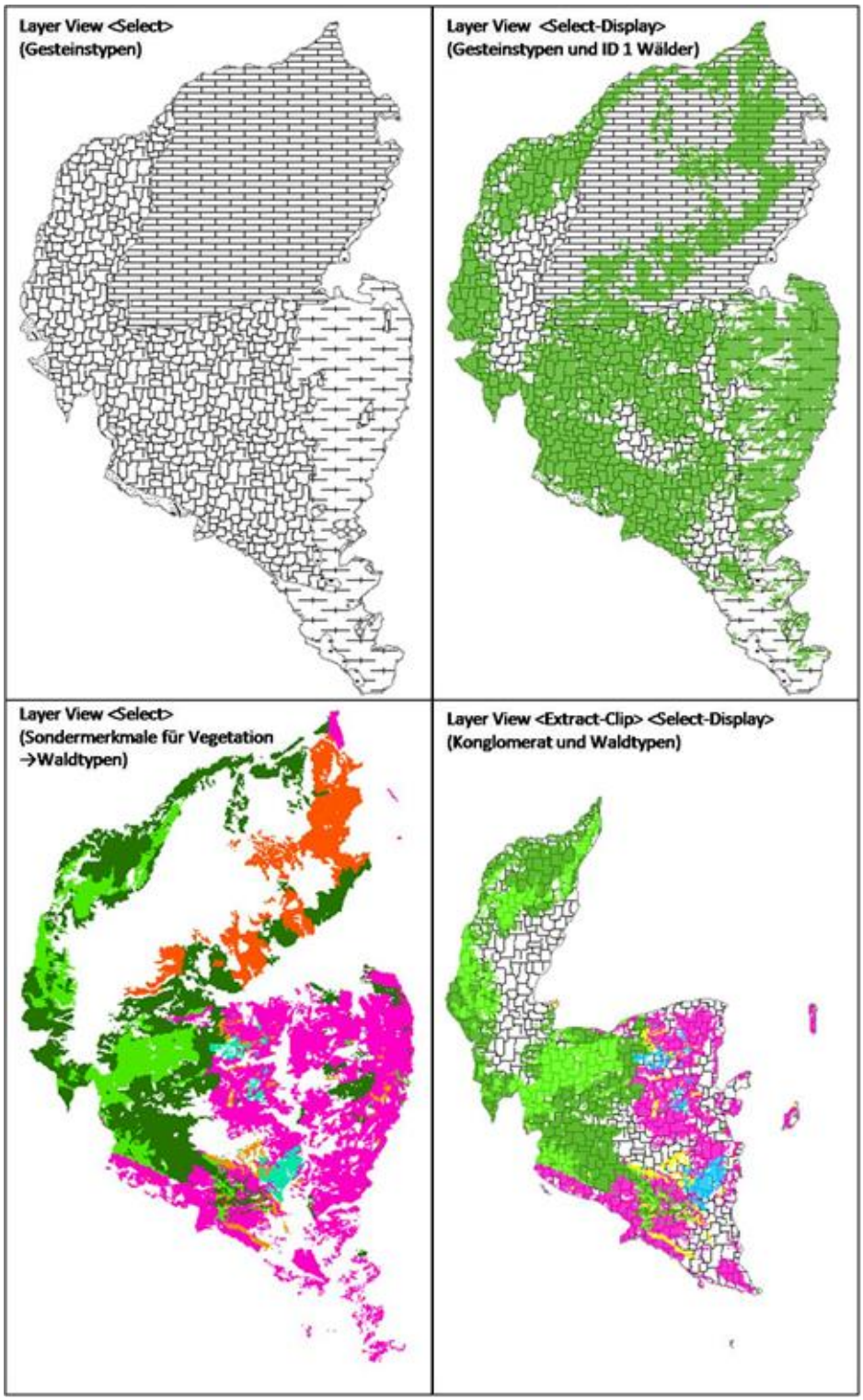

Figure 9. The steps for extracting the forest types of special features for vegetation with rock types

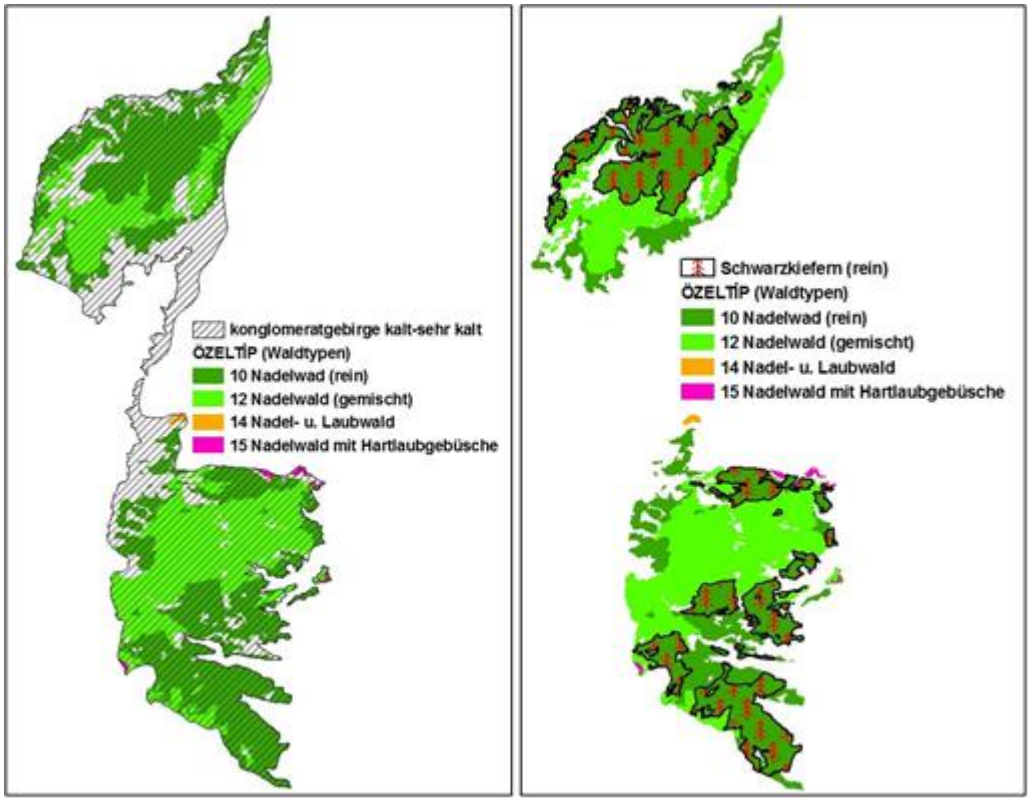

Figure 10. The intersection for the extraction of the conglomerate dry cold mountain forests, on slopes shielded against the influence of the sea (Level 2) and those of the black pine mountain forests (Level 3)

As a result of this study, maps were produced for each level. Eight biotope types were identified at the first level. The number of 3rd level biotop types in level 1 is also shown in (Fig. 11). The total area of the 1st level biotope types are given in (Fig. 12). Thirty-seven biotope types were identified at level 2. A total of 102 different biotope types in level 3 were distinguished in different surface areas. This map shows the all biotope types in the hierarchy at least. The forests were in the first place in terms of number of biotop types and total area size. The mapped all bitope types in level 3 shown in (Fig. 13).

Discussion

The biotope types were classified by coding the homogeneous biotope area based on their characteristic features. There are difficulties on compilation of data on vegetation, topographical land forms and land use becomes very complex. The available data and their informative value must be closely examined with regard to their quality for the determination of biotope properties. The biotope types are classified as the biotope type approach according to hierarchically arranged properties. All characteristic biotope features in the various hierarchical levels were determined in advance. This allows a clear classification and characterization of the biotope types at certain levels by coding the characteristics. The diversity of the characteristic values could be represented by numerous subdivisions of a biotope area into hierarchically classified types, which would otherwise have remained unstructured and unclear. Remote Sensing and GIS techniques are the most important tools for data capturing, analyzing and assessing biotopes. Due to their comprehensive coverage and rapid accessibility of the landscape elements and structures, and their linkability with other data layers by means of GIS are more favorable than field recordings, especially for area-wide biotope mapping. On the other hand it is possible, with the remote

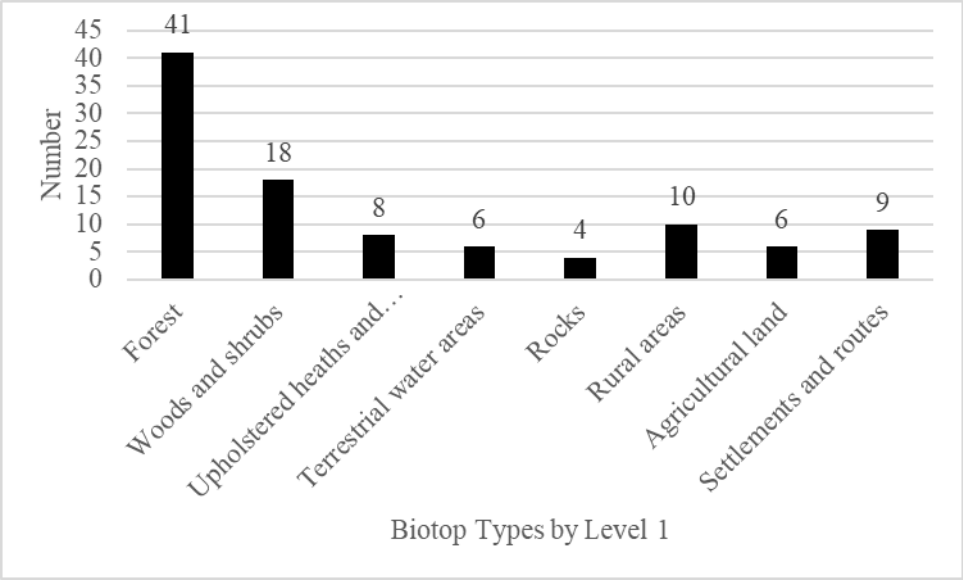

Figure 11. Number of biotope types by Level 1

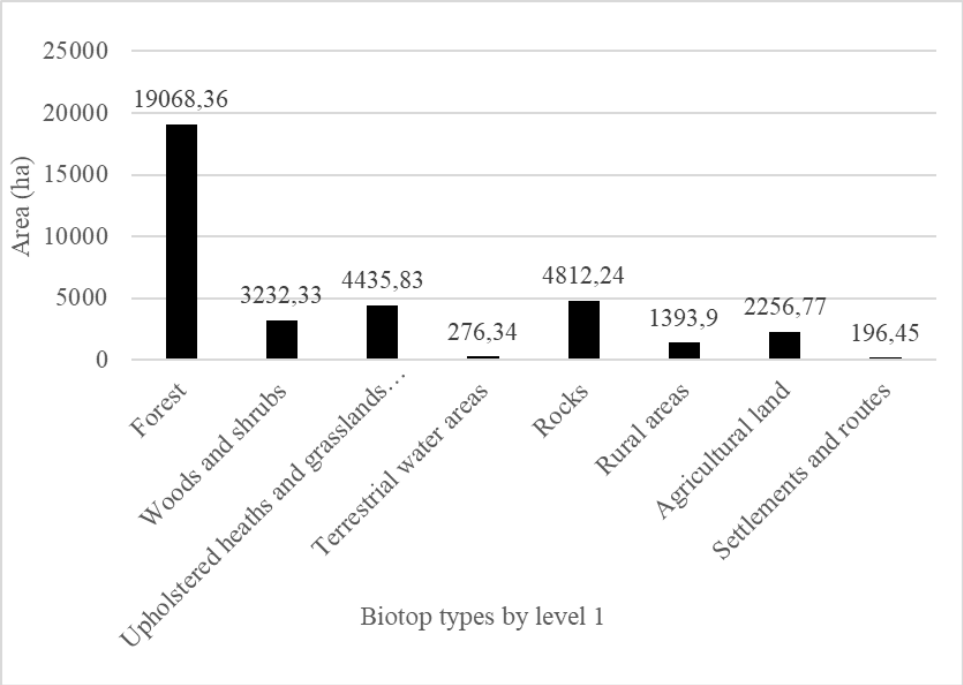

Figure 12. Areal distribution of biotope types by Level 1

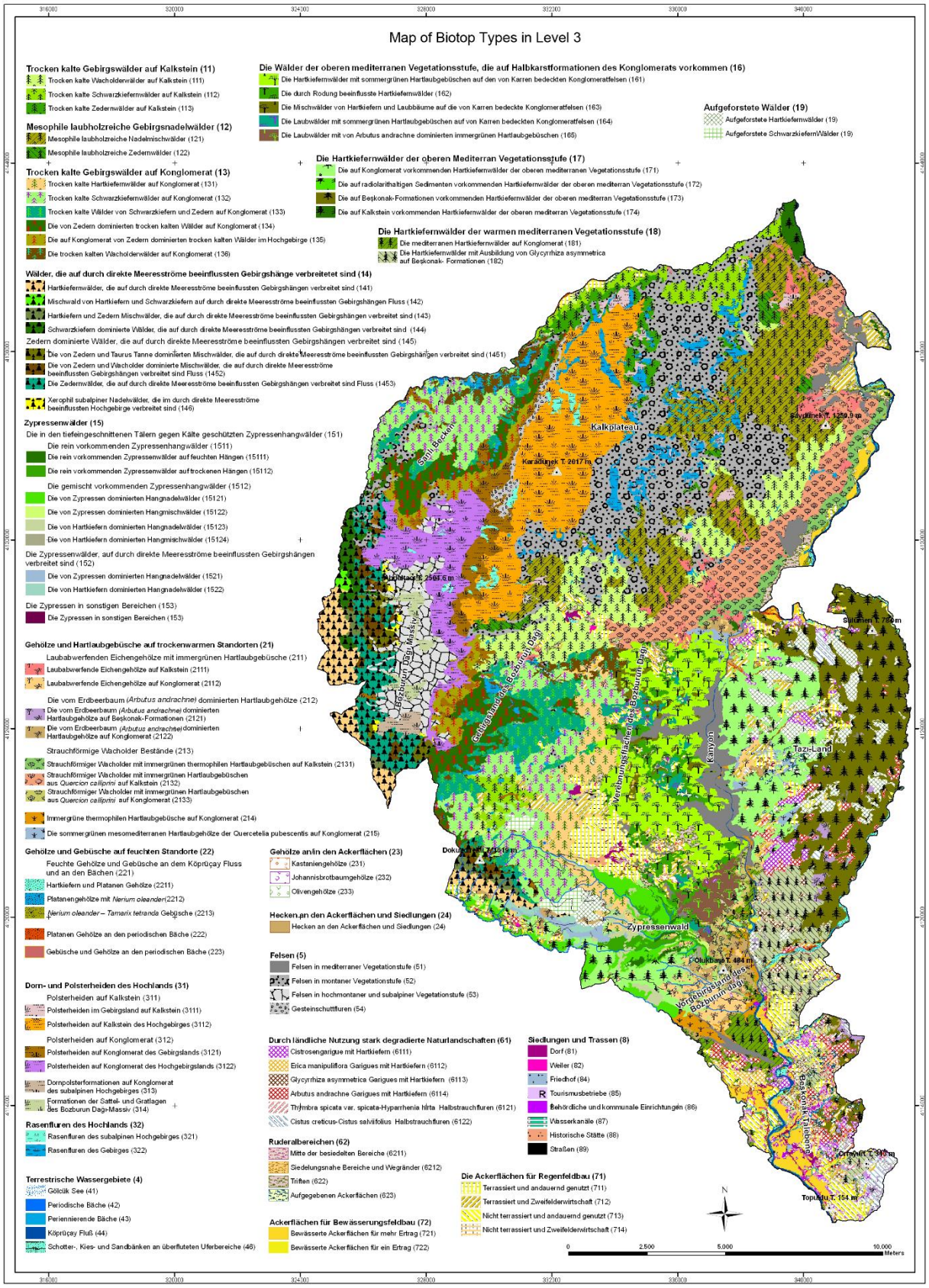

Figure 13. The bitope types of study area

data, to compile a complete collection or supplementation of the data that is essential for the biotope mapping, but in the existing data situation previously missing. The central importance of GIS analysis and assessment for this study lies in the spatial synthesis of properties and features to biotope types. In this study was given the important corner points of biotope mapping for Turkey. Turkey serves its membership negotiations with the EU since 2005. Those negotiations with Turkey are presented each year to the EU progress report. The requirements of biotope mapping in Turkey is reported since 2008. This study is expected to provide a significant contribution to biotope mapping work holds an important place for the protection of Turkey's nature. Mapping of biotope types is particularly important in the protected areas of Turkey.

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