

REMOTE SENSING FOR NATURA 2000 HABITATS - MAPPING AND MONITORING

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ABSTRACT

Scientific studies on natural habitats of Natura 2000 plays an important role in the European Union countries over the last decade. In this connection it is necessary that current and constant spatial data is available to the stakeholders. Such data can be provided by remote sensing, which can achieve accurate and repeatable quantitative and qualitative characteristics of natural habitats. This is necessary for their mapping and it will be useful for their monitoring. The main objective of this study is mapping the biophysical components of selected representative sites of Natura 2000 by using remote sensing data. For the study areas are chosen the protected sites "Dragoman" and "Rayanovtsi" which possess a rich set of biophysical components. In respect with the requirements for regular monitoring of the processes occurring in the protected NATURA 2000 areas it is necessary to track the status of a number of bio-components. This process requires monitoring and mapping of the changes and the bio-components recovering inside the protected areas. For this purpose in the study were applied modern scientific methods in the field of remote sensing classification and segmentation of objects of the land cover such as Geographic Object-Based Image Analysis (GEOBIA). For the monitoring of the spatial changes and the state of the representative test habitats the topographic maps and satellite images from different periods were used. In the presented material will be discussed both opportunities and challenges in the application of remote sensing methods for the area of interest.

Keywords: NATURA2000 MAPPING, GEOBIA, bio-components changes

INTRODUCTION

An indisputable advantage of Satellite technologies is the ability of gathering huge amounts of information that could be useful for the particular case to monitor and to access the conservation status of habitats. On the other hand as the most important advantage of satellite Earth observation when it comes to habitat monitoring, should be considered its capacity to enable temporal or spatial comparisons among different locations [1]. The Earth observation information could be used as a useful instrument for the examination of both structural (distribution) and functional changes (productivity, phenology, etc.) in the Natura 2000 habitats. However, Kalluri et al. (2003) [2], put the accent over the possibility most of the scientists and decision makers to processed and interpreted straightforwardly the data collected from satellites. The overwhelming amount of data to process/analyse on one hand and the inherent complexity of the variables measured on the other hand are serious obstacles to deal with. Such facts make it difficult to create an operational system for assessing habitat functioning. To detect changes of land cover/habitat condition usually relies on supervised processes of change detection, which requires ground reference information, provided from field data, or also by photo interpretation/from prior expert knowledge of the site, necessary for training the classifiers and to validate the results.

The usefulness of EO data for the purposes of biodiversity conservation and environmental management has been marked as an important part of the process by the remote sensing specialists and ecologists in recent years [3]. According to Pettorelli et al.(2014)[4] integration progress between the different specialties seems to be slower than anticipated, and requires focus over coordination between these two research communities in order to develop a common shared terminology, and problem definition. The key to improving the current potential for EO data effectively to support environmental management decisions by providing adequate value added products is to gain the progress of synchronization between different specialties thereby minimizing the effect of the error and subjectivity.

Practice shows that there is a clear need for standardizing vegetation mapping and map qualities assessment which should be adapted to such new technologies and methods. EO techniques, and the

presented class modelling approach here in particular, has the potential to decrease the high rate of subjectivity inherent to conventional methods used for habitat field mapping. This mainly refers to delineating and composition of habitat boundaries, a process which mainly depends on observer decisions in situ and is therefore not repeatable as such. According to Chen et al. (2012) [5], the object based change detection techniques provide better results for very high spatial resolution imagery. The pixel-based approach can be useful in practice when the objects of interest are smaller than the size of the spatial resolution of the image [6]. But the object based approach is more suitable in cases when the objects are composed of several pixels. As a consequence of this it can be concluded that the object-based image analysis (OBIA) would be especially useful when using HR and VHR images [7]. However, OBIA can be applied at different spatial resolution images for identifying homogenous regions [8].

The aim of this paper is to support the data management and mapping concerning the protection and conservation of valuable NATURA2000 habitats. The practice offers us a clear discourse between experts, ecologists and protected area managers on one hand, and EO experts on the other hand. By offering a unified approach for handling data received from Remote Sensing concerning the biodiversity conservation purposes, the representatives of various specialties could work more productively and also to receive further enhanced results. This article presents an attempt by author such an approach to be implemented in practice about seasonal vegetation changes in NATURA 2000 protected areas. The examined areas are represented by two maps of land cover classification. The paper concludes with a brief discussion focused over the advantages and limitations of EO data techniques for biodiversity assessment in protected areas.

NATURA2000 - GOAL AND NETWORK MISSION

In May 1992 European Union governments accepted legislation designed for protection of the most endangered habitats and species across Europe. The legislation is called the Habitats Directive and supplements the Birds Directive commissioned in 1979. The main goal of the both Directives is creation of a network of sites called Natura 2000. The Birds Directive provides the existence of Special Protection Areas (SPAs) for birds. The Habitats Directive similarly secure Special Areas of Conservation (SACs) which should be designated for other species, and for habitats. Together, SPAs and SACs make up the Natura 2000 network an effective instrument for conservation and protection of the endangered ecosystems [9].

Not only natural habitat types are covered, but also semi-natural ones, which depend on management of humans (e.g. certain types of grasslands, pastures etc.). It includes strictly protected nature reserves, but most of the land remains privately owned. The approach of conservation and sustainable use of the Natura 2000 areas is much wider, largely focused on people's attitude, and activities towards nature rather than against it [10].

As the process of choosing Natura 2000 sites faces conclusion, attention is focused over their management. In a period of six years of their designation as Sites of Community Importance, Member States has to designate these sites as Special Areas of Conservation (SACs) and also to adopt certain measures towards conservation involving, appropriate management plans and other dispositions which correspond to the ecological specific needs of the natural habitat types and species of Community interest [11].

In the article has been examined a section of the protected area of Dragoman. With its variety of karst landscapes the Dragoman protected site gives the opportunity different by their nature areas to be explored (wet meadows, marshy areas, open karst areas, and areas occupied by natural deciduous

forests). For the purpose of this study is selected arid karst terrain, in which has been traced the change in vegetation cover during the summer season.

DATA, METHODOLOGY AND SOFTWARE TOOLS

Input data

For incoming data in this study were used two images received from Pleiades-1B sensor respectively on 6/2/2015 9:30:10 am, and on 9/1/2015 09:30:01 am.

“Pleiades-1B satellite sensor was successfully launched on December 2, 2012.”[12]

The sensor was built by AIRBUS Defence & Space and the satellite was launched from a Soyuz launcher at the European Space Centre based in French Guiana.

The launch of the satellite was the third step in the formation of a constellation of four satellites which combines a double daily revisit capability and a resourceful range of resolutions (Table 1).

Table 1. Pleiades-1B Satellite Sensor Characteristics [19]

Imagery Products	50-cm black and white
	50-cm color
	2-meter multispectral
	Bundle: 50-cm B&W and 2-meter multispectral
Spectral Bands	P: 480-830 nm
	Blue: 430-550 nm
	Green: 490-610 nm
	Red: 600-720 nm
	Near Infrared: 750-950 nm
Preprocessing Levels	Sensor
	Ortho
Image Location Accuracy	With ground control points: 1m
	Without ground control points: 3m (CE90)
Imaging Capacity	Daily constellation capacity: 1,000,000 sq.km.
	Strip mapping (mosaic): 100 km x 100 km
	Stereo imaging: 20 km x 280 km
	Max. spots over 100 km x 200 km: 30 (crisis mode)
Imaging Swath	20 km at nadir
Revisit Interval	Daily

These images provide valuable EO data about the territory of the area of interest. After processing the data with appropriate software (ArcGIS 10.31 and eCognition Developer 9.1) were compiled two maps with three classes of land cover.

Methodology

“**Geographic Object-Based Image Analysis (GEOBIA)** is a newly evolving sub-discipline of GIScience devoted to partitioning remote sensing (RS) imagery into meaningful image-objects, and assessing their characteristics through spatial, spectral and temporal scale.” [13]

In order to functioning properly, each methodology has to fulfill some basic conditions. At the case of GEOBIA the process requires: “image segmentation, attribution, classification and the ability to query and link individual objects (a.k.a. segments) in space and time”. [14] To achieve this, GEOBIA brings together knowledge and experiences from an array of disciplines connected in generation and use of the geographic information (GI). Because of its unique focus on RS and GI GEOBIA is distinguished from related disciplines such as Computer Vision and Biomedical Imaging.

As a key objective of GEOBIA could be considered the development and application of an appropriate theory, tools and methods sufficient enough to replicate (and or exceed) an experienced human interpretation of RS images in automated/semi-automated ways, resulting in increased repeatability and production, and on the other hand reducing subjectivity, labor and time costs. “As a result, GEOBIA is increasingly recognized as an evolving integrative Geospatial paradigm that builds on concepts incorporated from a broad range of disciplines including: Remote Sensing, Geographic Information Systems (GIS), Image Processing, Knowledge Discovery in Databases (KDD), Geospatial Statistics, Cartography, Photogrammetry, Landscape Ecology, Geography, and many others.” [15]

Software tools

For the preparation of these maps were used the following methods and software:

The technical implementation of the map is performed with a software product developed by the German company Trimble – eCognition Developer (version 9.1). The eCognition Developer is a powerful development environment for object-based image analysis. It is used in earth sciences to develop rule sets (or applications for eCognition Architect) for the automatic analysis of remote sensing data. [16]

Definiens Developer, is a result from the continuous advancement of eCognition. It represents object based image analysis software which features various segmentation algorithms allowing users to generate a networked object hierarchy. These discrete objects can then be classified either as rule-based or sample based. Definiens Developer is part of the Definiens Enterprise Image Intelligence Suite which consists of client and server software products which meet the needs of any image-based business process. The client products are role-based and support the different user needs. The server products provide a consignment processing environment that allows the analysis of almost unlimited number of images. [17]

In the ex ante processing of incoming data are used the following functions and methods:

- Apparent reflectance function;
- Pan-sharpening function and method Gram-Schmidt;

Apparent reflectance function

Apparent reflectance function adjusts image brightness digital number (DN) values for some satellite sensors, in similar way like an atmospheric correction. The adjustments are based on sensor properties (gain/bias settings for each band), sun elevation and acquisition date. In general the function of apparent reflectance function could be described as that:

“The Apparent Reflectance function is used to adjust reflectance, or brightness, values of some satellite imagery based on the scene illumination and sensor-gain settings. The images are adjusted to a theoretically common illumination condition, so there should be less variation between scenes from different dates and different sensors. This can be useful for image classification, color balancing, and mosaicking.”[18]

The function performs two corrections:

- First one is based on the gain settings. Original brightness values are re-created from the image values by reversing the gain equations.
- Second type of correction has to do with differences in sun angle and brightness.

The results of the Apparent Reflectance function can also be expressed as Albedo, which is the percentage of the available energy reflected by the planetary surface.

Pan-sharpening function and method Gram-Schmidt

The Pan-sharpening function uses a higher-resolution panchromatic image (raster band) to fuse with a lower-resolution, multiband raster dataset. The Gram-Schmidt pan-sharpening method is based on a general algorithm for vector orthogonalization—the Gram-Schmidt orthogonalization.

RESULTS AND DISCUSSION

This article presents two maps of selected representative sample chosen from the study area. Maps represent classification of the land cover of those selected area samples which are located in one of the typical for the country's territory karst regions. The maps presented in this paper reflect to the 2015 state of the examined areas and they were compiled with maximum accuracy and information obtained from satellite images used as a basis. The maps presented in this work represent the land cover of selected karst region in the protected area of Dragoman. The examined region is an arid territory located in the karst hills locked between Tri Ushi, Chepan and Mala Mountain. Vegetation in the area is represented by a typical sub-continental and peripanonic shrub species. There are patches of separate groups with low trees. Both of the images used as basis for the research partially overlap each other. This helped the author to select an area of sufficient size and conditions in which could be shown the changes of the land cover from different periods of the year. The aim of both maps presented in this paper is to show the changes of the grass, trees and shrub vegetation during summer period. As it was mentioned above, for the purpose were used two adjacent satellite images received at the beginning of June 2015 and respectively in early September 2015.

The method of classification applied in the case is Sample-based classification method. After performing image segmentation in appropriate scale, the next step is to select test sites (segments) from the segmented image. The test segments were recognized manually by the author as certain types of land cover. They were used as basis by the software algorithm to calculate automatically the rest of the unclassified areas of land cover. The method gives very good results when examined territory has small area without large number of land cover classes. In this particular case 3 types of land cover classes were used - one for open karst areas and two different classes of vegetation. The presented maps shows a clear change in the state of the vegetation during the active growing season. From the spectral characteristics of the image obtained through m. September, representatives of deciduous vegetation are much more clearly distinguished than the grasslands (Figure 1).

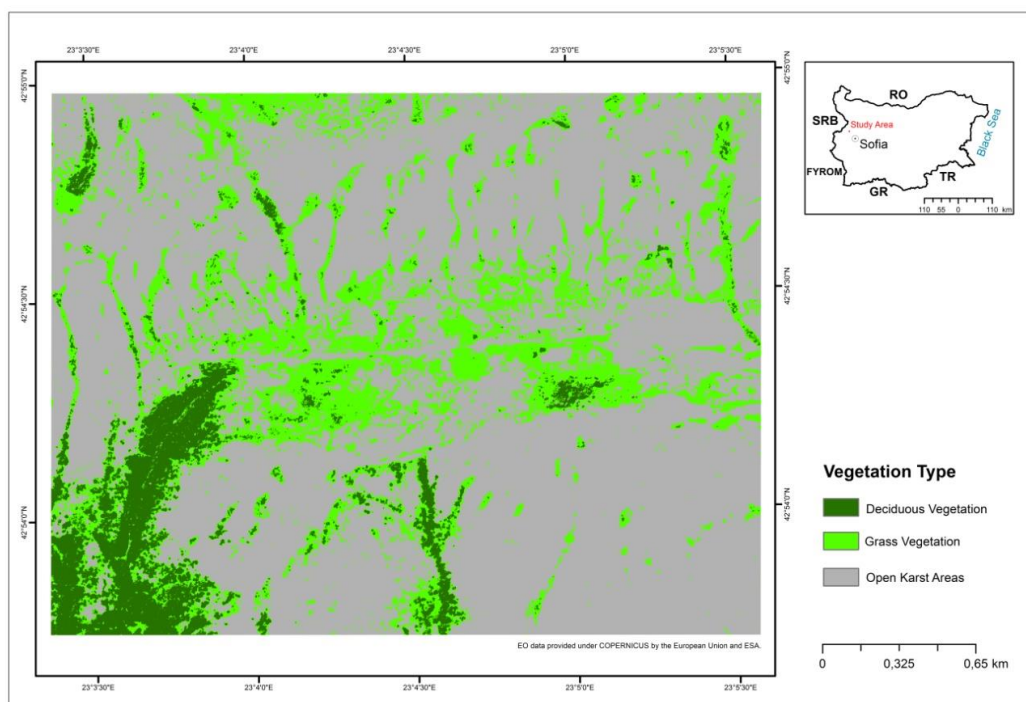


Fig. 1. Map of the land cover classes according to satellite image received on 9/1/2015

The Sample-based method used by the author for performing the classification had been affected by a certain degree of match between the spectral characteristics of grasslands and deciduous species. This is clearly visible in the results, obtained from the image received at the beginning of June where the fresh spring leaves were partially recognized as grass by the sensor (Figure 2).

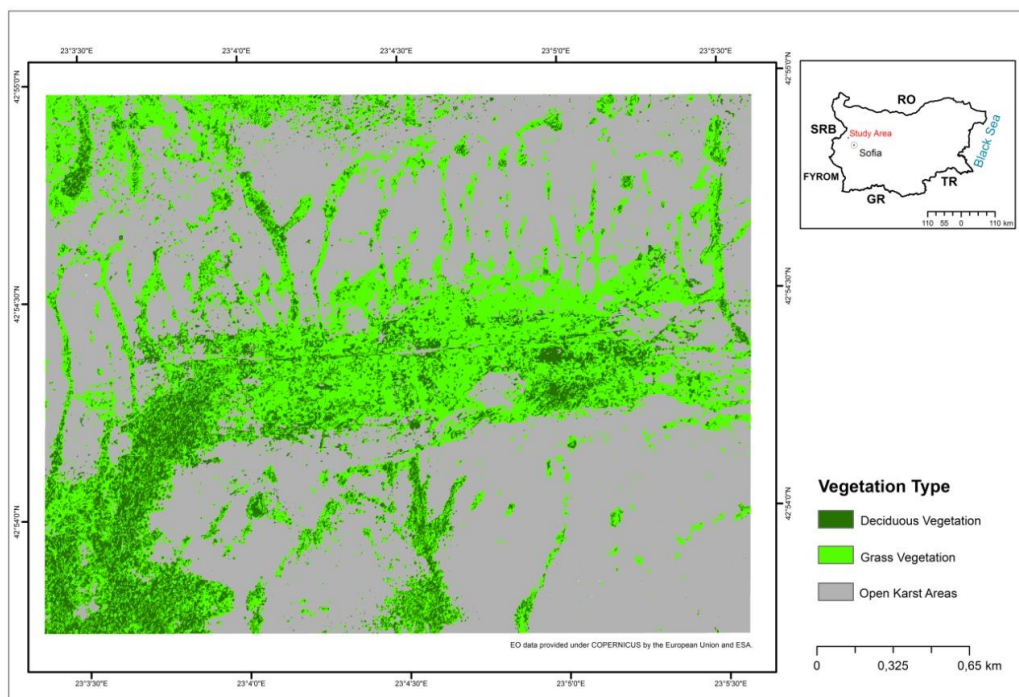


Fig. 2. Map of the land cover classes according to satellite image received on 6/2/2015

The fact should be considered by the users of the spatial data of such type if they decided to perform such classification method. The result contradicts to previous conclusions that the vegetation can be most clearly identified by using images from the early summer. The results from the classification are also shown in tabular form (Table 2) with the numerical and percentage ratio between land cover classes in the study area.

Table 2. Land cover classes area ratio

Land cover classes	Area in June (ha)	Area in September (ha)	Percentage in June	Percentage in September
Deciduous Vegetation	81,88	52,54	11,84	7,6
Grass Vegetation	187,96	140,43	27,19	20,32
Open Karst Areas	421,25	497,94	60,9	72,07

CONCLUSION

The purpose of this article is to support data management and mapping in terms of protection and preservation of valuable Natura2000 habitats. The study area is represented by two maps of land cover classification. The presented maps show clearly the change in the state of vegetation during the active growing season. In addition to the results in the material are discussed advantages and disadvantages of the applied methods and techniques. Despite some drawbacks and inaccuracies, with their help could be carried out regular monitoring of the status and changes of karst landscapes in the protected Natura 2000 site. In the future, similar methods would be useful for streamlining the periodic monitoring laid down in the Habitats Directive on the one hand and on the other to reduce subjectivity in the evaluation of size and distribution of various habitats.

REFERENCES

- [1] Vanden Borre J., D. Paelinckx, C. Mùcher, L. Kooistra, B. Haest, G. Blust, A. M. Schmidt, Integrating remote sensing in Natura 2000 habitat monitoring: Prospects on the way forward, *J. Nat. Conserv.*, 19, pp. 116–125, 2011. <http://dx.doi.org/10.1016/j.jnc.2010.07.003>;
- [2] Kalluri S., P. Gilruth, R. Bergman. The potential of remote sensing data for decision makers at the state, local and tribal level: experiences from NASA's Synergy program *Environ. Sci. Policy*, 6, pp. 487–500, 2003. <http://dx.doi.org/10.1016/j.envsci.2003.08.002>;
- [3] Nagendra H., R. Lucas, J.P. Honrado, R.H.G. Jongman, C. Tarantino, M. Adamo, P. Mairota, Remote sensing for conservation monitoring: assessing protected areas, habitat extent, habitat condition, species diversity and threats, *Ecol. Indic.*, 33, pp. 45–59, 2013;
- [4] Pettorelli N., W.F. Laurance, T. O'Brien, M. Wegmann, H. Nagendra, W. Turner. Satellite remote sensing for applied ecologists: opportunities and challenges, *J. Appl. Ecol.*, 51, pp. 839–848, 2014.
- [5] Chen G., G. J. Hay, L. M. T. Carvalho, M. A. Wulder, Object-based change detection, *Int. J. Remote Sens.*, 33, pp. 4434–4457, 2012;
- [6] Blaschke T., G. J. Hay, M. Kelly, S. Lang, P. Hofmann, E. Addink, R. Queiroz Feitosa, F. van der Meer, H. van der Werff, F. van Coillie, D. Tiede, Geographic object-based image analysis – towards a new paradigm, *ISPRS J. Photogram. Remote Sens.*, 87, pp. 180–191, 2014;

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- [7] Blaschke T., Object based image analysis for remote sensing, *ISPRS J. Photogram. Remote Sens.*, 65, pp. 2–16, 2010.
 - [8] Bisquert M., A. Bégué, M. Deshayes. Object-based delineation of homogeneous landscape units at regional scale based on MODIS time series, *International Journal of Applied Earth Observation and Geoinformation* Volume 37, pp 72–82, 2015.
 - [9] <http://www.natura.org/about.html>;
 - [10] http://ec.europa.eu/environment/nature/natura2000/index_en.htm;
 - [11] http://ec.europa.eu/environment/nature/natura2000/management/index_en.htm;
 - [12] <http://www.satimagingcorp.com/satellite-sensors/pleiades-1b/>;
 - [13] <http://www.ucalgary.ca/f3gisci/GEOBIA> ;
 - [14] <http://www.ucalgary.ca/f3gisci/GEOBIA>;
 - [15] http://www.mdpi.com/journal/remotesensing/special_issues/geobia;
 - [16] <http://www.ecognition.com/suite/ecognition-developer>;
 - [17] <http://wiki.ucalgary.ca/page/GEOBIA#Methods>;
 - [18] <http://desktop.arcgis.com/en/arcmap/10.3/manage-data/raster-and-images/fundamentals-of-panchromatic-sharpening.htm>;
 - [19] <http://www.satimagingcorp.com/satellite-sensors/pleiades-1b/>