STUDY ON ECOLOGICAL DYNAMICS OF FOREST VEGETATION IN THE REGION OF EAST RHODOPI ON THE BASE OF SATELLITES, GPS AND GROUND DATA

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Abstract: In this paper a study of forest vegetation in the territory of East Rodopi based on satellites, GPS and other ground-based data is presented. The local areas of forest communities in classes and their distribution depending on the topography are defined. In this study we analyzed the Normalized Deferential Vegetation Index (NDVI) between forest classes. The study is the result of cooperation between specialists from SSTRI-BAS and Sofia University. This study is the initial stage of a comprehensive research on the dynamics and development of natural systems in Bulgaria.

Key words: ecological dynamics, forest community, satellites data, East Rodopi Mts.

1. INTRODUCTION

The local ecological changes as an element of global changes are as a result of phenomena and processes that induce different effects in the biosphere. The dynamics in the main elements of the biosphere are the reason for running of various processes and phenomena associated with changes in environment quality. In this case, ecological control is needed to preserve the characteristics of the environment. The control gives an opportunity, based on a study on ecological dynamics elements, for identifying the acting factors and for predicting forthcoming processes with an aim to ensure the sustainable development of the biosphere.

The forest vegetation is one of the natural components that have significant ecological meaning as a climatogenic, edafogenic and water regulating factor for specific regions and for the biosphere as a whole. The study on the state and changes in the areas occupied by forests has important practical significance for assessing the changes in the environment, for predicting such changes and formation of appropriate environmentally-friendly management of forest resources for sustainable development of regions against the appropriate use of resources and environment conservation [1, 2].

The rational approach for disclosure of the dynamics of local areas and of forest communities is based on the application of modern information technology when ecological studies and ecological monitoring are conducted using satellite, GPS and other ground data. The main purpose of modern geoinformation technologies is the creation of dynamic local and global environmental databases needed to conduct a complex analysis and assessment of forest communities and environmental characteristics.

The problem of ecological dynamics of vegetation was studied by one of the authors, i.e. status and distribution of vegetation cover in the Chuprene reserve is assessed by spatial models in GIS environment. [3]. The purpose of the present study is a research on some elements of the ecological dynamics of forest vegetation in other area – East Rodopi, by using an original methodical approach for interpretation and implementation of satellites and ground data.

2. OBJECT AND METHODS

The studied region is located in East Rodopi, situated on an area within the boundaries 41.82^0 – 41.51^0 N; 25.08^0 – 25.67^0 E (UL/LR) with a total area of 1776.32 km^2. According to the climate zoning of the country the territory is referred to Continental–Mediterranean region [4]. The annual total solar radiation in the area is from 5100 to 6000 MJ/m^2. The photosynthetic active radiation for the period with air temperatures above 10^0C is from 1600 to 2100 MJ/m^2. The annual precipitation in the researched area is from 600 to 1000 mm. The annual evaporation is from 600 to 800 mm. The average air temperature in the warmest month: 20-23^0C. [6]

The investigated area is part of the Mediterranean soil region and East Rodopian-Sakar province. The main soil types in the region are: *Leptosols Chromic* and *Ferralic Cambisols*, *Planosols*, *Andosols Dystrict* and *Eutric Fluvisols*. [6]

According to geobotanical zoning in Bulgaria the researched territory belongs to the European broad leaved forest region in the province of Macedonia–Thrace and is part of East Rodopi region. It is characterized by a large percentage of Macedonian–Thrace floral elements and Mediterranean species,

dominated by formations of winter oak, pubescent oak and virgilian oak and by formations of Moesia, plain and eastern beech. The kseromesophytic mixed forests are common for the area but also there are relict forests of pine. [7]

The object of present study is the forest vegetation of the East Rodopi divided into three classes: Coniferous forests class; Broad leaved forests class; mixed forests class. The methodology is implemented on the basis of satellites, GPS and other ground data. Multispectral images from Landsat TM, registered on July 21, 1987 (chosen for the start of time interval of the research), June 14, 2000 and July 20, 2007 have been used as satellites data. Multispectral images from QuickBird and ASTER, panchromatic channel from QuickBird, and GPS data have been used for verification of test polygons included in the methodology of the present study.

A vegetation map of Bulgaria M1: 600 000, a map of forests in Bulgaria M 1:1 000 000, CLC 2000 is used as cartographic material [8, 9, 10]. The proposed methodology is based on the model presented by using the status vector – the parameters, which include factors influencing the ecological dynamics of forest vegetation and the elements of ecological dynamics. Formally, the status vector can be presented as follows:

$$VC = \{ f_1, f_2, \ldots, f_n, e_1, e_2, \ldots e_k \},$$

where VC is the status vector of forest vegetation, $f_1, f_2, \ldots, f_n$ – factors influencing the ecological dynamics (location, air temperature and air humidity, precipitation, etc.) and $e_1, e_2, \ldots e_k$ – the elements of ecological dynamics (vegetation indices of foliage, phytomass, forest vegetation state and type and others).

The methodology of the survey consists of two stages each of which includes a number of successive iterations. Originally a supervised classification based on pattern recognition sets is made. Test areas (polygons) selected on satellite composite image (channels 453 and 432 Landsat TM) are used as pattern recognition sets. These polygons are verified using multispectral images from QuickBird and ASTER, panchromatic channel QuickBird and GPS ground control points. The selected test areas correspond to the following classes: coniferous, broad leaved forest, mixed broad leaved–coniferous forests. The pattern recognition sets are selected on areas of the images where the distribution density of forest communities is the highest one and the probability for recognizing their position through ground and satellite sources of information is the highest. The pattern recognition sets are validated according to the metrics of complex criteria for distance between the classes (hierarchical classification method is used – dendrograms). The visual interpretation of satellite images available is carried out by detecting, identifying and recognizing the same classes – coniferous, broad leaved forest, mixed forest. The second iteration is a comparative analysis of the results from visual interpretation and supervised classification aiming to minimize errors in both classifications. The minimization of errors is made based on validation of results obtained by ground data.

The next stage is to determine the status of vegetation communities vector for the moment of satellite data registration (July 21, 1987 – beginning of interval of research, and July 20, 2007 – the final interval of research). In this case the following parameters of the vector status are defined – type of vegetation forest community (coniferous, broad leaved forest, mixed), location and local area, hypsometric dynamics of local area, registration data time, average monthly temperature, average monthly precipitations, vegetation index (NDVI). The status vectors are compared and the trends of variation in the timing of those values that depend directly or indirectly on the dynamics of forest ecosystems are reported. This means that in case certain vector status parameters are persistent, such as hipsometri, partly location and time, the trends of change in the value of vector status are determined by amending its other defined parameters [11].

3. RESULTS AND DISCUSSION

For the study period the following modification in the monthly temperatures for June and July is observed: 26.90, 25.90 and 27°C, respectively, in 1987, 2000 and 2007, i.e. the value of the monthly air temperature in July is respectively constant. The monthly sum of precipitation have varied for the same months as follows: July - 50 mm, June - 70 mm, July - 50 mm, respectively, in 1987, 2000 and 2007, i.e. monthly sum of precipitation is constant.

The thematic maps of the classifications presented in Fig. 1 show the dynamics of spreading area of vegetation classes. There is a stable tendency of reproduction of the broad leave forests of the study period from 1987 to 2007. By interpreting the classifications, a tendency of positive dynamics of the local areas of broad leaved class from 1987 to

2000 is observed, probably due to natural successions of broad leaved class regeneration over previously denuded territories. While for the period from 2000 to 2007 a negative dynamics of local areas of coniferous and mixed class has been observed.

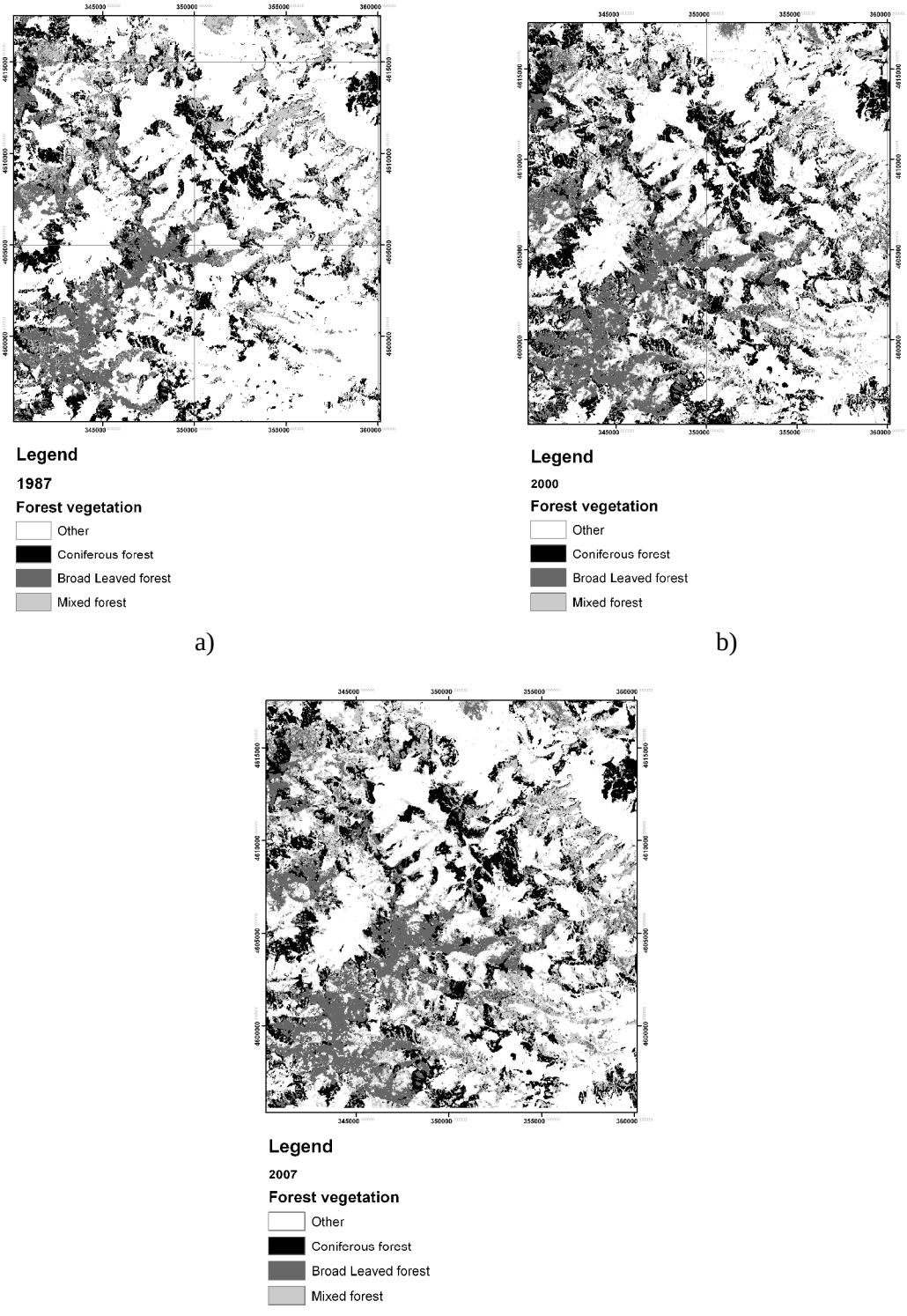
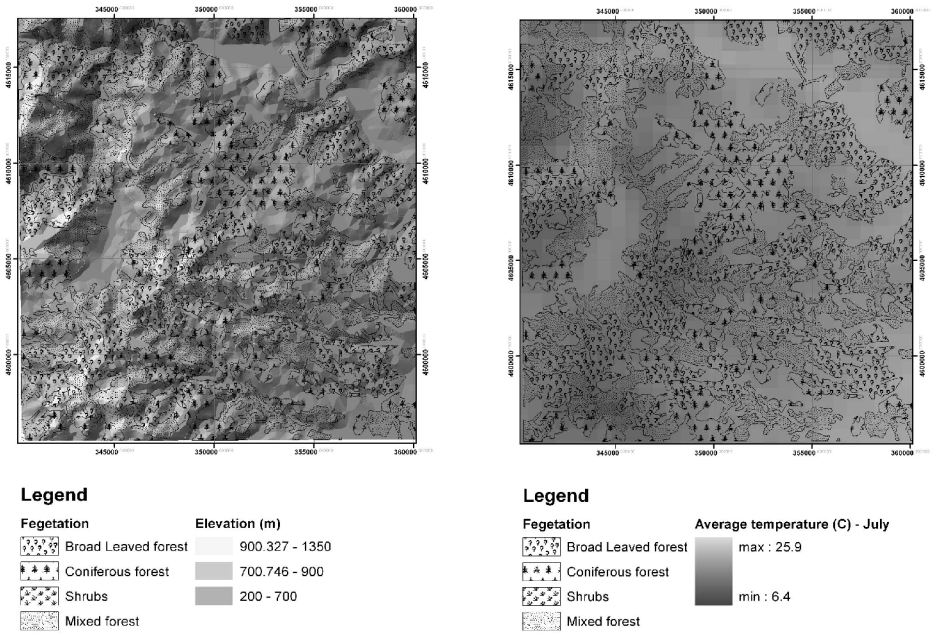


Fig. 1. Thematic maps of spreading areas of forest vegetation classes:
a) for 1987, b) for 2000, c) for 2007.



a) b)

Fig. 2. Thematic map of spreading areas of forest vegetation classes:
a) – by hypsometry; b) – by mean temperature in July for a period of 50 years

Most areas of coniferous class are located on 700-900 m altitude sea level and less part on 900-1350 m. This proves the anthropogenic impact on the area of coniferous forests, as most of the conifers with low-level location are crops. The range of broad leave forests is evenly distributed on relief. For the study period a gradual replacement of coniferous class with broad leave forests class is observed, especially where the coniferous forests are crops. (Fig. 2)

The metrics on complex criteria for distances between the classes of forest communities areas during the study period (1987-2007) is shown in Table 1 and in Fig. 3.

Table.1. Mean values of NDVI by years

	bl-c	bl-mf	mf-c	NDVIbl	NDVImf	NDVIc
1987	1.3151	0.6374	0.6777	0.5264	0.4518	0.3234
2000	1.2268	0.9342	0.2926	0.4703	0.3626	0.2188
2007	1.4137	1.06	0.3537	0.6384	0.5417	0.4279

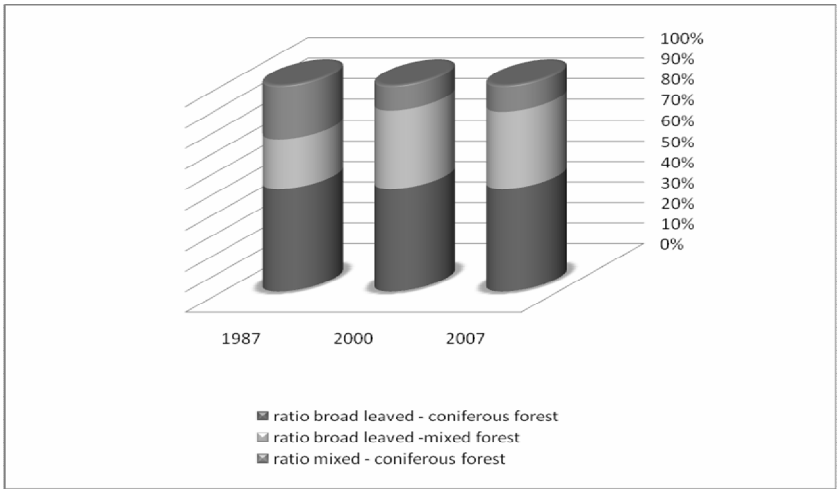
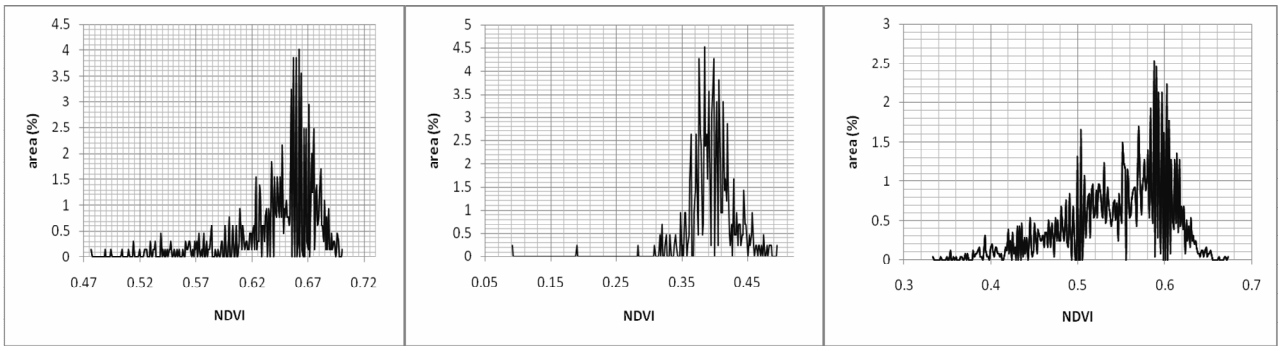


Fig. 3. Forest classes ratio, in percentage

The percentage ratio between the broad leaved class and coniferous class is preserved for the period of study. The ratio between broad leave class and mixed class is increasing, and the ratio between mixed and coniferous is decreasing. (Fig. 3)

The class of broad leaved forests is with maximum NDVI of 0.65, the class of coniferous forests – maximum of value of 0.40. The mixed forest class has two maximums corresponding to the other two classes The first maximum of the coniferous class is with NDVI 0.50, and the second maximum of the broad leaved class is with NDVI 0.60. The dominant part in the mixed class is for the broad leaved forest component (Table 1, Fig. 4).



a) b) c)

Fig. 4. Representative patterns of NDVI by forest vegetation classes:
a – broad leaved forest; b– coniferous forest; c – mixed forest.

4. CONCLUSION

For a period of twenty years variations in temperature and precipitations in July have been established. For the same period a tendency on increase of local area of broad leave class has been observed. The reverse tendency is established for the coniferous class which refers to the natural regeneration of broad leaved communities over previously denuded territories. The published data for some of the coniferous forests in the region confirm the observed variations in their local areas [12]. Referring to landscape researches in the region the established conclusions for broad leave forests are confirmed [14]. During the study some increase in NDVI for all selected classes has been observed. For the interpretation of the observed tendency additional researches are necessary.

The implemented methodical approach is suitable/appropriate for recognition of the selected forest vegetation classes and for observing the status and dynamics of the same vegetation. Its application including more characteristics for the environment status and variations in area, structure and functioning of forest communities is useful because a quick diagnostics and environment risk evaluation are possible to be conducted [13].

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Изследване на екологичната динамика на горската растителност в района на Източни Родопи на базата на спътникова, GPS и наземна информация

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Резюме: В разработката е представено изследване върху горската растителност на територията на Източни Родопи на базата на спътникови, GPS и други теренни данни. Определени са ареалите на горските растителни съобщества по класове, разпределението им в зависимост от релефа и са анализирани измененията на вегатационния индекс на отделните класове горската растителност. Изследването е резултат от съвместната работа на екип от ИКСЗИ–БАН и СУ „Св. Климент Охридски". То е начален етап от по-мащабна разработка за динамиката и развитието на природните системи в България.

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