EVALUATION OF ENVIRONMENTAL INDICATORS AT NATURA2000 HABITAT SITES

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Abstract

Today the remote sensing became common and efficient facilities all over the world. It provides possibility for researchers to survey and determine the condition of the natural features. In relation to Earth-observing satellite program, the airborne hyperspectral technology supplies further advantages for ecologist as a result of high ground resolution and wide spectral range. There are the two basic types of Natura 2000 sites: Special Areas of Conservation (SAC) under the Habitats Directive, and Special Protection Areas (SPAs) under the Birds Directive. The hyperspectral technology gives directly full information about habitat, which can not measured by other methods. Furthermore it enables to measure time series data according as the species what is required, so it could help to prepare and solve the tasks of the Birds Directive. This study represents some results of measuring methods to determine ecological parameters of habitats. The high resolution spectral data evaluation can help to identify different ecological indicators, and the dimension disturbing on the basis of supervised classification and texture examination. In the case of habitat management tasks, it is very important to locate that area, where natural phenomenon and anthropogenic impacts (treading, waste disposal, range of allergenic weed species) were taken place. The main advantage of the analysis of the hyperspectral images is the monitoring of the changes in a very fast way.

Key words: hyperspectral, classification, forest.

INTRODUCTION

Remote sensing is the science of acquiring, processing, and interpreting images and related data, acquired from aircraft and satellites, which record the interaction between matter and electromagnetic energy (Sabins, 1997). Small bandwidths distinguish hyperspectral sensors from multispectral sensors, acquiring spectral information of materials usually over several hundreds of narrow contiguous spectral bands, with high spectral resolution on the order of 20 nm or narrower (Polder & van der Heijden, 2001). As such, they allow identification of specific materials, whereas broadband multispectral data only allow discrimination between classes of materials (Kruse et al., 2003). Hyperspectral remote sensing combines imaging and spectroscopy in a discrete system that often includes large datasets. The contiguous, narrow-bandwidth characteristics of hyperspectral data enable an in-depth examination of surface features on the ground, features which otherwise would be 'lost' within the relatively coarse bandwidths acquired by the multispectral scanners. Over the past decade, extensive research and development has been carried out in the field of hyperspectral remote sensing. Hyperspectral images have also many applications in water-resource management, agriculture and environmental monitoring (Tamás et al., 2005; Kardeván et al., 2003; Plaza et al., 2009). The analysis and classification of the hyperspectral image is suitable for the identification of different objects and features (Lefcour et al., 2006; Plaza et al., 2009).

Hyperspectral imagery is also appropriate for vegetation analysis. Chlorophyll absorbs markedly spectral range between 450 – 670 nm, and the healthy vegetation reflects the 40-50% of the incoming energy between 700-1300 nm spectral ranges due to the internal structure of the canopy. In this way, the measured reflectance plays an important role in distinguishing different plant species, even if these species are seems to be similar based on visible spectral range (Berke et al. 2004).

MATERIAL AND METHOD

The Great Forest is a special treasure for Debrecen, because this was the first object which was protected by the Hungarian national laws in 1939. This 31 ha preserved area is now just a memory, because during the 50's the old forest have been cut except a 7 ha original spot. New oak and other deciduous trees were planted to these places. The whole area of the Great Forest was 1360 ha at the end of the last century. The total connected area is 1092 ha today. On the preserved area 2 highly protected, 49 protected vertebrate and 39 protected invertebrate animal species live. The trees are mainly young, older trees (above 80 years) can be only found on the reserved areas. The nationally important preserved area is one of the Natura 2000 sites. The whole area of the chosen sample area has Natura 2000 primary function, but there are several forest spots where the secondary function is forest park (Figure 1). The largest problem of the forest is the aridness, the degradation of the old oaks and the presence of invasive alien species. The examined area is shown in red polygons.

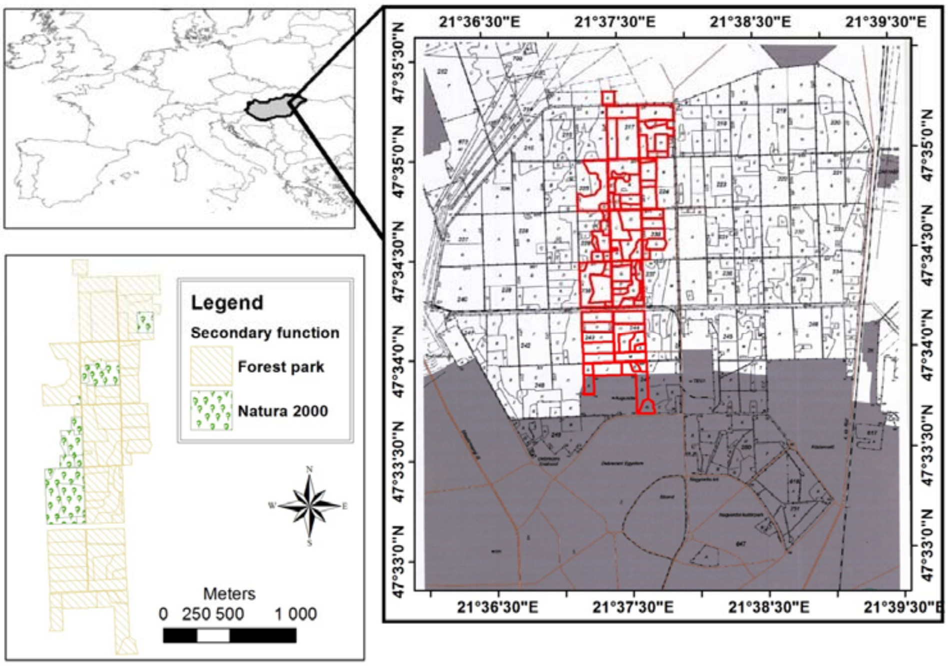

Fig. 1. Location of the Great Forest and the study area
(Projection: UTM, Zone 34 North; Datum: WGS-84)

We determined the tree species which take the larges rate of the area. From these sites we selected the parcels which have the highest natural degree. After this, based on the registry of the forestry, we assorted those parcels where the given tree species reaches 70% coverage. Based on the registry of the forestry we chose the following parcels as reference sites. In the mixed plantations the main tree has 50-70% coverage. With the results of field measurements we selected study areas for the classification and determined field identification points. For example on a clear-cut area we used old hold-over trees which are easy to identify.

The hyperspectral photo that was used as background was made in 2008, on which many parcels are uncovered meanwhile there are new plantations now.

In 2006, an AISA DUAL airborne hyperspectral cam system were installed and operated in cooperation the University of Debrecen, AMTC, Department of Water and Environmental Management with the Mechanization Institute of Agricultural Ministry in Gödöllő. The most important parts of the hyperspectral sensors are the spectrograph, which dissolve the electric waves arrived through the optical rift with the help of prisms and optical screen. The hyperspectral sensor consists of one optic, one spectrograph and one digital cam. The two hyperspectral sensors are assembled in a house; therefore it is known ASIA DUAL system. The two cams can perceive in the visible wavelength, near infrared range and short wave infrared range.

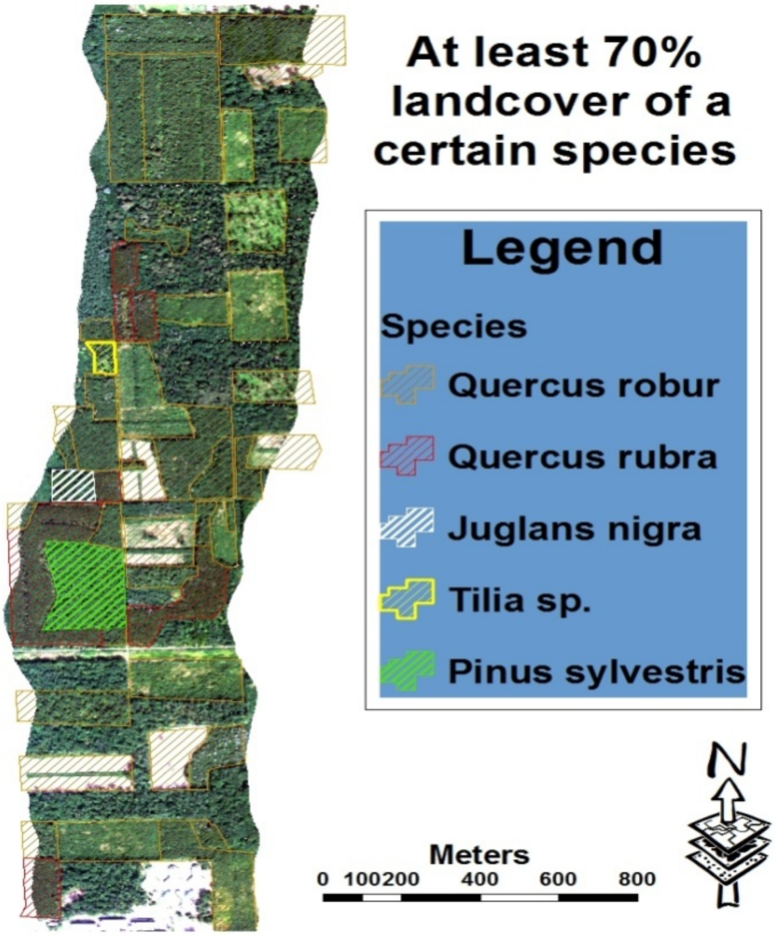

Fig. 2. Landcover types in the study area

Eight subsets from the selected parcels were created. Canopy analysis was carried out in order to classify the differences between vegetation types at the Great forest. To analyse vegetation parameters we masked out the chosen training sites (parcels) from background and create ROIs. Due to the 1.5 m spatial resolution the spectral signature of the different materials of pixels can be mixed. So we defined those pixels where a correct set of "pure" spectral signatures of the chosen tree species can be found (Endmember spectra) based on field measurements.

SAM (Spectral Angle Mapper) is an automated method for comparing image spectra to individual spectra or to a spectral library (Kruse et al., 1993; Plaza et al., 2009). SAM assumes that the data have been reduced to apparent reflectance (true reflectance multiplied by some unknown gain factor, controlled by topography and shadows). The algorithm determines the similarity between two spectra by calculating the spectral angle between them, treating them as vectors in n-D space, where n is the number of bands. Smaller angles represent closer matches to the reference spectrum. In this study, SAM was used to classify the different types of habitats. Supervised classification methods (Spectral Angel Mapper) were used to distinguish main 5 tree species based on the spectral properties of the area: deciduous forest (Quercus robur, Quercus rubra, Juglans nigra, Populus canescens) and coniferous forest (Pinus sylvestris). The results of the classifications were compared to a ground truth image in order to know the best process for classification. The ground truth image is based on ortophoto, topographic map, and GPS based field data collection.

RESULTS AND DISCUSSION

For the fast 2D scatter plot classification we chose a parcel where the 70% of the area is covered with well-fitting oak. Directly next to it there is a clear-cut area (Figure 3). On the scatter plot we highlighted parts of three different spectral density areas. Signing the most density areas on the map the related pixels appear which can be isolated in space too. The red represents the oak-plantation, the green is the clear-cut area. The borderline of the parcel gives the third density area which is shown with blue.

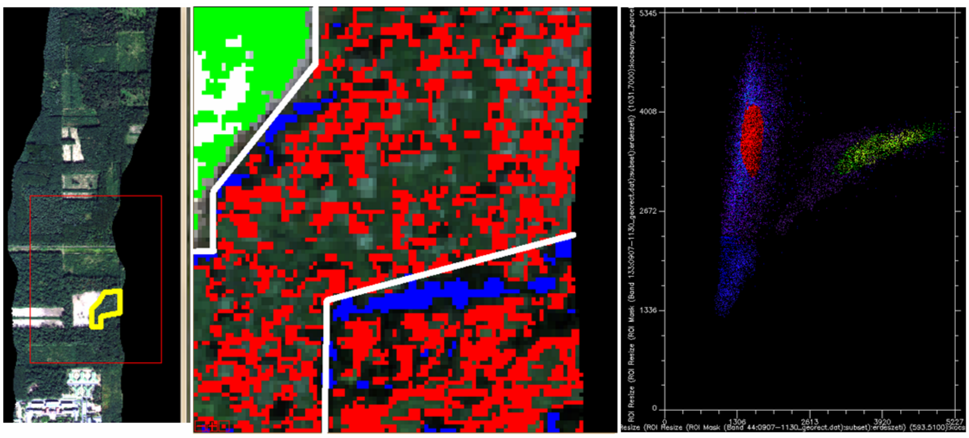

Fig. 3. Fast classification of the sample area with 2d scatter plot

Based on the field measurements we isolated the endmember spectrums that characterize the given species. The pinus sylvestris can be easily separated from the deciduous trees according to its spectral properties with the SAM method (Figure 4). While, the separation of the deciduous trees needs more-step procedure because the spectral values are affected by the state and age of the trees. But on the clear-cut parcels the pixels of the hold-over trees can be indentified easily thanks to the large spectral and space resolution. An example is shown on the bottom of the subset.

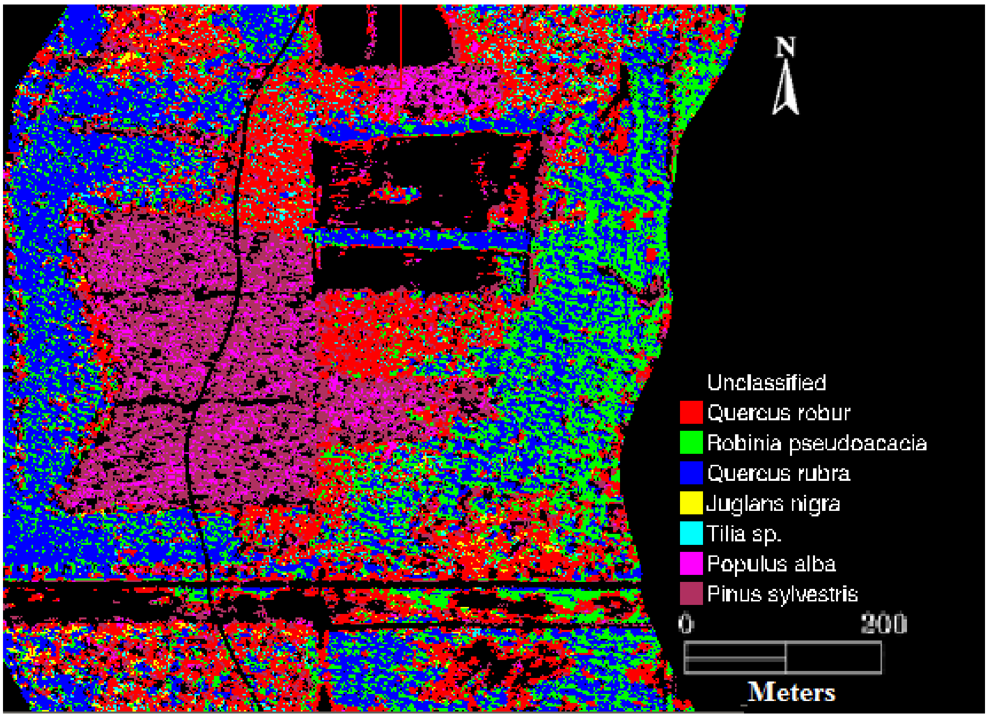

Fig. 4. The result of the SAM classification

As the result of the spectral classification the high coverage rate (74.45% - accuracy 88.6%) of the Pinus sylvestris was demonstrable on the middle parcel. According to the registry of the forestry we determined the accuracy of the classification in the case of the mixed species, which are follows: Quercus rubra 88.4 %; Juglans nigra 66 %; Quercus robur 16.8 %; Robinia pseudoacacia 15.1 %; Tilia sp. 11.8 %; Populus alba 12 %. This low rate of accuracy can be an error that is hard to eliminate in the case of deciduous trees, because of different age and health state.

CONCLUSIONS

Today the hyperspectral imaging has significantly developed and hundreds of spectral bands and analytical techniques are available. The results presented that hyperspectral remote sensing is an effective tool for the characterization of canopy and monitoring of canopy changes at the examined polluted sites. Most sharply and easily the pine plantation can be isolated than re-growth, grassland, bushy areas, deciduous trees (oak and beech) can be defined by different classification methods. More accurate classification is possible, which needs more research. With the use of the available data spectrum characterizing each species cannot be classified precisely. The tree-spectrums of the spectral library only characterize one phenological phase, so it cannot be used in every case. In the case of deciduous trees it seems the spectral differences not just only determined by characterization of the species but there are other conditions which are more deterministic than the species-feature. The classification of the species is the most successful if they are evaluated on the bands where the isolated categories have the sharpest differences.

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REFERENCES

1. Berke J., Kelemen D., Szabó J., 2004, Digitális képfeldolgozás és alkalmazásai. PICTRON Kft. Keszthely. (DVD)
2. Kardeván P., Vekerdy Z., Róth L., Sommer ST., Kemper TH., Jordan Gy., Tamás J., Pechmann I., Kovács E., Hargitai H., László F., 2003, Outline of scientific aims and data processing status of the first Hungarian hyperspectral data acquisition flight campaign, HYSENS 2002 HUNGARY. 3rd EARSEL Workshop on imaging spectroscopy. Herrsching. pp. 324-332.
3. Kruse F.A., Lefkoff A.B., Boardman J.W., Heidebrecht K.B., Shapiro A.T., Barloon J.P., Goetz A.F.H., 1993, The spectral image processing system (SIPS) - Interactive visualization and analysis of imaging spectrometer data. Remote Sensing of Environment. 44., pp.145-163.
4. Kruse F.A., Boardman J.W., Huntington J.F., 2003, Comparison of airborne hyperspectral data and EO-1 hyperion for mineral mapping. IEEE Transactions on Geoscience and Remote Sensing. 41. pp. 1388-1400.
5. Lefcourt A.M., Kim M.S., Chen YR., Kang S., 2006, Systematic approach for using hyperspectral imaging data to develop multispectral imagining system: Detection of feces on apples. Computer and Electronics in Agriculture, 54. pp. 22-35.
6. Plaza A., Benediktsson J.A., Boardman J.W., Brazile J., Bruzzone L., Camps-Valls G., Chanussot J., Fauvel M., Gamba P., Gualtieri A., Marcocini M., Tilton J.C., Trianni G., 2009, Recent advances I techniques for hyperspectral image processing. Remote Sensing of Environmental, 113, pp.110-122.

7. Polder G., van der Heijden G.W.A.M., 2001, Multispectral and hyperspectral image acquisition and processing. In: Tong, Q.; Zhu Y.; Zhu, Z. (szerk.) Proceedings of SPIE. pp. 45-48.
8. Sabins F.F., 1997, Remote Sensing - Principles and Interpretation. 3rd edn. W.H. Freeman. New York, NY., p. 494.
9. Tamás J., Kardeván P., Kovács E., Kovács E., Takács P., 2005, Evaluation of environmental risks of non point source heavy metal contamination using DAIS sensor. Zagajewski, B.; Sobczak, M. (szerk.) Imaging Spectroscopy, New quality in environmental studies. Publ. European Assosiatition of Remote Sensing Laboratories. Warsaw University. pp. 473-485.