# Remote Sensing Analysis of Riparian Vegetation Habitats

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**Abstract**
*The high resolution remote sensing data is becoming available increasingly and facilitating the applications of automated image analysis methods and techniques. These methods are advantageous in the evaluation of natural and semi-natural riparian ecosystems where traditional in situ field surveys are very time consuming and often problematic because of inundation. This study analysed the Szigetköz riparian wetland (Hungary) based on high resolution aerial imagery. The analysis proved that the detection of hybrid poplar stands is feasible through the application of decision tree image classification method. It is also concluded that a site-specific algorithm is transferable to the datasets with the same spectral and geometric resolutions of distant sites in the same wetland region applying the same spectral and textural parameters.*

## 1. Introduction

Vegetation cover mapping is an important step required for the management of natural ecosystems. The vegetation provides a base for all living beings and plays an essential role in affecting global climate change with an influence on terrestrial $CO_2$ production (Xiao et al., 2004). Traditional methods for vegetation analysis, like field surveys, map interpretation and ancillary data analysis are often not effective, because they are time consuming, often provide information about lagged dates and require high expenses (Xie et al., 2008). The analysis of remotely sensed imagery brings another perspective to vegetation studies, because it provides possibilities of detecting the patterns at different spatial scales which may not be obvious through on ground observations. This kind of analysis helps in the characterization of ecosystems in larger spatial extents. Apart from this, remote sensing data archives have great potential of facilitating systematic temporal analysis at various scales from recent past to several decades back (Xie et al., 2008). In the study of Lefsky and Cohen (2003) analogue aerial photography has been stated as the oldest, most frequently used and best understood form of remote sensing. It has been proven that high resolution historic aerial photographs dating back to 1930s are effective in the mapping of small ecosystems, fine-scale landscape features and successional pathways in some cases (Green and Hartley, 2000 and Morgan et al., 2010). Automated digital image analysis techniques provide a time-saving solution and eliminate the influence of the interpreter's subjectivity in vegetation delineation. The optimal approach depends primarily on the definition of the output products (e.g., the type of the maps) and is influenced by spatial resolution and inter-pixel variance (Wulder et al., 2004). The objective of the present study is to develop a method for land cover classification that overcomes the spectral differences inherently present in the aerial photos. The current study is based on the analysis of high spatial resolution aerial imagery (< 1 m/pixel). In that case the target features are considerably larger than the pixel size, where the application of object-based image analysis (OBIA) became the focus of interest. The main principle of OBIA is the grouping of pixels into meaningful objects before applying classification. Based on this, the current research analysed whether the vegetation classification method with spectral and textural parameters applied to a training image is applicable to the images of other areas in the same wetland region.

## 2. Study Site

The Szigetköz wetland (Figure 1) is a Danubian floodplain ecosystem, located in the interfluve of the Danube and Mosoni-Danube rivers in Hungary. Due to the diversion of the flow of the main Danube river into a side channel for power generation in 1992, several changes occurred in the region. These include a general decrease in the ground water level and a resulting alteration of the habitats from aquatic or aquatic-related forms to more terrestrial ones (Ijjas et al., 2010).


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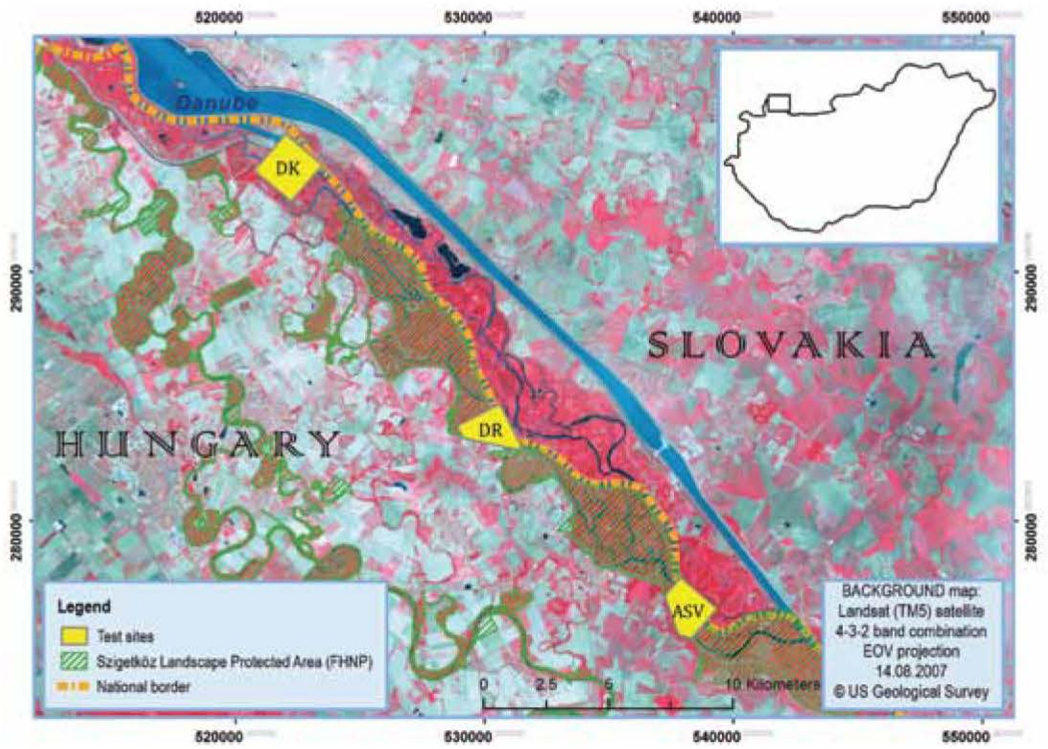


Figure 1: Test sites in the Szigetköz Danubian floodplain: Dunakiliti (DK), Dunaremete (DR) and Ásványráró (ASV)

Significant wetness changes were detected after 1992 in an area related to this study based on the analysis of medium spatial resolution Landsat satellite images (Kristóf, 2005). Several high spatial resolution campaigns were carried out for land cover mapping based on the analogue interpretation of aerial images (Licskó, 2002). In silvicultural applications, pixel-based image analysis techniques were found to be promising for the detection of forest leaf losses (ERTI, 2008).

### 3. Data and Methods

Digital orthophotos of three test sites (each of them covering 2-3 $km^2$) near to the villages Dunakiliti (DK), Dunaremete (DR) and Ásványráró (ASV) (Figure 1) taken on $6^{th}$ of August 2008 were obtained from the Institute of Geodesy, Cartography and Remote Sensing (FÖMI), Budapest. The photos were captured by a digital aerial camera, UltraCamX, in 0.5 m/pixel geometric resolution which had near-infrared (NIR), green (G) and blue (B) channels. Botanical and silvicultural maps aided the interpretation and classification of the aerial images. The botanical habitat map of DR prepared by the General National Habitat Mapping System in 2004 was provided by the Fertő-Hanság National Park. The silvicultural maps showing the forest stand type information of 2010 were provided about each site by the National Forest Inventory (Szombathely). A study of the DR test area by Kollár et al., (2013) showed that object-based image analysis with a combined set of spectral and textural features based on botanical and silvicultural data provided appropriate classification accuracies for the mapping of riparian habitats within a single photo scene. This analysis concentrated on the classification of the same site for different years with different types of aerial photos. Based on the in situ information on forest stands, the class description based classification algorithm developed by Kollár et al., (2013) was applied for each site separately and this provided overall accuracies higher than 90%. In the first step of the current research, vegetation classes were mapped for the DK site. The separation of water bodies was based on a multi-resolution segmentation of the image followed by the thresholding of the modified normalized difference vegetation index applied to the NIR and B channels: BlueNDVI = (NIR-B)/(NIR+B). In the second step, the unclassified part of the image was segmented into 20 m by 20 m square image objects.

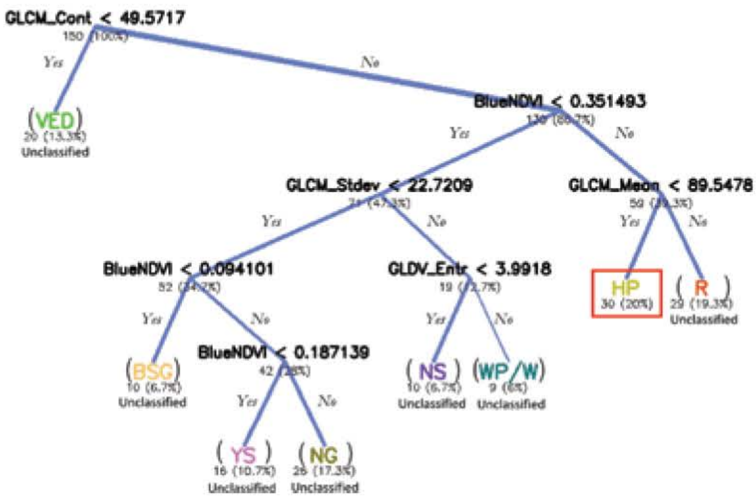


Figure 2: Decision tree computed based on the Dunakiliti training image. Regarding the textural parameters *GLCM_Cont* refers to the contrast, *GLCM_Stdev* to the standard deviation measure of the grey level co-occurrence matrix, *GLDV_Entr* means the entropy measure of the grey level difference vector. Vegetation classes other than *Hybrid poplar (HP)* were applicable only to Dunakiliti: *Vegetation on edges and dams (VED), Bare soil mixed with grass (BSG), Young stand (YS), Non-characteristic grass (NG), Non-characteristic shrubby (NS), Willow & poplar/Willow (WP/W), Robinia (R).*

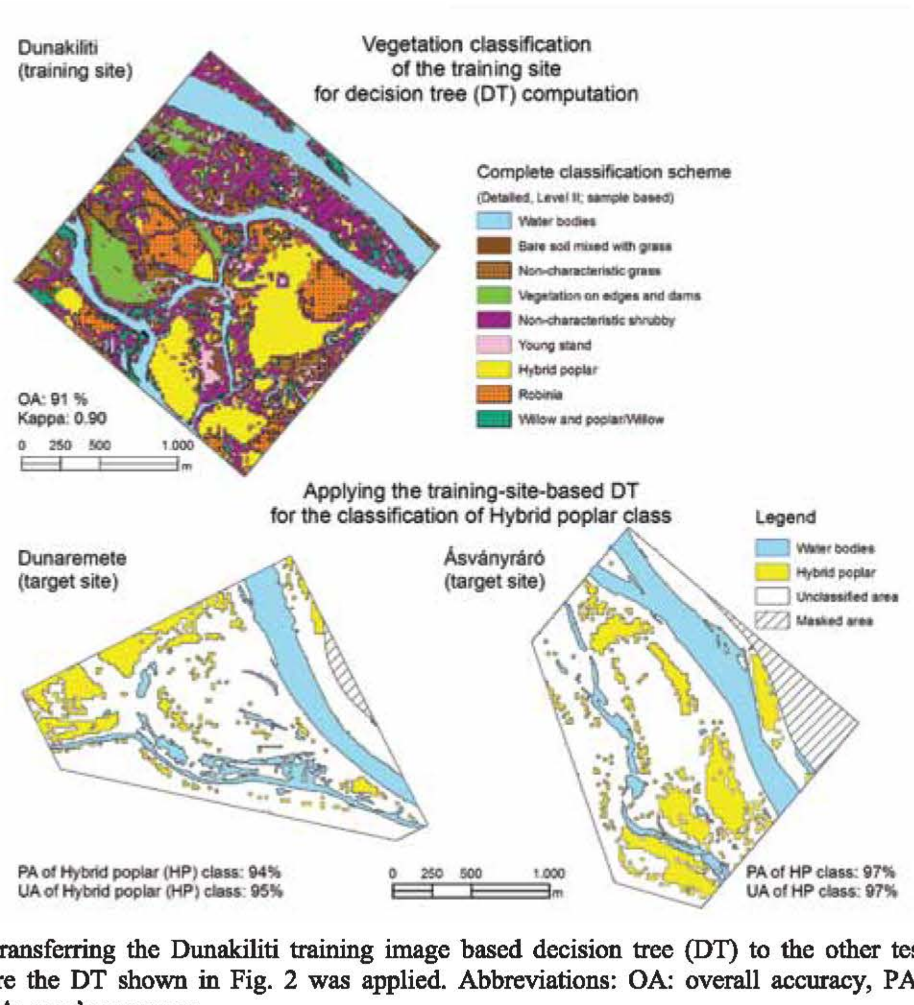


Figure 3. Transferring the Dunakiliti training image based decision tree (DT) to the other test sites (DR, ASV), where the DT shown in Fig. 2 was applied. Abbreviations: OA: overall accuracy, PA: producer's accuracy, UA: user's accuracy

The image segment size was defined by the semi-variogram analysis of the pattern of different vegetation habitats, which was previously described in detail in Kollár et al., (2013). The vegetation habitats were classified with the decision tree classification algorithm applying the following parameter set: BlueNDVI as spectral parameter and 4 textural parameters derived from the grey level co-occurrence matrix (GLCM) based on the first principal component band (PC1). GLCM characterizes the probability that radiometric values of each pair of pixels from a grey-scale image (here the PC1) co-occur in a given direction and at certain lag distance (Haralick et al., 1973). The selected measures of GLCM were the mean, the standard deviation, the entropy and the contrast. The application of the chessboard segmentation method and the selection of the mentioned parameters were based on the study of Kollár et al., (2013). For transferring the classification algorithm, decision tree method as a multi-stage classification technique was applied in the further analysis instead of the class description based fuzzy algorithm. The decision tree method is based on the concept of successively splitting the dataset into increasingly homogeneous subsets until the terminal nodes (target classes) are assigned (Laliberte and Rango, 2009).

**4. Results**

In a previous testing for classification transferability, the decision tree was computed firstly for the training site of DR and then it was transferred to the site of DK. In that case, the class of hybrid poplar habitat was detected with a producer's and user's accuracy higher than 86 %, whilst the accuracies for the other classes were lower than 55 % (Kollár, 2014). For that reason, instead of applying a complete vegetation classification, the classification transfer analysis concentrated on the detection of hybrid poplar forest cover afterwards. However, the training site for the decision tree classifier was changed to the DK test area, due to the existence of more homogeneous hybrid poplar stands. The original decision tree applied on the site of DK was modified to "Unclassified" at the "non-hybrid-poplar" end leaves (Figure 2) in order to exclude other vegetation classes than hybrid poplar. The modified decision tree was applied to the other test sites after the delineation of water bodies as described previously. The application of the modified decision tree to the DR and ASV sites resulted in a producer's and user's accuracy higher than 94 % (Figure 3). In the DK site, the training samples for the hybrid poplar class only included clear hybrid poplar stands based on the silvicultural reference data. In the DR and ASV sites mixed poplar stands, e.g., hybrid poplar mixed with domestic poplar type became also classified based on the decision tree transfer method. This means that the other types of poplar stands (non-hybrid poplar) show similar texture characteristics.

**5. Conclusions and Future Research**

It was found that the decision tree transfer method is effective for rapid assessment of hybrid poplar stands from colour infrared aerial imagery of a wetland region. Since the vegetation analysis was based on the pattern characteristics of square image segments of 20 m by 20 m size, the advantage of the originally high geometric resolution (0,5 m/pixel) was lost. However, the analysis of textural patterns was possible from the high geometric resolution. In future, further segmentation of high geometric resolution imagery should be investigated in order to define more accurate habitat boundaries. This will help avoiding the restriction of the pattern analysis on the currently applied segment size. Future research could show whether a similar image classification transfer method exists for the evaluation of other types of land cover as well as for other landscape regions.

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