USING LIDAR AND AERIAL PHOTOGRAPHY TO BUILD A GEOGRAPHIC OBJECT DATABASE TUNED FOR ECOLOGICAL MODEL

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ABSTRACT:

Ecological models require a large variety of variables in order to describe the biotic and abiotic conditions that define wildlife habitats and biotope distribution. Instead of providing this information using regular grids or categorical maps, geographic object-based image analysis allows to describe the land cover based on meaningful spatial regions which are closer to the natural habitats than regular grids and more flexible to the specific needs of models than categorical data. In the frame of the Lifewatch/Wallonia-Brussels project, we use GEOBIA to create a geographic object database closely related to the ecological concept of ecotope. Through an iterative process with ecological modellers, this database has been designed in order to define its key characteristics : it had to provide a quantitative description of the land cover within topographically relevant spatial regions and it integrates contextual information from different scales. The proof of concept of this new type of geographic database was done over the Wallon region in Belgium. This study area covers approximately 16800 square kilometers with a very fragmented landscape. A dataset including aerial photographs at 0.25 cm resolution and LIDAR at 0.8 pts/m has been provided by the Walloon region for the study. The data were resampled at 2m resolution for the purpose of the analysis. The data processing workflow includes three steps : pixel-based image classification, image segmentation and object-based integration. Pixel-based image classification consists in a supervised classification with the spectral values from the aerial photographs (NIR/Red/green/blue), the Digital Height Model extracted from the LIDAR and the intensity of the first LIDAR return. This yielded a classification into broadleaved trees, needleleaved trees, grass, bare soil, crop, pavement, building, water and shadows with more than 80% overal accuracy. The image segmentation approach is the main novelty of this research. In order to fit with the biotopes, image segments indeed had to take the type of slope into account. This was achieved by computing pseudo-hillshades for North-South and West-East orientation and including those two files together with the spectral information from the aerial photographs. The result of this analysis is a set of topographically relevant ecotope delineation. The last step applied contextual decision rules to consistently aggregate the land cover information at the ecotope level and add more information from ancillary datasets.

1. INTRODUCTION

Habitat suitability mapping and biotope prediction models are necessary to fill the gaps of field observation for biodiversity monitoring. Remotely sensed data are of paramount importance in providing some spatially comprehensive information that is necessary to the prediction over large regions. In this context, models are historically based on regular grids linked with permanent structured inventories. However, with the democratization of geopositioning devices and the raise of citizen science, the precision of the observation has tremendously increased. An alternative approach to grid based habitat and biotope prediction could therefore emerge with a partitioning of landscape based on GEOBIA.

In this study, we demonstrate the feasibility of automated land units characterization under the concept of ecotopes (Ellis et al., 2006). Ecotope is not a new concept in ecology but it was rarely used in practice due to the combined absence of automated method and spatially precise positioning of biodiversity observations. Contrary to ecological land unit, which are created by the intersection of multiple categorical data, ecotopes are defined as the smallest ecologically homogenous landscape units. A method was therefore designed to delineate and characterize those units at large scale.

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2. DATA AND STUDY AREA

The study area is the Walloon region in the Southern part of Belgium. This is a very fragmented landscape including coniferous forests (mainly spruce), broadleaved forests (mainly oaks and beeches), crops, natural and managed grasslands, peatlands, small water bodies, extraction areas and urban areas.

Two types of input data were available. First, a mosaic of orthorectified aerial photographs upscaled to 2 m resolution and including four 8-bit bands; Second, a LIDAR dataset rasterized at 2 m resolution. The DEM and the height of the vegetation were derived from this LIDAR dataset. This dataset was heterogeneous and required specific mathematical morphology analysis: an closing was applied on the West part (captured at 1550 nm) in order to compensate for the lack of multiple returns and an opening was applied the East part in order to remove power lines.

3. METHOD

The delineation and the characterization are two independent steps of the processing chain. The ecotopes are delineated and quantitatively characterized with a set of ecologically meaningful variables obtained by remote sensing or from other ancillary variables.

3.1 Delineation

The three variables of interest to discriminate ecological function at the scale of the analysis are the land cover, the topography and the soil type. However, soil type information was not precise enough and could be partly inferred by the topography. We therefore focused on topography and land cover. A commonly used trial and error segmentation with the multiresolution segmentation algorithm (Baatz and Schäpe, 2000) was applied for the ecotope delineation. The efficiency of a segmentation combining LIDAR height and multispectral image had already been proven (Geerling et al., 2009). However, the main originality of our method was to combine the spectral information from the orthophotos with the DEM in addition to the height information from the LIDAR. Including topography in a segmentation however require a transformation of the DEM data to highlight the different slope types and identify breaks. Slope aspect could however not be used the the segmentation algorithm because it is undefined when the slope in null and because it is a circular metric that jumps from 360 to 0. We therefore created two synthetic hillshade maps along the North-South and the East-West transects. The seven layer were then combined in a single image that was segmented with band weights providing equal contribution to spectral values, height and hillshade.

3.2 Characterisation

A large set of attributes have been derived from existing database and GIS analysis. This set includes bioclimatic variables, soil variables, topographic variables and land cover variables. Those variables have been selected based on expert knowledge and their contribution to habitat suitability models.

For the land cover variables, a pixel-based classification was first performed using the 4 spectral bands of the orthophoto and the LIDAR information. LIDAR data was used to mask out most water bodies based on the absence of returns and extreme intensities linked with the specular reflection on the waves. A maximum likelihood classifier was trained (Radoux et al., 2014) based on a reference dataset combining an existing land cover maps and a model to predict shadow position based on the LIDAR DSM. The a priori probability was computed based on the frequency of each land cover type within two height classes (below and above 50 cm). This step was particularly useful to discriminate forests, shrubs and buildings from the other land covers.

4. RESULTS AND DISCUSSION

Approximately 1.2 million image-segments were automatically created. Figure 1 shows a subset of the segmentation result highlighting the impact of the topography on the segments created inside the otherwise homogeneous forest. Indeed, homogeneous slope types are delineated in addition to the land cover induced delineation. As a result, the heterogeneity of the topographic attributes decreases and the separability of ecotopes increases. On the other hand, relevant continuous patches are delineated without the artefacts that risk to occur when two (or more) categorical maps are overlaid in a GIS (Hong et al., 2004).

From a modelling perspective, habitat suitability mapping was improved by using the ecotopes versus categorical maps. Furthermore, it was shown that the biotope mapping of *Aceron pseudoplatani* (ravine maple forests) was improved when using a topographic based segmentation.

5. CONCLUSION

This study highlighted how GEOBIA could provide appropriate input data for habitat suitability and biotope mapping. Detailed results and discussion will be presented at the GEOBIA conference.

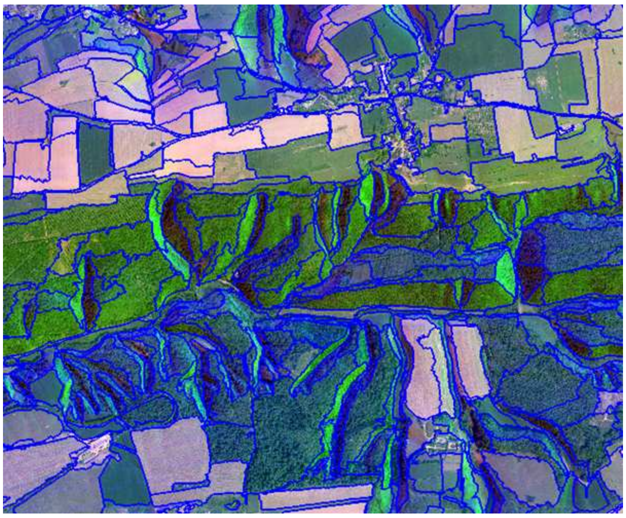

Figure 1. Image-segment overlaid on the input data. The color composite used the red, green and blue bands of the orthophoto in the RGB channels as well as the NS and EW hillshades with the red and green channels.

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